South East Water

Electrical Equipment and Installation Specification

Document Number AM 2714

Including equipment selection and installation requirements of power, instrumentation, control and communication systems

Contents

Document Control					
Rev	**Date**	**Revision Details**	**Clause**	**Author**	**Approved**
0	23/11/06	Draft		J Myyrlainen	J Myyrlainen
1	13/08/08	Instrumentation added		J Myyrlainen	J Myyrlainen
2	15/12/15	Various Revisions, Telemetry Section Removed as Obsolete		J Myyrlainen	J Myyrlainen
3	80/3/16	Local isolation, conduit entry and PLC expansion clauses added.	2.8, 2.3.6, 3.2.7	J Myyrlainen	J Myyrlainen
4	13/04/16	Appendix A - Approved Equipment Schedule added to doc.	Appendix A	J Myyrlainen	J Myyrlainen
5	20/04/16	Document number renamed from No 07-01 to AM2714		J Myyrlainen	J Myyrlainen
6	4/05/16	Fixed Equipment Connected to Socket Outlets, Safety Devices clauses added.	2.6.6, 2.7	J Myyrlainen	J Myyrlainen
7	24/05/16	Commissioning Inspection Test sheets added. Magnetic flowmeters	Appendix C, 5.1.7	J Myyrlainen	J Myyrlainen
8	8/06/16	Switchboard location details added	3.2.29	J Myyrlainen	J Myyrlainen
9	22/08/16	Magnetic Flowmeter clause revised.	5.1.7	J Myyrlainen	J Myyrlainen
10	03/11/16	Control of Equipment, Alternate Standby Generation Supply, Inspection Clauses, Electric Motors and UPS sections added. Instrumentation Section 5 headings revised.	3.3.9 , 4.1.5, 5, 6.1.1,12 & 13	J Myyrlainen	J Myyrlainen
11	10/1/17	Adhesive cable tie mount clause added. Approved Equipment – Surge Arrestors, Variable Speed Drive & Flow meter details revised. Vertical mounted motors.	2.2.1, Appendix A,12.1.8	J Myyrlainen	J Myyrlainen
12	31/3/17	Field Equipment Electrical Isolation clause include criteria for plug socket. Active Harmonic filter added to preferred equipment list. Cable pit clause revised.	2.8, Appendix A, 2.3.9	J Myyrlainen	J Myyrlainen
13	22/5/17	Special Tools clause revised. Drawing Integration clause added. Lock clause revised.	1.3.9,1.6, 3.2.15, 6.1.2	J Myyrlainen	J Myyrlainen

		Pre commissioning clause revised. Motor connections clause added. Magnetic flowmeter verification clause added	12.1.9, 5.2.4, 6.1.2		
14	14/9/17	Rev notation. Cable tie clause added. Non-metallic field control stations.	2.2.11, 3.3.9	J Myyrlainen	J Myyrlainen
15	27/10/17	Instrument transmission clause revised. Approved equipment list revised. Temperature Sensor, Generator Controller added.	5.1.9, Appendix A	J. Myyrlainen	J.Myyrlainen
16	7/2/18	Preferred UPS equipment added. UPS backup period changed from 2 to 4 hours.	Appendix A Section 13	J. Myyrlainen	J. Myyrlainen
17	5/3/18	Signal Convertor type added.	Appendix A	J. Myyrlainen	J. Myyrlainen
18	1/8/18	ELV VAC wiring colour revised. Arc fault clause added. MCC ELV control separated from LV function units. PLC space requirements, Form Rating, Control of Equipment location clause added. Indicator light colours revised.	2.2.7, 3.2.5, 3.2.6,3.2.7, 3.2.12, 3.3.3, 3.3.9	J. Myyrlainen	J. Myyrlainen
19	29/10/2018	Added new Network section and Appendix E - updated equipment lists for network related equipment. Document reformatted.	Section 8 and Appendix E	P. Hodkinson	J. Myyrlainen
20	16/1/2019	Update section 8.1.2 for better fibre ring physical redundancy, add Appendix E Topology Terms Examples and diagram	Section 8 and Appendix E	P. Hodkinson	J. Myyrlainen
20.1	3/5/19	Power Supplies DC - Meanwell SDR240-24 revised	Appendix A	J. Myyrlainen	J. Myyrlainen
21	1/7/19	Name change. Scope added. Improved integration with AM2779 Treatment Plant Monitoring and Control Spec, AM2779 Watershed collection details and AM2522 O&M Manual and Operator Training spec. New SEW doc template. Enhanced cross referencing	Various	R.Jagger	C. Paxman

		of standards. Updated Approved products List			
21	12/8/19	Electric Valve Actuators section added, Board Colours, Approved Products	Section 8	J.Myyrlainen	C. Paxman
21	May 20	Functional Safety, Sub-board gen connection, all boards in project same supplier, hazardous area classification, additional applicable standards, Common Cause Failures	Sections 1.5.11, 3,3.1,1.5.6, 2.8,5.3	A.Gabriel	C.Paxman
21	Aug 20	Modify Instruments enclosure requirements	6.1.2 & 6.13	J.Street	A.Gabriel

1. General Requirements

1.1 Acronyms and Abbreviations

All abbreviations and acronyms used in additional documentation, shall follow the conventions used through this and other related project documents.

Acronym	*Description*
3G 4G	Cellular Communications Service
ABS	Acrylonitrile Butadiene Styrene
AD	Active Directory
AI	Analogue Input
AO	Analogue Output
ATS	Auto Transfer Switch
COTS	Commercial Off The Shelf
CT	Current Transformer
Cu	Copper
DI	Digital Input
DIN	German Institute for Standards (Deutsches Institut für Normung)
DNP3	Distributed Network Protocol (version 3)
DO	Digital Output
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
FDS	Functional Description Specification
FOBOT	Fibre Optic Break Out Tray
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
ICS	Industrial Control system
iLO	Integrated Lights Out
IO	Input Output
IP	Ingress Protection
IR	Insulation Resistance
IT	Information Technology
ITP	Inspection Test Plan
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LV	Low Voltage

mAHD	Metre Australian Height Datum
NTP	Network Time Protocol
OTDR	Optical Time Domain Reflectometer
P&ID	Process & Instrumentation Diagram
PC	Personal Computer
PLC	Programmable Logic Controller
PSU	Power Supply Unit
PTC	Positive Temperature Coefficient
PVC	Polyvinyl Chloride
RCD	Residual Current Device
RTU	Remote Telemetry Unit
SAL	Site Alarm List
SAT	Site Acceptance Test
SCADA	Supervisory Control And Data Acquisition
SDM	System Design Matrix
SEW	South East Water
SFP	Small Form Pluggable
STP	Sewage Treatment Plant
TBA	To be advised
TBC	To Be Confirmed
TFT	Thin Film Transistor
TTP	Tertiary Treatment Plant
UF	Ultra Filtration
UPS	Uninterruptable Power Supply
UPVC	Unplasticised Polyvinyl Chloride
UV	Ultra Violet
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
VSD	Variable Speed Drive
WAN	Wide Area Network

1.2 Scope

This specification outlines South East Water's minimum standards for the selection, fabrication, delivery, installation and testing of electrical equipment and associated items used at new or renewed water and sewerage infrastructure sites.

Excluded from the scope of this specification are:

a. South East Water assets not containing water and sewerage infrastructure (eg: WatersEdge office, depots)

b. Functional or operational requirements relating to electrical assets.
c. Monitoring, protection, control and communication system design, configuration and programming. This is covered by other South East Water standards.
d. Civil, mechanical arrangements, pump selection, pump performance or hydraulic assessment.
e. Work practices associated with the management of electrical risks during construction and installation works.

1.3 Standards

The following standards shall apply in the given order of preference:

a) Australian Standards or its IEC equivalent
b) OH&S Regulations 2017 (Victoria)
c) Electricity Safety (Installations) Regulations (Victoria)
d) Victorian Service & Installation Rules
e) Essential Services Commission Electricity Distribution Code
f) Requirements of the Electricity Distribution Company
g) Electricity Safety Act (Victoria)
h) Manufacturer's Guidelines
i) Water Industry Standards, including:
    i. WSA04 Sewage Pumping Station Code Of Australia
    ii. South East Water supplementary manual to WSA04
    iii. South East Water Standard Electrical Drawings
    iv. AM2779_Treatment Plant Monitoring and Control Specification (SEW)
    v. AM2717_Generator Specification (SEW)
    vi. AM2522_O&M Manual Specification (SEW)
    vii. AM2755_Testing, Commissioning and Handover Plan (SEW)
    viii. AM2739_Corrosion Mitigation Specification (SEW)
    ix. AM2727_Covers for Underground Structures (SEW)
    x. AM 2758_Noise Specification (SEW)
    xi. AM2775_Watershed Collection Details (SEW)
    xii. AM2776.3_Air Treatment Unit Specification and Commissioning (SEW)
    xiii. AM2488_Drafting Specification

The order of precedence of documents shall be as follows:

a) Legislated requirements
b) Project specific specifications
c) Project specific drawings
d) South East Water standards
e) South East Water standard drawings
f) Water Industry Standards (WSAA)

1.4 Suggested Electrical Contractors

Electrical contractors and fabricators familiar with and experienced in supplying electrical installations for South East Water are listed in Appendix G. South East Water neither endorses nor requires that these fabricators and contractors be used, but notes that these suppliers have successfully worked on South East Water infrastructure in the past.

