



Engineering

Technical Standard

# TS 0300 : The supply and installation of low voltage electrical equipment

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**Government of  
South Australia**

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## Documents superseded by this standard

The following documents are superseded by TS 0300:

- a. DS 79, issued September 1998
- b. TS 79, issued 31 July 2016

## Significant/major changes incorporated in this edition

Updates in this version of the Technical Standard include:

- a. Updated in accordance with the SA Water Technical Standard Template Version 8.0 and the SA Water Style and Writing Standard Version 2.0.
- b. Internal references updated.
- c. Section 3.3.7.4 – surface treatment clarification
- d. Section 3.3.9(b) – vandal resistant hinges
- e. Section 3.3.11 – battery mounting details
- f. Section 3.4.1 – changes to CT wiring
- g. Section 3.4.6 – minor change
- h. Section 4.2.2 - minor changes
- i. Section 4.7 - minor change
- j. Section 4.10 - minor change
- k. Section 4.13.3 - minor change
- l. Section 4.14.2 - minor change
- m. Section 4.20 – requirement for alarm mitigation capability with the inclusion of phase imbalance/undervoltage
- n. Table 4-1 – minor change
- o. Section 4.22 - minor change
- p. Section 4.22.1 – major rewrite of surge protection requirements for main and distribution switchboards
- q. Section 4.23.4 – minor change
- r. Section 4.25 – minor changes to emergency stop requirements
- s. Section 4.26.2 - minor changes
- t. Section 4.27 - major changes to requirements for air conditioners for switch rooms
- u. Section 5.5 and 5.6 - minor changes
- v. Section 6.1 and 6.2 – motors and actuators with new requirements
- w. Section 7.11.5 – clarification of requirements for generator changeover switches
- x. Section 9.3 – minor addition
- y. Section 9.6 – minor changes
- z. Section 9.7.1 – minor addition
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- bb. Section 9.12 - minor change
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# 1 Introduction

SA Water is responsible for the construction and commissioning of an extensive amount of engineering infrastructure such that it is safe and functional.

This standard has been developed to assist in the design, maintenance, construction, and management of this infrastructure.

## 1.1 Purpose

The purpose of this standard is to detail minimum requirements to ensure that assets covered by the scope of this standard are constructed and maintained to consistent standards and attain the required asset life.

## 1.2 Glossary

The following glossary items are used in this document:

Term	Description
<b>ACB</b>	Air Circuit Breaker
<b>AS</b>	Australian Standards
<b>CFS</b>	Composite Fuse Switch
<b>ELV</b>	Extra Low Voltage: Not exceeding 50 V AC or 120 V ripple-free DC
<b>HMI</b>	Human Machine Interface – generally regarded as a ‘Touch Screen’ that shows the graphical representation of a process or system.
<b>HRC</b>	High Rupturing Capacity
<b>HV</b>	High Voltage: Exceeding low voltage.
<b>LED</b>	Light Emitting Diode
<b>LV</b>	Low Voltage: Exceeding extra-low voltage, but not exceeding 1,000 V AC or 1,500 V DC
<b>MCB</b>	Miniature Circuit Breaker
<b>MCCB</b>	Moulded Case Circuit Breaker
<b>Must</b>	Indicates a statement is mandatory
<b>PCN</b>	Plant Control Network
<b>PLC</b>	Programmable Logic Controller
<b>RCD</b>	Residual Current Device
<b>RTU</b>	Remote Telemetry Unit
<b>SA Water</b>	South Australian Water Corporation
<b>SAPN</b>	South Australian Power Networks
<b>SCADA</b>	Supervisory Control and Data Acquisition
<b>Shall</b>	Indicates a statement is mandatory
<b>Should</b>	Indicates a recommendation
<b>SPD</b>	Surge Protection Device
<b>TDRF</b>	Technical Dispensation Request Form
<b>TG</b>	SA Water Technical Guideline

Term	Description
TS	SA Water Technical Standard
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive

## 1.3 References

### 1.3.1 Australian and international

The following table identifies Australian and International standards and other similar documents referenced in this document:

Reference	Title
AS/NZS 1158	Lighting for roads and public spaces
AS 1289	Methods of testing soils for engineering purposes
Part 5.1.1	Lightning categories
Part 5.2.1	Road Classification
AS/NZS 1554	Structural steel welding
Part 1	Welding of steel structures
Part 6	Welding stainless steels for structural purposes
Part 6.2	External surface treatment
AS 1627	Metal finishing Preparation and pre-treatment of surfaces
Part 1	Cleaning using liquid solvents and alkaline solutions
AS/NZS 1680	Interior and Workplace Lighting
AS/NZS 1768	Lightning Protection
AS 2124	General Conditions of contract
AS/NZS 2293	Emergency evacuation lighting for buildings
Part 3	Emergency luminaires and exit signs
AS/NZS 2648	Underground marking tape
Part 1	Non detectable tape
AS 2700	Colour standards for general purposes
AS/NZS 3000	Wiring Rules
AS/NZS 3008	Electrical installations Selection of cables
Part 1.1	Cables for alternating voltages up to and including 0.6/1 kV
AS/NZS 3010	Electrical installations – Generating set
AS/NZS 3017	Electrical installations – Verification by inspection and testing
AS/NZS 3111	Approval and test specification – Miniature overcurrent circuit breakers
AS/NZS 3112	Approval and test specification – Plugs and socket-outlets
AS 3133	Approval and test specification – Air break switches
AS/NZS 3190	Approval and test specification Residual current devices (current operated earth-leakage devices)
AS/NZS 3191	Electric flexible cords

Reference	Title
AS 3715	Metal Finishing – Thermoset powered coating for architectural of aluminium and aluminium alloys.
AS/NZS 3760	In-service safety inspection and testing of electrical equipment and RCDs
AS 3996	Access covers and grates
AS/NZS 4024	Series: Safety of machinery
Part 1	Safety of machinery
AS 4070	Recommended practices for protection of low-voltage electrical installations and equipment in MEN systems from transient overvoltages
AS 4300	General Conditions of contract for design and construct
AS 4506	Metal finishing – Thermoset powder coatings
AS 4594	Internal combustion engines – Performance
AS/NZS 4680	Hot dip galvanised (zinc) coatings on fabricated ferrous articles
AS/NZS 5000	Electric cables
Part 1	Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV
Part 2	Polymeric insulated – For working voltages up to and including 450/750 V
Part 3	Polymeric insulated – Multicore control cables.
AS 60034	Rotating electrical machines
Part 1	Rating and performance
Part 2.1	Methods of determining losses and efficiency
Part 5	Degrees of protection provided by the integral design of rotating electrical machines (IP Code) – Classification
Part 9	Noise limits
AS/NZS 60079	Explosive Atmospheres
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS/NZS 60598	Luminaires
Part 1	General requirements and tests
Part 2.12	Particular requirements – Mains socket-outlet mounted nightlights
AS/NZS 60921	Ballasts for tubular fluorescent lamps – Performance requirements
AS/NZS 60947	Low voltage switchgear and control gear
Part 2	Circuit breakers
Part 3	Switches, disconnectors, switch-disconnectors and fuse combination units
Part 4.1	Contactors and motor-starters – Electromechanical contactors and motor-starters
Part 4.2	Contactors and motor-starters – AC semiconductor motor controllers and starters
Part 5.1	Control circuit devices and switching elements – Electromechanical control circuit devices
Part 7.3	Ancillary equipment – Safety requirements for fuse terminal blocks
Part 8	Control units for built-in thermal protection (PTC) for rotating electrical machines
AS 60099	Surge arresters
Part 4	Metal-oxide surge arresters without gaps for AC systems
IEC 61000	Electromagnetic compatibility (EMC)

Reference	Title
<b>Part 3.6</b>	Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
<b>AS/NZS 61000</b>	Electromagnetic compatibility (EMC)
<b>Part 6.1</b>	Generic standards – Immunity for residential, commercial and light-industrial environments
<b>AS/NZS 61347</b>	Lamp control gear
<b>Part 2.8</b>	Requirements for ballasts for fluorescent lamps
<b>AS/NZS 61439</b>	Low voltage switchgear and control gear assemblies
<b>Part 0 (TR)</b>	Guide
<b>Part 1</b>	General rules
<b>Part 2</b>	Power switchgear and control gear assemblies
<b>Part 3</b>	Distribution boards intended to be operated by ordinary persons
<b>AS/NZS 61386</b>	Conduits and fittings for electrical installations
<b>Part 1</b>	General Requirements
<b>Part 21</b>	Rigid plain conduits and fittings of insulating material
<b>Part 23</b>	Flexible plain conduits and fittings of insulating material
<b>Part 22</b>	Corrugated conduits and fittings of insulating material
<b>Part 21</b>	Rigid metal conduits and fittings
<b>Part 23</b>	Flexible conduits and fittings of metal or composite material
<b>AS 61869</b>	Instrument transformer
<b>Part 2</b>	Additional requirements for current transformers
<b>AS/NZS 62040</b>	Uninterruptible power systems (UPS)
<b>Part 2</b>	Electromagnetic compatibility (EMC) requirements
<b>Part 3</b>	Method of specifying the performance and test requirements
<b>AS/NZS CISPR 11</b>	Industrial, scientific and medical (ISM) radio frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement
<b>AP-S0280/1</b>	Paint standard
<b>IEC 60085</b>	Thermal evaluation and classification of electrical insulation
<b>IEC 61643</b>	Low-voltage surge protective devices
<b>Part 11</b>	Surge protective devices connected to low-voltage power systems – Requirements and test methods
<b>IEC 62305-4</b>	Protection against lightning - Part 4: Electrical and electronic systems within structures
<b>ISA-S71.04</b>	Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants
<b>ASTM A480/A480M</b>	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip



### 1.3.2 SA Water documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Reference	Title
TS 0100	Requirements for technical drawings
TS 0105	Quality Requirements
TS 0132	Operation & Maintenance Manuals
TS 0112	Process and Instrumentation Diagrams
<del>TS 0270</del>	<del>The Design &amp; Construction of Small / Medium Gas Chlorination Systems</del>
TS 0340	Design, Supply, Installation and Testing of High Voltage Equipment
TS 0360	PLC and HMI systems
TS 0371	Arc flash hazard assessment and design aspects
TYP-03-00001-25c	Example of electrical drafting quality standards
TYP-03-00001-40	Example of electrical drafting quality standards

### 1.4 Definitions

The following definitions apply to this document:

Term	Description
<b>Accuracy</b>	The level of closeness of an estimated value – measured or computed – of a quantity to its true or accepted value.
<b>Constructor</b>	The organisation responsible for constructing and installing infrastructure for SA Water whether it be a third party under contract to SA Water or an in-house entity.
<b>Contractor</b>	A person or firm that undertakes a contract to provide materials or labour to perform a service or do a job.
<b>Corrosive Environments</b>	Any environment where there is a presence of destructive chemicals in which the electrical assets are subject to deleterious effects. Examples of destructive chemicals are: <ol style="list-style-type: none"> <li>Hydrogen Sulphide.</li> <li>Ammonia.</li> <li>Chlorine.</li> <li>Sodium Chloride; etc.</li> </ol> Any installation located close (within 1 km of the ocean) or in high groundwater environments (exhibiting salinity) should be considered as a corrosive environment for the purposes of this Technical Standard.
<b>Critical Infrastructure</b>	Any SA Water asset that must continually operate, including those prescribed under adverse events (i.e. natural disasters)
<b>Designer</b>	The organisation responsible for designing infrastructure for SA Water whether it be a third party under contract to SA Water or a Constructor, or an in-house entity. A Designer is a person who effects design, produces designs or undertakes design activities as defined in the <i>Work Health and Safety Act 2012 (SA)</i> .
<b>Inspection</b>	Measuring, testing or examining of Work, materials or goods or services (includes raw materials, components and intermediate assemblies) for determining conformity with the Requirements.

Term	Description
<b>Manufacturer</b>	A person, group, or company that owns and operates a manufacturing facility that provides materials for use in SA Water infrastructure.
<b>Responsible Discipline Lead</b>	The engineering discipline expert identified in the 'Approvers' table (via SA Water's Representative).
<b>SA Water Representative</b>	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): <ul style="list-style-type: none"> <li>a. Superintendent's Representative (e.g. AS 4300 and AS 2124 etc.)</li> <li>b. SA Water Project Manager.</li> <li>c. SA Water nominated contact person.</li> </ul>
<b>SAPN Service and Installation Rules (latest revision)</b>	Manual no. 32 published by SA Power Networks and approved by the Technical Regulator, incorporating the 'Technical Installation Rules' referred to in Regulation 76 of the Electricity (General) Regulations 2012 under the Electricity Act 1996.
<b>Shall and Should</b>	In this standard, the word "shall" indicates a requirement that must be adopted to comply with the standard. The word "should" indicates practices that are advised or recommended.
<b>Standard</b>	Reference to a SA Water Technical Standard.
<b>Supplier</b>	A person, group or company that provides goods for use in SA Water infrastructure.
<b>Switchboard</b>	An assembly of circuit protective devices, with or without switchgear, instruments or connecting devices, suitably arranged and mounted for distribution to, and protection of, one or more submains or final subcircuits or a combination of both.
<b>Technical Dispensation Request Form (TDRF)</b>	This form is part of SA Water's Technical Dispensation Request Procedure which details the process by which those required to comply, or ensure compliance, with SA Water's technical requirements may seek dispensation from those requirements.
<b>Terminology</b>	<ul style="list-style-type: none"> <li>a. Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Constructor.</li> <li>b. Directions, instructions and the like, whether or not they include the expression "the Constructor shall" or equivalent, shall be directions to the Constructor, unless otherwise explicitly stated.</li> <li>c. Where a submission, request, proposal is required and it is not stated who the recipient should be, it is to be provided to SA Water's Representative for review.</li> <li>d. Each word imparting the plural shall be construed as if the said word were preceded by the word "all".</li> <li>e. Each word implying persons shall, where appropriate, also be construed as including corporations.</li> <li>f. "Authorised", "approval", "approved", "selected", "directed" and similar words shall be construed as referring to the authorisation, approval, selection or direction of SA Water's Representative in writing.</li> <li>g. "Allow" shall mean that the cost of the item referred to is the responsibility of the Constructor.</li> <li>h. "Provide" shall mean "supply and install".</li> <li>i. "Submit" shall mean "submit to the SA Water Representative or their nominated delegate".</li> </ul>

Term	Description
	j. Submissions, requests, proposals are to be provided at least 10 business days prior to work commencing or material ordering (unless noted otherwise). k. "Informative" shall mean "provided for information and guidance".
<b>Tolerance</b>	The required degree of accuracy. The amount by which the measurement or calculation might change and still be acceptable. In this document, Accuracy and Tolerance can be interchangeable.
<b>Voltage</b>	a. Extra-low voltage: Not exceeding 50 V AC or 120 V ripple-free DC b. Low voltage: Exceeding extra-low voltage, but not exceeding 1,000 V AC or 1,500 V DC c. High voltage: Exceeding low voltage.
<b>Work</b>	Elements of a project which require design and/or construction.

## 2 Scope

### 2.1 Scope and application of this Technical Standard

This Technical Standard Specification covers the general requirements for the supply and installation of low voltage electrical equipment and extra low voltage equipment where it applies to control and instrumentation.

This Technical Standard Specification shall be read in conjunction with the associated project specification, drawings, and any documents annexed to the project specification. The provisions of this Technical Standard Specification shall apply unless they are specifically deleted or amended in the project specification or drawings which shall then take precedence. The currency of these standards should be checked prior to use.

### 2.2 Works not in scope

N/A

### 2.3 Technical dispensation

Departure from any requirement of this Technical Standard shall require the submission of a Technical Dispensation Request Form (TDRF) for the review and approval (or otherwise) of the SA Water Principal Engineer listed in Page 3, on a case-by-case basis.

The Designer shall not proceed to document/incorporate the non-conforming work before the Principal Engineer has approved of the proposed action in writing via the Technical Dispensation Request Form (TDRF).

SA Water requires sufficient information to assess dispensation requests and their potential impact. The onus is, therefore, on the proponent to justify dispensation request submissions and provide suitable evidence to support them.

Design projects that are carried out without being appropriately sanctioned by SA Water shall be liable to rejection by SA Water and retrospective rectification by the Designer/Constructor.

### 2.4 Hazards

Hazards shall be identified and addressed in accordance with TS 0101.

### 2.5 Approval to deviate from this standard

The SA Water Principal Electrical Engineer may ultimately approve to deviate from the requirements as stipulated in this standard if the functional requirements, for example, asset life, ease of use, maintainability, etc., for the asset differs from those stated in the standard but is assessed as still being acceptable. Any approval to deviate from the stated requirements of this standard shall not be seen as creating a precedent for future-like projects. Any request to deviate from this standard must be carried out on a project-by-project basis, where each alternative proposal will be individually assessed on its merit. No action should be taken until a written reply to such a request has been received.

SA Water encourages and welcomes suggestions for improving this standard for future releases. These suggestions should be passed on to the SA Water Principal Electrical Engineer.

## 2.6 Design criteria

The design criteria must be ascertained and agreed upon with SA Water or its representative during all stages of investigation, concept design, and detailed design in order to achieve a value-for-money installation that is functional and with minimum or negligible risks to SA Water. The design criteria should consider the following aspects:

a. Life cycle costs

Designs should be innovative and incorporate the appropriate techniques and technology, in conjunction with selecting proper equipment, to minimise the life cycle costs while satisfying operation and maintenance requirements. Energy consumption must be given particular attention in this respect.

b. Security of operation

Designs should consider that the failure of a single item of equipment or a fault in a particular area of an installation is confined to the associated part of the installation and does not affect the continuous operation of the remaining parts of the installation, where possible.

c. Reliability

The installations are to be designed to the likelihood of a failure, considering the electricity supply characteristics, ambient conditions, load characteristics, and operation and maintenance requirements.

d. Upgradability

The installations are to be designed to facilitate future upgrades where applicable.

e. Interchangeability

The installations are to be designed to maximise the interchangeability of components and assemblies as far as practical, improving flexibility and reducing the spare parts inventory.

f. Operation, maintenance and fault-finding facilities

The installations are to be provided with suitable and adequate facilities to allow ease of operation, maintenance and fault finding.

g. Environmental considerations

The installations are to be designed, and suitable equipment is to be selected to avoid or minimise unacceptable environmental impact as much as possible.

h. Safety considerations

The installations are to be designed with the safety and welfare of construction, operation and maintenance personnel, and the general public in mind, complying with statutory regulations. Wherever possible, electrical equipment and wiring should not be located in areas classified as hazardous.

## 3 Switchboards and control/telemetry panels

### 3.1 General

Switchboards, control/telemetry panels and cubicles housing electrical equipment shall be constructed in accordance with this Technical Standard and AS/NZS 3000. Individual components shall comply with the relevant standards.

All work shall comply with the requirements of the electricity supply authority and shall be suitable and approved for connection to a 400/230 V AC, 50 Hz earthed neutral (MEN) supply.

Enclosures that are tendered in variance to these requirements shall have information submitted with full details for subsequent approval.

### 3.2 Design verification

Testing certificates shall be provided for Design Verification and Routine Verification to AS/NZS 61439 in accordance with 13.3.

### 3.3 Construction

Switchboards with a rated current of greater than 250 A per phase shall follow the design, construction, and installation principles and receive an arc flash assessment in accordance with TS 0371.

#### 3.3.1 General

Switchboards and control/telemetry panels shall comply with the following general requirements:

Assemblies shall conform to the forms of construction as defined in AS/NZS 61439.1.

- a. Adequate derating of equipment and/or ventilation of the cubicles shall be provided to protect the equipment against the effects of excessive temperature rises within the cubicles. Any ventilation shall not compromise the IP rating and form of segregation of the cubicles.
- b. All components mounted on the outside of any Switchboard or control/telemetry panel shall be selected and installed so that the degree of protection specified for that panel is maintained.
- c. In-service accessibility for inspection and maintenance shall be provided in accordance with clause 8.4.6.2 of AS/NZS 61439.1.
- d. Locks shall be keyed alike to the Lenlock key code 320, except for vandal-resistant cubicles, which shall be in accordance with section 3.3.9. The exception to this is for indoor radio/RTU telemetry cabinets, where:
  - i. If the cabinet is accessible by third parties, for example, shared site/building, the locks shall be in accordance with section 3.3.9.
  - ii. If the panel is in a secure location within a building, not accessible by third parties, a cam lock insert will be suitable.
- e. Cubicle doors shall be 3-point locking for all doors of height greater than 1000 mm.
- f. All outdoor cubicles shall be provided with rigid stays of robust construction to hold all doors in a not less than 100° open position. The same requirement shall apply for indoor cubicle doors with dimensions greater than 500 mm in width and 900 mm in height. It shall be possible to open all doors simultaneously.

- g. With the doors open, all accessible internal live parts shall be protected against accidental contact to not less than IP2X.
- h. Proprietary, off-the-shelf, Soft Starter, and VSD panels may be granted an exception to this Technical Standard on a project-specific basis, subject to approval by the SA Water Principal Electrical Engineer. All custom-built Soft Starter and VSD panels are categorised as falling under Switchboards and control/telemetry panels as they contain switchgear and control gear and must be constructed and supplied to this standard.
- i. Low Voltage shall not be wired directly to a door panel or escutcheon. The exceptions to this are for multi-function meters (which need to meet the requirements of section 4.13.4 and 230 V door-mounted cooling fans, which need to have interlocks to cease operation on door opening).

### 3.3.2 Form of segregation

The form of segregation shall be in accordance with the following:

- a. Switchboards and control/telemetry panels with a rated current less than or equal to 250 A per phase shall be, at minimum, Form 1 assemblies in accordance with AS/NZS 61439.2.
- b. Switchboards and control/telemetry panels that have a rated current of greater than 250 A per phase shall be, as a minimum, Form 3b or 3bi assemblies in accordance with AS/NZS 61439.2, with segregated compartments for each of the following:
  - i. Incoming functional unit (main switch)
  - ii. Busbars
  - iii. External cable terminals
  - iv. Outgoing functional units
  - v. General power and lighting distribution panel
  - vi. Common control/telemetry panel.

In addition, Switchboards with a rated current of greater than 250 A per phase shall be provided with increased security against the occurrence or effects of internal arcing faults in accordance with Appendix ZC of AS/NZS 61439.1. Testing to Appendix ZD of AS/NZS 61439.1 shall be applied for switchboards that require arc fault containment. The alternative Form 3bih segregation indicated in Appendix ZB of AS/NZS 61439.2 is precluded.

### 3.3.3 Arrangement of cubicles and equipment

The cubicles and equipment comprising the switchboard or control/telemetry panel shall be arranged in accordance with the following:

- a. The incomer cubicle shall be located on the left-hand end of the assembly.
- b. Cubicles and compartments housing switchgear and control gear for plant equipment shall be grouped into functional groups or arranged in the same order as the plant equipment's process sequence, as far as practical. Similarly, control and indication devices on the front of individual cubicles and compartments shall be arranged to correspond with the physical layout or process sequence, wherever practical.
- c. Switchboards shall be designed to be readily extendable at either end.
- d. The provision of power circuits in switchboards shall include a minimum of 20 per cent spare power circuits, or as specified in the project specification, whichever results in a greater spare requirement.
- e. Adequate spare space shall be provided in the cubicles or compartments to accommodate all future equipment associated with the spare circuits, including circuit protective devices, motor starters, control equipment, terminals, and control and indicating devices.

- f. All controls, operating handles, meters, and indicators shall be mounted at least 500 mm and not more than 2000 mm above ground or floor level.
- g. All touch-screen HMIs shall be mounted with a vertical centre between 1500 mm and 1600 mm from floor level.
- h. Switchboard assemblies shall be designed to be able to be split for ease of transportation, installation, removal, replacement and demolition.
- i. In control/telemetry panels where a PLC is installed, a portable tray to rest a laptop shall be incorporated into the enclosure.

### 3.3.4 Busbars

Busbars shall be air-insulated and constructed from high-conductivity copper.

For Corrosive Environments, all busbars shall be tin-coated according to section 4.1.3.

The busbar phasing order shall be red, white, and blue from top to bottom, left to right, and back to front, all relative to the front of the panel. The neutral conductor shall occupy an outer position.

Each busbar section shall be colour-coded to correspond with the phase to which it is connected.

Mechanical joints between busbars shall be adequately made, bolted or clamped joints. To complete the joint, bolted joints shall use high-tensile steel bolts with plain washers, nuts, and lock nuts. Care shall be taken to ensure that all contact surfaces are clean and flat, and that adequate pressure is obtained to ensure that a low-resistance, trouble free joint is obtained. Torque verification of all joints shall be indicated with a suitable marking pen across all busbar nut/bolt assemblies.