1.5 Materials, Equipment and Components

1.5.1 Quality

All electrical components and materials shall be selected and installed to ensure reliable and satisfactory operation in which safety is the first consideration, and to facilitate inspection, cleaning and repairs. Materials shall be new, of the best quality and class and shall withstand the variations of temperature and atmospheric conditions without distortion or without affecting the strength and suitability of the various parts for which they have to perform.

1.5.2 Selection

Equipment shall be selected from established manufacturers regularly engaged in the manufacture of such equipment, who issue comprehensive rating data and certified test data on their products.

To maintain standards between sites, the preferred South East Water equipment schedule shall be followed as per Appendix A. If alternative equipment is proposed the contractor shall provide supporting documentation indicating equipment is of equal or better quality.

Not all approved products may necessarily be appropriate in all installations. It is the designer's responsibility to assess the approved product to validate that it is suitable, and where it is not, propose an alternative product.

Commercial Off the Shelf products shall be used wherever possible. No open source or custom-built components may be used without specific approval from the South East Water.

1.5.3 Access to Equipment

The arrangement of equipment and cable support systems shall permit reasonable access to components for installation, addition, isolation, inspection, maintenance and replacement. Equipment shall be accessible from a standing position, otherwise a permanent structure shall be provided to provide safe access.

1.5.4 Non-Standard Control Equipment

Control Equipment not designated in Appendix A requires South East Water approval.

If non-standard equipment such as an embedded PLC in a process skid is supplied by the Contractor, all configuration software, programming cables and any other non-standard items are to be supplied as part of the works. This includes spares as specified in this document.

If a local HMI is supplied as part of the skid package it shall be as per Appendix A, configured as described in the relevant Monitoring and Control standard.

1.5.5 Principal Supplied Equipment

Certain items of equipment may be supplied by SEW. These are generally IT hardware and communications devices which will be provided in accordance with project documentation.

1.5.6 Rating

Equipment shall be selected to conform to the designed rated voltage, load current, prospective fault current level, insulation class, ingress protection (IP), duty cycle, electromagnetic compatibility and hazardous area classification (if applicable).

1.5.7 Electromagnetic Compatibility

Equipment with nonlinear voltage/current characteristics that generate harmonic disturbances, radio frequency interference or rapid fluctuations of the power supply shall be selected and appropriately uninstalled to meet acceptable levels as outlines by AS/NZS 61000 (parts of) Electromagnetic compatibility (EMC) and the Essential Services Commission Electricity Distribution Code.

1.5.8 Consistency

For the whole quantity of each material or product use the same manufacturer or source and provide consistent type, size, quality and appearance.

Do not provide without approval products that are obsolete, discontinued or about to be discontinued.

1.5.9 Efficiency

Give due regard to equipment selections and system design to minimise energy usage, operating and maintenance costs.

1.5.10 Noise

Select and install plant and equipment and provide acoustic control measures so that the noise levels arising from simultaneous operation of all services do not exceed the maximum sound levels requirements regarding noise to the external environment emanating from plant. Refer AM2758_Noise Specification for requirements.

1.5.11 Safety

Provide all necessary safety devices for the protection of personnel against injury and the protection of plant and equipment against damage including effective earthing of electrical components, insulation, barriers, electrical interlocks, warning lights, and signs, alarms and local lighting.

Comply with Australian and International Functional Safety standards such as *AS 61508*, *AS 62061, AS61511* and *AS 4024.1503* (*ISO13849-1* and *ISO13849-2*) where appropriate.

1.5.12 Special Tools

Supply special tools necessary to dismantle equipment requiring periodic maintenance or replacement. Such tools shall not be used for the erection of equipment during construction.

Equipment requiring configuration or setup using a proprietary hand held device or PC connection shall be supplied with either or a hand held unit, configuration software, leads, convertors and connections. The number of configurator units / peripherals shall be one per each installed piece of equipment with a maximum of two per equipment type.

Example, supply 2 No infrared hand held configurators when three electric valve actuators are installed.

1.6 Drawings

1.6.1 Standards:

AM2488 Drafting (South East Water standard)

AS1102.107	Graphical symbols for electrotechnical documentation - Switchgear, control gear and protective devices.
AS1101.6	Graphical symbols for general engineering - Process measurement control functions and instrumentation.

South East Water has a number of standard electrical drawings which shall be used as much as practical in the generation of electrical project drawings. These area available in CAD format so that as much of the content as possible can be exactly copied and pasted to ensure exact replication.

1.6.2 Drawings to be Included

Prepare electrical schematics in a logical manner for ease of use in AutoCAD 2017 version or more recent.

Adequate spare space shall be left in drawings for spare/unused terminals on equipment to allow for future use of the spares and inclusion of additional equipment (e.g. spare IO on PLC or telemetry equipment). All drawings shall have either line or grid numbers, and cross references are to be shown for all contacts on each item of equipment (e.g. relay contacts).

Drawing shall consist typically of but not limited to.

- Process and Instrumentation Diagrams (P&ID).
  Refer to AM2488-2D and 3D Drafting and associated CAD template files for standard P&ID blocks.
- Single line diagrams for all Control Assemblies and Distribution Boards.
- Instrument schedules.
  Refer to AM2488-2D and 3D Drafting and associated CAD template files for standard instrument labels.
- Instrument loop diagrams.
- Plant room layout plans identifying all electrical equipment.
- Switchboard and control panel general arrangement.
- Electrical equipment schedules.
- Label schedules.
- Embedded conduit arrangement and pit locations
- Earthing Arrangement Diagrams
- Power and Lighting Plans
- Cable route drawings.
- Cable support systems
- Cable Identification schedule showing cable type, size, identification tag and cable route (notably routes between field pits).

The following drawings shall also be included in the drawing set as specified in AM2779 Treatment Plant Monitoring and Control Specification and AM2780 Network Facility Monitoring and Control Specification:

- Electrical control schematics.
- Motor Starter Diagrams
- PLC IO module connection/wiring diagrams.
- PLC and communications network topology.
- RTU connection diagrams.
- Any other drawings as specified within the Monitoring and Control standards.

1.7 Pre-Construction Submissions

1.7.1 Procedure

Submit for review electrical schematics, equipment schedules, equipment location plans, switchboard general arrangements, calculations and shop drawings.

Calculations shall include but not limited to the following.

- Selection of safety devices as per AS4024 (set) - Safeguarding of Machinery.
- Cable Voltage Drop Calculations
- Circuit protection Co-ordination / Selection
- Arc Fault Protection
- Maximum Demand
- Cable Sizing
- Conduit Sizing
- Fault-loop Impedance
- Fault Level Calculations
- Power Factor Correction
- Harmonic Analysis
- Standby Generator Sizing

1.7.2 Timing

Make submissions in a timely manner, to suit the construction program. Allow time for review and possible amendment and re-submission.

Avoid delays by making early and adequate submissions.

Give notice before commencing work affected by contractor's submissions, unless the submissions have been reviewed with no exception taken.

Where hold points are specified, do not commence work affected by contractor's submissions until the submissions have been reviewed with no exception taken.

1.8 Drawing Integration

Where electrical modification, augmentation or decommissioning works are part of an existing electrical installation, relevant drawings shall be created, revised or reproduced to indicate the integration between existing and the completed works. Revision of drawings shall consist of but not limited to those listed in clause 1.6.2.

1.9 Facility and Plant Area Lighting

All work area and access lighting shall be LED type. Where practical, all lighting located greater than 3m above floor level shall be fixed to swivel poles or be accessible from access platforms.

Work area and access lighting shall conform to the requirements and recommendations of the current revisions of AS/NZS 1680, with particular attention to the following parts:

- Part 0 - Interior lighting safe movement
- Part 1 - General principles and recommendations

- Part 2.2 - Circulation spaces and other general areas
- Part 2.4 - Industrial tasks and processes
- Part 3 - Measurement, calculation and presentation of photometric data
- Part 5 - Outdoor workplace lighting

In all buildings, emergency lighting shall be designed and installed in accordance with AS 2293 Emergency escape lighting and exit signs. Exit and emergency lighting is to be 'non-maintained' such that is not illuminated until such times as normal power supply is lost.

For treatment plants, lighting of the facility entrance and main carpark shall be controlled via a separate a 3 pole Manual-Off-Auto switch located at the main switchboard for the facility (labelled "front entrance lighting"). When switched to "Auto", this lighting shall be switched using industrial grade dual-technology PIR detectors focused on the facility entrance. The PIR detectors shall be set up so that once the lighting circuit is powered, it remains powered for 5 minutes after the motion detector(s) cease to detect motion. When in "Auto", lights shall be able to be switched on or off via the SCADA host whereby the PIR detector switching will be overridden. When switched from "Manual" to "Auto", this lighting shall stay active for at least 5 minutes to enable safe egress of workers from the facility.

Each plant area (functional area) shall have a separate lighting circuit whereby all lighting fixtures in that plant area come on or off together. Each lighting circuit shall be controlled via a 3 pole Manual-Off-Auto switch located at the local plant area electrical board. Lighting of circulation spaces (labelled "general lighting" for paths which transit between plant areas) or smaller facilities with only one plant area shall be controlled via a 3 pole Manual-Off-Auto switch located at the facility's main switchboard. When control switches for these areas are in "Auto", lights shall be able to be switched on or off by operators via the SCADA host.

2. Installation Requirements

2.1 General

2.1.1 Requirements

Provide all stands, cabinet fixing components, supports, brackets, plates etc. for the mounting and positioning of all electrical, instrumentation equipment and systems.

All equipment unless stated otherwise shall be installed in accordance with the manufacturer's requirements.

Mount equipment on fixed structures. Where no fixed structure exists, supply and install an approved structure for the mounting of the equipment.

Fix all plant directly to structure in approved manner. Submit details of types of fixings, locations and loads for approval.

Fix only lightweight items to non-structural building elements.

Unless specifically stated otherwise all supports, brackets and fixings within corrosive areas shall be 316 stainless steel.

Protect all equipment and cables from weather, fire (as much as practical), UV, ingress of dirt, moisture, vandalism and tampering. Provide vandalism and tampering protection also within sites that include compound fencing. All equipment shall be arranged and installed to minimise the risk of fire and the damage which may result in the event of fire.

2.1.2 Access

Provide access to all components without the use of portable or mobile platforms unless specifically stated otherwise.

2.1.3 Building Penetrations

Seal penetrations around conduits and sleeves with cement mortar or mastic. Seal around cables within conduits and sleeves. If the building element is weather proof, acoustic rated or subject to pressure, maintain the rating. Acoustically seal penetrations through plant room walls and floors.

Limitations

Do not penetrate, or chase the following without approval:

- Structural building elements including external walls, core walls, fire walls, floor slabs, beams and columns.
- Acoustic barriers
- Other building services.
- Membrane elements including damp-proof courses, waterproofing membranes and roof coverings.

2.1.4 Metalwork

Use metalwork capable of transmitting the loads imposed, and sufficient to ensure the rigidity of the assembly without causing deflection or distortion of finished surfaces. Construct to prevent rattle and resonance.

To avoid galvanic corrosion prevent contact between dissimilar metals, by using insulating insertion layers.

Keep edges and surfaces clean, neat and free from burrs and indentations. Remove sharp edges.

2.1.5 Bolts, nuts, washers and jointing materials

Bolts, nuts, washers and other demountable fastenings shall be appropriate material and shall remain unpainted. Isolating washers shall be fitted between dissimilar metals.

Metal coating using electro-galvanising, nickel, cadmium, chromium or other similar type of plating process shall not be acceptable in external to building applications.

Fixing into concrete shall be by chemical anchors with Grade 316 stainless steel studs.

All bolts and nuts shall have metric threads to AS 1111 and AS 1112.

2.1.6 Mechanical protection

Supply and install approved mechanical protection of all electrical equipment and in particular under the following conditions:

- all conduits for a distance of 300 mm above any floor, walkway or concrete surface.
- where subject to damage during plant operation and maintenance.
- on which scaffolding and/or planks may be placed, or which may be used as means of access for abnormal plant maintenance.

Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed to withstand the shock loading likely to occur in the area. Covers shall be constructed of material suitable to the environment as per AM2739 Corrosion Mitigation Specification.

2.2 Cables

Design, supply and install all cable routes and related materials, eg. cable trays, ladders, conduits and the like necessary for the overall cabling of the plant and associated sites.

2.2.1 Installation of Cable

Process, Power and Control Cabling in the switch room shall be neatly arranged in cable trays or ladders and shall be segregated from one another. Cables on ladder shall not exceed two layers.

Cables throughout the site shall be segregated into the following groups.

- Power – main incomer
- Power - sub mains
- Power - motor cables
- 240V control cables
- 24V dc control cables, thermistor cables etc.
- Instrumentation cables, potentiometer cables, PLC data cables etc.

The minimum segregation requirements for cabling throughout the site shall be instrumentation and control cabling (ELV) 300 mm to all power cabling and shall occupy separate housing systems.

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

Run cables without intermediate straight-through joints unless unavoidable due to length (>300 M) or difficult installation conditions. Located cable joints suitably in s.s junction boxes above ground level or provide cast resin submarine type joins located with an accessible pit.

In external applications protect all cables from UV deterioration due to sunrays.

Adhesive cable tie mounts shall not be used to support cables or wiring looms.

2.2.2 Low Voltage Sheathed Cables

Minimum V75 insulation rating with stranded copper conductors rated to AS/NZS 3008.1, *Cables for alternating voltages up to and including 0.6/1kV.*

Use cables with current ratings suitable for the ambient air temperature and for temperature rise limits of equipment within the installation.

Provide cables capable of withstanding maximum thermal and magnetic stresses associated with relevant fault level and duration.

Cables up to and including a cross section of 300 mm^2 installed external to switchboards shall be of a multi core construction.

2.2.3 Cable Markers

Identify power and control cables between switchboard assemblies and equipment in accordance with the cable schedules and/or interconnection wiring diagrams.

For indoor applications or environments corrosive to 316 stainless-steel, PVC ring type ferrules characters supported on a PVC carrier fastened using nylon cable ties

For outdoor areas, 316 stainless steel marker plates engraved or laser etched characters fastened using stainless steel ties.

Install cable markers in switchboards above the gland plates in the cable zones clearly visible from the access position.

2.2.4 Spare or Unused Cables

All spare power, control and instrument cables shall be terminated in a manner that provides a minimum degree of protection of IP 2X in accordance with AS 60529 Degree Of Protection and labelled accordingly.

Within switchboards – connect to DIN mounted screw terminations or cover cable ends with resin heat shrink sleeve.

Within cable trenches or pits – cover cable ends with heat shrink sleeve or cover cable ends within a polycarbonate termination enclosure appropriately glanded.

2.2.5 Cable Glands

Only one cable shall occupy each cable gland opening unless multi hole cable glands inserts are used.

Unused cable glands shall be removed and penetrations filled with stop ends.

Cable entries using bushed penetrations may not be suitable in maintaining the IP rating of switchboards.

2.2.6 Cable Size

The following cable sizes shall be observed where not specified.

Control Wiring	0.50 mm2 stranded (minimum) Cu.
PLC IO	0.50 mm2 stranded Cu.
Instrumentation Wiring	0.30 mm2 stranded (twisted pair, individual & overall aluminium Mylar screen and base copper drain wire) Cu.
Instrumentation power	Flexible cord to AS 3191.
CT Secondary Wiring	2.50 mm2 stranded Cu.
General Power Wiring	2.50 mm2 stranded Cu.
Lighting	1.50 mm2 stranded Cu.

2.2.7 Cable Colours

For fixed wiring, use coloured conductor insulation. If this is not practicable, slide at least 150 mm of close fitting coloured sleeving on to each conductor at the termination points.

A phase	Red
B phase	White

C phase	Blue
Neutral	Black
Earth	Green-yellow
Control, LV VAC	Grey
Control Neutral, LV VAC	Black
Control ELV VAC	Orange
Control Neutral ELV VAC	Orange
Control ELV VDC	Violet
Control Neutral ELV VDC	Violet
Instrumentation (Screened) Positive	White
Instrumentation (Screened) Negative	Black

2.2.8 Wire Number Identification

Standard

South East Water standard drawing SEWL-STD-037.

Wire Number Series

0 Reserved for special purposes

1 LV Control

2 ELV Control

3 Instrumentation

4 Reserved for special purposes

5 Indications where separate circuits are used

6 Alarms

7 Telemetry or PLC Inputs /Outputs

8 Reserved for special purposes

9 Reserved for special purposes

Example

LV Control 1 0 6

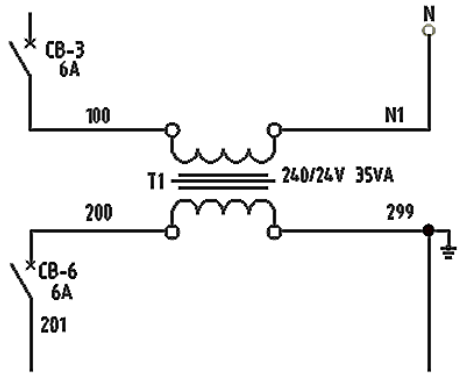
Number Series Identifier

After the identifier reaches 99, continue at 100 e.g. 1100

Convention

Typically ELV control, PLC and DC supply circuits the identifier start at 00 with the return or 0V at 99.

Example



Equipment Number

Wire numbers may be duplicated where circuits have no commonality. Where circuits are collective or where circuits create ambiguity an equipment prefix maybe used.

Example. PM01 - 1 0 6

*Equipment Number Series Identifier

*Refer to Appendix B – Equipment Identification.

Power

R 0 6

Phase Identifier as per isolation device designation.

Lables

Terminated cables shall be identified by the means of a printable insert set into a square faced transparent cable carrier. The printed insert shall have the ability to be changed before or after termination. Printed inserts shall be white with black lettering.

2.2.9 Cable Sizing

Calculate cable rating and voltage drops based upon actual cable lengths and selected make of cables. Allow for standby plant and future demand as indicated within the indented Electrical Scope of Works. Take into consideration installation conditions and external influences, short circuit fault levels and ratings of protection equipment.

2.2.10 VSD Earthing

Where variable speed drive fed motor cables are installed, the VSD manufacturers' installation recommendations shall be followed. This will typically include grounding of the cable at both

ends, the use of braided earth straps between the VSD and the earth bars, the use of screened cable with appropriate earthing rings and metallic glands.

2.2.11 Cable Ties

Where cable ties are used in areas directly exposed to sunlight, 316 stainless-steel ties shall be used.

2.3 Conduits

2.3.1 Requirements

Conduit may be either steel or PVC subject to the following requirements:

- Conduit on a surface exposed to mechanical damage: Galvanised steel conduit
- Exposed external conduit: Galvanised steel or PVC painted with a light coloured acrylic paint or covered from UV exposure.
- Conduit cast into concrete, chases or concealed areas: PVC conduit may be used. Light duty rigid PVC conduit may be used in areas where not subject to the risk of mechanical damage.
- Conduit buried in ground: Heavy duty UPVC conduit.

2.3.2 Minimum sizes

Metallic and non-metallic conduits: 20mm.