### 3.3.5 Metal outdoor cubicles

Metal outdoor cubicles for Switchboards and control/telemetry panels shall be in accordance with the following additional requirements:

- a. Constructed either of Aluminium or mild steel with a minimum galvanised coating of Z275, or 316 stainless steel, in accordance with section 3.3.7.
- b. Steel cubicle construction shall have a minimum body thickness of 1.5 mm for all floor-mounted cubicles. A small wall or post-mounted cubicle not exceeding 400 mm high x 400 mm wide may have a minimum body thickness of 1.0 mm. The minimum body thickness for all Aluminium cubicles shall be 2 mm.
- c. Doors greater than 800 mm in width, or doors where the total combined cut-outs exceed 25 per cent of the door area, shall have additional thickness or stiffeners added to ensure rigidity. An exemption to this thickness specification may be granted for fully type-tested enclosures. However, to obtain an exemption, type-test certificates must be provided for pre-approval on each occasion.
- d. Front access for all outdoor control/telemetry panels shall be provided with hinged lockable doors. Opening the doors shall give access to a dead front panel on which controls and indications are mounted. Locks and hinges shall be in accordance with section 3.3.1.
- e. Installed with sun shields in non-sheltered aspects, with a minimum of 50 mm air gap between the enclosure and sun shield.
- f. Rain hoods, where specified for non-wall-mounted cubicles, shall be constructed so that the top surface slopes to prevent water accumulation and direct water away from the front of the cubicle.
- g. With doors and covers in position, a degree of protection of not less than IP56 in accordance with AS 60529 is required.



- h. Equipment which is installed within outdoor cubicles shall be protected against the effects of excessive temperature through a combination of:
  - i. The equipment being de-rated to accommodate the higher ambient temperatures which are to be expected within the cubicles.
  - ii. The cubicles being ventilated/cooled/arranged to ensure that the cubicle internal temperatures do not exceed the temperature ratings of the equipment. Any ventilation shall not decrease the IP rating of the enclosure.
  - iii. The fitting of a metal sun shield of appropriate design.
  - iv. Panel mounting orientation/location when installed.
- j. Ground and floor-mounted cubicles shall have a bolt-on, hot-dip galvanised (to AS/NZS 4680) rolled steel channel plinth, 100 mm high. Stainless steel plinths should be used for stainless steel-constructed cubicles, and Aluminium plinths should be used for aluminium-constructed cubicles. Insulation of dissimilar metals needs to be considered in all cases. The toes of the plinth shall turn outwards at each end with two minimum 12 mm diameter holes to facilitate the bolting of the plinth to the floor or concrete pad using a minimum size of M10 bolts, depending on expected structural loading. A sheet of bitumen-impregnated felt or other approved moisture barrier shall be placed under the plinth.
- k. Where 50 mm diameter holes have been provided in the plinth for lifting of panels, metallic plugs of compatible material need to be provided with holes or mesh to allow for air circulation beneath the panel whilst excluding vermin.
- l. Switchboards and floor-mounted control/telemetry panels shall be provided with interior switchable ELV LED lamp(s) and a switched socket outlet that is accessible when the front door is open.
- m. The control/telemetry sections of cubicles shall be provided with thermostatically controlled anti-condensation heaters, in accordance with section 4.11.
- n. Where specified, applied with paint finish as per section 11.3.
- o. The maximum dimension of a control/telemetry panel intended to be wall-mounted shall be no greater than 1200 mm(H) x 1200 mm(W). All cubicles required to be larger than these dimensions shall be ground mounted.

### 3.3.6 Metal indoor cubicles

Metal indoor cubicles for Switchboards and control/telemetry panels shall be in accordance with the following additional requirements:

- a. Painted Zincseal sheet steel construction or Aluminium, both with paint finish as per section 11.2, or constructed of 316 stainless steel in accordance with section 3.3.7.
- b. The sheet steel shall have a minimum thickness of 1.5 mm for all floor-mounted cubicles. Small wall-mounted cubicles not exceeding 400 mm high x 400 mm wide shall have a minimum thickness of 1.0 mm.
- c. Doors greater than 800 mm in width, or doors where the total combined cut-outs exceed 25 per cent of the door area, shall have additional thickness or stiffeners added to ensure rigidity.
- d. The maximum dimension of a control/telemetry panel intended to be wall-mounted shall be no greater than 1200 mm(H) x 1200 mm(W). All cubicles required to be larger than these dimensions shall be floor-mounted.
- e. Indoor cubicles shall provide a degree of protection in accordance with AS 60529 as follows:
  - i. Not less than IP51 in areas where water ingress is excluded.

- ii. Not less than IP54 in areas where water ingress is likely, for example, due to possible hosing down operations or the proximity of pumps or pipework.
- iii. Not less than IP56 for 316/316L stainless steel cubicles.

For LV cubicles in high-voltage switch rooms, refer to the requirements stipulated in TS 0340.

- j. All floor-mounted cubicles shall have a bolt-on, hot-dip galvanised (to AS/NZS 4680) rolled steel channel plinth not less than 75 mm high. Stainless steel plinths should be used for stainless steel cubicles, and Aluminium plinths should be used for Aluminium cubicles. Insulation of dissimilar metals needs to be considered in all cases.

Where the cubicles are mounted directly onto a floor without a concrete plinth and which may be subjected to dampness, for example, due to possible hosing down operations or the proximity of pumps or pipework), a sheet of bitumen-impregnated felt or other approved moisture barrier shall be placed under the plinths.

The plinth's toes shall turn outwards at each end with a minimum of two (2) 12 mm diameter holes to facilitate bolting the plinth to the floor or concrete pad using a minimum size of M10 bolts, depending on expected structural loading.

- k. Where 50 mm diameter holes have been provided in the plinth for lifting of Switchboards, metallic plugs of compatible material need to be provided with holes or mesh to allow for air circulation beneath the Switchboard whilst excluding vermin.
- l. Switchboards and floor-mounted control/telemetry panels shall be provided with interior switchable ELV fluorescent or ELV LED lamp(s) and a switched socket outlet, accessible when the front door is open.
- m. The control/telemetry section of panels shall be provided with thermostatically controlled anti-condensation heaters, in accordance with section 4.11.

### 3.3.7 Stainless steel cubicles

#### 3.3.7.1 Required application

316/316L stainless steel cubicles shall be provided:

- a. For installations (indoor and outdoor) in Corrosive Environments (refer to Definitions section); or
- b. Where required by the project specification.

**Note:** Refer to TS 0270, which advises that stainless steel equipment should be avoided in chlorine dosing and gas storage rooms. In chlorine rooms, stainless steel cubicles should not be used, with chlorine resistant polymer or marine grade aluminium cubicles preferred.

#### 3.3.7.2 General

Cubicles shall be manufactured from grade 316 or 316L stainless steel.

Cubicles, doors, and escutcheons shall be fabricated from stainless steel sheets with a minimum thickness of 1.5 mm. Bracing, stiffening, internal brackets, plinths, and other structural components shall also be manufactured from type 316/316L stainless steel of a minimum thickness of 2.0 mm.

Internal components, such as mounting plates (gear trays), may be constructed of mild steel, treated and painted as per section 11.2.

### 3.3.7.3 Welding

Any welding shall be carried out in accordance with AS 1554 Part 6. The weld quality and surface finish for the welds shall be:

- a. Internal welds - 2B, II (a)
- b. External welds - 2B, I (120#).

### 3.3.7.4 Surface treatment

The external surface finish for the cabinets shall be a polished No 4 finish as defined in ASTM A480/A480M, with an average surface roughness generally up to 0.6 micrometres. The cabinets shall be manufactured with the polish directionality in the vertical direction.

Where the original machine polishing lines are parallel to the line of a weld, the weld bead shall be dressed down by grinding and then finished by polishing with 120 grit polishing wheel driven by a portable machine. The traversing of the wheel should be kept in line with the run of the weld bead so that its cut lines are kept parallel to those of the original machine machine-polished surface. Care shall be taken to bring the metal joint flush with that of the base metal in order to avoid residual ridges or grooves.

Where the machine-polished lines are not parallel to the lines of the weld, the final manual polishing shall be conducted in the original direction of the machine polishing.

Where the original polished lines on the two sides of a joint are not parallel, the final manual polishing shall be in the direction with the least visual impact on the component.

Any heat tint on the external surfaces caused by internal welding shall be removed, and the original external surface finish reinstated.

The internal surfaces of the cubicles require no special surface finish other than cleaning, as specified above, for the internal welds.

### 3.3.7.5 Fasteners

All fasteners shall be type 316 stainless steel.

### 3.3.7.6 Hardware

All hinges shall be type 316 stainless steel.

Locks and handles shall be type 316 stainless steel.

## 3.3.8 Plastic enclosures

Plastic enclosures shall only be installed in pre-approved situations, preferably out of direct sunlight. Plastic enclosures shall be in accordance with the following:

- a. Made from high-impact-resistant, flame-retardant material.
- b. Electrically insulated.
- c. Have a degree of protection not less than IP56 to AS 60529 when the covers are in position.
- d. Covers that, when removed, give access to live equipment shall require the use of a tool to remove the covers.

## 3.3.9 Vandal-resistant cubicles

Vandal-resistant cubicles shall be manufactured from sheet steel in accordance with section 3.3.5.

Additional design and construction features to improve the security of the cubicles from theft and vandalism shall include the following:

- a. No switches, indicators, etc., on the outside of the cubicle unless required by the project specification.
- b. ~~Vandal-resistant hinges.~~
- c. Doors and covers designed to eliminate, as far as is practicable, leverage points that would enable the doors or covers to be forced open.
- d. Doors to be provided with high security swing-type handles (Emka 1107 type or approved equivalent) with locking facilities for SA Water approved security padlocks. All padlocks to be keyed alike, as per SA Water security requirements.
- e. Fixing bolts, screws, etc. shall, as far as practicable, be concealed to prevent unauthorised removal. Fastener heads, which are accessible from the outside of the cubicle, shall be of a type that will not allow the unscrewing of the fastener from the outside of the cubicle.

### 3.3.10 Cable entry

Cable entry to all switchboards and control/telemetry panels shall be bottom entry, where possible. If bottom entry is impractical, top/side/back entry is permitted, but only indoors or undercover, not outdoors, where water can settle.

Cable entry facilities shall be suitable for the number and size of cables specified, or alternatively, if sizes are not specified, for cables rated for the full load current of the connected load. Appropriate deratings for temperature and grouping of cables shall be allowed for when determining cable sizes, as per AS/NZS 3008.

Cubicles shall be protected from the entry of vermin through suitable glanding of cables and sealing of any ducts beneath cubicles.

### 3.3.11 Mounting of equipment

All equipment within a Switchboard or control/telemetry panel shall be installed on mounting plates affixed to the interior rear of the panel (i.e. not on top, side or bottom panels), except for batteries, anti-condensation heaters and vent fans, which shall be as per project specifications.

All equipment within a Switchboard or control/telemetry panel, with the exception of cable ducts and batteries, shall be installed not less than 300 mm and not greater than 2000 mm above ground or floor level.

~~Where access to the terminals of a large battery (weighing over 10kg) is restricted by the cabinet layout, the battery shall be installed on an extendable tray to facilitate safe and easy installation and more convenient access to terminals for maintenance and load testing. This will assist in minimising the risk of accidents or injuries when working with large batteries.~~

### 3.3.12 Electricity supplier energy metering

Where energy metering is required, a meter box complying with the requirements of clause 3.3.5 shall be provided and located preferably on an external wall of the building. The meter configuration and location shall comply with the requirements of SA Power Networks (SAPN) Service and Installation Rules, where connection is made to their network.

Metering shall be upstream of all Switchboard load consuming equipment.

For main Switchboards which have a full load current rating of 100 A or more, adequate arrangements shall be made within the Switchboard to mount the electricity supplier's metering current transformers in an enclosure which is capable of being sealed by the electricity supplier. The facilities shall be acceptable to the electricity supplier and shall allow for the on-site fixing, connecting and changing of the metering transformers without disturbing the incoming cables. The contractor shall supply and install the metering transformers to the electricity supplier's requirements.

Potential wiring for the electricity supplier's metering shall be protected by 100 A busbar-mounted fuses, or approved equivalent, in accordance with the electricity supplier's requirements. The fuses shall be enclosed within the sealed current transformer enclosure and located so that they do not interfere with the installation of the main service cable or the installation and/or removal of the current transformers.

Adequate provision shall be made for the outgoing potential and current transformer secondary wiring to the electricity supplier's meters.

Metering current transformers and potential fuses are generally not required on main Switchboards rated at less than 100 A.

## 3.4 Internal wiring

### 3.4.1 Type

Wiring shall be of PVC or XLPE insulated stranded copper conductor in accordance with AS/NZS 5000.1, 5000.2, 5000.3, and AS/NZS 3191 as applicable.

The wiring shall be adequately sized to carry the current, and the minimum conductor size shall be as follows:

- a. Signal wiring to PLCs and similar devices – 0.5 mm<sup>2</sup>
- b. Control relays and timers – 0.50 mm<sup>2</sup>
- c. Current transformers – minimum of 4.0 mm<sup>2</sup> unless termination on the measurement device prevents this size, in which case, wiring should be sized in accordance with AS/NZS 3008 to ensure the total burden of the circuit does not exceed the rated value of the CT.
- d. Contactors and other power circuits – Conductor sized in accordance with AS/NZS 3008.

### 3.4.2 Colour coding

The insulation of cables and wires shall be used to provide colour coding as follows:

- a. Low voltage three-phase AC power circuits and CT wiring to be colour-coded in accordance with the phase to which they are connected, that is, RED, WHITE, BLUE with neutrals coloured BLACK.
- b. Low-voltage single-phase AC power circuits and control cables are to be colour-coded in accordance with the phase to which they are connected until they terminate into a protection device, such as a circuit breaker, fuse, etc., at which point the active colour will change to WHITE with BLACK neutral.

**Note:** Control supplies shall be derived from the white phase unless otherwise indicated.

Low-voltage DC and extra-low-voltage DC circuits are to be colour-coded GREY (+) and PINK (0 V).

**Note:** For three-wire DC systems, a green wire shall be used for the earth wire, and a grey or pale pink conductor will be used for the supply wire, depending on whether the supply is positive or negative with respect to earth.

- a. Extra low-voltage AC circuits should have BROWN for the active conductor and BLACK for the neutral conductor.
- b. All analog signals, for example, 4~20 mA DC, 0~10 V DC) to be colour-coded VIOLET where not included within screened cables. Core colours within screened cables may be to the manufacturer's standard.
- c. Critical digital signals are to be colour-coded ORANGE. The critical signal wire colour shall apply for cubicle wiring between the terminal and the device on the mounting plate.

- d. All earth cables shall be GREEN/YELLOW.

### 3.4.3 Wiring installation

Wiring of size 1.5 mm<sup>2</sup> or less shall be run, wherever possible, inside slotted PVC ducts with snap-on covers. Ducts shall be adequately sized to accommodate the wiring, plus at least 20 per cent spare capacity. Where ducting is impractical, wiring may be loomed using proprietary looming or sleeving.

Where applicable, wiring shall be arranged so that the equipment can be removed without the plug being disconnected from the equipment, that is, the plug can fit through any conduits or restrictions along its path.

### 3.4.4 Segregation

Cables for low-voltage circuits and extra-low-voltage circuits may be enclosed in the same wiring system, provided that compliance with AS/NZS 3000 is maintained.

### 3.4.5 Termination

The boundary between internal and outgoing wiring shall be a DIN rail-mounted clip-on type terminal strip within the control/telemetry panel or switchboard.

Outgoing low-voltage circuits with conductors 25 mm<sup>2</sup> or above and general-purpose power and lighting circuits may terminate directly on the switchgear, provided that the equipment's terminal arrangement can accommodate the cable selected.

Terminals for control and instrumentation signals shall be grouped logically according to the signal types, such as, digital inputs, digital outputs, pulse inputs, analog inputs, and analog outputs. The following spare terminals shall be provided for each group of signals as a minimum:

- a. 20 per cent for total installed I/Os of up to 100.
- b. 10 per cent for total installed I/Os exceeding 100.

Extra low-voltage terminals shall be segregated from low-voltage terminals, and AC voltages shall be segregated from DC voltages. All low-voltage terminals shall be adequately shrouded to prevent accidental contact, with hazardous voltage labelling included on the shroud.

### 3.4.6 Small wiring protection

Small wiring that feeds directly from the busbars, for example, voltmeter wiring, wiring to voltage-operated protection relays) shall be protected by means of fuses ~~(or, where acceptable, from circuit breakers per clause 3.3.12)~~ which shall be in accordance with section g The fuses shall be located as closely as practicable to the point of tee-off from the busbar system but in a position that allows maintenance access.

## 3.5 Labelling

### 3.5.1 General

Labels shall be made of engraved multi-layered Phenolic plastic sheet, such as Gravoply, Rowmark, or approved equivalent, giving white lettering on a red background for warning labels, and black lettering on a white background for all other labels. Embossing tape shall not be used. Labels for outdoor equipment shall be resistant to corrosion and sunlight.

Labels shall be fixed by pins, screws, or an approved adhesive. Labels that are fixed to the outside surfaces of outdoor Switchboards, control/telemetry panels, and other equipment shall be fixed with corrosion-resistant (preferably stainless steel) pins or screws. Adhesives shall not be used for fixing outdoor labels.

Labels such as cable ducting lids shall not be affixed to removable covers.

Where applicable, the location of the main switch room shall be clearly identified by a permanent sign at the entrance or at the fire indicator board, in accordance with AS/NZS 3000.

### 3.5.2 Main titles and subtitles

Switchboards, control/telemetry panels, and their sub-sections shall be labelled with the titles provided in the project specification and drawings or, where these are not specified, titles that adequately and accurately describe the units.

Minimum lettering height shall be as follows:

- a. Main Titles 20 mm.
- b. Sub Sections 10 mm.

Nameplates for Switchboards and control/telemetry panels shall be in accordance with section 3.5.5.

### 3.5.3 Naming convention

In the absence of any other site convention, the Main Switchboard shall be labelled as MSB, followed by a unique number (where location numbers are assigned, they should be used as the unique number) to differentiate the Switchboard from other Switchboards on site.

Distribution boards shall be labelled as DB, followed by the Main Switchboard or Distribution board number from which the distribution board is fed, followed by a unique number to differentiate the distribution board from other distribution boards within that supply circuit. (For an example, refer to Figure 1).

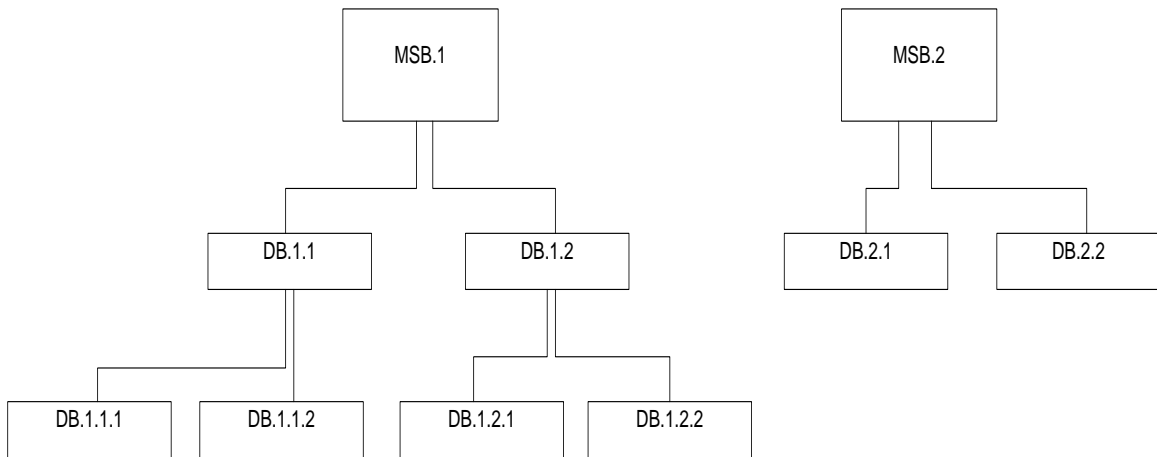


Figure 1 – Example of switchboard and distribution board naming convention

### 3.5.4 Panel controls and indications

Panel controls, indications, and features shall be labelled with the titles provided in the project specification and drawings or, where these are not specified, titles that adequately and accurately describe their function.

The manufacturer's standard escutcheon plates may be used for panel control and indicator items.

The minimum lettering height for purpose-made labels shall be 4 mm.

### 3.5.5 Switchboard nameplates

In addition to the requirements of AS/NZS 61439.1, low voltage Switchboards and control/telemetry panels that have a rated current of 100 A or more per phase or a rated prospective short circuit current of 5 kA or more shall have a label(s) fitted which includes the following information, if not already provided on other labels:

- a. The number of the standard (including country of origin) with which the equipment complies.
- b. Manufacturer's name or trademark/logo.
- c. Identification of the assembly, such as model, type, catalogue number, etc.
- d. Assembler's name or trademark/logo, if different from the manufacturer's.
- e. Degree of protection in accordance with AS 60529.
- f. Form of segregation.
- g. Rated operational voltage.
- h. Rated frequency.
- i. Rated current.
- j. Type-tested short circuit rating.
- k. Any other information required to be marked on the equipment by the standard with which the equipment is purported to comply.

The nameplate shall be manufactured from laminated plastic or other approved material and shall be attached to the front structure of the Switchboard in compliance with section 3.5.1.

### 3.5.6 Contactors, relays, and circuit breakers

Contactors, relays, circuit breakers, and other components shall be labelled with the designations or label names used in the control circuits. Labels shall be affixed adjacent to each individually mounted circuit breaker to designate the circuit. If room limitations do not permit a description of the device's function, then this may be omitted. A printed (not hand-written) legend shall be included in the general LV power distribution section of every Switchboard and Control/Telemetry panel.

Where plug-in relays are used, the labels shall be fixed on, or adjacent to, the associated sockets and not on the relays or other removable parts, such as cable duct covers.

The minimum lettering height shall be 4 mm.

### 3.5.7 Instrumentation equipment

Instrumentation equipment shall be labelled with the P&ID mnemonic, the loop number and loop description, in accordance with the instrumentation loop diagrams. Panel displays shall be labelled with the variable description and engineering units.

The minimum lettering height shall be 4 mm.

### 3.5.8 Terminals

Terminal blocks shall be labelled per the termination schedules using the manufacturer's label systems, where possible.

### 3.5.9 Wiring

Wiring shall be labelled by means of slip-on ferrules or similar, numbered to correspond with wire numbers generated from schematic diagrams, in accordance with section 13.1.3.



Jumper wires less than 50 mm in length and visible for their entire length need only be labelled once, but other wiring shall be labelled at each end.

Where equipment terminal strips accommodate high-density wiring, or in the case of pre-wired looms, such as PLC I/O cards and the like, where it is not physically possible to fit wire labels, these may be dispensed with.

### 3.5.10 Fuses

Labels shall be fitted on, or immediately adjacent to, each fuse base or each 3-phase set of bases to identify (where possible) the function and designation of the fuses and to specify the current ratings of the fuse links. If room does not permit a description of the function of the fuse, then this may be omitted.

## 4 Components

### 4.1 General

#### 4.1.1 Ratings

Electrical equipment shall be adequately rated for the specified duty and operating conditions. Adequate derating shall be applied where the operating conditions exceed those for which the equipment is designed, such as high ambient temperatures.

Where current and/or voltage ratings for components are specified and/or shown on the specification drawings, components shall have ratings not less than those specified or shown.

Where current and/or voltage ratings are not specified or shown, components shall have current and voltage ratings adequate for the duty to which they are to perform.

When determining the ratings, allowance shall be made for:

- a. Frequency of usage.
- b. Making and breaking currents.
- c. Power factor (where applicable).
- d. Prospective fault current.
- e. Ambient temperatures, which will occur at the point of installation.

Components not characterised by current ratings, such as multi-function meters, programmable logic controllers, protection relays, and instrumentation equipment, shall have temperature ratings suitable for the point of installation.

#### 4.1.2 Degree of protection

Unless otherwise specified, the degree of protection of components shall be suitable for the location and application.

#### 4.1.3 Corrosive environments

Unless otherwise specified, equipment in corrosive environments shall be designed and installed in accordance with the following:

- a. A risk assessment shall be completed at each site to determine areas of plant most at risk of a Corrosive Environment. The risk assessment shall include determining the air quality as guided by ISA-S71.04.
- b. Determine specific requirements for any equipment in those risk areas, for example, conformal coating of electronic equipment, tin plating of busbars and wiring conductors, stainless steel or corrosion-resistant non-metallic cable supports), including mitigation measures for electrical enclosures and switch rooms.