2.3.3 Rigid conduits

Provide straight long runs, smooth and free from rags, burrs and sharp edges. Set conduits to minimise the number of fittings. Remove sharp edges prior to drawing-in wires.

2.3.4 Flexible conduits

Flexible conduit shall only be used where rigid conduit cannot be supported or in applications where equipment requires frequent removal due to maintenance, example electric motors. Flexible conduit shall consist of heavy duty spiral reinforcing with PVC only used in indoor applications. Flexible conduit shall be limited to <600mm in length.

2.3.5 Set out

Install conduits truly vertical or horizontal and in parallel runs with right angle changes of direction.

2.3.6 Conduit Entry

Conduits subjected to moisture shall enter into a switchboard, junction box, isolator or instrument enclosure via a bottom entry. Vertical conduits from above shall incorporate a drip loop if side entry is the only option to bottom entry.

2.3.7 Inspection fittings

Provide in accessible locations.

2.3.8 Draw Cords

Provide draw cords in conduits not in use. Leave 1 m of cord coiled at each end of the run.

Polypropylene cord, conductive wire shall not be used.

2.3.9 Cable Pits

Provided cable pits at every major change in direction of underground conduit or at 100 m minimum intervals on long straight duct and conduit routes.

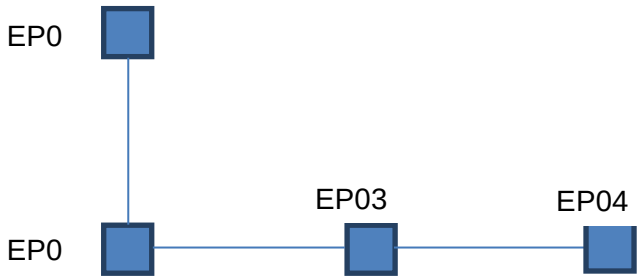
Minimum 600 x 600mm pit size allowing for turning of cables at above the minimum acceptable bending radius.

Pit covers shall be selected to suit expected loads of pedestrian or vehicular traffic in the location in which it is installed.

Pit shall be constructed of polyethylene or precast concrete. Polymer concrete or glass reinforced concrete pits shall not be accepted.

Pit shall be numbered using the following convention: EPXX.

Where X is a number within an incremental numeric sequence used to identify individual pits.



The pit identification number shall be engraved or laser etched with black filled lettering on a 316 stainless steel, 1.5mm minimum thick round label. The label shall be fixed to the pit cover using a high quality, single component joint sealant / high adhesive strength such as ‘Soudal Fix All High Tack’ or ‘Sikaflex 11FC’.

2.3.10 Draw-In Boxes

Provide draw-in boxes in accessible positions and at intervals not exceeding 30m in straight runs, and at changes of level or direction. Provide draw-in boxes no greater than 7.5 m apart for vertical lengths of conduit runs.

2.3.11 Sealing Conduits

Seal buried entries to ducts and conduits using waterproof seals. Seal spare ducts and conduits immediately after installation. Seal other ducts and conduits after cable installation. Seal the ends of conduits entering the building with expanding foam to prevent moisture and vermin entry.

2.4 Bends and elbows

Make with easy sweeps. Provide bends of 90° with a radius of not less than three times the external diameter of the conduit, without mechanical stress sufficient to cause deformation. Limit the number of 90° bends between boxes in any conduit run to 2.

2.4.1 Conduit saddles and brackets

Space conduit saddles a maximum of 1200 mm apart for metallic conduit and 1000 mm apart for non-metallic conduit. In areas subject to high ambient temperatures or other severe duty, provide maximum saddle spacing for non-metallic conduit of 500 mm.

Provide conduit support saddles close to flexible couplings to permit free movement for expansion and contraction.

To minimise eddy current effects ferrous cable saddles shall not be fitted over single core cables.

Where two or more conduits are run in parallel they may be grouped. Provide suitable surface brackets where conduits cannot be fixed.

Provide stainless steel saddles in exterior or high corrosive environments.

2.4.2 Corrosion Protection

For steel conduits, paint ends and joint threads with zinc rich binder. 316 stainless steel conduit shall be used where metallic conduit is required to penetrate through soil level.

2.4.3 Sets and bends

Form with a spring or other device inserted in the conduit to prevent distortion of the walls. The forming of conduit bends using heat from a naked flame or similar method which may damage or deform the conduit shall not be accepted.

2.5 Cable Trays

Provide a complete cable support system consisting of trays or ladders and including brackets, fixings and accessories. Fabricate brackets, racks and hangers from structural steel sections or other materials in sections of equivalent strength.

Cable ladder tray used on open tanks shall be mounted on the inside of walkway handrails to prevent personnel requiring access to the tank or for having to be physically restrained to work on.

Maintain earth continuity of the entire cable support system.

Provide rounded support surfaces under cables where they leave trays or ladders.

Provide cable tray covers on externally installed cable ladder systems subject to UV exposure.

2.5.1 Spare

Provide an additional 20 percent (20%) spare ladder and cable tray space in excess of that determined by the design calculations and the known future cabling.

2.5.2 Applications

For interior applications provide Zinc-coated steel, or steel with two-pack liquid coating, air-drying enamel or stoving enamel finish.

For general exterior applications provide hot dip galvanised steel or within corrosive environments e.g. marine, underground pits or waste water treatment plant applications 316 stainless steel shall be used.

2.6 Underground Services

2.6.1 Excavation

Make trenches straight and at uniform grade between pits, personnel access ways and junctions. Preferably changes in route shall be at right angles.

2.6.2 Dewatering

Keep trenches free of water. Place bedding material, services and backfilling on firm ground free of surface water.

2.6.3 Backfilling

Install underground marking tape to AS/NZS 2648.1 and backfill service trenches as soon as possible after the service has been laid, bedded and tested. Place the backfill in layers ≤ 150 mm thick and compact to the density applicable to the location of the trenches, to minimise settlement, and so that pipes are buttressed by the trench walls.

2.6.4 Backfill Material

Underground conduit and pits shall be backfilled as per gravity sewers and structures in accordance with the MRWA Backfill Specification 04-03.

2.6.5 Underground Cable Routes

General

Provide all changes in grade or direction in easy stages, and bends with a radius of not less than fifteen times the conduits overall diameter.

Survey

Accurately record the routes of underground cables before backfilling. Accurately plot conduit routes, pits, junction boxes, etc., and note levels of ducts at the following points:

- Changes in direction.
- Entry and exit from structures.
- Changes in depth.

2.7 Labels

2.7.1 General

Mark equipment, electrical switchboards, circuit breaker designations, electrical cables, instruments and controls with a means of identification to match design drawings and conforming to Appendix B – Equipment Identification.

2.7.2 Material

For indoor applications or environments corrosive to 316 stainless-steel, engraved two-colour laminated PVC or Traffolyte. Stencil with black or white lettering contrasting with black or white background.

For outdoor areas, engraved or laser etched with black filled lettering on 316 stainless steel minimum thickness 1.5mm.

Note printed self-adhesive shall not be permitted.

2.7.3 Size

If labels exceed 1.5mm thickness, use radius or bevelled edges.

Minimum lettering heights:

- Major equipment nameplates: 40mm
- Minor equipment nameplates: 20mm
- Main switches 10mm
- Outgoing electrical functional units: 8mm
- Danger, warning and caution notices: 10mm for heading 5mm for text (White on Red).
- Automatic controls electrical equipment and instruments: 5mm
- Components inside electrical enclosures and control panels: 3.5mm.
- Minor lettering: 3mm

2.7.4 Fixing

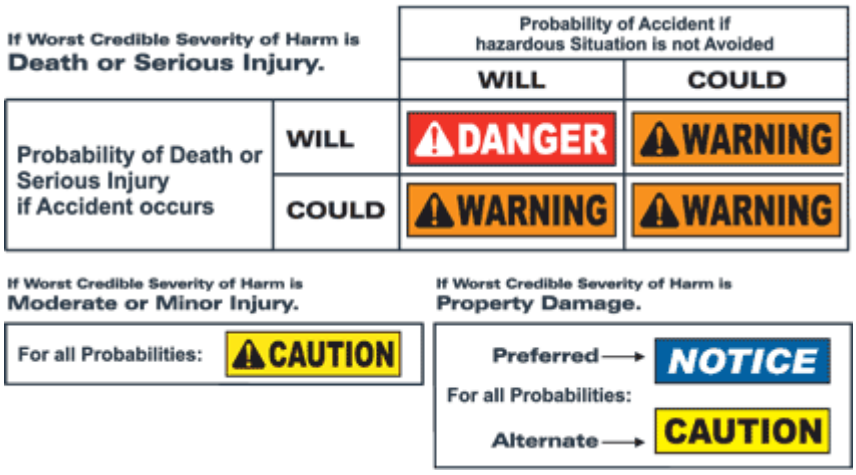
Locate labels so that they are easily seen from normal access adjacent to the item being marked. Do not install labels directly onto components or equipment.

Use mechanical fixings, at least two pins or screws per 80 mm of label length for labels fixed to flat surfaces. Where flat surfaces are not presented fit labels to equipment using nylon or stainless steel cable ties where appropriate.

Self-adhesive shall not be permitted.

2.7.5 Danger, Warning and Caution Labels

Provide labels where applicable as recommended by equipment manufacturer or as a result of a risk assessment.



DANGER: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. Safety Signs identified by the signal word DANGER should be used sparingly and only for those situations presenting the most serious hazards.

WARNING: Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury. Hazards identified by the signal word WARNING present a lesser degree of risk of injury or death than those identified by the signal word DANGER.

CAUTION: Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury. It may also be used without the safety alert symbol as an alternative to “NOTICE”.

NOTICE: is the preferred signal word to address practices not related to personal injury. The safety alert symbol should not be used with this signal word. As an alternative to “NOTICE”, the word “CAUTION” without the safety alert symbol may be used to indicate a message not related to personal injury.

2.7.6 Fixed Equipment Connected to Socket Outlets

Fixed or stationary equipment connected by a low voltage single or polyphase phase flexible cable to a socket outlet where the cable is not flexed, not moved in normal use, not exposed to damage or not in a hostile environment shall have the equipment tagged with a ‘INSTALLED’ label indicating the connected equipment start date of operation. The label type shall be of a 'Self Debossing Foil Write on Label'.

2.8 Safety Devices

Safety devices shall be installed to eliminate or minimise personnel hazards and risks as well as safeguarding of machinery. Design, implementation and selection of devices shall be determined as per AS4024 (set) - Safeguarding of Machinery. Standards such as AS 61508, AS 62061, AS61511 and AS 4024.1503 (ISO13849-1 and ISO13849-2), may be applied where necessary.

Safety guards shall be compliant with Regulation 77 of the OH&S (Plant) Regulations 2017 (Victoria).

Operator controls shall be compliant with Regulation 78 of the OH&S (Plant) Regulations 2017 (Victoria).

Emergency stop devices shall be compliant with Regulation 79 of the OH&S (Plant) Regulations 2017 (Victoria).

2.9 Field Equipment Electrical Isolation

All field equipment supplied by a voltage equal to or greater than low voltage shall be fitted with a local isolator. Local isolation shall include lockable isolators for hard wired equipment, de-contactors or plug socket combinations. Field equipment shall be defined as equipment installed external to a switchboard assembly or motor control centre.

A plug socket combination as opposed to a local isolator shall be installed on equipment where either of the following applies.

- The equipment is required to be moved to perform regular reactive maintenance. i.e. pump blockages.
- The equipment is required to be replaced by an immediate critical spare.
- Disconnection is regularly required by non-electrical licensed personnel.
- Unique equipment can only be connected.

- Personal safety is evident.

Non-metallic field isolators subject to direct sunlight shall be shrouded by either a stainless steel or aluminium cover.

Where practicable the location of isolators shall be adjacent to the equipment i.e. line of sight within 2 metres.

The isolator switching capacity shall have an utilisation category conforming to the intended load characteristics.

Where electromagnetic compatibility is to be maintained suitable EMC enclosures shall be used complete with EMC cable glands and earth termination.

Exemption to the Field Equipment Electrical Isolation clause includes local isolation of lighting or equipment otherwise specified.

2.10 Junction, Termination or Electrical Equipment Enclosures

Where applicable provide enclosures with a suitable degree of protection and material to suit the following.

Indoor - ABS, polycarbonate, glass reinforced plastic or powder coated *mild steel.

Outdoor - 316 stainless steel or aluminium.

*Mild Steel unsuitable within indoor applications subject to moisture or corrosive environments.

3. LV Switchboards

All LV switchboards shall be inspected and tested in accordance with section 11.

At this point in time, modular switchboards are only accepted for type tested applications.

Switchboards constructed after year 2021 shall comply to AS/NZS 61439 type test standard for all assemblies having a rated short-time withstand current or rated short circuit current exceeding 10 kA rms. There will be a significant shift in the construction of most switchboards when this requirement comes into effect.

At treatment plants, each sub board shall have a Manual Transfer Switch (MTS) and generator connection point.

3.1 Approved Switchboard Fabricators

It is recommended that Switchboards be fabricated by a supplier listed in Appendix G.

All boards built for a project shall be constructed by the same switchboard supplier.

3.2 Contractor's Submissions

Submit shop drawings indicating:

- Switchboard form.
- Types and model numbers of items of equipment.
- Overall dimensions.
- Switchboard general arrangements, plan view, front elevations and cross-section of each compartment and clearances or inadvertent operation, such as handles, knobs, arcing-fault venting flaps and withdrawable components.
- Front and back equipment connections and cable entries.
- Door swings.
- Locking systems.
- External and internal paint colours and paint systems.
- Construction and plinth details, ventilation openings and gland plate details.
- Terminal block layouts and control circuit identification.
- Busbar arrangements, links and supports, spacing between busbar phases, and spacing between assemblies, the enclosure and other equipment and clearances to earthed metals.
- Dimensions of busbars and interconnecting cables in sufficient detail for calculations to be performed to AS standards.
- Internal separation and form of separation and details of shrouding of terminals
- Labels and engraving schedules.
- Paint colours and finishes.
- Access details.

3.3 Switchboard Position and Protection

Switchboards shall be located within buildings where buildings are associated with the facility (ie: Treatment Plants or larger facilities where control rooms, toilets etc are required).

Switchboards located inside switch rooms shall be positioned to provide safe and easy access for operation and maintenance of all equipment. A minimum of 0.6 m clear access shall be provided in front of all open doors.

The switch room layout shall allow any individual switchboard to be removed from the building and later reinstated whilst all other switchboards and any other fixed equipment remain in place.

Where main busbar connections are located behind any module, the switchboard shall have removable rear covers with a minimum of 600mm clearance to any wall, column or structure.

External switchboards shall be protected from damage as per SEW's Facility Security Standard AM2759. Typically bollards and careful placement away from overhanging trees and flood prone areas is required at a minimum.

External switchboards shall be located such that while any doors and covers at the facility are being opened, those covers and doors can never be closer than 0.6m from each other. External switchboards shall also be positioned so that there is at least 1.5m clearance between open doors and underground structure openings, steps, guardrails or above ground structures.

External switchboards shall be supplied with carport style roofs that extend 2m past the front of the board and 1m past the sides and rear of the switchboard. These carport roofs shall have colour bond roofing and guttering to match the switchboard colour, with downpipes located to direct stormwater away from work areas. Lighting shall be provided to illuminate the switchboard and the area surrounding the carport style roof.

Wherever practicable, external switchboards located in full sun shall be aligned north/south to minimise the effect of the sun with heat sensitive equipment located at the south end of the switchboard. Where not practicable, east/west aligned switchboards shall arrange heat sensitive equipment at the east end.

3.4 Switchboard Assemblies

Switchboards shall be designed so that common equipment shall be located in dedicated compartments within the switchboard. For example, LV power system devices shall be located in one compartment, control and communications equipment shall be located in a separate compartment.

3.4.1 Construction

Provide rigid, ventilated switchboards consisting of panels, doors, or both, giving the designated enclosure separation and the required degree of protection.

3.4.2 Materials

Internal Switchboards - Constructed from 2.0 mm (minimum) Cold Rolled Commercial Quality mild steel folded and welded construction, powder coated finish.

External Switchboards – Constructed from 3.0 mm 5005 H34 grade aluminium folded and welded construction, powder coated finish.

Powder Coating shall be selected and implemented as per WSA 201, Selection and Application of Protective Coatings (ie: AS 4506, with minimum pre-treatment and coating thickness requirements suitable for atmospheric classification D – High Marine/Industrial).

3.4.3 Degree of Protection

Situation	Required Minimum IP Rating
Indoor assemblies isolated or separated by more than 5m **from pressure pipe**	IP52
Indoor assemblies in line of site and within 5m of pressure pipework	IP55
Exterior assemblies, outer surfaces	IP56
Exterior assemblies, inner surfaces (escutcheon)	IP41

All seams shall be fully welded.

3.4.4 Colours

Colours: To AS 2700, Colour standards for general purposes.

Electrical panels and control panels:

- Indoor assemblies: Orange X15
- Outdoor assemblies: Rivergum 2700Green G62
- Internal surfaces: White N14
- Instrumentation panels: White N14

3.4.5 Fault Levels

Rated short-circuit current: Maximum prospective symmetrical r.m.s. current at rated operational voltage, at assembly incoming supply terminal, excluding effects of current limiting devices (Imsc).

3.4.6 Arc Fault Protection

Arc fault protection shall be provided for switchboards rated at 800 A or greater per phase to reduce the incident energy of an arc-flash event. Detection equipment shall consist of optical arc detectors located at specified switchboard locations connected to an arc monitor relay, and an incoming current sensing unit which prevents operation of the system unless the switchboard incoming peak current exceeds the switchboard maximum short term peak current demand. The arc fault monitor shall be equipped with a solid state high speed relay to enable tripping of switchboard main and auxiliary supply breakers.

Arc fault detectors shall be located so as to determine the location of an arc faults occurring:

a) At the point of switchboard connection to the incoming supply(s)
b) In the incoming circuit breaker compartment
c) Along the main busbar, unless this is fully insulated
d) Along the distribution busbar, unless this is fully insulated
e) In outgoing circuit breaker compartments

3.4.7 Switchboard Separation

Form of separation and degree of protection subject to switchboard rating and application.

- Switchboards shall be provided with internal separation by use of Form 4b in accordance with AS/NZS 3439.1.
- Alternate forms of separation shall be confirmed by South East Water pertaining to switchboard criticality, process isolation and accessibility for maintenance.

3.4.8 Spare Capacities

Where an upgrade is required, existing spare capacity of the rear gear tray may be used. Full access to existing equipment shall be maintained and the side walls of control compartments shall not be used to mount new equipment.

Where there is inadequate spare rear gear plate to install new equipment, new switchboard compartment(s) shall be provided for the new equipment.