#### 4.1.4 Ambient temperatures

Where not otherwise specified, the Contractor shall design and install equipment in accordance with the following:

- a. All equipment in an outdoor environment shall be suitable for continuous operation with an ambient temperature range of  $-5^{\circ}\text{C} \sim 50^{\circ}\text{C}$ . Outdoor enclosures shall be adequately ventilated/cooled to ensure the maximum temperature will not exceed the equipment design temperature.

- b. All equipment in an indoor environment shall be suitable for continuous operation with an ambient temperature range of 0 °C ~ 40 °C. Indoor environments and electrical enclosures shall be ventilated/cooled to ensure the maximum temperature will not exceed the equipment design temperature.
- c. Equipment housed in outdoor enclosures shall be adequately de-rated to allow for the increase in ambient temperature inside the enclosure.

## 4.2 Circuit breakers

### 4.2.1 Discrimination

Where circuit breakers are installed in series, every effort should be made to provide discrimination for tripping currents up to the maximum prospective fault current for the installation. If full discrimination cannot be achieved between protective devices, options must be explored with the SA Water Principal Electrical Engineer or a dispensation sought.

### 4.2.2 Air circuit breakers

Air circuit breakers (ACBs) shall be in accordance with AS 60947.2 and the following:

- a. Three pole air insulated.
- b. Suitable for 400 volt 3 phase 50 Hz operation.
- c. Withdrawable with service, test, and isolated positions being available and clearly indicated.
- d. Provided with pad-lockable automatic shutters over both the live and load side connections.
- e. Provided with interlocks to:
  - i. Prevent movement of the unit to or from the service position whilst the breaker is closed.
  - ii. Prevent the compartment door from being opened whilst the breaker is in the service position and the breaker is closed.
- f. Manual closing.
- g. Trip free.
- h. Manual and overcurrent opening.
- i. Provided with a mechanical indication of status, such as, open, closed, and fault.
- j. ~~Provided with the necessary facilities to allow remote switching, unless the project or retrofitting specification allows otherwise. An example of the required facilities might be as such:~~
  - ~~'OPEN' and 'CLOSE' control pushbuttons.~~
  - ~~'ACB FAULT', 'ACB READY TO CLOSE', 'ACB CLOSED', and 'ACB OPENED' indicator lights.~~
  - ~~'LAMP TEST' pushbutton for testing the indicator lights.~~
- k. Lockable in the open position.
- l. Pad-lockable in the test and isolated positions.
- m. Designed to be maintained.
- n. Suitable for uninterrupted duty.

~~**Note:** Consideration shall be given to remote switching enabled/disabled functionality and the inclusion of warning beacons, depending on the site arrangement.~~

- o. Rated for the full load current.
- p. Have an interrupting capacity of not less than the prospective fault current of the supply.
- q. Provided with adjustable instantaneous and adjustable inverse time delay tripping.
- r. Provided auxiliary contacts for indication of the circuit breaker's open, closed, and tripped status.

### 4.2.3 Moulded case circuit breakers

Moulded case circuit breakers (MCCBs) shall be in accordance with AS 60947.2 and the following:

- a. Three pole.
- b. Suitable for 400 V AC, 3 phase 50 Hz operation.
- c. Quick make manual closing.
- d. Quick break manual opening.
- e. Trip free.
- f. Automatic opening on overcurrent and short circuit.
- g. Provided with mechanical status indication, such as, open, closed, and fault.
- h. Lockable in the open position.
- i. For Form 3 switchboards, provided with safety interlocks to prevent the compartment door from being opened with the breaker in the closed position and to prevent the breaker from being closed with the compartment door opened.
- j. Suitable for uninterrupted duty.
- k. Rated for the full load current of the circuit.
- l. Have a rated short circuit-making capacity that is not less than the prospective short circuit current of the supply.
- m. Have a rated service short circuit breaking capacity not less than the prospective short circuit current of the supply.
- n. Provided with instantaneous tripping.
- o. Provided with inverse time delay tripping.

### 4.2.4 Miniature circuit breakers

Single-pole and multi-pole miniature circuit breakers (MCBs) shall be in accordance with AS/NZS 3111 and the following:

- a. Shall have a current interrupting capacity suitable for the prospective fault current and not less than 5 kA symmetrical.
- b. Lockable in the open position via a permanently fixed locking device (except for Extra Low Voltage applications where the lockable requirement to be as per project specification).

## 4.3 Residual current devices

Residual current devices shall be in accordance with AS/NZS 3190 and the following:

- a. Shall be type II devices unless otherwise specified.
- b. Site tested in accordance with section 12.4.3 before being placed into service.
- c. Either one of the following configurations shall be provided:

- i. Combined miniature circuit breakers/residual current devices, which shall be in accordance with the requirements of AS/NZS 3111 and section 4.2.4.
- ii. Protected on the supply side against overcurrent and short circuit by miniature circuit breakers or fuses, which shall be in accordance with section 4.2.4 or g, respectively.

## 4.4 Isolating switches

Isolating switches shall be in accordance with AS/NZS 3133. Any switch that is used to directly isolate its associated electric motor by switching the phase conductors shall be a motor control switch as defined in the standard and shall, in addition, be provided with facilities to padlock the switch in the OPEN or OFF position.

Isolators mounted through hinged escutcheons or doors shall be mechanically interlocked with the power supply isolators such that the door cannot be opened with the isolator closed and the isolator cannot be closed with the door open. For modules less than 160 A, mechanical interlocking of escutcheons may only be excluded in the case where the escutcheon is fixed in place entirely with bolts that require a tool to remove it.

The requirement for locking facilities detailed above shall also apply to crane isolator switches.

All single-phase isolating switches rated at 20 A and above and all multiphase isolating switches shall include a positive status indication. The indication shall include the words 'ON' and 'OFF' or the symbols 'I' and 'O' for the respective positions of the switch.

## 4.5 Air break switches

Air break switches shall be in accordance with AS/NZS 60947.3 and the following:

- a. Fast make/fast break, independent manual operation, preferably with double break contacts on each pole of the switch.
- b. Fitted with a positive indication of the position of the switch, which shall include the words 'ON' and 'OFF' or the symbols 'I' and 'O' to indicate the switch position.
- c. Provided with facilities to padlock the switch in the OPEN or OFF position.
- d. Equipment used for the direct switching of an associated electric motor shall have a utilisation category AC-23. Other equipment shall have a minimum utilisation category of AC-22.

## 4.6 Composite fuse switch units

Composite Fuse Switch (CFS) units shall be in accordance with section 4.5 and the following:

- a. Accommodate HRC fuses in accordance with section g.
- b. Triple pole units.
- c. Individual contacts to be separately and fully shrouded.
- d. Barriers included between fuse cartridges to reduce the possibility of a phase-to-phase or phase-to-earth fault.
- e. Shrouds, barriers and the complete moving contact assembly shall be removable from the CFS enclosure for maintenance.
- f. Provided with facilities to padlock the unit in the OPEN or OFF position.
- g. Provided with safety interlocks to prevent the compartment door from being opened with the CFS unit in the closed position and to prevent the CFS unit from being closed with the compartment door opened.

## 4.7 Low-voltage fuses

Low voltage fuses shall be in accordance with the applicable requirements of AS/NZS 60947 part 7.3 and the following:

- a. Suitable for use on a 400/230 V AC, 50 Hz supply.
- b. Fuse links shall:
  - i. Have a rated breaking capacity of not less than 50 kA at 400 V AC, 50 Hz or the prospective fault level at the point of installation, whichever is higher.
  - ii. Be of the 'gG' or 'gM' type.
- c. Fuse holders shall:
  - i. Have a protection rating of not less than IP2X in accordance with AS 60529 with the fuse carriers removed.

## 4.8 Motor contactors

Motor contactors shall be in accordance with the following:

- a. Air break, electromechanical type with short-circuit protective devices in accordance with AS 60947.4.1.
- b. Provided with Type 2 coordination in accordance with AS 60947.4.1.
- c. Utilisation category AC-3 and intermittent duty not less than Class 12 as defined in AS 60947.4.1, or a higher category and/or duty class to suit the specified operation requirements, if required.
- d. A mechanical endurance of not less than 1 million operating cycles.
- e. Operating coils shall operate at either 24 V DC or 230 V AC.

## 4.9 Soft starters

Soft starters shall be AC type in accordance with the following:

- a. Stepless variable voltage output, adequately rated for the maximum temperature, which will occur inside the cubicle.
- b. Adjustable start and stop ramp times and ranges in accordance with the project specification.
- c. In-built fault indications with diagnostics and a changeover voltage-free contact for remote fault indication.
- d. Provided with a bypass contactor facility.
- e. Protection against short-circuit faults with fast-acting semi-conductor fuses for starters rated above 22 kW, in accordance with manufacturer's recommendation.
- f. Provided with overload protection of the connected motors with Type 2 co-ordination, with the short-circuit protective devices in accordance with AS 60947.4.2.
- g. Electromagnetic compatibility in accordance with clause 8.3 of AS 60947.4.2.
- h. Utilisation category AC-53a as defined in AS 60947.4.2, or AC-53b where bypass contactors are provided.
- i. Intermittent duty as defined in AS 60947.4.2 with the number of operating cycles per hour (S value) of not less than 10 or to suit the specified duty, whichever is higher. The ratio of the on-load period to the total period (F value) shall be not less than 70 per cent or to suit the specified duty, whichever is higher.

- j. Communications port to interface with other devices such as PLCs, including Ethernet, where specified.

## 4.10 Variable speed drives

Where space and the installation environment/methodology allow, VSDs shall be IP54 and mounted external to the switchboard, that is, on the switch room building's internal wall.

Variable Speed Drives (VSDs) shall comply with the following requirements:

- a. Variable voltage variable frequency type, rated for continuous operation at full load, under the specified maximum ambient temperature.
- b. Electromagnetic and Harmonic disturbances shall comply with the requirements of AS/NZS CISPR11 and AS/NZS 61000 and SAPN Service and Installation rules.
- c. Harmonic calculations shall be provided during design, and verification measurements taken during commissioning to validate the compliance of the mitigation technique.
- d. Electromagnetic immunity in accordance with AS/NZS 61000.6.1.
- e. Capable of sustaining not less than 110 per cent rated output current for a minimum duration of 1 minute.
- f. ~~Infinitely variable speed control over the required speed range, directly proportional to the setpoint control signal.~~
- g. Adjustable minimum and maximum speed limits.
- h. Adjustable current limits.
- i. Soft start with adjustable acceleration and deceleration ramp rates.
- j. In-built PID controller for closed-loop control, where specified by the project.
- k. Power loss ride-through to allow continued operation of a rotating motor after a short power interruption.
- l. Where the project specification requires an emergency stop, a risk assessment of a ramp-to-stop arrangement or coast-to-stop arrangement shall be documented.
- m. Galvanic isolation between remote and internal circuits to not less than 1 kV DC.
- n. Provided with the following minimum controls and indications available on the front of the VSD unit:
  - i. Running
  - ii. Fault
  - iii. Output current
  - iv. Output voltage
  - v. Output frequency (or speed)
  - vi. Power
  - vii. Adjustment of all drive parameters.
- o. Provided with the following minimum protection, with indications available on the front of the VSD unit:
  - i. Lightning and voltage transients
  - ii. Overvoltage
  - iii. Undervoltage
  - iv. Overcurrent
  - v. Short circuit

- vi. Earth fault
  - vii. Input phase failure
  - viii. Output phase failure
  - ix. Overtemperature
  - x. Motor overload
  - xi. Motor winding overtemperature (where applicable)
  - xii. Loss of 4~20 mA DC control signal.
- p. If required, in accordance with the manufacturer's recommendation, additional protection against short-circuit for drives rated at 22 kW and above.
- q. Provided with the following minimum remote interfaces:
- i. Digital Inputs:
    - o Local/Remote selection.
    - o Start/Stop (or Run) control.
    - o Preset speed selection (where applicable).
  - ii. Digital Outputs:
    - o VSD Running.
    - o VSD Fault (incorporating all the protection in (o) above).
  - iii. Analog Input:
    - o 4~20 mA DC speed control signal.
  - iv. Analog Outputs (only where specified):
    - o Not less than two programmable 4~20 mA DC outputs to enable any two parameters to be selected, for example, power, current, frequency, or speed). Each analog output shall be capable of driving a load of not less than 600  $\Omega$ .
  - v. Network Interface (where required):
    - o Communications port to interface with other devices, such as PLCs. Where this facility is utilised, the minimum requirement of analog outputs can be incorporated into the network interface communications.

## 4.11 Cubicle heaters

Cubicle anti-condensation heaters shall be provided for all outdoor control/telemetry cubicles, where the internal cubicle temperature is expected to drop to 10 °C or below, or in locations where condensation could form inside the cubicle. The exception to this rule is for standalone solar or battery-powered panels. Justification must be provided for not providing cubicle heaters; otherwise, heaters shall be installed in all control/telemetry cubicles in accordance with the following:

- a. Black heat strip heaters rated at approximately 20 watts per square metre of cubicle surface area and suitable for operation at 230 V AC. Heaters powered with 230 V AC shall be protected with an RCD.
- b. Shall be of a number and installed so that heat from the heaters can readily circulate throughout the cubicles without damaging materials or components.
- c. Provided with a thermostat in each section of a cubicle with heaters fitted that will energise the heaters when the air temperature inside the cubicle is below 10 °C. The thermostat can be either built-in or separate and shall preferably be adjustable. For long cubicles, additional thermostatically controlled heaters shall be supplied and installed to ensure adequate temperature control within the control/telemetry cubicle.



- d. Heater and thermostat terminals shall be IP2X in accordance with section 3.3.1 (g).
- e. Provided with a label adjacent to the heater indicating the origin of the supply.

## 4.12 Motor protection units

### 4.12.1 Thermal overload units

Thermal overload units shall be provided for the protection of motors rated at less than 15 kW. Thermal overload units shall be in accordance with AS 60947.4.1 and the following:

- a. Triple pole, differential action to enhance the performance of protection against phase imbalance or phase failure.
- b. Incorporate ambient temperature compensation.
- c. Include provision to allow the trip setting to be adjusted.
- d. Suitable for alternative manual or automatic reset and initially set to automatic reset if the control circuit has a separate lockout facility and RESET pushbutton.

### 4.12.2 Electronic motor protection relays

Electronic motor protection relays shall be provided to protect motors rated at 15 kW and above. Protection relays shall be in accordance with the following:

- a. Provide protection and separate indication for each of the following:
  - i. Overload.
  - ii. Winding over-temperature using thermistors.
  - iii. Single phasing and asymmetry.
- b. Have selectable current and trip time settings.
- c. Have a test feature.
- d. Suitable for operation from a 230 V AC supply.
- e. Provide finger protection for the terminals (IP2X) other than the main connections.
- f. Unaffected by the passage of short circuit currents through the unit.

Directly connected units, that is, without the need for external current transformers are preferred.

### 4.12.3 Thermistor control units

Thermistor control units shall be used to monitor the operation of thermistors built into motors and auto-transformers unless the thermistors are monitored by an electronic motor protection relay.

The control units shall be in accordance with AS 60947.8 and the following:

- a. Suitable for a 230 V AC supply voltage.
- b. Provide a visual indication that a trip has occurred.
- c. Match the type of thermistor, such as, positive or negative coefficient type.

## 4.13 Meters

### 4.13.1 General

Ammeters and voltmeters shall be provided where required by the project specification and drawings. These may be square bezel pattern type, of nominal size 96 mm with an

approximate 120° movement. Alternatively, a multi-function meter digital display or HMI may be used to measure and display the required parameters in a single unit.

### 4.13.2 Ammeters

Ammeters shall be in accordance with the following:

- a. Where used for measuring 3 phases, provided with a selector switch to allow selection of individual phase currents. An OFF position shall be provided.
- b. Accuracy of  $\pm 2.5$  per cent or better.
- c. Scaled to correspond to the rated primary current.
- d. Where used for measuring motor current, be over-scaled to approximately six times the rated current of the associated motor. Full load current shall occur between 60 per cent and 90 per cent of full scale.
- e. Where used for other than measuring motor current, be over-scaled to approximately two times the rated current of the circuit.
- f. Provided with insulating shrouds on exposed terminals.

### 4.13.3 Voltmeters

Voltmeters shall be in accordance with the following:

- a. ~~Provided with a voltmeter selector switch and potential fuses (or, where acceptable, from circuit breakers per clause 3.3.12) to allow selection of individual phase-to-phase voltages. No OFF position shall be provided.~~
- b. Accuracy of  $\pm 2.5$  per cent or better.
- c. Scaled to read between 0 and 500 V.
- d. Provided with insulating shrouds on exposed terminals.

### 4.13.4 Multi-function meters

Multi-function meters shall be in accordance with the following:

- a. Measure and display voltage, current, and power in a single integral unit at not less than  $\pm 1$  per cent accuracy.

Additional parameters (energy, power factor, individual and total harmonic distortions, etc.) shall be included as required by the project specification and/or drawings. The display shall be retained during power failure where used for energy measurement.

The multi-function meter shall be capable of measuring, storing and displaying maximum load.

- b. Panel mounting facilities.
- c. Suitable for monitoring a 3-phase unbalanced supply and load.
- d. Operation from a 230 V AC auxiliary supply.
- e. Provided with insulating shrouds on exposed terminals.
- f. Provided with the following remote interfaces, where required by the project specification:
  - i. Digital and analog inputs/outputs, programmable to represent the selected parameters.
  - ii. A communications port with industry-standard protocol, for example, Ethernet.

## 4.14 Current transformers

### 4.14.1 Metering current transformers

Metering current transformers shall be in accordance with AS 60044.1 and the following:

- a. Accuracy not lower than Class 1M or, where used with test sockets, kW meters, kWh meters or multi-function meters, not lower than Class 0.5M.
- b. Rated secondary current of 5 A.
- c. Rated burden sufficient to cover the burden imposed by the connected equipment, including cables. Where a test socket is required, in accordance with section 4.23.8, an additional burden of 5 VA shall be allowed for external equipment which may be plugged into the socket.

### 4.14.2 Protection current transformers

Protection current transformers shall be in accordance with AS 61869.2 and the following:

- a. Designated as 10P150F20 unless otherwise specified or required to suit the protection relay.
- b. Rated secondary current of preferably 1 A.
- c. The transformer ratio shall be determined for the correct operation of the associated relay under fault conditions, considering the rated accuracy limit factor of the transformer and the burden of the connected circuit.
- d. Provided with test taps, where required, to be used with a test socket.

## 4.15 Control relays

All control, interposing, latching, and auxiliary relays shall be in accordance with AS 60947.5.1 and the following:

- a. If no voltage is specified, then 24 V DC shall be used.
- b. Relays shall be suitable for the voltage and type of duty required and shall have a current rating adequate for the load and, in any case, not less than 1 A.
- c. The operational life shall be not less than 10,000,000 cycles.
- d. Finger protection for terminals (IP2X in accordance with AS 60529).
- e. Provided with an LED status indicator.

## 4.16 Timing relays

Timing relays shall be in accordance with the following:

- a. Electronic type with an adjustable range.
- b. If no voltage is specified, then 24 V DC shall be used.
- c. Relays shall be suitable for the voltage and type of duty required and shall have a current rating adequate for the load and, in any case, not less than 1 A.
- d. Accuracy Class 1.5 or better.
- e. The operational life shall be not less than 10,000,000 cycles.
- f. Finger protection for terminals (IP2X in accordance with AS 60529).
- g. Provided with LED status indicators.

## 4.17 Programmable logic controllers

Programmable logic controllers (PLCs) shall comply with the requirements of TS 0360 – PLC and HMI Systems.

## 4.18 Programmable relays

Programmable relays (also referred to as intelligent or smart relays) may be used for basic control applications and shall comply with the following requirements:

- a. Programmable with a personal computer.
- b. Programming software and hardware shall be supplied for the programmable relay and provide complete editing, debugging, monitoring, testing, and documentation functions.
- c. Display screen to facilitate basic monitoring, fault finding, and diagnostics.
- d. Minimum of one (1) year program backup time (including all timer/counter values) in the event of a power failure.
- e. System clock (where applicable).
- f. Shall operate from 24 V DC unless otherwise approved.
- g. Provided with a minimum of 20 per cent spare inputs and outputs of each type installed.
- h. Digital inputs and outputs shall be in accordance with the following:
  - i. Digital input signals to the programmable relay shall be failsafe for fault indications.
  - ii. Digital outputs shall be protected from short-circuit faults through the provision of a fuse or other means. The type of output selected shall be in accordance with the voltage, current, and type of load.

## 4.19 Hours run meters

Hours run meters shall have a display capable of registering not less than 9999 hours and shall not be resettable on the unit itself. Where the project specification calls for the provision of HMIs, hours run data should be calculated in the relevant PLC and displayed on the relevant HMI, if possible. 230/400 V supplies running to these meters when they are escutcheon/door mounted is discouraged. (Consider the use of interposing relays.)

## 4.20 Undervoltage and phase imbalance relays

~~Each Distribution Board and/or MCC shall be fitted with a relay combining phase imbalance and undervoltage with a contact opening for the following:~~

- a. Voltage below 80 per cent of rated site voltage.
- b. Phase imbalance greater than the value set. This value shall be adjustable from 5-15 per cent and initially set at 10 per cent.

~~Where a PLC controls equipment and/or load supplied by this board, the relay shall provide phase imbalance / undervoltage status to the PLC, so it can be used for alarm mitigation in the event of supply failure and/or isolation.~~

For single-phase installations, a similar relay designed for single-phase monitoring shall be used for monitoring voltages below 80 per cent of the rated site voltage.

## 4.21 Control switching devices and indicator lights

Pushbuttons, rotary switches, and indicator lights shall be in accordance with AS 60947.5.1.

Indicator lights shall be clearly visible under all indoor and outdoor ambient light conditions. Suitable sun shields or other means shall be provided for outdoor situations to improve visibility, if necessary. Indicator lights shall be high-intensity LEDs. Where only one or two lamps exist on a panel, the LAMP TEST pushbutton may be replaced with lamps with an integral lamp test function. Ensure these lamps are clearly labelled as 'push to test'.

The colours of pushbuttons and indicator lights shall be in accordance with Table 4-1 and Table 4-2, respectively.

Table 4-1: Colours of pushbuttons

Colour	Application													
<b>RED</b>	Action in case of EMERGENCY STOP, STOP or OFF: <ol style="list-style-type: none"> <li>Emergency stop (mushroom head).</li> <li>Emergency close a valve (mushroom head).</li> <li>Stop or Off.</li> <li>Combined stop and reset.</li> <li><del>Open a circuit breaker or switch.</del></li> </ol>													
<b>YELLOW</b>	Intervention (e.g., to avoid danger or unwarranted change): <ol style="list-style-type: none"> <li>Sound a horn.</li> <li>Interrupt an automatic sequence.</li> <li>Bypass an inhibit.</li> </ol>													
<b>GREEN</b>	START or ON: <ol style="list-style-type: none"> <li>Start.</li> <li><del>Close a circuit breaker or electrical switch.</del></li> </ol>													
<b>BLUE</b>	Not used unless required by the project specification.													
<b>BLACK</b>	No specific meaning. To be used for all other applications, e.g.:													
	<table border="0"> <tr> <td>a. Reset.</td> <td>h. Raise.</td> </tr> <tr> <td>b. Acknowledge.</td> <td>i. Lower.</td> </tr> <tr> <td>c. Lamp Test.</td> <td></td> </tr> <tr> <td>d. Open (a valve).</td> <td></td> </tr> <tr> <td>e. Close (a valve).</td> <td></td> </tr> <tr> <td>f. Forward.</td> <td></td> </tr> <tr> <td>g. Reverse.</td> <td></td> </tr> </table>	a. Reset.	h. Raise.	b. Acknowledge.	i. Lower.	c. Lamp Test.		d. Open (a valve).		e. Close (a valve).		f. Forward.		g. Reverse.
a. Reset.	h. Raise.													
b. Acknowledge.	i. Lower.													
c. Lamp Test.														
d. Open (a valve).														
e. Close (a valve).														
f. Forward.														
g. Reverse.														

Table 4-2: Colours of indicator lights

Colour	Application
<b>RED</b>	Danger or alarm: <ol style="list-style-type: none"> <li>Chlorine extraction fan not running.</li> <li>Fire alarm.</li> <li>High fluoride dose rate alarm.</li> <li>Alarms that automatically shut down the plant or process. For example:                             <ol style="list-style-type: none"> <li>Motor winding over temperature.</li> <li>Pump discharge failure.</li> <li>Tank overflow.</li> </ol> </li> <li>Circuit breaker or switch closed (only on the switchgear panel).</li> </ol>

Colour	Application
<b>YELLOW</b>	Caution: a. Stage 1 alarm (Stage 2 being shutdown). b. Alarm which allows operation in an abnormal mode (e.g.: non vital fault which allows a variable speed controller to operate in fixed speed as backup). c. Machinery with exposed moving parts operating.
<b>GREEN</b>	Safety or authorised to proceed: a. Circuit breaker or switch open (only on the switchgear panel). b. Earth switch closed.
<b>BLUE</b>	The following have been assigned: a. Off. b. Stopped. c. Valve Closed. d. Remote. e. Local. f. Automatic. g. Manual. h. Normal. i. Standby. j. Circuit breaker or switch open (remote from the switchgear panel).
<b>WHITE</b>	The following have been assigned: a. On. b. Available (illuminated when power available, and in remote (or auto) mode and no faults, and no E-Stop). c. Running. d. Valve Open. e. Electrical supply available. f. Circuit breaker or switch closed (remote from the switchgear panel).