Required capacity shall be calculated as follows:

1) Establish the requirements for the current project
2) Estimate the requirements for planned or proposed future work, assuming all spare capacity from the current project would by then be **un**available.
3) Add the required allotment of spare capacity based on the combined requirement for 1) and 2). Eg: if 0.3m^2 is required for the control compartment gear tray in this project and future proposed upgrade is estimated to require an additional 0.15m^2, then the control compartment gear tray area A should be: A = 1.5 x (0.3 + 0.15) = 0.675m^2.

All spare quantities nominated below are minimums.

Item	Requirement
Power Supply & Distribution	
Main Switchboard	25% spare volume
Switchroom	25% spare floor space
Distribution boards	50% spare poles
Motor control centres	25% spare compartments
Ducts and cableways	50% spare volume
RTU / PLC and IO	
Control compartment	50% spare gear tray area. This is the space required for future IO terminals, PLC / RTU racks and relays etc.
Memory	25% spare memory capacity in each PLC / RTU
IO Installed	25% spare IO for each type of IO used (ie: dig in, dig out, analogue in and analogue out) including at least one spare point per analogue card
PLC Racks	One spare rack per control system
Spare Slots per Rack	3 spare slots per rack shall be provided as spare. Space for spare slots shall have a suitable blank placed into the rack that is compatible with the IO type installed
Terminal strips and spare IO	All spare (unused) IO points in PLC/RTU cards to be wired and ferruled to terminal strips
Terminal strips for future IO	Provision should be provided for the installation of terminal strips for all future IO cards based on the number of spare slots available in installed IO racks and the maximum density card available for the installed IO type

Item	Requirement
Communications	
Fibre Cores	Number of fibre cores shall be 12 cores per fibre type (i.e. for both fibre types of Single-Mode and Multi-Mode)
Spare Fibre Cores	50% spare fibre cores or spare conduit capacity
Subnet & Programming Ports	1 port per VLAN on the network shall be allocated for programming use
Spare Network Switch Ports	25% spare ports per switch (Total ports used includes ports allocated for programming)

3.4.9 Cable Entries

Indoor cable entries: Top and bottom, to suit location.

Outdoor cable entries: Bottom only.

For bottom cable entry provide a horizontal cable zone above the switchboard plinth. The cable zone shall include a hinged lockable front panel to allow access to ground level cables beneath the switchboard.

For a bottom entry switchboard, the cabinet and any marshalling cubicle shall have a minimum 150mm (W) x 100mm (H) cable duct installed along the bottom of the gear pan. There shall be a minimum 200mm vertical clearance between the gland plate and the bottom of this cable duct. This duct shall remain empty of switchboard control wiring and shall be dedicated to field cable entries.

For a top entry switchboard, the cabinet and any marshalling cubicle shall have a minimum 150mm (W) x 100mm (H) cable duct installed along the top of the gear pan. There shall be a minimum 100mm vertical clearance between the gland plate and the top of this cable duct. This duct shall remain empty of switchboard control wiring and shall be left dedicated to field cable entries.

Cable entry area shall come ready drilled with holes for all required cables plus 30% spare capacity. The spare holes will be of various sizes to approximately match the ratios of existing holes. Unused holes will be plugged.

3.4.10 Bus Bars

Switchboards constructed with main bus connecting joints and cable connection terminal pads shall have the bus bar tinned where the switchboard to installed in areas subject to high concentrations of hydrogen sulphide.

3.4.11 Component labels

Provide engraved two-colour laminated PVC labels fixed to equipment gear trays and control escutcheon doors to depicting component designations matching the design schematics. Labels shall not be fixed to cable ducts.

3.4.12 Multiple Supply Warning Notices

Provide warning notices stating that assemblies may be energised from more than one source i.e. generator stand-by supply, UPS or spate control supply.

3.4.13 Layout

- Position equipment to provide safe and easy access for operation and maintenance with adequate clearances at front, rear, sides and overhead.
- Optimise functional relationships between items of equipment in laying out the assembly.
- Section sizes: Limit dimensions to facilitate transport to final position.
- Withdrawable switchgear: Provide for withdrawal without opening adjacent doors.
- Locate equipment to permit dismantling or removal without disturbing other equipment or wiring.
- Allow space for cable entry and terminations.
- Equipment shall not be installed on internal / external side walls.
- Separate ELV control terminations from MCC functional units, LV terminations and vertical busbar compartments.

Equipment mounting heights above floor to the centre line of the equipment:

- Toggles and handles of circuit breakers, fused switch units and isolators:
  - Wall mounted assemblies: 500-1900mm.
  - Floor mounted assemblies: 200 - 1900mm
- Control switches, indicating lights, meters and instruments on doors:
  - Wall mounted assemblies: 1000 - 1700mm.
  - Floor mounted assemblies: 1000 - 1700 mm.

Equipment on doors: Set out in a logical manner in functional unit groups, so it is accessible without the use of tools or keys (internal mounted switchboards only).

Common control equipment: Group common control relays, timers and fuses in a common panel or compartment.

3.4.14 Gland Plates

Gland plates: Provide removable gland plates fitted with gaskets to maintain the degree of protection.

3.4.15 Doors

Where lids or doors in any insulating enclosure can be opened without the use of a tool or key, conductive parts shall be located behind an insulating barrier that provides a degree of protection not less than IP2X.

Width:	900 mm maximum.
Door Swing:	At least 120° - with positive retainer in open position. Door retainer fixed and shall not be removable without the use of tools.
Adjacent doors**:**	Space adjacent doors to allow both to open to 90 at the same time.
Construction:	Provide single right angle return on all sides and fit resilient neoprene seal to provide the degree of protection and prevent damage to paintwork.

All doors exceeding 500 mm in width or 750 mm in height shall be provided with internal channel section stiffener.

Hanging: Provide corrosion-resistant pintle hinges or integrally constructed hinges to support doors. For removable doors, provide staggered pin lengths to achieve progressive engagement. Provide 3 hinges for doors higher than 1m.

Door hardware: Internal switchboards.

- Doors ≥ 1.5m high - Corrosion-resistant “T” handles located at three points.
- Doors <1.5m high - as applicable. Corrosion-resistant "T" handles located at one or two points

Door hardware: External switchboards.

- Doors ≥ 1.4m high – and bottom lock 213 deadbolt. Recessed handles, dual locking, top lock 100 night latch,
- Doors <1.4m high - Recessed handles, single lock, 100 night latch.

Escutcheon Doors:

Power Distribution: Captive, corrosion-resistant knurled thumb screws. Thumb screws secured by ‘nutserts’ within cubicle body.

Other:

- Doors ≥ 1.5m high - Corrosion-resistant “T” handles located at three points.
- Doors <1.5m high - as applicable. Corrosion-resistant "T" handles located at one or two points

3 point locking mechanisms by means of a rods are not acceptable.

Door mounted equipment: Protect or shroud door mounted equipment and terminals to prevent inadvertent contact with live terminals, wiring, or both.

Drawing pockets: Provide internal pockets for wiring diagrams and circuit schedules.

Earthing: Maintain earth continuity to door mounted indicating or control equipment using multi-stranded, flexible earth wire, or braid of equal cross-sectional area, bonded to the door.

Door & Escutcheon Stays shall be proved where:

- Doors and escutcheon of enclosures dedicated to switchboards that open into a passage or narrow access way shall be capable of being secured in the open position to prevent workers being inadvertently pushed towards the switchboard.
- Doors and escutcheon of enclosures dedicated to switchboards located in outdoor areas.

Door seals to be self-adhesive neoprene rubber. Seals incorporating metal reinforcement shall not be used.

3.4.16 Locks

External Switchboards

Network Assets i.e. waste water, water pump stations, tanks, pressure reducing stations etc.

Abloy 201 cylinder locks, 5AP100 locking system keyed to M3 security level. Available from Stewarts / API Locksmiths.

Waste Water Treatment Plants

South East Water security level “A” key – Lockmart Frankston.

Internal Switchboards

Locks keyed to standard CL001.

Enclosures

Housing cable terminations - Double Bit 3mm DIN  Locks

3.4.17 Neutral and Earth Links

Links

Configuration: One [1] neutral and one [1] earth terminal shall be provided for each spare circuit breaker pole.

- Mounting: Mount neutral links on an insulated base.
- Control circuits: Provide separate neutral and earth links.
- Labels: Provide labels for neutral and earth terminals.
- Cables > 10mm2 provide bolts or studs.

3.4.18 Cable Ferrules

Provide suitably sized cable lugs or ferrules unless the equipment (circuit breaker, contactor, thermal overload and alike) comprise of tunnel type terminals and the conductor size is larger than 4.0mm2.

3.4.19 Mounting Rails

Screw or rivet mounting rails to assembly $\leq$ 500 mm centres. Provide sufficient length to accept a further 20% terminals.

3.4.20 Terminations

Connection to circuits $\leq$ 16 mm^2:	Provide DIN-type tunnel terminal blocks. Terminal blocks screw-tightened, clip-on, 35 mm DIN-type.
Connection to circuits > 16 mm^2:	Provide stud-type terminals $\geq$ 5mm diameter, sized to continuously carry the load.
Cables > 70 mm^2:	Stud type terminals, fixed to a DIN-type or G rail.
Location:	Locate terminals to provide access for connections to outgoing terminations.
Marking:	Number terminals individually to match design drawings.

Spring loaded, ‘push in’ tension clamp or self-pierce insulation terminal technology shall not be used.

All instruments shall have a disconnect in the IO terminal.

3.4.21 Termination Organisation

Terminate switchboard internal wiring to one side of the terminal block, leaving the other side for outgoing circuits.

Where mixed voltages exist on common terminal rails provide oversized barriers to partition each group of terminals having different voltages.