### 4.21.1 Motor control centre – control selector switch

Unless otherwise specified, MCCs, as a minimum, shall have 3-way selector switches for selecting the motor control operating mode. These 3-way selector switches shall be configured as:

- a. AUTO/OFF/MANUAL for equipment that does not have automatic or manual control from SCADA (this typically applies to small wastewater pump stations and valve sites).
- b. REMOTE/OFF/LOCAL for equipment that has automatic and manual control from SCADA (this typically applies to treatment plant equipment).

3-way control operating mode selector switches shall not be lockable.

Control operating mode selector switches requiring more than three ways shall be determined and approved during the project's design phase.

### 4.22 Surge protection

Surge arresters for limiting voltage surges on AC power circuits shall be in accordance with the following:

- a. ~~Comply with the requirements of AS/NZS 1768, AS 4070 and IEC 61643-11.~~
- b. ~~Non-linear metal-oxide type in accordance with AS 60099.4.~~

- c. Shall operate at a nominal system voltage of (Vrms) 230/400 V, 50 Hz.
- d. Provided with failure indication.
- e. Indicators visible without opening the escutcheon/enclosure door, unless remote indication is provided (for example, on the HMI).
- f. Surge Protection Devices are to be mounted as close as practicable to the Neutral/Earth bar of the supply, with wiring run as straight and direct as possible.

Where cables are connected to output equipment with a potentially damaging high current output under short circuit conditions, the cables and output equipment shall be protected against short circuit unless the output equipment is inherently current-limited or short-circuit proof.

#### 4.22.1 Main and distribution switchboards

Low Voltage surge arrester devices for Main and Distribution Switchboards shall also comply with the following minimum design, construction, and performance requirements:

- a. Device Technology:
  - i. Type 1 + Type 2 combined lightning current and surge arrester (i.e. Cat C fully enclosed spark gap with a facility to prevent follow-on current and a directly coordinated Cat B / Type 2 MOV with thermal disconnection capability. (L-E / L-N)
  - ii. Gas Discharge Tube (GDT) – N-E (for non-MEN only);
  - iii. Type 2 / Cat B surge arrester. MOV and GDT N-E (for non-MEN only) technology with low leakage current.
- b. Category Type 1, Type 2, Type 3 or B, C1, C2, C3 as per IEC 62305-4 and AS/NZS 1768;
- c. Degree of protection: IP20;
- d. A backup fuse, circuit-breaker or dedicated SPD disconnecter separate to the SPD to provide for the safe disconnection of a failed SPD (as per manufacturer's maximum backup fuse rating);
- e. Auxiliary contacts: voltage-free SPST to indicate status with distances between main and auxiliary circuits to be double insulated;
- f. Main terminal size: suitable for maximum 35mm<sup>2</sup> stranded cable;
- g. External alarm terminals: suitable for maximum 1.5mm<sup>2</sup> stranded cable;
- h. Temporary overvoltage withstand mode: 335 volts for 5 sec as per IEC61643-11;
- i. Temporary overvoltage failure mode: 440 volts for 120 minutes as per IEC61643-11;
- j. Discharge currents for Type 1+Type 2 devices (combined 8/20  $\mu$ s and 10/350  $\mu$ s wave shape) as per IEC61643-11:
  - i. Impulse discharge current (Iimp 10/350  $\mu$ s): 25kA(L-N) / 25kA(L-PE) / 100kA(N-PE);
  - ii. Nominal discharge current (In 8/20  $\mu$ s): 25kA(L-N) / 25kA(L-PE) / 100kA(N-PE);
  - iii. Maximum discharge current (Imax 8/20  $\mu$ s): 50kA(L-N) / 50kA(L-PE);
- k. Discharge currents for Type 2 devices (8/20  $\mu$ s wave shape) as per IEC61643-11:
  - i. Nominal discharge current (In 8/20  $\mu$ s): 20kA;
  - ii. Maximum discharge current (Imax 8/20  $\mu$ s): 40k;
- l. Back up fuse: HRC type as per IEC 61643-11 or purpose-specific CB Type:
  - i. Main Switchboard: As per manufacturer's maximum backup fuse rating or from 63 to 125A (HRC gG rated fuse);

- ii. Distribution Switchboard: As per manufacturer's maximum backup fuse rating or from 32 to 63A (HRC gG rated fuse);
- m. Voltage protection level (Up): As defined in IEC 61643-11. The recommended voltage protection level for IEC-approved surge protection devices shall not exceed 80% of the rated impulse withstand voltage level of the relevant electrical equipment. (Advisable protection level (Up)  $\leq$  2.5kV);
- n. The Maximum Continuous Operating Voltage, shall be at least 275 V;
- o. Failure mode: Priority to continued operation. Back up fuse must be coordinated with supply fuse or circuit breaker; and
- p. Short circuit current rating: 50kA for Type 1 or Type 1 + Type 2 combination devices, and 50 kA for Type 2 devices.

## 4.22.2 Process instrumentation systems

Low Voltage and Extra Low Voltage surge arrester devices for Process Instrumentation Systems shall also comply with the following minimum design, construction and performance requirements:

- a. Gas Discharge Tube and Transzorb type construction.
- b. Suitable for Category A locations as per AS/NZS 1768.
- c. Degree of protection: IP20.
- d. External backup HRC fuses or purpose-specific Circuit Breaker.
- e. Internal thermal fuses on individual MOVs, if parallel segments per phase.
- f. Status display: Internal alarm shall indicate device failure, visible without opening the escutcheon/enclosure door.
- g. External alarm contacts: Voltage-free SPDT shall indicate status.
- h. Main terminal size: suitable for maximum 2.5 mm<sup>2</sup> stranded cable.
- i. External alarm terminal: suitable for maximum 2.5 mm<sup>2</sup> stranded cable.
- j. Nominal discharge current:  $\geq$  10 kA per line to line and  $\geq$  5 kA per line to earth.
- k. Maximum discharge current: (1 impulse 8/20  $\mu$ s wave shape)  $\geq$  20 kA per line to line and  $\geq$  10 kA per line to earth.
- l. Voltage protection level shall be no more than double the continuous operating voltage.
- m. Failure mode: Priority to continued operation with local indication and switched output for condition monitoring.
- n. Communication surge protection (say, for Profibus or DeviceNet) shall incorporate high-speed switching.

## 4.23 Instrumentation equipment

This Technical Standard does not provide specific direction on the specification of particular instruments. Each project or location will give direction as to the selection requirements or preferences of instrumentation. The sections below provide general information as to the integration of instrumentation.

### 4.23.1 General

Instrumentation loops shall comply with the following:

- a. Signals shall be linear to the measured variables and shall be 4~20 mA DC.



- b. For Critical Infrastructure and for control and instrument loops that, if interrupted, would cause a significant incident, provided with a test injection facility per section 4.23.8, in each primary loop for plant testing or maintenance purposes. A purpose-made disconnect terminal will suffice for all other instrumentation loops.
- c. Equipment that is of the plug-in type shall be capable of being unplugged without open-circuiting the instrumentation loop.
- d. Where a primary loop is required to drive several secondary loops, a signal isolator shall be provided for each secondary loop to maintain the integrity of the primary loop so that a fault in a secondary loop does not affect the primary loop and other secondary loops. (Ensure the primary loop is monitored for 'out-of-range' condition (in PLC/RTU), or any secondary loop that performs a control function is also monitored.)
- e. Where it forms a control loop with other equipment, such as RTU, PLC, VSD, or SCADA, the loop shall be electrically isolated from other loops, the power supply, and the earth and capable of driving the total loop impedance.
- f. Provided with lightning protection at the control panel side of cables where the equipment is installed in separate buildings or structures, or where the field transducer is located outdoors at a distance of 50 m or greater from the control panel.
- g. Where a communication protocol, that is, MODBUS, HART, Ethernet is used in the transmission of instrument signals, an additional 4~20 mA hardwired signal must be used for any control signal functions.

The requirement for lightning protection shall be determined in consultation with the Regional Maintenance representative.

#### 4.23.2 Scale indicators

Scale indicators shall be in accordance with the following:

- a. Accuracy of  $\pm 1.5$  per cent or better.
- b. Dial type indicators shall be square bezel pattern of 96 mm nominal size and having a concentric scale with an approximately 90° movement.
- c. Scaled in engineering units.
- d. Suitable for use with a 4~20 mA DC signal.

#### 4.23.3 Digital indicators

Digital indicators shall be in accordance with the following:

- a. Number of digits to suit the appropriate displays.
- b. Accuracy not less than  $\pm 0.2$  per cent  $\pm 1$  count.
- c. Height of digits not less than 12.5 mm.
- d. Suitable for panel mounting.
- e. Zero suppression or elevation capability not less than full scale.
- f. Readout in percent or engineering units as appropriate.
- g. Suitable for 4~20 mA DC input.
- h. Voltage drop in the current loop shall not exceed 2.5 V.
- i. Shall not earth the instrument loop at either input.

#### 4.23.4 Flow integrators

Flow integrators shall be in accordance with the following:

- a. ~~Direct reading digital type in the specified units with 7 digits.~~
- b. Calibrated to display total flow in the specified units.
- c. Inhibited from operation when the flow rate is below 0~15 per cent (adjustable) of the maximum flow.
- d. Reading shall be retained during a power failure.
- e. Shall not earth the instrument loop at either input.
- f. Provide a signal from the flow transmitter integrator over Modbus, HART, or similar connection, for totaliser flows through to SCADA.

#### 4.23.5 Signal isolators

Signal isolators shall be in accordance with the following:

- a. Complete electrical isolation between the input, output and power supply.
- b. Provide a boosting capacity to suit the load requirements.
- c. Provide a 4~20 mA DC output proportional to a 4~20 mA DC input with an accuracy of  $\pm 0.25$  per cent of span or better.
- d. Shall not earth the instrument loop at either input or output.

#### 4.23.6 Signal alarm units

Signal alarm units shall be in accordance with the following:

- a. Adjustable differential over the full range.
- b. Repeatability of alarm operation shall be  $\pm 0.5$  per cent or better.
- c. Shall not earth the instrument loop at either input or output.

#### 4.23.7 Lightning protection units

Lightning protection units shall be in accordance with the following:

- a. Discharge current rating of not less than 20 kA for surges with a characteristic corresponding to a standard as defined in AS/NZS 1768.
- b. Protection against differential and common mode transients extending from the power supply input.
- c. Include both voltage-limiting devices and overcurrent fuses.

#### 4.23.8 Test points and test injection points

For Critical Infrastructure and for control and instrument loops that, if interrupted, would cause a significant incident, test points for instrumentation loops shall be of Type A, B or C in accordance with Figure 2 or as specified in the project specification. Test injection points shall be provided with a NORMAL-TEST selector switch in accordance with

Figure 3. Test points and test injection points shall be located inside the cubicles.

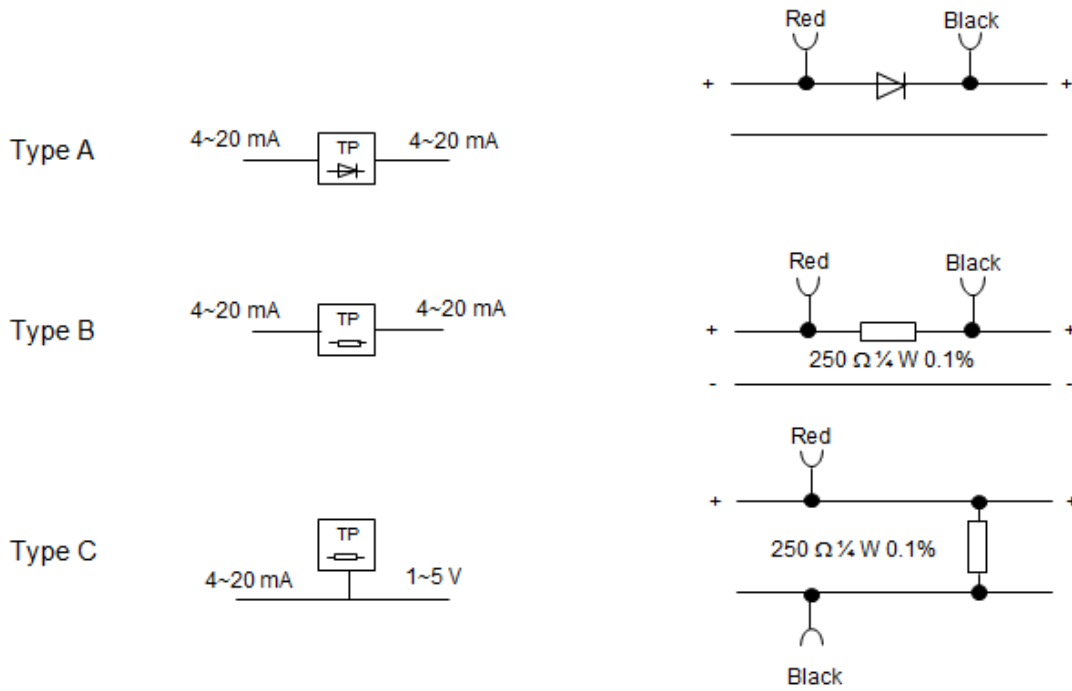


Figure 2 – Test points

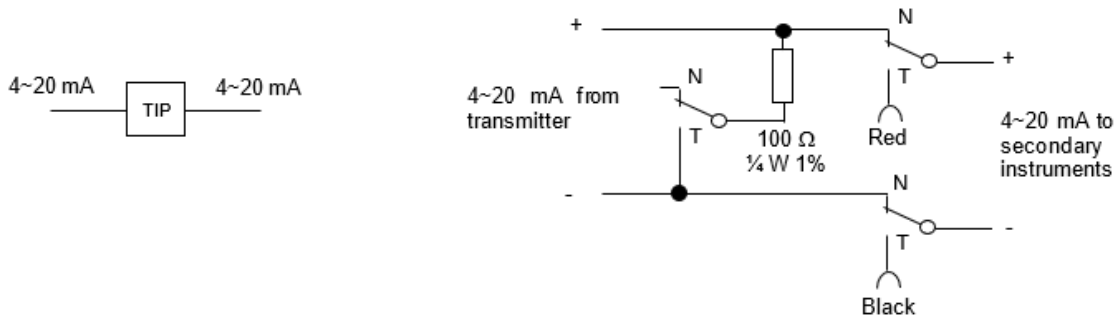


Figure 3 – Test injection points

## 4.24 Human Machine Interfaces (HMI)

Human Machine Interfaces (or touch screen displays) shall comply with the requirements of TS 0360 – PLC and HMI Systems.

## 4.25 Emergency stop circuits

An Emergency Stop circuit is a facility initiated by human action and intended to shut down equipment in an emergency. A Process Stop circuit commands equipment or a process plant to come to a controlled stop in any of the local or remote modes. A screening process will need to be completed using a risk assessment to ascertain if an Emergency Stop or a Process Stop is required. This section prescribes the requirements for an emergency stop circuit.

Emergency stop circuits shall comply with AS/NZS 4024 series and AS/NZS 3000 requirements. A risk assessment (as a part of the Safety in Design process) shall dictate the requirements of Emergency Stop circuits on a project-by-project basis.

Emergency Stop pushbuttons shall be:

- a. Red, palm, or mushroom-headed with a push-to-operate motion and a twist-to-release action in order to release it from its operated position.

- b. Mounted on a yellow backing plate and clearly labelled, identifying its function and what equipment it relates to, for example, "EMERGENCY STOP AERATOR No 1".
- c. IP rated to at least that of the panel/enclosure to which the Emergency Stop is installed.
- d. Mounted in a position that will not impede its use (to be approved on site by SA Water Operations personnel).
- e. Hard wired directly into a relay used for the contactor control circuit (for AS/NZS 4024 series Category 0 installations only) or into a safety relay (for installations other than Category 0).

Emergency Stop lanyards shall be:

- a. Pull to operate motion and a pushbutton to release action to release it from its operated position.
- b. Clearly labelled, identifying its function and what equipment it relates to, for example, "EMERGENCY STOP AERATOR No 1".
- c. A minimum IP 56 rated.
- d. Mounted in a position that will not impede its use (to be approved on site by SA Water Operations personnel).
- e. Hard wired directly into a contactor control circuit (for AS/NZS 4024 series Category 0 installations only) or into a safety relay (for installations other than Category 0).

Emergency Stop circuits shall be:

- a. Designed such that releasing an Emergency Stop button will not cause any equipment to move/restart.
- b. Only capable of being reset by pressing a dedicated Emergency Stop reset button. The reset function shall be provided by either hardwired panel mount button or via local HMI. For certain remote applications with no battery backup, the Emergency Stop circuit may be reset using a power-up pulse only if it is deemed low risk, following a risk assessment.
- c. Provide a local visual indication that the Emergency Stop circuit has been tripped. This indication shall be either hardwired panel mount or via local HMI. If installed, the AVAILABLE indicator lamp shall not be illuminated when the Emergency Stop circuit is tripped.
- d. Provide a signal(s) to the control system, indicating the status of the Emergency stop/Emergency stop circuit. The status signal(s) shall be displayed/alarmed in SCADA.

Emergency Stop Installations:

- a. A risk assessment shall be performed to determine whether more than one Emergency stop pushbutton is required, for example, for large equipment or equipment where access may be restricted. The risk assessment shall also include consideration of field cable types and routes.

## 4.26 General lighting and power equipment

### 4.26.1 Lighting fittings (general)

Where applicable, all lighting fittings shall be in accordance with AS/NZS 60598.1 and AS/NZS 60598.2, with a preference for energy-efficient fittings, that is, LED type to be installed.

Lighting fittings shall be of high efficiency and high power factor and require minimum maintenance. All materials forming part of the lighting installation shall be suitable for the duty and environment of operation.

Materials used in lighting installations shall be selected using appropriate safeguards to minimise the effect of galvanic corrosion between dissimilar metals.

Lighting fittings in the following locations shall have a degree of protection of not less than IP56 in accordance with AS 60529:

- a. Indoor locations which are subject to dampness, high humidity, or ingress of water.
- b. Corrosive environments.
- c. All outdoor locations.

Lighting fittings in hazardous areas shall be certified for the appropriate classification of the hazardous areas in accordance with AS/NZS 60079.

Lighting fittings in corrosive environments shall be constructed of a material suitable for that environment.

Lighting fittings in ELV sections of Switchboard and Control/Telemetry panels shall be ELV powered, rather than LV powered.

#### 4.26.2 Fluorescent fittings

Fluorescent lighting fittings shall be supplied and installed complete with all necessary auxiliary equipment, including reflectors, louvres or diffusers (if specified). Each fluorescent tube shall be provided with a separate electronic ballast which shall be in accordance with AS/NZS 61347.2.8 and AS/NZS 60921.

The internal wiring of fluorescent fittings shall have a temperature rating of not less than 105 °C. Each terminal in the connector block shall be suitable for the connection of not less than 3 x 1.5 mm<sup>2</sup> PVC insulated conductors.

#### 4.26.3 High intensity discharge fittings

High intensity discharge lighting fittings shall be power factor corrected so that the power factor is not less than 0.8 lagging. Capacitors shall be located so as not to be affected by heat generated by the lamp or ballast.

The internal wiring of the fittings shall have a temperature rating of not less than 105 °C. Each terminal in the connector block shall be suitable for the connection of not less than 3 x 1.5 mm<sup>2</sup> PVC insulated conductors.

#### 4.26.4 Emergency fittings

Emergency luminaires and exit signs shall be type-tested self-contained fittings in accordance with AS/NZS 2293.3. Emergency luminaires shall preferably be non-maintained type, integrated within normal fluorescent lighting fittings.

#### 4.26.5 Lighting switches

Lighting switches shall be in accordance with AS/NZS 3133 and the following:

- a. Switches in office areas shall be white and flush mounted with concealed wiring.
- b. In other areas, switches may be either flush mounted or surface mounted and shall be either white with white mounting blocks or shall match the colour of the associated wiring conduit.
- c. Lighting switches in the following locations shall have a degree of protection of not less than IP56 in accordance with AS 60529:
  - i. Indoor locations which are subject to dampness or ingress of water.
  - ii. Indoor locations where additional mechanical protection is required.
  - iii. Corrosive environments.
  - iv. All outdoor locations.

- d. Lighting switches in hazardous areas shall be certified for the appropriate classification of the hazardous areas in accordance with AS/NZS 60079.
- e. Lighting switches in corrosive environments shall be constructed of a material suitable for that environment.

#### 4.26.6 Socket outlets

Socket outlets shall be in accordance with AS/NZS 3112, AS/NZS 3190 and the following:

- a. Socket outlets shall be switched.
- b. Outlets in office areas shall be white and flush mounted with concealed wiring.
- c. In other areas outlets may be either flush mounted or surface mounted and shall be either white with white mounting blocks or shall match the colour of the associated wiring conduit.
- d. Socket outlets supplied by UPS shall be colour-coded blue and/or appropriately labelled.
- e. Socket outlets in the following locations shall have a degree of protection of not less than IP56 in accordance with AS 60529:
  - i. Indoor locations which are subject to dampness or ingress of water.
  - ii. Indoor locations where additional mechanical protection is required.
  - iii. Corrosive environments.
  - iv. All outdoor locations.
- f. Plugs and socket outlets in hazardous areas shall be certified for the appropriate classification of the hazardous areas in accordance with AS/NZS 60079.
- g. Plugs and socket outlets in corrosive environments shall be constructed of a material suitable for that environment.
- h. Socket outlets shall be clearly labelled to indicate the associated circuit breaker feeding the outlet.
- i. Wiring to three-phase outlets shall be such that, when viewing the socket from the front and reading the phases clockwise from the earth pin, the phases shall be red, white, and blue. The neutral pin, where fitted, shall be the central pin.

#### 4.27 Switch room air conditioners

Unless detailed in project specifications, the minimum requirements for installing air conditioners in electrical control/switch rooms shall be as per this section and any additional specifications of ISO245 - Design Requirements for Ventilation and Cooling Systems.

Where more than one unit is specified (e.g. due to heat load requirements or for the requirement of redundancy), each air conditioner shall have the BTU (British Thermal Unit) capacity, plus 30 per cent, to maintain the temperature of the entire environmentally controlled space at no more than 35°C in the event of failure of one of the units.

All air conditioners shall auto restart after a power outage and self-defrosting in the event of icing up. No drip trays or plumbing joints shall be installed above switchgear. Ducted air conditioning systems are not preferred. They shall be set up for cool mode only.

Air conditioners shall be fitted with at least one monitoring alarm output for air conditioner general fault where this general fault is any one of critical mechanical, electrical, or thermal faults detected by the internal air conditioner controller. A separate room temperature sensor shall be provided to allow for connection to a local PLC for monitoring of the room's internal temperature. Air conditioner controls shall be hardwired rather than wireless 'remote' type control units. 'Occupancy' push buttons shall be installed where required, as per ISO245.

Dust filters shall be used on any ventilators or grilles to the exterior of the building. The cable entry points to the building are to be sealed off with a removable seal upon completion of installing the cables to prevent ingress of dust and vermin.

All steelwork required to support the external compressor unit shall be galvanised and firmly secured. An external pad-lockable and labelled isolating switch shall be fitted adjacent to the air conditioning units. In public spaces, a suitably applied galvanised cage is to be fitted to ensure the security of the outdoor unit.

Each air conditioning unit shall be fitted with a minimum 20 mm diameter PVC condensate drain. The drains shall extend vertically down the walls of the building (with a minimum of three fixings to each drain) to a suitable drainage point, such as a roof guttering downpipe.

The system shall be installed by qualified gas fitters.

Where applicable, a clean set of changeover contacts rated at a minimum of 230 V AC shall be installed and wired to a suitably labelled terminal block within the FIP (Fire Indicator Panel) for each of the following functions:

- a. One clean 230 V AC changeover contact to disconnect the AC supply from the air conditioners via a contactor and
- b. One spare clean 230 V AC changeover contact.

## 5 Field cables and equipment

### 5.1 Power cables

Power cables shall be in accordance with AS/NZS 5000.1. Unless otherwise specified, sheathed cables shall have a PVC sheath and be suitable for use underground.

Power cables shall be screened in the following situations:

- a. Where required to comply with the specified electromagnetic emission limits or as required by the manufacturer of the connected equipment, for example, variable speed drives.
- b. Where the power cables are installed near data or signal cables and it is not possible to provide adequate separation between the power cables and data or signal cables to prevent interference in the data or signal cables.

All cables shall be of multi-strand construction and of copper conductor unless otherwise specified.

The minimum cross-sectional area of any cable core shall be 2.5 mm<sup>2</sup> except for:

- a. Current transformer wiring, which shall be a minimum of 4 mm<sup>2</sup>
- b. Lighting circuits, which may be a minimum of 1.5 mm<sup>2</sup>

The Contractor shall be responsible for selecting cable sizes where not shown on the specification drawings, in accordance with AS/NZS 3008.1.1.

Where not otherwise specified, the Contractor shall select required cables in accordance with the following:

- a. For sizes between 1.5~6 mm<sup>2</sup>, they shall be minimum Cu 450/750 V, V-90 PVC/PVC insulated and sheathed.
- b. For sizes 10~16 mm<sup>2</sup> they shall be Cu 0.6/1 kV, V-90 PVC/PVC insulated and sheathed.
- c. LV Power Cables with a cross-sectional area greater than 16 mm<sup>2</sup> shall be Cu 0.6/1 kV, X-90 XLPE/PVC insulated, and sheathed.
- d. VSD Motor Cables shall be at least 2.5 mm<sup>2</sup> Cu 0.6/1 kV, X-90 insulated, 3C+3E, PVC bedded, Cu tape screened, and PVC sheathed (Olex 'Varolex' or approved equivalent).

### 5.2 Control cables

Control cables required to operate at low voltages shall be stranded PVC-insulated PVC-sheathed copper conductor cables manufactured in accordance with AS/NZS 5000 and having a minimum conductor cross-sectional area of 1.0 mm<sup>2</sup>.

Control cables required to operate at extra low voltage shall be rated for the voltages and currents they have to carry. The conductor cross-sectional area shall be at least 0.50 mm<sup>2</sup>.

Multi-core cables shall be provided with several spare cores, not less than two, or 20 per cent of the total number of installed cores, rounded to the next higher whole number, whichever is the greater. The application of mixed voltages (LV and ELV) within the same multi-core cable is not permitted.

Control cables shall be screened where required by the manufacturer of the connected equipment, such as variable-speed drives.

In all situations, voltage drop needs to be considered in the selection of cable size for the final installation.

A minimum of 20 per cent of spare cores for control cables shall be terminated in terminals on DIN rail. Excess cores shall be insulated and secured to avoid accidental contact with



conducting parts. For PLC/RTU I/O, at least 20 per cent of spare/unused I/O shall be wired for each I/O type installed.

### 5.3 Instrumentation cables

Instrumentation cables shall consist of either single pair or multiple pairs, with each pair being of twisted PVC insulated stranded copper conductors in either case.

Each instrumentation cable shall have an overall screen with a stranded tinned copper drain wire and PVC sheath.

The conductors of each pair shall have a minimum conductor area of 0.5 mm<sup>2</sup>.

Multi-pair cables shall be provided with a number of spare pairs equal to or greater than 20 per cent of the total number of installed pairs, rounded to the next highest whole number.

A minimum of 20 per cent of spare cores for control cables shall be terminated in terminals on DIN rail. Excess cores shall be insulated and secured to avoid accidental contact with conducting parts. For PLC/RTU I/O, at least 20 per cent of spare/unused I/O shall be wired for each I/O type installed.

### 5.4 Data cables

Cables used for data transmission shall be suitable for the transmission rate, route length, and installation conditions and as specified by the equipment suppliers, that is, Cat 6 Shielded Twisted Pair designed for use in industrial environments. The outer sheath colour will be dependent on the tier of the network being connected to, as defined in TS 0360 4.3.1.3 Topology, and shall follow the below convention:

The outer sheath colour convention that shall be adopted for data transmission cables is as such:

- a. Blue – Business network cabling/OSN
- b. Green – Plant Control Network communications (PCN) (site Ethernet network – also covers PLC to RTU)
- c. Red – Device level communications (Remote IO Networks as defined in TS 0360)
- d. Yellow – Non-Ethernet, for example, RS485 communications.<sup>3</sup>

**Notes:**

1. In small sites such as water/sewer pump stations and tank sites, unless there is a separate remote I/O network, then the local network shall be deemed to be the PCN.
2. Coloured sleeve is acceptable if outer sheath colour is incorrect.
3. Proprietary cables do not need to conform to yellow as its colour.

### 5.5 Cable trays and ladders

Cable trays, ladders, and fittings, for example, brackets and supports, shall be in accordance with the following:

- a. General indoor and outdoor locations – Hot-dip galvanised to AS/NZS 4680, or approved equivalent.
- b. Corrosive environments, for example, marine, sewage pumping stations, and sewage treatment plants – Marine grade aluminium, fibreglass, insulating (non-metallic) in thermoplastic raw material (PVC), GRP or Grade 316 stainless steel.

Where aluminium is in contact with concrete surfaces less than 12 months old, a suitable material, such as bituminous sheet, shall be used to isolate the contact areas.

~~Alternative products of comparable performance may be acceptable, provided the manufacturer demonstrates proof of equivalence.~~

## 5.6 Conduits and fittings

Electrical conduits and conduit fittings shall comply with one or more of the following:

- a. ~~Heavy-duty rigid UPVC conduits and fittings in accordance with AS/NZS 61386.21.~~
- b. ~~Flexible PVC conduits and fittings in accordance with AS/NZS 61386.23.~~
- c. ~~Corrugated conduits and fittings in accordance with AS/NZS 61386.22.~~
- d. ~~Rigid screwed steel conduits and fittings in accordance with AS/NZS 61386.21.~~
- e. ~~Flexible steel conduits and fittings in accordance with AS/NZS 61386.23.~~

UPVC conduits and fittings installed in locations that are subject to direct sunlight shall be protected by one of the following methods:

- a. ~~Complying with high protection classification against solar radiation in accordance with AS/NZS 61386.1.~~
- b. Painted with an exterior gloss acrylic paint complying with APAS specification AP-S0280/1. The surface shall be degreased and lightly sanded prior to application.
- c. Provided with sun shields.

Steel conduits and fittings shall have the following protection classifications against corrosive or polluting substances in accordance with ~~AS/NZS 61386.1~~, as follows:

- a. Medium Protection or higher, for indoor locations.
- b. High Protection for outdoor locations.

Generally, conduit runs shall be rigid steel or rigid UPVC, with flexible or corrugated conduits used for special or difficult points in the installation, for example, connection to vibrating or moveable equipment. Alternative materials/systems appropriate for the application may be proposed with prior approval.

## 6 LV Motors and electric actuators

### 6.1 Motors

Three-phase motors in all power ratings are preferred. Single-phase motors should only be used where a three-phase supply cannot be economically provided.

Electric motors shall comply with the following:

- a. ~~Three-phase motors shall be high-efficiency induction motors not less than IE3 rating and generally in accordance with AS 60034.~~
- b. Three-phase motors shall be rated for connection to a 400 V AC, 3 phase 50 Hz supply. Single-phase motors shall be rated for connection to a 230 V AC single-phase 50 Hz supply.
- c. Constructed to withstand direct-on-line starting forces.
- d. Adequately de-rated for the effects of ambient temperature, harmonics, and unbalanced supply. ~~Motors installed outdoors in direct sunlight shall be adequately de-rated for the maximum external ambient temperature or provided with a removable sun shield.~~
- e. ~~After the appropriate derating in accordance with (4) above, have a maximum continuous rating of not less than 1.10 per cent of the maximum load.~~
- f. Provide adequate accelerating torque to the load under the worst conditions of load and electricity supply.
- g. Totally enclosed air-cooled with a degree of protection to ~~AS 60034.5~~ as follows:
  - i. Indoor motors – Not less than IP54.
  - ii. Indoor motors that are subject to water ingress and all outdoor motors—not less than IP56.
- h. Provided with winding insulation Class F or higher in accordance with IEC 60085.
- i. Provided with anti-condensation heaters for all (non-submersible) indoor and outdoor motors rated at 15 kW and above.
- j. A warning label shall be provided at the Switchboard or control panel and at the motor with the wording 'MOTOR HEATERS ON WHEN MOTOR STOPPED'. In addition, an appropriately labelled isolating switch shall be provided at the Switchboard or control panel.
- k. Provided with positive temperature coefficient thermistors, RTDs or thermostats embedded in each phase winding to protect the motor windings from the effects of overload and, if possible, stalling for motors rated at 15 kW and above in accordance with AS 60947.8. The over-temperature detectors shall be wired to the motor auxiliary terminal box.
- l. Provided with a terminal box for stator power cables with all 6 winding terminals available at the motor and a separate terminal box for auxiliaries, for example, motor heaters and thermistors. Cable entries shall be from below unless otherwise specified. Consideration should be given to the position of the terminal boxes.
- m. Motors directly coupled to loads shall be provided with grease-lubricated steel caged ball bearings at both the drive and non-drive ends. Roller bearings shall be used at the drive ends where the motors are coupled to the loads via gears or belts due to the high radial loads. Each bearing housing shall be fitted with a grease nipple and ~~with a relief system~~ to prevent overfilling of the bearing with grease. Bearings shall be designed for an L10 life of not less than ~~40,000 hours~~.

- n. ~~Rating plates shall show the direction of rotation and bearing identification and grease type. Rating plates shall be stainless steel for outdoor motors and corrosive environments.~~
- o. Provided with vibration measurement points at both drive-end and non-drive-end bearing housings for motors rated at 110 kW and above. If the non-drive-end bearing housing is not accessible, the vibration measurement point shall be located on the motor casing as near as practical to the bearing housing.
- p. Each vibration measurement point shall consist of three machined pads of 25 mm diameter with a centrally located spot drill point nominally 6 mm in diameter. The machined pads shall be located such that a studded accelerometer with its wiring can be easily screwed into a hole tapped into the pad at a later date, that is, sufficiently clear of guards and to allow measurement points to be positioned in the horizontal-radial, vertical-radial and axial directions. However, the radial measurement points need not necessarily be horizontal and vertical, provided they are perpendicular to each other and the motor axis.
- q. Where specifically stated, continuous vibration monitoring compatible with SA Water's existing vibration monitoring platform shall be provided. This will typically be the case for a motor and the associated pump larger than 300kW or where the site is considered of high operational criticality. SA Water's Representative should be consulted regarding the requirements in this respect.
- r. Provided with a lifting facility. The weight of the motor shall be clearly visible on the nameplate.

## 6.2 Electric actuators

Electric actuators shall be of adequate capacity to open and close the associated equipment under all operating conditions, and consideration shall be given to the protection of the final mechanical configuration in terms of shear-pin or other over-torque protection. In general, electric actuators shall incorporate the following features:

- a. ~~Electric motor operation from a 400 V AC, 3 phase, 3 wire, 50 Hz electricity supply unless otherwise specified in the project specification. Where the project specification requires, due to site specific considerations, alternative power supplies based on FLV DC or single phase 230V AC may be used, dependant on the mechanical requirements. The actuator internal control circuit shall operate at FLV DC.~~
- b. Either a phase rotation discriminator operating such that the actuator motor can only operate when the electricity supply is connected with the correct phase rotation or an actuator that is insensitive to the direction of phase rotation.
- c. Motor winding insulation shall be not less than Class 130 to IEC 60085.
- d. Inbuilt reversing starter for the actuator motor. The starter shall incorporate thermal overload protection for the actuator motor, preferably on all three phases. The starter shall have a utilisation category of AC4 and an intermittent duty appropriate for the application.
- e. Inherently self-locking.
- f. A LOCAL-OFF-REMOTE selector switch.
- g. Local control through integral controls providing OPEN, STOP and CLOSE functions.
- h. ~~Remote controls to suit the specified control systems. Consideration may be given for the use of remote control panels designed by the manufacturer to suit the actuator.~~
- i. In-built over-travel and over-torque protection. It shall be possible to drive the actuator out of the over-torque limit.

- j. Local OPEN, CLOSED and FAULT indications. A separate voltage-free changeover contact for each open and closed position operated from adjustable travel limit switches shall be provided for remote indications and controls.
- k. Anti-condensation heater, if specified.
- l. Enclosure with a degree of protection of not less than IP56 in accordance with AS 60529.
- m. Cable entries from below,
- n. Fully numbered wiring terminals or sleeves for all control wiring.
- o. An auxiliary manual hand wheel mechanically independent of the electric drive for emergency operation, incorporating automatic disconnection if the actuator is energised electrically. The hand wheel shall operate clockwise to close the valve/gate.
- p. An integral position indicator that gives continuous indication of position, in addition to OPEN and CLOSED indications. This indicator shall be visible while operating the manual hand wheel.
- q. 4~20 mA DC valve position input/output signals for controls and indications where relevant.

The preference is for actuators to be arranged so that the motor resides above the gearbox in the final arrangement.

## 7 Generator sets

Unless otherwise noted, this section covers all types and sizes of generator sets including transportable with standalone electrical connection, transportable with a permanent switchboard connection, and permanent installations.

### 7.1 General

Generator sets shall be in accordance with AS/NZS 3010 and shall comprise a diesel engine and a generator mounted on a common skid base, complete with engine cooling radiator, automatic starting system, control equipment, battery and charger, fuel storage tank and lifting facility as specified in the following sections.

The weight of the complete generator set (including sound-proofing casing, etc.) shall be clearly visible on the nameplate or on a separate permanently applied label.

### 7.2 Ambient temperatures

Generator sets shall be suitable for continuous operation over the following ambient temperature ranges unless otherwise specified in the project specification:

- a. Indoor: 0 ~ 40 °C.
- b. Outdoor: -5 ~ 50 °C.

Equipment housed in outdoor enclosures shall be adequately de-rated to allow for an increase in ambient temperature inside the enclosures.

### 7.3 Power rating

Where power rating and load characteristics for an application are not specified, the Contractor shall determine the required power rating for the application based on the following criteria:

- a. Duty Cycle (Standby, Prime or Continuous).
- b. Maximum ambient temperature, as specified in section 7.2.
- c. The ability to run at 10 per cent overload for 1 hour.
- d. The ability to start the motor with the highest starting kVA, (DOL, soft starter, or VSD) when this motor is the last load added to achieve full load, with a voltage dip not exceeding 20 per cent.

A load bank in accordance with section 7.13 shall be provided, if recommended by the manufacturer, to avoid problems associated with running the engine on light loads over long periods of time.

### 7.4 Isolation

A lockable isolating switch shall be provided at a readily accessible location within 10 metres to isolate the generator supply. This isolating switch shall disconnect all live conductors (including the neutral conductor) as per AS/NZS 3010. The generator protection circuit breaker may be used for isolation, provided it is readily accessible.

### 7.5 Outdoor enclosures

Where permanent generator sets are installed outdoors, they shall be enclosed in a weatherproof enclosure with a degree of protection of not less than IP46 in accordance with AS 60529. The enclosure shall be vandal-resistant and shall provide soundproofing to comply

with the requirement of section 7.8. Lifting points shall be provided to allow the complete removal of the enclosure.

Generators rated below 25kVA used in outdoor locations may forego the requirements of this section, provided the enclosure for the electrical components is rated at least IP56 in accordance with AS 60529.

Easy access shall be provided for viewing all instruments and indicator lights. Access for operation shall be available by opening key-lockable hinged doors/panels only. Access for all adjustments and routine service and maintenance shall be available by opening doors or hand removal of covers by one person, the doors or covers being lockable or requiring special tools for opening or removal. In areas open to the public, these doors need to be pad-lockable. Removable doors or covers shall be ergonomically designed for manual handling, and hinge doors shall be fitted with stays.

Acoustic louvred air vents shall be provided to allow air circulation through the enclosure. Any opening in the enclosure shall not reduce the enclosure's IP rating and shall be protected against the ingress of birds and vermin.

## 7.6 Mounting assembly features

The generator mounting assembly shall be in accordance with the following:

- a. Robust steel construction protected against corrosion by fuel and oils. In corrosive environments (as per the definition outlined in section 1.4), special consideration of construction materials shall be considered to ensure the plant's longevity. The SA Water representative shall be consulted in such situations.
- b. Possess lifting points such that the generator remains horizontal when lifted.
- c. Permanently mounted generators shall be capable of being resiliently fixed on a concrete plinth with anti-vibration mountings selected to minimise noise and vibration transmission. There shall be a clearance between the underside of the base frame and the concrete base to give access to handling equipment. Where anti-vibration mounts are provided between the base frame and the engine/generator as an alternative, the base frame shall be levelled on the concrete base with grout. Details of the lifting method shall be provided with this alternative.

## 7.7 Guarding

The internal operations of the generator set shall be protected by machine guarding in accordance with AS 4024.1 in addition to the guarding provided by the acoustic enclosure.

## 7.8 Noise and vibration levels

When operating at the full rated load, the maximum sound pressure level of permanently installed generator sets shall not exceed 85 dB(A) at a distance of 1 metre from the generator set. The noise level limit at the plant property boundary shall be in accordance with the Environment Protection Act 1993. An acoustic enclosure shall be provided, if necessary, to meet the requirements of the Act.

The generator set shall not suffer from excessive internal vibrations. The manufacturer's responsibilities are the out-of-balance, torsional vibrations and critical operating speeds and shall be subject to the Contractor's guarantee. Factory performance vibration tests shall be provided for permanently mounted generator sets in accordance with section 12.3.7.

## 7.9 Engine

The engine shall be in accordance with AS 4594 and the following:

- a. Water-cooled, turbocharged, or after-cooled compression-ignition (diesel) type and a rated speed of 1500 rpm.
- b. For generators of size 25 kVA and over, provided with a thermostatically controlled 230 V AC water jacket heater with a labelled isolating switch on the set. The supplier shall recommend the coolant treatment (anti-freeze/corrosion inhibitor) required to suit the specified ambient temperature range without the jacket heater, and any water conditioning required to minimise scale formation and corrosion. Coolant filling and draining facilities shall be secured within the acoustic enclosure (where provided) and accessible without removing the enclosure. Ready but secured access to check the coolant level shall also be provided without removing any equipment or covers.
- c. The fuel tank shall provide a minimum storage capacity of 8 hours of continuous operation at full rated load or longer. Tank filling and draining facilities shall be secured within the acoustic enclosure (where provided) and accessible without removing the enclosure. Suitable bunding arrangements are required for permanently installed generator sets.
- d. Speed governor of accuracy Class M3 in accordance with AS 4594.4.
- e. Replaceable dry-type air cleaner, fuel filter, and oil filter, which shall be secured within the acoustic enclosure (where provided) and accessible without removing the enclosure.
- f. The exhaust system shall be fitted with a spark arrester. The exhaust pipe shall be routed to the outside of the enclosure or building for fixed indoor units, terminating in a weatherproof cap. The connection between the exhaust pipe and engine shall be made by a suitable stainless steel flexible connector and shall be oil tight. The full length of the exhaust pipe and silencer (if fitted) shall be lagged to minimise heat and noise transmission.
- g. For generators of size 25 kVA and over, provided with the following instruments and sensors, as a minimum:
  - i. Coolant temperature gauge.
  - ii. High coolant temperature sensor.
  - iii. Coolant low-level sensor.
  - iv. Fuel level gauge.
  - v. Oil pressure gauge.

## 7.10 Generator

The generator shall be in accordance with AZ/NZS 3010 and the following:

- a. For three-phase generators: Verified, 4 pole 400 V AC, 50 Hz, 4 wire star connected, horizontal, self-exciting, and brushless type. For single phase generators: Verified, 230 V AC, 50 Hz, self-exciting and brushless type.
- b. For permanent and portable installations, the neutral star point shall have no earth connection to the generator set.
- c. Ingress protection of not less than IP22 to AS 60529.
- d. Winding insulation must be at least Class 180 in accordance with IEC 60085. All windings shall be impregnated with moisture-proofing varnish or epoxy resin and, for permanently connected units, provided with anti-condensation heaters.
- e. Solid-state voltage regulator with the following functions:
  - i. Automatic voltage regulation in accordance with the following criteria:
    - Voltage regulation under steady-state conditions:
      - Voltage variation max (per unit):  $\pm 0.025$



- Voltage restoration after transient change (seconds): 10
- Voltage regulation under transient conditions:
  - Load Current (per unit): 0.60
  - Recovery voltage: 0.97
  - Maximum recovery time (seconds): 0.50
  - Transient voltage rise after rejection of rated kVA at 0.8 power factor lagging (per unit) 0.26
- ii. Short circuit field forcing to at least 300 per cent of rated output current
- iii. Under frequency protection
- iv. Manual voltage adjustment of  $\pm 10$  per cent of nominal voltage.
- f. For generators of size 25 kVA and over, limits of electromagnetic interference shall not exceed those specified in AS/NZS 61000.6.1.
- g. For generators of size 25 kVA and over, total harmonic distortion of the output voltage waveform shall not exceed 3.5 per cent at no load and 5 per cent at a balanced linear load.

## 7.11 Controls, indications, and protection

### 7.11.1 General

Control cubicles not integrated with the generator assembly shall be constructed in accordance with section 3.3 and shall house all the electrical equipment required for controlling, indicating, and protecting the engine, generator, and ancillary equipment.

All control switches, indicator lights, instruments, and meters shall be mounted on the front of the cubicle and readily accessible, clearly labelled and visible.

### 7.11.2 Controls

The following minimum control facilities shall be provided on the front of a remotely located control cubicle, either through a key-operated five-position switch or preferably through the facility of an HMI. Mode selection needs to be communicated to the site PLC, preferably through a MODBUS connection, to ensure continuity of supply to the plant is maintained at all times.

Mode selection:

- a. OFF.
- b. AUTO.
- c. TEST WITH NO CHANGE OVER.
- d. TEST WITH CHANGE OVER.
- e. MANUAL.

With the OFF mode selected, the starting circuit shall be isolated so that the generator set cannot be started. In addition, if running, the generator set shall stop when the OFF mode is selected.

With the AUTO mode selected, the generator set shall be on automatic standby and controlled by the automatic transfer sequence. An AUTO ENABLED indicator light shall be illuminated on the front panel.

The TEST WITH NO CHANGE OVER mode starts the generator set and enables the complete automatic operation to be tested without transferring electrical load to the generator.

The TEST WITH CHANGEOVER mode shall start the generator set and enable the complete automatic operation, including the automatic transfer sequence to be tested by simulating a mains power failure. The electrical load shall be automatically transferred to the generator set in this mode.

In an emergency, the MANUAL mode shall be used to bypass all automatic control functions and incorporate a spring return contact (or separate start button) to start the generator set manually. In this position, the load transfer contactors shall be controlled manually.

In addition, the following control facilities are to be provided such that only authorised and trained personnel can activate them:

- a. EMERGENCY STOP pushbutton (Latched OFF).
- b. RESET pushbutton.

### 7.11.3 Automatic operation

At sites where permanent generator facilities exist, external control equipment shall be provided for the automatic start and stop of the generator set, and the automatic transfer between the mains and standby supplies. Electrical and mechanical interlocks shall be provided to ensure that feedback cannot occur between the two supplies. Where the generator sets are required to operate in parallel with the mains supply, all necessary control, metering, and protection equipment shall be provided to enable the generator supply to be connected to and synchronised with the mains supply in accordance with the requirements of the electricity supplier.

A minimum 'run-on' timer shall be provided to run the generator after restoration of the mains supply. If the mains supply fails again while the set is in run-on mode or stopping, the generator shall, after the pre-set mains failure time delay, immediately be re-started. All time delays in the automatic sequence shall be readily adjustable.

### 7.11.4 Indications

For sites with permanently connected generators of size 25 kVA and over, the following minimum indications shall be provided on the front of the generator set control cubicle and be made available to the site PLC/RTU through contacts brought out to terminals or signals available through a serial link, such as MODBUS:

- a. GENERATOR ON.
- b. AUTO ENABLED.
- c. Generator Synchronised to Mains (where applicable).
- d. Emergency Stop activated.
- e. Individual fault indicator lights (where provided).
- f. Load bank fault indicator light (where provided).
- g. Fuel level LOW.
- h. Hours run.
- i. The following items may be provided by a digital multivariable meter:
- j. Voltage.
- k. Current.
- l. kW.
- m. kWh.
- n. Frequency.

Generator Circuit Breaker status (tripped/off) shall be provided on an external (remote) switchboard.

### 7.11.5 Protection

For sites with permanently connected generators of size 25 kVA and over, the generator set shall be provided with automatic protection against:

- a. Failure to start.
- b. Engine oil pressure low.
- c. Engine coolant temperature high.
- d. Engine overspeed/underspeed.
- e. Generator armature overcurrent.
- f. Generator field overcurrent.
- g. Generator over voltage/under voltage.