Within each voltage partition, segregate and label terminals so that each section of terminals contains common elements as follows:

Device Type	Segregation	Order
Control IO	Analogue In	Alphabetical or numerical order of wire ID
	Analogue Out	
	Digital In	
	Digital Out	
Telemetry (SCADA) IO	Analogue In	Alphabetical or numerical order of wire ID
	Analogue Out	
	Digital In	
	Digital Out	
Power Supply	ELV	Group by Battery, Instrument, Actuator or Control & Telemetry Devices
Power Supply	Single Phase LV	Group LV related to common plant / functional area or common cable size
Power Supply	Three Phase LV	Group LV related to common plant / functional area or common cable size

Provide insulating covers on terminals where voltages exceed ELV and where a degree of protection to a minimum of IP2x is required. Provide and clearly display a warning notice to prevent accidental contact by persons during service.

Self-adhesive type cable mounts shall not be accepted.

3.4.22 Ventilation

Provide adequate low level inlet and high level outlet vents at top, sides or rear of switchboards as required to keep all contained equipment to less than 50^{o}C.

Provide mechanical forced ventilation for equipment where required air refresh specified rates exceed natural ventilation.

Cover ventilation openings using non-combustible and non-corroding 1mm mesh complete with replaceable dust filters (where specified) of adequate area.

3.4.23 Equipment Mounting Trays

Shall be strong enough to support the weight of mounted equipment. Construct using 3mm mild steel plate, 15mm fold on all edges, bolted to switchboard studs.

3.4.24 Earth Continuity

Effectively bond equipment and assembly cabinet metal frames to the protective earth conductor. Strip painted surfaces and coat with corrosion resistant material immediately before bolting to the earth bar. Provide serrated washers under bolt heads and nuts at painted, structural metal-to-metal joints.

3.4.25 Lifting Provisions

For assemblies with shipping dimensions exceeding 1.8 m high x 600 mm wide, provide fixings in the supporting structure and removable attachments for lifting.

3.4.26 Supporting Structure

Provide concealed fixings or brackets to allow assemblies to be mounted and fixed in position without removing equipment.

3.4.27 Wall-mounting

Reinforce at bolt holes. For flush or semi-flush assemblies, provide angle trims of the same material and finish as the enclosure.

3.4.28 Floor-mounting

Provide mild steel channel plinth, galvanized, nominal 75 mm high x 40 mm wide x 6 mm thick, complete with fixing tabs to enable vertical drilling. Drill M12 clearance holes in assembly and channel and bolt assemblies to channel. Bolt channels to structural floor. Provide shimming for levelling. Backfill air gaps with epoxy.

3.4.29 Mounting

Floor mounted: Assemblies generally.

Wall mounted: Front access assemblies with frontal areas <1m^2 where space permits.

3.4.30 Hard stand Area

Provide a concrete hard stand area in front of all external switchboards. Similarly provide a concrete hard stand areas for cubicles and equipment were maintenance activities are performed e.g. control cubicles, instruments, analysers, security panels, solar invertors and alike.

The hard stand area dimension shall be as follows.

- Width - full width of a switchboard /cubicle.
- Length – front of switchboard / cubicle plus 600 from open door swing radius.
- Minimum width and length of 900 x 900.

3.5 Switchboard General Items

3.5.1 Switchboard Construction Unlicensed Access Areas

To enable switchboard areas requiring access by unlicensed personnel to perform duties such as programming of PLC / RTUs or calibration of instrumentation, switchboards shall be designed and constructed to segregate ELV from LV such that any adjacent LV items have a minimum protection rating of IP4X from ELV accessible areas (Refer 3.4 Electrical Switchboard Access Labelling).

3.5.2 Variable Speed Drives

Motors greater than 90KW controlled by a VSD shall be fitted with insulated bearings NDE (Non Drive End) & earthing ring installed on DE (Drive End). The stator windings shall have a

minimum insulation voltage rating of 1,200V, nominal operating voltage of up to 430V and a withstand maximum voltage gradient (dV/dt) not less than 5,200 V/µs.

Operation of equipment fitted with a VSD shall be limited to panel mounted control switches with manual speed control via a 10 turn potentiometer.

Motors fitted directly with an integrated VSD shall not be accepted.

Drives installed in corrosive atmospheres shall be supplied with conformal coated circuit boards (includes electronic soft starters.).

Ventilation arrangements to reduce operating temperatures to below the manufacturer nominated operating temperature shall be assessed according to the load, number of VSDs or other heat loads operating in parallel and the size the of switchboard, switch room or building. For example, a 110 kW free standing VSD within a pump building may not require any additional ventilation compared with the same arrangement located within a switch room or switchboard.

To limit operational temperatures within the limits of the drive, measures may include:

- Venting VSD back channel heat directly external to the switchboard, switch room or building by means of vents, ducts or covers.
- Fan forced inlet or extraction within switchboards, switch rooms or buildings.
- Air conditioning within switchboards or switch rooms.
- Combinations of the above.

3.5.3 Indicator Lights

Construction

Separate termination block and LED globe.

Colours

Unless denoted on the electrical design schematics the following lens colours shall follow.

Examples not limited to.

Red	Not Operating / Fault:	Valve Closed, Motor Fault, Batching, PLC Fault
Green	Operating:	Valve Open, Motor Running, Generator Running, Mixing, Dosing.
Amber	Process Fault Condition:	High Level, No Flow.
Blue	Function:	Pump Duty Call, Backwash, Motor Heaters Operating.

Lamp Test Facility

Provide individual push-to-test or common test circuit.

3.5.4 Control Relays

Construction

Provide test button and energisation status indicator either light emitting diode or mechanical flag.

3.5.5 Phase Failure Relays

General: Provide separate solid-state phase failure relays which release at

- 85% of normal voltage; adjustable hysteresis
- single phase failure; or
- Reverse phase sequence after an appropriate time delay.

Sensing circuit: Rejects induced voltage spikes, and disturbances with frequencies other than 50Hz.

Back-up protection: Provide high rupturing capacity fuses to each phase.

3.5.6 Anti-Condensation Heaters

General

Rating: Provide heaters rated at not less than 20 W/m^2 of total external area including top of weatherproof enclosure.

Type: Black heat type which may be touched without injury, mechanically protected and thermostatically controlled.

3.5.7 Transient Protection

Primary Protection

High discharge capacity tested with an 8/20 µs waveform: 20 or 40 kA per phase.

- Lines protected L-L, L-N, L-G, N-G
- LED indication representing protection status and surge event
- Remote contact output representing surge event.
- Modular construction per phase and neutral.

Connection

- Maximum length between main circuit supply active and associated fuse, isolator, arrestor, neutral and earth conductor connections: 1 m.
- Maximum length between earth conductor and earth grid/electrode system: 5 m.
- Minimum cable size: 6 mm^{2,} stranded, green/yellow PVC insulated cable installed such that it is segregated from all other cables.

3.5.8 Tools and Spares Storage

Spare parts shall be provided as per Section 11.10.

To store spares, provide one of the following storage facilities in the given order of preference:

a) locate within existing spares shelving where there is adequate unallocated space, or

b) locate within new additional shelving located adjacent existing spares shelving, or.

c) Locate within new shelving where there is adequate space in an indoor utility area within the facility, or

Spares shelving shall be:

- located indoors
- on shelving rated for the loads
- Electrical, control and instruments shall be stored in a dust proof facility.
  PLC and RTC cards shall be sealed in their original packaging.

- have special tools (eg: racking handles) in one partitioned area and spares in another section
- have all spares stored on shelves or within bins which are labelled with the contents
- be accessible by trolley through doors > 1.5m wide.

Large spares not sensitive to dust or water may be located on undercover racks on approval of South East Water. Racks shall be located at ground level unless a folk lift is available, can safely access the racking and multilevel racking is already located on site.

3.5.9 Control of Equipment

General

Provide panel or field mounted selector switch and/or pushbuttons to determine equipment modes of operation. Typical selectable modes are: Manual - Off - Automatic. The use of proprietary keypads for example as provided on VSDs, soft starters and valve actuators shall not be used to select the equipment modes of operation.

Equipment

Pumps, fans, compressors, motorised valves, solenoid valves, mixers, blowers, screws, scrapers, skimmers, conveyors and the alike.

Modes of operation

Start, stop, run, manual, jog, on, off, open, close, forward, reverse, speed up, speed down, local, remote and auto.

Location

Where practicable, position control switches within direct line of sight of the equipment to be controlled. Exceptions are remote internal motor control centres.

UV Protection

Non-metallic field control stations subject to direct sunlight shall be enclosed within a either a stainless steel or aluminium enclosure.

3.6 Electrical Switchboard Access Labelling

Provide labels on switchboard doors and escutcheons to indicate authorised access level.

Label	*Switchboard Degree Of Protection (IP Rating)*	*Additional Information*
Authorised Person Only	min *IP2X	Label requirements for Low Voltage switchgear and control gear assemblies intended to be installed in places where unlicensed persons require access for their use.
Licensed Person Only	Unrestricted.	Electric shock risk sign required. Access may only be gained by the use of a tool.

*The degree of protection of an item of enclosed equipment is expressed as an IP (International Protection) rating, in accordance with AS60529.

3.6.1 Definitions

Authorized Person

The person in charge of the premises, appointed contractor or other persons appointed by the person in charge to perform duties on the premises.