Each fault shall open the generator contactor control contact, stop the set, illuminate a fault indicator light, and operate a changeover common fault contact for remote indication. A manual fault reset shall be provided. Alarms made available to the site PLC/RTU through a serial link, such as MODBUS, is preferred.

Protective devices shall be fitted with suitable time delays to prevent them from operating during acceptable transient conditions in normal service.

In addition, short circuit and sustained overload protection of the generator output shall be provided by means of a suitably rated automatic circuit breaker. Reference to the overcurrent and alternator data is required for the correct selection of a suitable overcurrent protective device. The circuit breaker shall be located in a readily accessible position.

~~The circuit breaker shall be in accordance with section 4.2.3.~~

~~Where generator changeover switches are used as switchboard isolation devices, the rating of the upstream circuit breaker shall be specified accordingly as the first item in the circuit, if the correct labelling is applied to both sets of switchboard drawings and both sets of switchboards.~~

## 7.12 Batteries and chargers

### 7.12.1 Batteries

For sites with permanently connected generators of size 25 kVA and over, separate batteries for control and engine starting purposes shall preferably be provided.

The batteries shall be in accordance with the following:

- a. Starting battery adequately sized to provide at least three successive 10 second cranking periods with a cold engine, and then capable of a further two cranks for 10 seconds, not more than two hours later. (After three cranks, if the engine has not started, an alarm shall be raised).
- b. Installed on the generator set (not in the charger cubicle), protected from the weather, ventilated, and readily accessible for inspection and maintenance.
- c. Electrolyte level indicator for each cell (if applicable).
- d. Provided with terminal insulators.
- e. Provided with explosion-proof vent plugs (if applicable).

## 7.12.2 Chargers

For sites with permanently connected generators of size 25 kVA and over, either a common charger with two separate outputs or two separate chargers shall be provided for the batteries, in addition to the integral generator-driven battery charger, to maintain battery charge when the generator set is not being used for extended periods.

The battery charger(s) shall be in accordance with the following:

- a. Constant voltage, current limited type, providing automatic boost and float charge facilities.
- b. Adequately rated for the ambient conditions.
- c. Capable of fully recharging the battery within 24 hours following a full discharge.
- d. Ensure the battery is fully charged at all times.
- e. Suitable for operation from a 230 V AC +10 per cent – 6 per cent, 50 Hz single phase supply.
- f. Provided with the following indications at the charger cubicle:
  - i. Group alarm "Charger Fail" output.
- g. Provided with a common voltage-free changeover fault contact for remote indication.
- h. Provided with a battery tester to indicate the battery condition.
- i. Provided with the following protection:
  - i. Input overcurrent.
  - ii. Output overcurrent and short circuit.
  - iii. Lightning and transient over-voltages.
- j. The charger cubicle shall be generator set mounted or wall mounted in the building and may be integral with the generator set control panel.
- k. As a minimum, an indication of CHARGER FAILURE shall be made available to the site PLC/RTU through contacts brought out to terminals or signals available through a serial link, such as MODBUS.

## 7.13 Load banks

Load banks, if required, shall be in accordance with the following:

- a. Multi-stage or continuously adjustable to provide a minimum load to avoid engine glazing, as recommended by the manufacturer, taking into consideration the operation of the plant loads.
- b. Automatic controls to maintain the minimum load in response to the varying plant loads.
- c. Adjustable set points for both minimum and maximum loads.
- d. Resistance elements shall be made of a durable material and shall be individually replaceable.
- e. Located so as not to obstruct the removal or maintenance of the generator set and to comply with the requirements of AS 4024.1.
- f. Enclosure shall be constructed in accordance with section 3.3. External covers shall be removable to provide maintenance access and shall be secured with locks keyed alike to the generator set enclosure.
- g. Adequate heat dissipation to prevent excessive temperature rise within the enclosure. All accessible external surfaces shall be insulated, if necessary, to ensure that they are safe

to touch. The temperature of the discharge air and the manner it is discharged shall not create a safety hazard.

- h. All equipment and wiring shall be adequately rated for the maximum temperature within the enclosure.
- i. Over-temperature protection, with the appropriate status and fault indications, shall be provided on the generator set control panel.

## 8 Uninterruptible power supplies

This section includes requirements of Uninterruptible Power Supplies (both battery-backed 24 V DC and 230 V/400 V AC power supplies).

### 8.1 General requirements

Uninterruptible/Battery-Backed power supply units shall be in general accordance with the following:

- a. Uninterruptible Power Supplies shall comply with AS 62040.
- b. In general, battery backup times should be calculated on the diversified maximum demand of the applicable loads, rather than the demand plus the spare capacity.
- c. Provide an online, no-break supply in the event of a mains supply failure for a continuous period of eight hours or greater, if specified in the project specification.
- d. Provide "seamless" output voltage transition when operation changes from battery power to mains power, when mains power is restored.
- e. For PLC and Control systems, be suitability designed, sized and installed to ensure that local controls and indications continue to operate in the event of a power failure.
- f. For RTU's, be suitability designed, sized and installed to ensure that the communications system will continue to operate in the event of a power failure.
- g. The power supply shall be provided via a dedicated final sub-circuit protected by a miniature circuit breaker in the distribution board.
- h. Automatic static bypass upon a rectifier or inverter failure.
- i. Manual bypass to allow maintenance to be carried out without disconnecting the loads.
- j. Connected load shall not exceed 80 per cent of the full load capacity, that is, 20 per cent spare capacity.
- k. Sealed batteries with integral automatic battery charger in accordance with section 8.2.
- l. Automatic preservation of battery charge in the case of a prolonged power outage, in accordance with section 8.3.
- m. Be fitted with a 12 V DC or 24 V DC (or 2 x 12 V DC) battery with a capacity of not less than 1.2 Ah and a minimum design life of 5 years under the conditions in which it will operate. The battery shall be rated to supply the backed-up system for a continuous period of eight (8) hours for standard outstations and sixteen (16) hours for SCADA and Control link repeater sites, or greater, if specified. In cases where a permanently connected on-site generator is in use, SA Water representatives may be approached to determine if the backup time may be reduced.
- n. Where applicable, suitable for continuous operation from an input voltage of 230 V AC single phase or 400 V AC, 3 phase (as specified in the project specification) with an input voltage fluctuation of +10 per cent – 15 per cent and an input frequency variation of  $\pm 5$  per cent.
- o. Where applicable, output voltage shall be 230 V AC single phase or 400/230 V AC three-phase in accordance with the project specification. Output voltage regulation shall be not greater than  $\pm 3$  per cent, and output frequency variation shall be not greater than  $\pm 0.5$  per cent.
- p. Where applicable, output power factor within the range of 0.8 lagging to 0.8 leading.
- q. Harmonics in the mains supply caused by a UPS shall not exceed the limits specified in AS/NZS 61000.3.6, and the radio frequency interference caused by the UPS shall not exceed the limits specified in AS 62040.2.

- r. Overload capacity of 103 per cent full load for 10 minutes continuous, 125 per cent full load for more than 30 seconds, and 150 per cent full load for more than 10 seconds.
- s. Capable of performing a cold start, that is, starting in the absence of AC mains supply.
- t. Non-encased battery terminals shall be provided with insulating covers.
- u. The following alarms shall be indicated on the front panel of the UPS:
  - i. LOW BATTERY VOLTAGE.
  - ii. UPS FAULT.

(A voltage-free common alarm contact or MODBUS/Ethernet interface shall be provided for remote alarm monitoring.)

- v. The following instruments shall be provided on the front panel of the UPS:
  - i. Input voltmeter.
  - ii. Input ammeter.
  - iii. Output voltmeter.
  - iv. Output ammeter.
  - v. Output frequency meter.
  - vi. Battery voltmeter.
  - vii. Battery ammeter.

The meters shall be appropriately scaled to accommodate the normal operating conditions and the specified one-hour overload capacity.

## 8.2 Battery and charger

The UPS shall be provided complete with an integral battery charger and battery capable of continuous operation at the full rated load (not the connected load) of the UPS for the specified duration.

The charger shall be of adequate capacity to supply the full rated load and to simultaneously charge a fully discharged battery to at least 95 per cent fully charged state within a period of 12 hours. The output voltage and current characteristics of the charger shall be suitable for the type of battery used and for the UPS inverter. The charger shall be capable of both float and boost charge operation, with the changeover between the two modes being automatic with manual override. Both float and boost operating characteristics shall be in accordance with the battery manufacturer's recommendations.

The UPS charging and monitoring circuit shall not be plugged into the output of the UPS.

## 8.3 Shutdown operation

During prolonged power outages exceeding the UPS backup time, the UPS shall automatically disconnect the supplied load before its output drops below that required by the load.

After shedding its connected load, the UPS shall disconnect the battery, if necessary, to prevent permanent damage to the battery.

## 8.4 Isolation

Where the UPS output is reticulated, an isolating switch shall be provided at a readily accessible location to isolate the UPS supply.

Where a floating neutral exists for supplies broken out from a UPS, then double-pole circuit breakers shall be used for subcircuits. Appropriate labelling shall be applied to the equipment, highlighting the potential hazard.



## 9 Installation

### 9.1 General

All electrical work shall be in accordance with AS/NZS 3000, this document, project specification, statutory requirements and the electricity supplier's service and installation rules and applicable Technical Standards. The installation shall be suitable for and approved for connection to the electricity supply network.

All electrical work shall be carried out by Registered Electrical Workers and a competent person in accordance with AS/NZS 3000 and Certificates of Compliance shall be provided, where required, in accordance with the Electricity Act and Regulations.

### 9.2 Fixing

Items of electrical equipment shall be rigidly secured in their respective positions using fixtures provided with the equipment or as otherwise specified. Electrical equipment mounted on concrete surfaces shall be secured by means of approved anchors.

Uncoated steel bolts, screws etc., shall not be used to affix electrical equipment in the following areas:

- a. Outdoor areas.
- b. Damp environments.
- c. Corrosive environments.

Materials that may be satisfactory depending on the environment include Aluminium, hot-dip galvanised steel, brass or stainless steel.

Electrical equipment, tray, conduit, etc., shall not, as a practice, be attached to structural steelwork and shall be separate from, and not attached to any pipework.

If approval for welding to structural steelwork is given, such welding shall be in accordance with AS 1554.1.

For galvanised and zinc coated steelwork, the mounting brackets and weld areas shall be cleaned by abrading till bright steel is exposed. Two coats of zinc rich paint type B14, complying with AS/NZS 2311, shall be applied. For all other coated steelwork, the coating system shall be the same as, and match that, as originally applied.

Conduit saddles which are attached to steelwork shall be fixed in the approved locations only and shall be fixed by means of metal thread screws either screwed into drilled and tapped holes in the steelwork or fitted to drilled clearance holes in the steelwork and fitted with nuts and lock washers.

### 9.3 Switchboards and control/telemetry panels

Switchboards, control/telemetry panels and cubicles housing electrical equipment shall be installed in accordance with this document, the project specification and AS/NZS 3000.

The following clearances shall be provided around Switchboards and control/telemetry panels:

- a. Horizontal clearances shall be in accordance with AS/NZS 3000.
- b. A vertical clearance from the ground, platform or other walked-on surfaces to a height of 2 m or not less than the height of the Switchboards and control/telemetry panels, whichever is the greater.

Openings, doorways and emergency exits and paths shall be in accordance with AS/NZS 3000.

Where provision has been made on the cubicle for lifting purposes, the Contractor shall use this provision whenever lifting is required.

The cubicles shall be fastened to the floor or wall as appropriate by means of bolts screwed into masonry anchors and made of a compatible material with that of the cubicle material.

The Contractor shall level the cubicles and shall then grout underneath all floor and ground-mounted cubicles.

Cubicles which are mounted directly on a concrete plinth shall be provided with a sheet of bitumen impregnated felt or other approved moisture barrier between the underside of the cubicle and the plinth. This requirement shall also apply to cubicles on metal plinths located in areas which are damp or likely to be damp, for example, due to leakage or hosing down operation and in all outdoor locations.

~~Consideration must be given to future maintenance for cubicles that require side or rear access. (e.g. rear mounted busbar systems.) Suitable space or other access provisions must be considered during the design process.~~

Outdoor cubicles shall be positioned such that no openings are facing the prevailing weather.

At the completion of the mechanical installation of the cubicles and prior to any field electrical connections being made, all mechanical and electrical connections shall be checked for tightness. Mechanical checks shall include for tightness of bolts holding sections of the cubicle together, tightness of busbar supports and tightness of mountings of circuit breakers, composite fuse switch units, isolators and switches, fuse bases, contactors and relays. Electrical checks shall include joints in busbars and all wiring terminations. Covers shall be removed as required for these checks and shall be replaced and secured immediately after the checking of connections is completed.

Any damage to painted surfaces at the completion of installation shall be reinstated in accordance with section 11.5. Damaged or scratched surfaces on stainless steel cubicles shall be repaired or replaced to the satisfaction of SA Water's Representative.

The Contractor shall maintain the degree of vermin proofing as required to achieve the IP rating as per section 3.3 of this document.

## 9.4 Cable trays and ladders

Final locations and fastenings of cable trays, ladders and supports shall be determined on site in cooperation with SA Water's Representative.

Cables ladders/trays shall, where possible, be of ample width and support strength to accommodate the cables specified with a 30 per cent allowance for future cabling.

The cable trays and ladders shall be supported at not greater than the manufacturer's recommended intervals and there shall be no discernible deflection of the trays or ladders evident to the naked eye.

Cover plates shall be provided in situations as follows:

- a. Providing cable protection to:
  - i. Protect cables against mechanical damage where cable trays or ladders are installed across areas in which personnel or machinery access or the like is probable.
  - ii. Protect cables against damage by sunlight.
  - iii. Reduce the effect of heat gain from solar radiation, which may affect the cable current rating.
- b. Where specified or shown on the drawings.

Where galvanised cable trays or ladders are installed outdoors, any damaged surfaces shall be reinstated using zinc-rich primer type B14 complying with AS/NZS 2311. Two coats shall be applied to clean, rust-free surfaces.

Electrically conductive cable trays and ladders shall be bonded to the earthing system in accordance with AS/NZS 3000 and equipment manufacturer installation requirements and the following:

- a. Cable ladder shall be earthed back to the main earthing system via two main earth conductors, or via one earth conductor with a bonding loop installed to each side rail.
- b. Where bonding between cable ladder sections is provided with fixed multi-bolted splice plates, no additional earth wire conductors are required.
- c. Where cable ladder sections are separated and are not joined via splice plates, two off earth conductors shall be provided to maintain a continuous earth.
- d. Where expansion gaps or sliding expansion joints are used, a bonding earth wire shall be installed to maintain a continuous earth.
- e. Where adjustable splice plates are used, these shall include an earth-bonding conductor.

## 9.5 Conduits

Conduits shall be sized in accordance with AS/NZS 3000 for the number and size of cables to be installed within each conduit and the additional requirements of this section. Conduits shall be a minimum size of 20 mm diameter.

Conduits shall be saddled on either side of every bend and elbow. Conduit saddles and clips shall be secured using purpose-made fasteners. In outdoor locations, fasteners and fixings shall be made of brass, stainless steel, hot-dip galvanised or other approved corrosion resistant materials. Electroplated zinc fasteners and fixings may be used for indoor locations only.

Approval shall be obtained from SA Water's Representative before any holes are drilled in any structural steelwork.

Conduit shall, wherever possible, be run in horizontal or vertical planes, shall be grouped and generally be as inconspicuous as possible. Where conduits are required to run adjacent to non-planar surfaces, the conduits shall be shaped to closely follow the surface on which they are to run.

If there is an open point of entry of cables into conduits that may admit water or vermin, then openings shall be filled with a non-degrading sealant. The type of sealant used should be easily removable to allow for future installation of cables.

Pull boxes shall be provided in long runs of conduit to facilitate installation of cables. Junction boxes shall be provided at all tee-offs in conduit runs. All conduits shall be installed with a polypropylene draw wire in place to facilitate the drawing in of cables. A draw wire shall also be left in place for future use after the cables have been drawn in and be suitably restrained to prevent accidental withdrawal into or out of the conduit.

In above ground situations, adequate provision shall be made to allow the conduits to expand and contract with temperature, either at bends or by the use of expansion couplings.

Rigid conduits shall not connect directly to vibrating equipment. A short length of flexible conduit shall be provided for such connections.

Underground conduits shall be installed in accordance with AS/NZS 3000 and section 10. Cable route markers and cable pits shall be provided for underground conduits in accordance with sections 9.7.3 and 9.6 respectively.

Buried conduits shall generally be laid in straight lines and even falls. Nominally level conduit runs shall be laid with falls to create a high point midway in each run to allow moisture to run

back to the cable pits. Conduits entering buildings should be installed to stop liquid from draining into the building.

Where conduits are required to be cast into concrete foundations, the conduits shall be provided with a minimum of 60 per cent spare cross-sectional capacity inside each conduit after all cables are installed and a minimum of one spare conduit for each LV and ELV/telecommunications conduit, where present. All spare conduit ends shall terminate into a pit, cable void space, or cabinet base.

Where conduits pass under roads, footpaths, and foundations, the conduits shall be provided with a minimum of 60 per cent spare cross-sectional capacity inside each conduit after all cables are installed and a minimum of one spare conduit for each LV and ELV/telecommunications conduits, where present. All spare conduit ends shall terminate into a pit, cable void space, or cabinet base.

## 9.6 Cable pits

Cable pits shall be provided for all underground conduit runs where the conduits change direction and at intervals not exceeding 50 m in straight runs. Cable pits shall be constructed to avoid the ingress of groundwater and provided with drainage facilities. A drainage point should be connected from the base of the pit to a suitable soak-away. For landscaped applications, where only foot traffic is anticipated, it is recommended that at least 150mm of a gravel base is laid at the bottom of the pit to act as a drain and help prevent the enclosure from sinking.

~~Cable pits, including lids and surrounds, shall be rated in accordance with AS 3996 as required for the specific location. Footpaths and locations where no vehicle traffic is expected over the life of the installation require a minimum of Class B. Where vehicle traffic is anticipated, Class C or Class D shall be used at a minimum as required by the specific location. The Detailed Design shall clearly show the cable pit requirements on the drawings.~~

~~Cable pits shall be sized to accommodate the bending radius of cables and so as to allow physical access to install cables.~~

All cabling within cable pits shall be individually identified with appropriate labelling in accordance with section 9.7.9.

## 9.7 Cable installation

### 9.7.1 General

Power, instrumentation and control cables shall be installed in accordance with AS/NZS 3000 and this Specification. Data and communication cables shall be installed in accordance with ACMA Technical Standards.

~~Some additional requirements may need to be noted when terminating LV service connections from SA Power Networks. SAPN Service and Installation Rules need to be consulted in such instances.~~

Different wiring systems shall be segregated in accordance with clause 3.9.8.3 of AS/NZS 3000, for example, by installing power cables in separate conduits from control, instrumentation and data cables.

Cables shall not be installed on suspended ceilings unless the ceilings are designed to support the weight of the cables.

Intermediate joints in cables are not permitted.

### 9.7.2 Installation of cables in wastewater treatment/pumping areas

The following guidelines shall be adopted within designated areas of wastewater treatment/wastewater pumping installations. SA Water Asset Owners/Plant Operations must

be consulted when determining the designated areas that require rodent-proofing of cables and cabling systems.

In general, the following guidelines are to be adhered to, understanding that each situation is unique and an approach of 'best endeavours' is to be applied:

The use of vertically installed cable tray is preferred. Above-ground cable installation is preferred over underground cable installations. When cables require replacement, then the principles outlined below are to be followed:

a. Underground Cables

- i. All cables that are installed in an underground ducting/conduit system are to use rodent-proof rated conduit sealing systems and, where available for the application, rodent-proof cable, for example, steel wire armoured or wound steel tape cables.

b. Above Ground Cables or Cable Tunnels

- i. All cables installed on an outdoor or indoor horizontal cable tray/ladder are to use rodent-proof cable, for example, steel wire armoured or wound steel tape cables.
- ii. All cables installed in an outdoor or indoor vertical cable tray/ladder do not need to use rodent-proof cable, for example, steel wire armoured or similar unless the plant area has been designated by the Asset Owner/Plant Operations to be prone to cable damage caused by rodents.
- iii. Use of vertically installed cable tray is preferred. Cables that are installed on a vertical cable tray need to be clipped from the top of the tray downwards.

c. Fibre Backbone Communication Cables

- i. All fibre backbone communications cables shall use rodent-proof cable, for example, steel wire armoured or wound steel tape.

d. Cable System Sealing

- i. All conduits shall be sealed with a rodent-proof rated sealant.
- ii. All switchboards and control/telemetry panels shall be sealed to prevent vermin ingress.

### 9.7.3 Cable handling

Cables shall be installed in a manner that is not inferior to the manufacturer's instructions.

Care shall be taken during installation of cables such that cables are not cut, abraded, kinked or otherwise damaged or subject to a bending radius greater than that specified by the cable manufacturer.

Any cables that are damaged during installation shall be repaired or replaced by the Contractor to the satisfaction of SA Water's Representative at the Contractor's expense.

### 9.7.4 Installation of data cable

Each run of an Ethernet ring shall be mounted in a separate conduit or on a separate ladder to ensure a redundant path is achieved. Field network cables shall be colour-coded in accordance with section 5.4 and shall be labelled in accordance with the numbering system in section 9.7.10.

### 9.7.5 Cable termination

Cables shall be supported at all points of termination to prevent undue mechanical strain on the terminations. Support may be by means of fittings supplied with the various items of equipment or, if these are inadequate or insufficient, additional supports.

~~A minimum of 20% of spare cores for control cables shall be terminated in terminals on DIN rail. Excess cores shall be insulated and secured to avoid accidental contact with conducting parts.~~

Compression lugs shall be properly sized in accordance with the size of cable to be terminated, which shall be applied using approved compression tools in accordance with the manufacturer's written recommendations. Compression lugs used on control cables, instrumentation cables or small power cables shall be of the pre-insulated type and, when fitted, shall support the cable insulation.

All bolted connections shall be made with cadmium-plated high tensile bolts and nuts fitted with lock nuts.

### 9.7.6 Instrumentation cable screens

Screens on instrument cables shall be isolated from each other and metal components of cubicles and earthed at one point only (namely the instrument earth bar).

At field equipment, cable screens shall generally be cut back and isolated from earth (depending on the instrument manufacturer's recommendations).

At junction boxes and control/telemetry panels, where the cable screen breaks out from the cable tray, the screen shall be isolated from all other cable screens and earth. The screen drain wire shall then be insulated using green or clear sleeving and terminated onto a unique terminal provided for the screen. This terminal is to be connected to the instrument earth bar.

**Note:** that it is permissible to connect the cable screen directly onto the instrument earth bar if this is adjacent to the point where the cable is to be terminated.

Where a multi-pair cable with an overall cable screen only is connected via a junction box to numerous single cables, each having a screen, the terminals containing the screen connections shall be linked together. In this way, the multi-pair overall screen will provide the connection to the instrument earth bar for all the single cable screens.

Where a multi-pair cable with individual and overall screens is connected via a junction box to numerous single cables, each having a screen, the terminals containing the screen connections shall NOT be linked together. Each individual screen on the multi-pair cable shall only be connected to the screen of the associated single cable. In this way each screen will be provided with a single path to the instrument earth bar, thus ensuring circulating earth currents cannot be formed.

### 9.7.7 General power and lighting cables

Wiring for the general power and lighting installation shall commence at the appropriate general power and lighting distribution boards. For non-office areas, the cables for general power and lighting shall be run along ducts, trays or in surface-mounted rigid conduits. In office areas, cables for general power and lighting shall be concealed and shall utilise wall cavities, where available.

Wiring connection to light fittings shall be arranged such that a fitting can be readily disconnected and/or removed without having to disconnect or remove other fittings.

### 9.7.8 Cable fixing

Cables which run on cable trays shall be fixed to the tray and such fixings shall be in accordance with AS/NZS 3000.

Cables that are run in cable ducts or on cable trays shall run parallel to the sides of the duct or tray. Where such cables must negotiate a bend, the centre of curvature shall generally be common for all cables and shall be determined by the largest cable of the group so that a neat installation is obtained.

Single core cables which form part of one multiphase circuit shall be run in proximity to each other.

Control and instrumentation cables may be bunched. A clearance of not less than 25 mm shall be maintained between power and control or instrumentation cables.

### 9.7.9 Cable and wire labelling

Cables shall be identified at the ends by a durable corrosion-resistant tag printed with the cable identification used on circuit diagrams.

Cables shall be identified at both ends, both inside and outside of panel/gland plates. Labels installed in the horizontal plane shall be read from left to right. Labels installed in the vertical plane shall be read from bottom to top. In addition to this, cables passing through cable pits shall also be labelled.

Individual wires (cores) of control or instrumentation cables shall be labelled with printed slip on type full circle ferrules.

### 9.7.10 Cable numbering system

All cable numbers shall be unique in an installation. Cables connecting equipment external to Switchboards or control/telemetry panels shall be labelled as follows:

TT-XXXX-YYYY-ZZ-zz where:

TT = Cable Type

PH High Voltage Power

PL Low Voltage Power

DC DC Power

PV\* PV Solar Power

PE Power Earth

CC Control

CE Control Earth

IA Instrumentation Analog

ID Instrumentation Digital

IX Instrumentation Mixed Analog and Digital

IP Instrumentation Power

IE Instrumentation Earth

DD Data

XXXX, YYYY = Equipment Identification at the Points of Connection

Internal switchboard data cables shall be identified using XXXX-YYYY-ZZ; that is, there is no need for the DD prefix.

Equipment identification shall be the tag name as assigned to the plant.

XXXX shall precede YYYY generally in accordance with the following descending order:

PV\* This may also be used with additional identifiers as such:

PV/T PV Tail (\*P1 and \*N1)

PV/S PV String (\*P1 and \*N1)

PV/R PV String Tracker Column Jumper Cable (\*P1 and \*N1)

PV/M PV String Tracker Motor Jumper Cable (\*P1 and \*N1)

PV/X PV String Extender Cable (\*P1 and \*N1)

PV/H PV String Harness Cable (\*P1 and \*N1)

- a. Generator/Transformer/Power Supply/Instrument Transducer.
- b. Main Switchboard.
- c. Area Switchboard/Motor Control Centre.
- d. Local Control cubicle.
- e. RTU.
- f. Field Equipment (pumps, valves etc.).

Where the order of precedence cannot be distinguished, for example, interlocks between two Switchboards or cables carrying bi-directional signals between two locations of the same order, the tag names shall be arranged in alphabetical/numerical order.

XXXX is optional where all the cables originate from a single source in the same area, for example, in a simple installation consisting of a single Switchboard only.

ZZ = Cable Sequential Number

A 2-digit number to differentiate two or more cables of the same type and identification.

zz = Wire Sequential Number

A 2-digit suffix number to identify individual wires (cores) of a cable, where required.

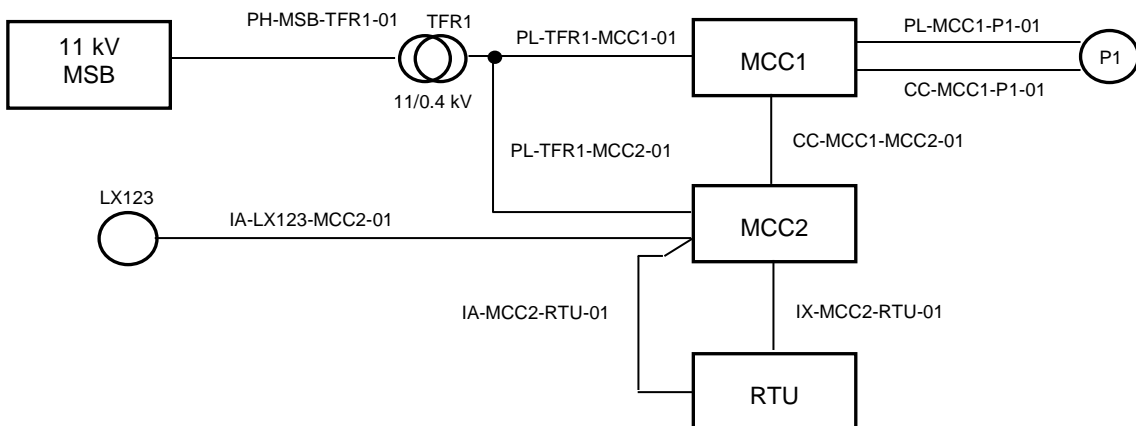


Figure 4 – Example cable numbering

PH-MSB-TFR1-01	11 kV feeder cable from main Switchboard MSB to transformer TFR1
PL-TFR1-MCC1-01	400 V supply cable from transformer TFR1 to motor control centre MCC1
PL-TFR1-MCC2-01	400 V supply cable from transformer TFR1 to motor control centre MCC2
PL-MCC1-P1-01	400 V motor power cable from motor control centre MCC1 to pump P1
CC-MCC1-P1-01	Control cable from motor control centre MCC1 to pump P1
CC-MCC1-MCC2-01	Interlock control cable between motor control centres MCC1 and MCC2
IA-MCC2-LX123-01	4~20 mA DC instrumentation cable between loop-powered level transducer LX123 and MCC2
IA-MCC2-RTU-01	4~20 mA DC instrumentation cable between MCC2 and RTU
IX-MCC2-RTU-01	Instrumentation cable carrying mixed analog and digital signals between MCC2 and RTU



### 9.7.11 Wire numbering system

No two wire numbers in interconnected wiring systems shall be the same unless the wires are physically linked.

All wire numbers shall be generated from Schematic Diagrams in accordance with section 13.1.3 (b) such that the wire number references back to the drawing of origin and a cross reference location of the wire on that drawing.

Wire numbers shall be prefixed with the drawing number, or part thereof, or in the case where a drawing set has only one drawing number with many sheets, shall be prefixed with the sheet number, or a combination of drawing number and sheet number, as required, such that every wire number in an interconnected wiring system is unique.

The remaining identifier of the wire number shall be a cross-reference to where the wire is located on the drawing. The cross reference shall be made at the point of origin/source. (For example, a PLC output wire number shall be generated at the PLC output end of the wire, not the field end. Whereas a PLC input wire number shall be generated from the point of source, being the field device, rather than the PLC input card.)

For LV systems, the neutral wire number should be prefixed with the respective active supply wire number. For example, if the Supply wire number is 25100, the neutral should be labelled 25100-N. This label should then follow through for all circuits that share the common neutral rail.

For ELV systems, the 0 V DC wire number should be prefixed with the respective positive supply wire number. For example, if the Supply wire number is 25100, the 0 V DC should be labelled 25100-0 V. Thus, different labels will apply for different discrete power supplies.

Wire numbers on each side of test links and inject terminals shall be labelled the same.

## 9.8 Lighting systems

Lighting fittings shall be provided in accordance with section 4.26.1 and this Specification.

After completion of the installation, any fittings that are considered excessively noisy by SA Water's Representative shall either be repaired or replaced by the Contractor.

All equipment that forms part of the general power and lighting installation and which, under the requirements of AS/NZS 3000, is required to be earthed shall be earthed by means of earthing conductors to the earthing bar of the relevant general power and lighting cubicle.

### 9.8.1 Lighting and small power distribution boards

Lighting distribution boards shall be constructed with integral wiring and, where required, include relays to achieve compliance with this Technical Standard. In facilities such as pumping stations, the light and small power distribution board shall be incorporated into the LV switchboards. In smaller facilities, such as valve houses, the light and small power distribution board shall be a separate distribution board.

Each distribution board shall be fitted with a main incoming isolating load break isolator, which supplies a proprietary chassis. The line side of the main isolator shall be shrouded to IP4X as a minimum.

The Contractor shall provide and fix, inside each distribution board, an 'As Built' schedule clearly indicating the circuits controlled. This schedule shall be on material of permanence, suitably protected by a transparent cover.

Circuit breakers supplying lighting circuits shall incorporate earth leakage protection units, set to operate at not more than 30 mA. For hazardous areas, single-phase circuits shall be protected by two pole circuit breakers. Three-phase circuits shall be protected by four pole circuit breakers.

## 9.8.2 Indoor lighting design

Lighting systems shall be designed in accordance with AS/NZS 1680 with advice from SA Water Operations and Maintenance teams and guidance from the Building Code of Australia. Lighting design shall be for end-of-life lighting levels.

The design shall aim to minimise energy consumption. The design shall also consider and minimise light overspill to nearby properties and roads.

The levels of "maintained illuminance" as defined in AS/NZS 1680.1 shall be determined using the following criteria:

- a. The contribution of daylight shall be excluded from any illuminance calculations.
- b. The 'uniformity of illuminance' shall not be less than 0.6.
- c. The minimum levels shall not be reached until after 24 months of lighting operation (for conventional lighting) or five (5) years (for LED lighting) with an acceptable level of failure rate.
- d. A suitable value of reflectance shall be considered for the purpose of any illuminance calculations.

### 9.8.2.1 Illumination levels

The lighting design shall ensure uniform light distribution and shall provide lighting levels as specified in Table 9-1 in accordance with the AS/NZS 1680 series. The design of the lighting installation for facilities such as pumping stations and valve houses shall allow for switching to be arranged into multiple banks of lights.

Table 9-1: Minimum illumination levels and colour

Lighting bank area	Maintained illuminance (minimum) [Lux]	Lamp colour appearance group	Lamp rendering index (Ra) range	Maximum glare index
Indoor plant area – general	120	1, 2	60 to 80	25
Indoor plant area – supplementary task lighting	400	1, 2	80 to 90	22
Plant area – control/telemetry panels	160	1, 2	80 to 90	-
Electrical switchrooms	240	1, 2	80 to 90	-

### 9.8.2.2 Emergency lighting and exit signs

Emergency lighting in accordance with AS 2293 shall be provided to enable the safe movement of persons from all areas of the facility if the normal lighting system fails.

Emergency lighting, exit signs and warning systems shall be provided in accordance with the Building Code of Australia.

Emergency and exit lighting shall be provided at strategic positions to enable personnel to safely move around and evacuate the facility in the case of a power failure. All switchrooms shall have emergency lighting. Emergency lighting shall be arranged on dedicated circuits to ensure batteries are kept charged and for ease of testing and maintenance.

### 9.8.3 Outdoor lighting design

If not defined in the project specification, outdoor lighting requirements and design shall be determined in accordance with the AS 1158 series with advice from SA Water Operations and Maintenance teams.

The design shall aim to minimise energy consumption. The design shall also consider and minimise light overspill to nearby properties and roads.

Outdoor area lighting is generally not required for unattended automatic installations. However, local lighting shall be provided for safe entry and exit to buildings/structures to comply with statutory requirements.

### 9.8.4 Lighting arrangement

The arrangement of lighting needs to be such that adequate access is available for operation and maintenance without affecting personnel safety and that the location is minimised in the effects of vibration.

The completed installation shall have a neat and pleasing appearance.

Light fittings that are mounted within reach distance, 2.5 m, from a designated walkway or platform shall be guarded against contact with hot surfaces.

Suspending of light fittings from the ceiling in some facilities is not possible due to overhead travelling cranes.

Care shall be taken to ensure that light is correctly directed towards the areas intended. In particular, lighting a lower level through floor grating, from a level above will not be acceptable.

Where light fittings are arranged in rows, they shall be mounted so that they are aligned both horizontally and vertically.

### 9.8.5 Lighting control

Lighting switches shall be provided and switching arranged so that all lights in the building can be switched from a switching panel adjacent to each access door. The lights shall be switched in a logical manner, that is, per room or per section, if the room is deemed to be reasonably large.

The lighting circuits shall be divided into logical groups such that the failure of any individual group will not result in total darkness in any one area. Two-way switching should be provided for galleries, tunnels, etc. Consider the use of illuminated light switches in locations where these switches may be hard to see in low-light conditions.

In plant areas where rotating machinery is present, lighting shall be supplied from at least two different phases.

### 9.8.6 Labelling

All lighting distribution boards shall be labelled according to the board name, equipment number and point of supply.

All luminaires shall be labelled with their supply point distribution board and circuit number.

Labels shall be fixed in positions where they can be easily seen and read.

### 9.8.7 Wiring of lighting circuits

All wiring of lighting circuits shall be in accordance with AS/NZS 3000 and shall be wired with minimum Cu 450/750V, V-90 PVC/PVC insulated and sheathed multi-core cable with a minimum conductor size of 1.5 mm<sup>2</sup>. Lighting and small power loads shall be phase-balanced.

Junction boxes may be used to connect to light fittings where necessary. Junction boxes used shall incorporate tunnel terminals as appropriate for the application.

## 9.9 Earthing

The installation shall be earthed in accordance with the requirements of AS/NZS 3000 and, in particular the multiple earthed neutral (MEN) provisions of the rules.

Bare earth conductors and earth connections shall be protected against damage and corrosion, especially in areas where H<sub>2</sub>S is likely to be present, through suitable sealing systems.

### 9.9.1 Main power earth bar

All low-voltage Switchboards shall be provided with a suitably rated earth bar. The earth bar shall be connected to the installation main earthing system. All cables connecting to the main earth bar shall be labelled according to their function.

The earth bar should be located to allow easy access for cables leaving the switchroom or equipment and be adequately sized for the prospective fault current and the number of connections required.

### 9.9.2 Earth electrodes

The choice of earth electrode system shall be governed by the following factors:

- a. System voltage.
- b. Fault ratings.
- c. Whether a combined or separate earth system is adopted.
- d. The pH, resistivity and conductivity of the soil, the terrain and difficulty of installation.

A minimum of one copper-clad, mild steel earthing rod of minimum diameter 15 mm and minimum length 2400 mm shall be fully driven into the ground at a distance of not less than 5 m from any supply transformer installation and shall be connected to the main earth bar of the installation. The main connections at the earth rods shall be protected against damage and corrosion through suitable termination in an inspection pit, in accordance with AS/NZS 3000.

The use of ground enhancing materials may be used with prior approval of SA Water.

### 9.9.3 Equipotential bonding

All exposed conductive parts or extraneous conductive parts of a site's electrical infrastructure shall be protected against potentially dangerous differential voltages in accordance with AS/NZS 3000 'Equipotential Bonding'.

The floor slab reinforcement of new infrastructure shall be provided with equipotential bonding.

All electrical enclosure doors shall be provided with an equipotential bonding earth conductor.

In situations where metallic pipework is accessible, both suction and delivery pipework shall be individually connected to the installation main earth bar for the purpose of equipotential bonding.

### 9.9.4 Main instrument earth bar

A high-integrity instrument earth bar shall be established at a suitable location, usually in the equipment room or switchroom. This instrument earth bar shall be mounted on insulating blocks, providing a minimum clearance of 30 mm to surrounding structures.

Whenever possible, the instrument earth bar shall be connected to the main earth bar of the installation. Two connections shall be made between the instrument earth bar and the main earth bar, each being a minimum of 6 mm<sup>2</sup> copper cable. The instrument earth system shall have a resistance of less than 1  $\Omega$  to the main earth bar, with each of the connections to the main earth bar disconnected in turn.

All earth bars shall be appropriately labelled and shall identify their function.

### 9.9.5 Instrument earth bars located in cubicles

Instrument earth bars located in cubicles shall be of hard-drawn copper and mounted on insulating blocks, providing a minimum spacing of 10 mm to the cubicle frame.

All the instrument system earth bars may be connected in a daisy chain arrangement to form a ring or as a star and shall be appropriately labelled and shall identify the function of the earth bar.

The earth connections shall be provided with identification labels at both ends of the cable.

## 9.10 Power factor correction

The power factor of a completed electrical installation shall not exceed the limits specified in the electricity supplier's service and installation rules. Power factor correction equipment shall be provided, if required, to comply with the specified limits.

## 9.11 Harmonics

Total Harmonic Distortion of an electrical installation shall be in accordance with the electricity supply authority's regulations.

Harmonic mitigation techniques shall be required when the harmonic levels do not comply with the supply authority's regulations, Australian Standards and IEEE standards. The Contractor is required to provide calculations to indicate that either the existing installation does not need additional mitigation techniques, or that the mitigation complies appropriately.

## 9.12 Lightning and transient overvoltage protection

Where lightning protection for an installation is requested, a risk assessment shall be completed. The risk assessment and lightning protection of persons and buildings shall be provided in accordance with AS/NZS 1768.

Irrespective of the requirements of lightning protection of persons and buildings, all voltage-sensitive equipment shall be provided with secondary protection against damage by transient and lightning induced overvoltages in accordance with AS/NZS 1768.

Instrumentation equipment shall be provided with lightning protection in accordance with section 4.23.1.

## 10 Excavation and backfilling of trenches for underground conduits

### 10.1 General

The Contractor shall supply all labour, materials, etc., for the excavation and backfilling of trenches for the laying of electrical conduits. All underground cables shall be in conduits unless otherwise specified.

The Contractor shall be responsible for the location of existing buried services and shall hand dig ('pot hole') in the vicinity of those services. BYDA (Before You Dig Australia) services should be used.

### 10.2 Clearing

The Contractor shall not damage any trees or shrubs which are required to remain inside or outside the working area.

In open ground, organic topsoil shall be stripped to a minimum depth of 150 mm and stockpiled for use in reinstating the surface of the trench.

### 10.3 Trench width and conduit spacing

Trench width shall be adequate to accommodate all the conduits with a minimum spacing of 50 mm between the outside conduits and trench wall, and the space shall be filled with sand.

The spacing of conduits shall be in accordance with the design specifications and drawings. Cables shall be de-rated in accordance with AS/NZS 3008.

### 10.4 Fill materials

#### 10.4.1 Sand

Bedding sand shall consist of clean, coarse sand of such grading that no more than 10 per cent shall be coarser than 2.36 mm mesh sieve, and fines shall have a linear shrinkage of not more than 2 per cent.

The sand used for bedding and backfilling around conduits shall be free from dangerous and noxious weeds, as proclaimed in South Australia by regulations under the Weeds Act with amendments. The sand shall be free from rocks and lumps and shall be non-plastic.

#### 10.4.2 Quarry rubble

Quarry rubble shall be of a nominal size of 20 mm. Quarry rubble shall be clean, sound, hard and durable, free from adherent coating and other foreign matter, and graded in accordance with Table 10-1.

Table 10-1: Grading of quarry rubble for bedding and backfilling

Sieve size mm	Percentage passing
26.5	100
19.0	90 ~ 100
13.2	74 ~ 96
9.5	61 ~ 85
4.75	42 ~ 66
2.36	28 ~ 50
0.425	11 ~ 27
0.075	4 ~ 14

## 10.5 Bedding and backfilling

### 10.5.1 Bedding

All pipes and fittings laid underground shall be bedded over the full trench width on 75 mm thickness of clean sand or an approved equivalent crushed fine granular material.

The bedding shall be compacted to a density not less than 95 per cent of the maximum standard dry density of the material, as determined by AS 1289.5.1.1.

### 10.5.2 Backfill around conduits

Sand shall be placed around the conduits and shall extend to not less than 75 mm above the conduits. The sand backfill shall be compacted to not less than 95 per cent of the standard maximum dry density of the sand in accordance with AS 1289.5.1.1.

An orange marker tape shall be installed above the sand fill in accordance with AS/NZS 2648.1.

### 10.5.3 Backfill in roadways and footpaths

In roadways, road shoulders and footpaths, quarry rubble shall be placed from 75 mm above the conduit to the underside of the base course. Compaction shall be 95 per cent of its modified maximum dry density (AS 1289.5.2.1) for roadways and 90 per cent of its modified maximum dry density for footpaths. Unless specified or directed otherwise, the formed pavement shall then be reinstated to the original condition.

### 10.5.4 Backfill in other locations

In verges, open ground etc., the trench fill shall be inorganic fill material with a maximum stone size of 75 mm, either imported or obtained from the trench excavation. The trench fill shall be brought up to within 150 mm of the finished surface level. The trench fill shall be placed in layers not exceeding 300 mm compacted thickness, and each layer given nominal compaction, for example, with an excavator bucket sufficient to eliminate long-term settlement.

The top 150 mm of the trench shall be reinstated using stockpiled topsoil or imported soil similar to that in the vicinity of the trench.

# 11 Painting

## 11.1 General

All steel or other surfaces of items of electrical equipment which would generally be painted or are specified as requiring painting shall be protected by painting in accordance with this Section.

## 11.2 Indoor cubicles

Following fabrication of the cubicles, all surfaces shall be degreased in accordance with AS 1627.1. All welds and bare metal areas shall be ground to remove all surface rust, scale and weld spatter.

Bare steel and Zincseal surfaces where the phosphate coating has been damaged shall be coated with etch primer applied in accordance with the manufacturer's data sheets.

Custom-built and modified cubicles and enclosures must be painted as per the requirements of this section. Exterior and interior surfaces (excluding any internal removable panels) shall be finished in high gloss air dry spraying enamel, stoving enamel or polyester powder coat to colour Opaline G32 to AS 2700 and applied according to AS 4506 or AS 3715. Internal removable panels, for example, bolt-in panels to which electrical equipment will be mounted shall be gloss white in colour. The coating shall be applied in accordance with the manufacturer's data sheets and shall include any primers or undercoats if recommended by the manufacturer.

Off-the-shelf cubicles and enclosures that do not require any modification prior to installation, other than fitting out with electrical equipment, do not require additional coating and may remain as per the manufacturer's factory-supplied colour, except where there is a requirement to colour match with existing cubicles.

Where the cubicles are required to match the existing cubicles, as specified in the project specification, the finish colour shall match the existing colour as closely as possible.

Stainless cubicles and enclosures shall not be painted.

## 11.3 Outdoor cubicles

Following fabrication of the cubicles, all surfaces shall be degreased in accordance with AS 1627.1. All welds and bare steel areas shall be ground to remove all surface rust, scale and weld spatter. Edges shall be rounded to a minimum 3 mm radius. All surfaces shall be treated with an acid etch pre-treatment solution, or two-pack etch primers approved by the coating supplier.

The coating system shall consist of 125 microns of epoxy followed by 50 microns of two-pack polyurethane complying with APAS 2911.

Custom built and modified cubicles and enclosures must be painted as per the requirements of this section. Colour shall be Opaline G32 to AS 2700, or Rivergum G62 (or Wilderness 013 - HEX #64715E) to AS 2700 if the cubicles are located in a natural environment, and applied according to AS 4506 or AS 3715.

Internal removable panels, for example, bolt-in panels to which electrical equipment will be mounted, may be coated in accordance with section 11.2 or this section and shall be gloss white in colour.

Where approved for use on a project-by-project basis, commercial 'off-the-shelf' cubicles and enclosures that do not require any modification prior to installation other than fitting out with electrical equipment do not require additional coating and may remain as per the manufacturer's factory-supplied colour, except where there is a project specified requirement.



Where the cubicles are required to match the existing cubicles, as specified in the project specification, the finish colour shall match the existing colour as closely as possible.

Stainless cubicles and enclosures shall not be painted unless specified.

## 11.4 Other equipment

Equipment other than custom-built Switchboards and control cubicles may be finished in the manufacturers' standard colours unless otherwise specified.

## 11.5 Coating reinstatement

Following installation, any damaged paintwork shall be prepared by using abrasive paper to prepare the surface and feather back edges. Coatings shall be applied in accordance with the original requirements to match the original coating system.

## 12 Inspection and testing

### 12.1 General

Reference shall be made to the project specification for requirements associated with the inspection, testing, commissioning and running-in of the equipment and installation.

### 12.2 Inspection

The manufacture of equipment under the Contract shall be subject to inspection by SA Water's Representative at the Manufacturer's work.

### 12.3 Works tests

#### 12.3.1 General

All equipment manufactured under the Contract may be tested at the Manufacturer's works to ensure that the equipment complies with the project specification.

Witness tests shall be carried out in the presence of and to the satisfaction of SA Water's Representative.

All test instruments shall have current calibration certificates, if applicable, and all certificates shall be made available for checking by the Inspecting Officer before testing commences.

The Contractor shall give SA Water's Representative a minimum of ten working days' notice of the manufacturer's intention to conduct tests.

At the same time, or earlier, the Contractor shall:

- a. Submit a copy of the latest certified drawings of the Switchboards, cubicles and control/telemetry panels.
- b. Submit for approval by SA Water's Representative, a copy of the proposed testing procedure and test sheets. Testing shall not commence until SA Water's Representative has approved the testing procedure and test sheets.
- c. Submit pre-test results. Testing shall not commence until SA Water's Representative has reviewed the pre-test results.

#### 12.3.2 Test results

The following test results shall be submitted to SA Water's Representative for approval:

- a. Certificates of design verification or unwitnessed routine verified equipment.
- b. Results of all witnessed tests recorded during the progress of the tests on the approved test sheets. A copy of the test sheets, co-signed by the manufacturer and the Inspecting Officer, shall be handed to the Inspecting Officer upon completion of the tests.
- c. A copy of formalised test sheets upon which all test results shall have been typed within ten days of the equipment successfully completing the tests.

#### 12.3.3 Dispatch of equipment

The equipment shall not be dispatched from the Manufacturer's works until SA Water's representative has authorised it. Dispatch will be authorised only after each item has been shown to comply with the specified test requirements and guaranteed performance.

### 12.3.4 Power switchboards/MCCs

Witness testing and inspection of power Switchboards shall be carried out for routine verification as per AS/NZS 61439 series. All motor circuits (including VSDs and soft starters) shall be powered up in the Constructor's/Manufacturer's works and tested in 'automatic' and 'manual' modes.

### 12.3.5 Control/telemetry panels

Control/telemetry panels shall be subjected to witnessed routine tests in accordance with AS/NZS 61439.

Each cubicle shall be put through a series of witness tests to thoroughly test all functions of control, including alarm, indication, pushbutton and contactor operations. External contact operations shall be simulated by application or removal of jumper links at appropriate terminals on the outgoing terminal blocks. Outputs shall be indicated on a suitable lamp or meter across respective output terminals.

### 12.3.6 Motors

Motors shall be works tested generally as part of performance testing of pumping units or other coupled equipment.

For motors rated up to and including 22 kW, work tests are not required.

For motors rated at 30 kW to 90 kW inclusive, work tests are required but need not be witnessed. Results of unwitnessed work tests shall be provided to SA Water's Representative in accordance with section 12.3.2.

For motors rated at 110 kW and above, witnessed works tests shall be carried out in accordance with the following:

- a. One of each type of motor shall be performance tested in accordance with the relevant parts of IEC 60034. The remaining motors shall be routine tested. Should a motor fail a performance test, the remaining motors of that type shall be performance tested.
- b. Performance tests shall include temperature rise, momentary overload, dielectric, winding insulation resistance, efficiency, power factor, locked rotor current, locked rotor power factor, locked rotor torque, noise and vibration. Tests shall be carried out with the motor connected direct-on-line. Measurement of voltage, current and power shall be made for all tests.

Efficiency and power factor shall be measured at 50 per cent, 75 per cent and 100 per cent loads.

The methods of measurement and test conditions for noise tests shall be in accordance with IEC 60034.9. Vibration measurements shall be in accordance with IEC 60034.14 and section 6.1.

- c. The performance test certificate shall include all information necessary to allow the calculations to be checked and shall include motor serial numbers, normal winding configuration and winding configuration during resistance measurements.
- d. Declared efficiencies shall be determined by the summation of losses method in accordance with IEC 60034.2.1&2. The guaranteed efficiencies shall not include the negative tolerances specified in IEC 60034.1. The declared efficiencies shall be achieved.
- e. The performance-tested motors shall be delivered to the pump Manufacturer's works to test the relevant pumps or coupled equipment in accordance with the project specification.
- f. All data required for setting of electronic motor protection relays shall be provided, including:
  - i. Maximum overload current.

- ii. Earth fault current including recommended maximum time delay to overcome CT phase imbalance during motor starting inrush.
- iii. Motor thermal capacity in seconds.
- iv. Run-up time for the starting method proposed.

### 12.3.7 Generator sets

The tests outlined in this section apply to generators of size 25 kVA and over or when called for by the project specification.

Generator sets shall be fully run-in and ready for the specified duty before the specified tests are performed at the Manufacturer's works. Running-in shall consist of not less than 8 hours of running at loads of 80 ~ 100 per cent of the continuous rating, or such running as the manufacturer recommends to run the engine in.

Each complete set shall be tested for correct assembly and to prove satisfactory operation, including starting, stopping, rated output, governing, voltage regulation, transient performance, overload, short circuit current, and all control, indication, protection and alarm functions, including the batteries and chargers.

The noise level of each complete set shall be measured across the range of expected loads during the test. The radiator fan shall be running for the noise level measurement. The sound power level shall not exceed the Contractor's designed sound power level required to ensure that the specified noise levels are not exceeded.

~~In addition, vibration tests shall be carried out on each complete set in accordance with IEC 60034.14.~~ Test certificates shall be provided to prove compliance with the standard.

The engine shall be tested for torque, power output and fuel consumption at 1500 rpm in accordance with AS 4594.

The generator shall be performance tested in accordance with ~~IEC 60034.1.~~

Tests shall be carried out to check for correct assembly and sound mechanical and electrical operation.

Performance tests shall also be carried out and shall include the following:

- a. Short-circuit withstand (not required if a verified design certificate is provided).
- b. Overload.
- c. Temperature rise.
- d. High voltage.
- e. Functional tests of all safety and protection devices.

Where facilities for a temporary generator set are provided, system performance tests shall be carried out using a hired generator set.

### 12.3.8 Uninterruptible power supplies

Each UPS shall be routine tested in accordance with AS 62040.3, and the tests shall include but not be limited to the following:

- a. All control, indication and protection functions.
- b. Operation of the static bypass and maintenance bypass.
- c. Verification of the backup duration with the UPS operating at full load current from the batteries without mains supply input. The battery protection system shall be checked during this test.

## 12.3.9 Other equipment

Works testing of other equipment shall be in accordance with the project specification, where applicable.

## 12.4 Site tests

### 12.4.1 General

At the completion of the installation or at the completion of agreed subsections of the work, the Contractor shall, in the presence of SA Water's Representative (or his nominated Inspecting Officer), conduct site acceptance tests on all equipment that has been supplied and/or installed as part of the Contract. The tests shall demonstrate to the satisfaction of SA Water's Representative that the installation is in accordance with the specified requirements and that the installation operates correctly.

Unless otherwise specified, equipment that has been satisfactorily performance tested or witness tested in the Manufacturer's works need not be site tested except for the following:

- a. Check the installation and interconnections.
- b. Check for any damage or deterioration which may have occurred since the works tests.
- c. Demonstrate that the system functions in accordance with the project specification.

The Contractor shall give SA Water's Representative not less than ten working days' notice of intention to undertake the tests.

At the same time or earlier, the Contractor shall:

- a. Make available the latest drawings and PLC program listings for the equipment to be tested.
- b. Submit for approval by SA Water's Representative a copy of the proposed testing procedure and test sheets. Testing shall not commence until SA Water's Representative has approved the testing procedure and test sheets.

The provision of all necessary equipment for testing shall be the responsibility of the Contractor. All test instruments shall have current calibration certificates, if applicable, and all certificates shall be made available for checking by the Inspecting Officer before testing commences.

### 12.4.2 Test results

Test results shall be supplied in the SA Water Operations and Maintenance Manual. The results of all witnessed site tests shall be neatly and legibly recorded during the progress of the tests on the approved test sheets. A copy of the test sheets, co-signed by the Contractor and the Inspecting Officer, shall be handed to the Inspecting Officer on completion of the tests.

### 12.4.3 Switchboards, control/telemetry panels, associated equipment and cabling

The following site tests shall be carried out (where applicable) to demonstrate the integrity and correct operation of the system in accordance with AS/NZS 3017 and any other relevant standards:

- a. Insulation resistance.
- b. Earth resistance.
- c. Earth fault loop impedance.
- d. Continuity.
- e. Polarity.

- f. Calibration checks.
- g. Control sequencing.
- h. Functional tests.

Such testing shall include protective devices, manual operations, remote operations, indications and controls, as a minimum.

The sequencing of control circuits, etc., shall be checked against the control schematic drawings and not against the formalised test sheets. The test sheets shall state that the circuits were tested against the drawings and list any defects.

All adjustable parameters shall be properly setup and recorded for each equipment item or device, and the record submitted to SA Water's Representative at the completion of the tests.

Devices that cannot be adjusted, for example, miniature circuit breakers shall not have calibration tests performed. However, fixed residual current devices shall be tested before being placed into service to ensure that:

- a. The tripping current is set to the appropriate value.
- b. The unit trips in less than 40 milliseconds at a test current of 10 mA for a Type I device or in less than 300 milliseconds at a test current of 30 mA for a Type II device.

Protective units, relays, etc., which allow current injection or similar to check their settings shall, during testing, have each function tested and calibrated.

Units which may be adjusted, for example, thermal overload relays shall be adjusted to the appropriate settings in accordance with the manufacturer's written instructions prior to being placed in service.

Equipment which is connected via a flexible power supply cord and plug and comes under the scope of AS/NZS 3760 shall be inspected and tested in accordance with AS/NZS 3760.

#### 12.4.4 Motors

Site tests shall be conducted in accordance with the project specification to verify the system performance under site conditions.

#### 12.4.5 Generator sets

Site tests for generator sets shall include the following as a minimum:

- a. Running of each set over the full load range to establish that the installation is satisfactory and complies with guaranteed performance.
- b. Continuous running at a power output equivalent to the continuous engine rating for a period as agreed by the Principal's Representative or project specification to prove the onsite engine cooling system.
- c. Multiple actual power failure start-ups to investigate various power failure scenarios, as agreed with the Principal's Representative or project specification.
- d. Noise measurements shall be taken at the generator set and at the property boundary at the specified times when the generator set is running at full rated load.

Fuel for the site acceptance tests shall be supplied by the Contractor.

The plant loads and load bank (where provided under the Contract) may be used for site tests. Any additional test load or equipment required shall be the responsibility of the Contractor.

The generator set shall be run-in according to the run-in period specified by the manufacturer.

## 12.4.6 Other equipment

Site testing of other equipment shall be in accordance with the project specification, where applicable.

## 13 Technical information and drawings

### 13.1 Drawings

#### 13.1.1 Tender drawings

Drawings which shall clearly explain the proposed construction, layout and physical size of the electrical Switchboards, control/telemetry panels, etc., shall be submitted with the tender.

#### 13.1.2 Prior to manufacture

The Constructor shall provide a copy of detailed drawings at the earliest practical date but not later than four weeks prior to:

- a. The construction of any relevant portion of the works.
- b. The commencement of manufacture of equipment.
- c. Placing firm orders for any components.

The detailed drawings shall contain all necessary information for the manufacture and installation of the equipment, including the following, where applicable:

- a. Dimensioned general arrangement drawings, including critical tolerances.
- b. Equipment layout drawings.
- c. Single line diagrams.
- d. Control circuit schematic drawings.
- e. Layouts for Switchboards, control/telemetry panels and other cubicles.
- f. Cable block diagrams.
- g. Termination drawings.
- h. Materials and parts listings.

The details required in section 13.1.3 shall be shown on the appropriate drawings.

These drawings will be examined to determine general compliance with the specified requirements, but this shall not absolve the Contractor from the responsibility to achieve a fully workable installation. Work shall not proceed on the manufacture or supply of equipment, components or structure until the relevant drawings have been approved by SA Water's Representative. If manufacture or assembly is commenced prior to the approval of the drawings, any restoration or modification work shall be at the Contractor's expense.

Should SA Water's Representative require additional information and/or drawings or any amendments to the previously submitted drawings, then the Contractor shall supply the additional information and/or drawings or amended drawings within two (2) weeks from the date of request. The cost of providing the additional information, drawings and amendments shall be borne by the Contractor.

The Contractor shall allow a period of at least one (1) day per drawing or ten (10) working days following each submission, whichever is the longer, for the examination or re-examination of the information or drawings, unless otherwise agreed.

The drawings shall be prepared in accordance with TS 0100, as they will form the basis of drawings to be submitted as final contract drawings. In particular, the fourth line of the drawing title block should describe the drawing type 'sub-category'.

#### 13.1.3 Drawing details

Final contract drawings shall include the following details where applicable:



a. Single-line diagrams detailing the following:

- i. Current rating and fault rating of main busbars
- ii. Current ratings of all major incoming and outgoing switchgear (circuit breakers, fuses, isolating switches, etc.)
- iii. Type and sizes of all major incoming and outgoing cables
- iv. Voltmeters, ammeters, kW meters, kWh meters
- v. Current transformer ratios
- vi. Protection relays
- vii. Motor starters
- viii. Others as appropriate to the installation, for example, voltage transformers, auxiliary supply transformers, earth switches, interlocks etc.

If necessary, the following additional drawings should also be provided to define the requirements more clearly where applicable:

- i. Control system block diagrams
- ii. Typical control schematics
- iii. Process and instrumentation diagrams
- iv. Earthing system
- v. General arrangements.

b. Full schematic diagrams of control circuits, including terminal, wire and cable numbers.

A system of mnemonics shall be used in the labelling of contacts and coils. The system shall follow the guidelines laid down in Drawing TYP-03-00001\_40 in Figure 6 and as outlined below:

- i. Schematics shall be drawn as vertical ladders with each line (rung) numbered referencing the drawing sheet number and sequential line (rung) number.
- ii. Each wire shall be numbered with the sheet/line number suffixed by a sequential number indicating the horizontal position of the wire. The wire adjacent to the coil shall have the suffix number 9.
- iii. Components shall be numbered by device type, sheet/line number, for example, K2514, 25 represents sheet 25, 14 represents the line number.
- iv. Cross-referencing of remote contacts, etc., shall be shown using sheet/line numbers and other drawing numbers as appropriate.
- v. Spare cores of field cables shall be identified by their respective cable, core and terminal numbers, where applicable.
- vi. PLC/RTU digital input/output label conventions to be enunciated such that they include a description of the device and the status of the input/output when in the 'ON' or 'HIGH' state. The I/O description shall match the SCADA tag description as closely as possible. This may mean that a fault state is inverted to describe the I/O in the high state, for example, 'AC Power Supply Not Faulted'.
- vii. Suitable mnemonics shall be placed adjacent to the indicator lamp and pushbutton symbols on schematics to indicate their colour clearly.

**Note:** TYP-03-00001\_40 in Figure 6 is included for information and as a means of establishing quality standards only. The circuitry shown shall not be taken as an indication of the facilities required, or as an indication of the methods to be adopted to achieve any specified requirements.

c. Instrument loop diagrams shall be drawn using the standard symbols:

- i. Preferably, one loop per A3 drawing sheet shall be provided.

- d. Instrumentation and control equipment shall be shown on P&ID drawings in accordance with TS.0112.
- e. Layouts for Switchboards and control/telemetry panels.
- f. Network drawings including:
  - i. A drawing sheet describing the overall network ring, where applicable.
  - ii. Drawing sheet(s) detailing the connection of all devices to each switch, PLC, etc., in the network.
  - iii. Details to be included:
    - All network cable numbers.
    - IP addresses of all devices.
    - Label names of all devices.
- g. Any other details specified in the project specification to be provided (either tender, acceptance or final contract).
- h. All final drawings shall include the 'as constructed' information.

## 13.2 Manuals

Unless otherwise specified, the Contractor shall supply all manuals in accordance with TS 0132 Operating and maintenance manuals.

## 13.3 Test certificates

### 13.3.1 Information to be submitted with tenders

Where this section requires the submission by the Tenderer of certificates from a recognised Testing Authority, Tenderers need not provide additional copies of any certificates that they have previously lodged in the central file of test certificates held by the South Australian Water Corporation. However, reference shall be made, by number, in the Tender to the certificate(s) that apply to the Switchboards covered by the Tender. Submission of certificates with previous Tenders does NOT constitute lodgement in the central file. The other requirements of this section shall still apply.

Information to be submitted with Tenders shall include the following:

- a. Certificate(s) from a recognised Testing Authority to verify the short circuit capacity of the Switchboard.

The certificate(s) shall be complete and show all details of the tests undertaken. Only limited sections of untested busbar will be allowed, for example, the connection from the main incoming unit to the main busbar provided that short circuit capacity is extrapolated from verified designs. The Contractor will be required to provide calculations or written justification to support any such extrapolation prior to manufacture in accordance with section 13.3.2 (a).

The following details shall be provided:

- i. The components or sections of the Switchboard that are covered by the certificates.
- ii. The parts of the various certificates which apply to specific components or sections of the Switchboard.
- iii. The components or sections of the Switchboard that are not covered by the certificates and will be subject to extrapolation.
- iv. Drawings and sketches which show the proposed busbar arrangement and detail which certificate(s) apply to individual sections of the busbar.

- b. Either:
  - i. Full copies of relevant certificates from a recognised Testing Authority to verify the temperature rise of the Switchboard busbars.
  - ii. A guarantee shall be provided that the busbars are adequately rated for the specified full load currents without exceeding the specified maximum temperatures. The Contractor will be required to justify any such guarantee prior to manufacture in accordance with section 13.3.2 (b).
- c. A guaranteed maximum temperature rise above ambient at full load of the incoming and outgoing power conductor termination facilities. The Contractor will be required to justify any such guarantee in accordance with section 13.3.2 (c).

### 13.3.2 Information to be submitted prior to start of manufacture

The Contractor shall supply a copy of the following to SA Water's Representative (refer also to section 13.1.2):

- a. Full calculations and/or written justification (and any associated drawings) to prove that any extrapolation or departure from the verified design (as allowed for in section 13.3.1 (a)) is capable of withstanding the specified fault conditions.
- b. Full calculations (and any associated drawings) to prove that the busbar temperature rise (as allowed for in section 13.3.1 (iv)) is within the specified range if certificates were not provided.
- c. Full calculations (and any associated drawings) or other documented evidence that the temperature rise of the incoming and outgoing conductor terminations (as allowed for in section 13.3.1 (c)) are within the limits guaranteed.

Calculations (together with any associated drawings) will be examined to determine general compliance with the specified requirements, but this shall not absolve the Contractor from the responsibility to achieve a fully workable installation. If modifications are required as a result of the examination of the calculations (and drawings), a copy of modified or further calculations or modified drawings shall be delivered for further examination. The cost of these modifications shall be borne by the Contractor.

The Contractor shall allow a period of at least ten (10) working days after each submission of the calculations (and drawings) for the above examination or re-examination.

The Contractor shall not commence manufacture until SA Water's Representative has given written approval to do so. If manufacture commences prior to approval, then any restoration or modification work shall be at the Contractor's expense.

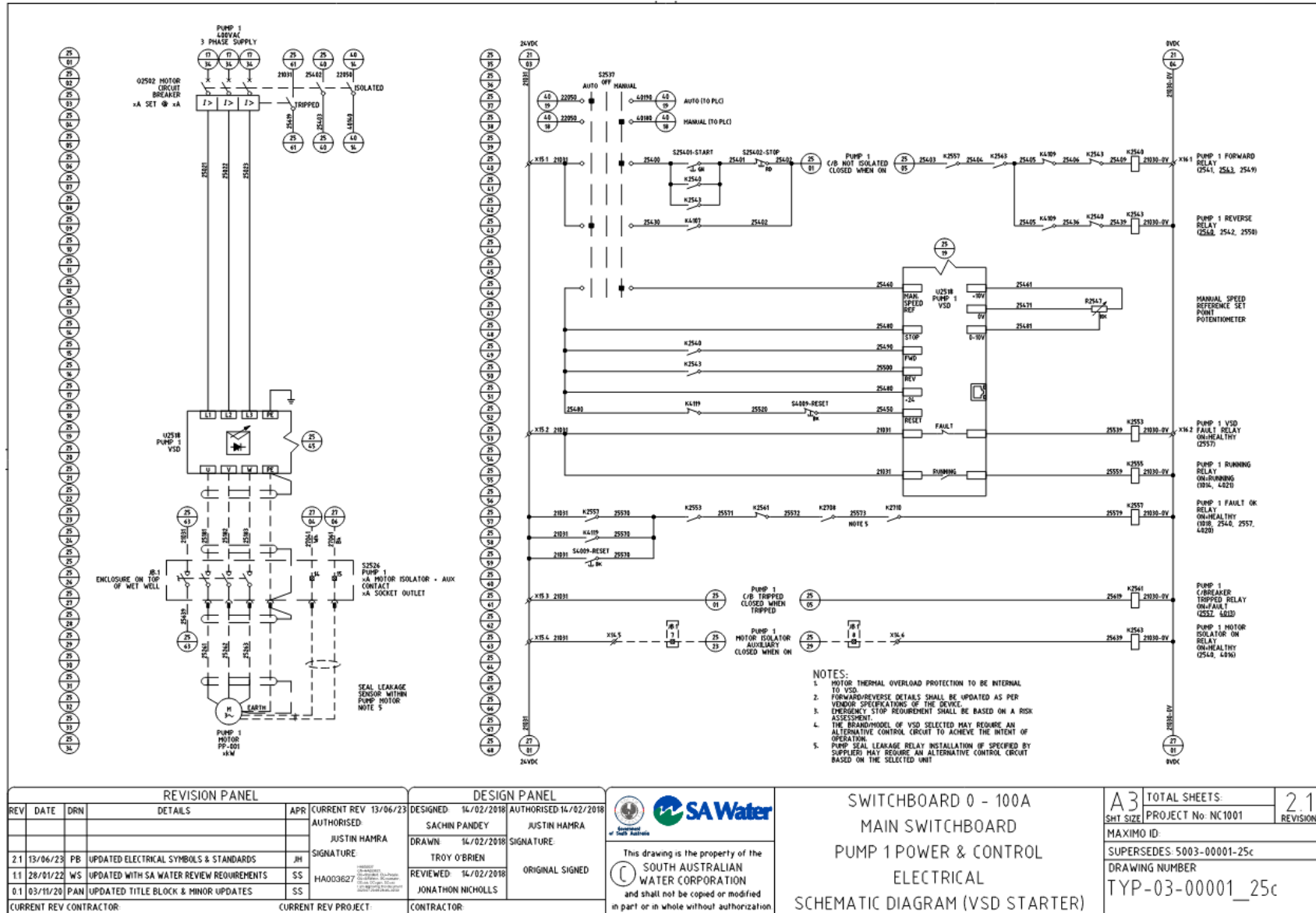


Figure 5 – Example of electrical drafting quality – drawing 1

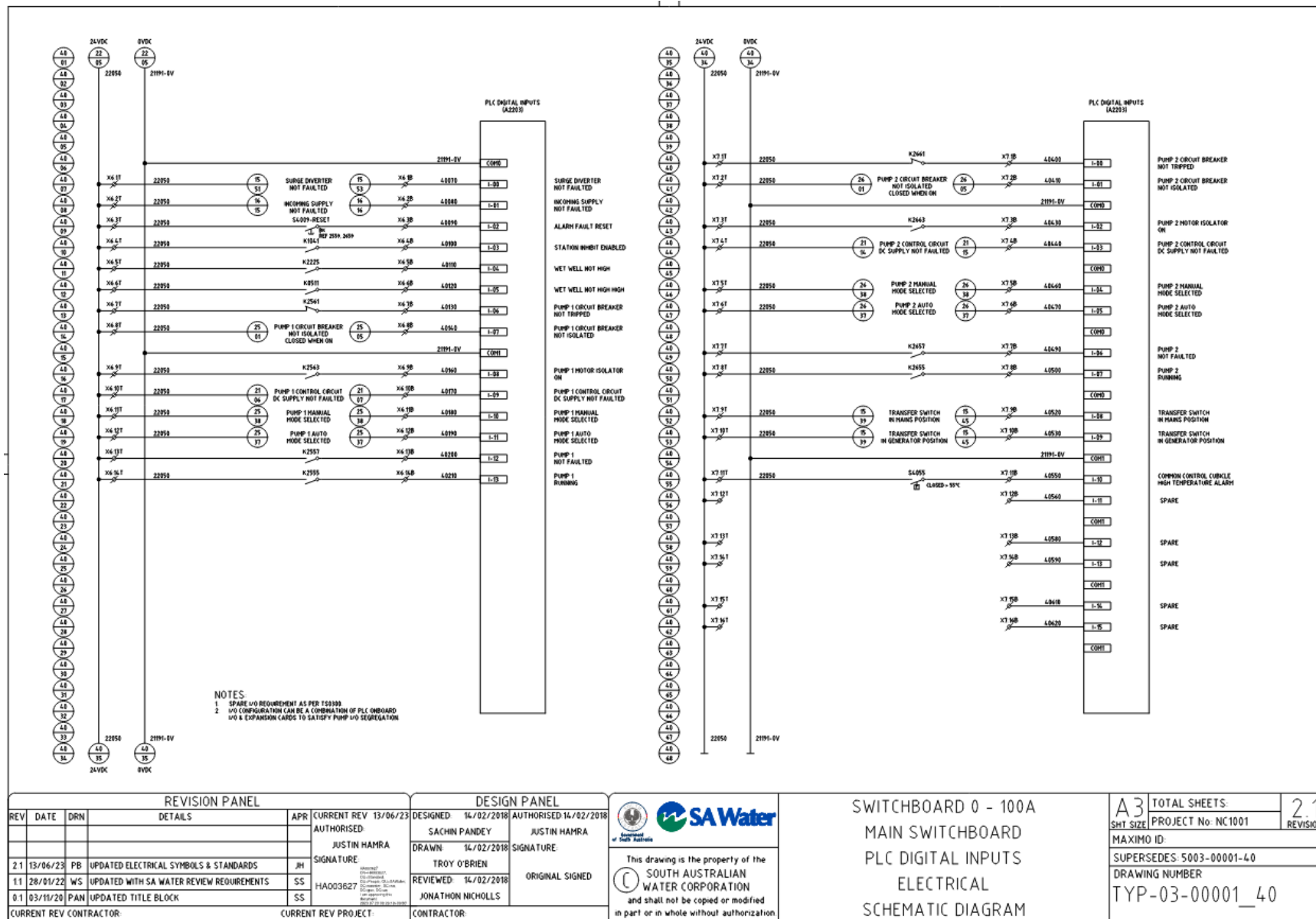


Figure 6 – Example of electrical drafting quality – drawing 2