Licenced Person

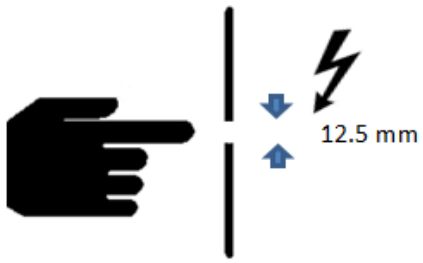
Holder of a Victorian Electrical Worker's Licence entitled to carry out low voltage electrical installation work.

Low Voltage

Exceeding 50 Va.c. or 120V ripple-free d.c, but not exceeding 1000 Va.c. or 1500 Vd.c.

IP2X

Switchgear and control gear assemblies constructed such that the jointed finger shall have adequate clearance from hazardous parts. Penetrations of >12.5 mm diameter sphere not allowed.



3.6.2 Electric Shock Risk Signage

Where access to live parts is required, attention is required for the removal of covers and the like:

In addition, a danger sign with appropriate message displayed on the enclosure of the assembly to alert person to the hazard.

4. Electricity Supply

4.1 General

4.1.1 Definitions

Ipsc: The Prospective Short Circuit current that would flow at point in the installation where a connection of negligible impedance is provided across all phases, without a change in supply.

Imsc calculation: The maximum Ipsc for the installation at any time is subject to the supply transformer impedance, cable impedance and voltage drop. The maximum Ipsc determines rms kA rating of protection devices.

4.1.2 Electricity Supply

The electricity supply configuration shall follow a 400/230 low voltage, three phase, four wire 50Hz with a Multiple Earth Neutral earthing system.

4.1.3 Capacity

Calculate the supply cables size to support the required and nominated future load with a minimum 15 % spare capacity.

4.1.4 Power Factor Correction

Power correction shall be installed where the site power factor is less than 0.9 and the installation is subject to distribution kVA demand charges.

Distribution demand and/or usage criteria are as follows.

Ausnet

NSP56 Critical Peak Demand multirate > 50 kVA and < 400 MWh

NSP75 Critical Peak Demand multirate > 150kVA and < 750 MWh

NSP76 Critical Peak Demand multirate > 280kVA and > 750 MWh

NSP77 Critical Peak Demand multirate > 550kVA and > 2 GWh

NSP78 Critical Peak Demand multirate > 850kVA and > 4 GWh

United Energy

LVkVATOU Low voltage large KVA time of use > 150KVA and/or >400MWh

4.1.5 Alternate Standby Generation Supply - Permanent

All switchboards (main switchboards and sub-boards) shall be fitted with connections to either permanent generators or temporary standby generators (refer section 4.1.6).

Where a permanent standby generator is specified, the switchboard shall incorporate the standby generator supply changeover system. Supply changeover switches shall consist of two circuit breakers with mechanical interlock, contactors shall not be accepted.

External to the switchboard, an intermediate junction cubicle shall terminate the generator supply feeders. Terminations within the junction cubicle shall allow connection of a secondary generator in the event the primary generator is offline due to failure or prolonged maintenance.

Reference document - South East Water Standby Diesel Generator Specification AM2717.

4.1.6 Alternate Standby Generation Supply – Temporary

All switchboards (main switchboards and sub-boards) shall be fitted with connections to either permanent generators (refer section 4.1.5) or temporary standby generators.

Where a temporary standby generator connection point is specified, the switchboard shall incorporate the standby generator supply changeover system. Supply changeover switches shall consist of a manual load break switch incorporating an off position.

External to the switchboard generator connection shall be via a decontactor socket or Powerlock connectors complete with a sequential mating box. Either systems shall be housed within a lockable weatherproof enclosure.

4.2 Electricity Distribution and Retail Company

4.2.1 Point Of Supply

Liaise with the Distribution Company requesting the electricity point of supply to resource the site's maximum load and future demand.

Where applicable ascertain the distribution company's supply contribution charge, scope of works and deliverable time.

4.2.2 Connection

Pay for all Distribution Company costs and charges associated with the permanent connection of the consumer mains, metering provision and relevant inspections.

4.2.3 Preferred Retailer

Contact South East Water to determine current electricity retailer and metering provider.

5. PLC & RTU Installation

The following requirement outlines PLC or RTU installation for both new and retrofitted installations. For retrofit applications the requirement shall be met where practical.

5.1 General

PLC and RTU installations shall meet the following requirements:

- PLCs and RTUs shall be located within a separate compartment of the switchboard which shall contain the programmable devices, relevant I/O, communications interfaces and associated terminal strips and interposing relays. This compartment shall be designed and installed in accordance with section 3.5.
- PLCs and RTUs shall be supplied with power from the 24VDC system.
- Each PLC and RTU rack shall have its own protected power supply module.
- Daisy chaining of Ethernet devices is not permitted e.g. between variable speed drives.
- PLC and RTU IO voltages shall nominally be 24 VDC.
- Analogue signal IO shall be 4 - 20mA.
- Space shall be allocated within the PLC and RTU sections of the switchboard to terminate all spare slots (cards).
- A 240VAC double GPO shall be installed within the PLC cabinet. This is to be installed in a location such that the 240VAC cabling will not be run with ELV (24 VDC) control cabling.
- Interposing relays shall be installed for all digital outputs.

5.2 IO Termination

IO shall be terminated as follows:

- Where possible and for all new PLC or RTU installations, IO terminal strips shall be used between field wiring and PLC IO terminals.
- Multicore cable with pre-numbered cores shall be used between PLC IO cards and IO terminal strips, with numbered cable identification at the junction of each core at the IO terminal strip.
- These terminal strips shall be DIN rail mounted.
- Terminal strips are to be labelled and segregated into a) input analogue, b) input digital, c) output analogue, and d) output digital.
- In each terminal strip, order terminals in alphanumerical order in accordance with the wire's unique identification number.
- Digital inputs and outputs shall be individually fused at the IO terminal strip with a test link for the common terminal; each common supplying a group of inputs shall also be separately fused.
- Analogue input and output IO terminal strips shall have a fuse installed on the positive (+) and a test link installed on the negative (-). In addition to this, each analogue IO point shall contain a terminal for the connection of outgoing shield connection.
- Space shall be allocated within the PLC and RTU compartment of the switchboard to terminate all spare slots (cards). Refer section 3.4.8 for details.

5.3 IO Segregation

Where plant or equipment has operational redundancy, the control system IO shall be configured to ensure the plant redundancy is maintained if there is a failure of a control system IO card. In such cases, all PLC IO shall be segregated between IO cards / modules for each piece of redundant plant equipment. E.g. Dosing pumps in a duty / standby arrangement shall have all inputs / outputs for each pump connected to different IO cards in the PLC.

Where plant equipment has further redundancy employed such as redundant paths or redundancy of entire plant processes, the IO should be segregated into different IO racks in separate switchboard compartments that each comprises all of the equipment associated with each redundant plant item. Common-cause failure(CCF) shall be considered in designing the system. Common cause failure occurs when multiple (usually identical) components fail due to shared causes.

5.4 IO Surge Protection

All field analogue input cables >5 metres long shall have surge protection both at the instrument and PLC IO card end. Refer section 6.1.10 for details.

6. Instrumentation

6.1 Installation

6.1.1 Arrangement

Instruments shall be arranged so that adjustments can be readily made in the field. Permanent access shall be provided for all field indicators, transmitters, analysers, actuators and points of calibration or challenge testing. Where applicable provide drain and test points with associated isolation valves for in situ calibration without the requirement to dismantle supports or pipework.

6.1.2 Field Enclosures

Mount field instruments within enclosures between 800 and 1500 mm above ground providing the following degree of protection.

- IP 56 minimum for all equipment above the ground
- IP 67 minimum for all equipment in the pits, e.g. valve pits,
- IP 68 for the equipment subject to submergence.

Enclosures shall be constructed from marine grade aluminium folded and welded construction or of 316 stainless steel construction, powder coated finish. Locking systems to conform to clause 3.2.15. Provide adequate ventilation where applicable.

6.1.3 Instruments within Buildings

Mount instruments collectively on a common panel. Panel material to be Non-metallic, 10mm Grey PVC or equivalent.

6.1.4 Support

Where applicable instruments shall be mounted using brackets as supplied by the manufacturer. No instrument shall be installed dependent only on its impulse piping, process or electrical connection.

6.1.5 Electrical Isolation

Instruments supplied by a voltage equal to or greater than low voltage shall be fitted with a local isolator. Local isolation shall include lockable isolators for hard wired equipment or plug socket combinations. Refer clause 2.8.

6.1.6 Instrument Clean Earth

An Instrument Clean Earth shall be installed at the location of each field instrumentation enclosure. The Instrument Clean Earth shall be isolated from the site structure and other metal work. The Instrument Clean Earth shall be bonded to the main electrical earthing system at a single point only. The Instrument Clean Earth shall be labelled accordingly.

Instrument signal cabling containing an earth screen shall be left floating in the field end. It shall be electrically continuous from the field equipment and be connected to the Instrument clean Earth bar in the receiving switchboard.

6.1.7 Piping

Provide pipe unions, isolation valves, test and drain points to enable removal or in situ calibration of in line instruments with threaded connections such as pressure transmitter switches, and gauges, rotameters etc.

All small bore fittings shall be Swagelok gaugeable fitting.

All threaded joints shall be BSP threads. NTP threading, BSB tapered and BSP parallel threading may be required for connection of some components.

All cock valves shall be Swagelok quarter turn ball valves. All needle valves shall be Swagelok screwed bonnet needle valves.

All piping and impulse tubing shall be 316 Stainless Steel or flexible nylon. Flexible nylon tubing shall be rated to 1.5 times the maximum measurement value and be fitted with Swagelok gaugeable fittings.

6.1.8 Identification

All equipment and instruments shall be identified by means of 316 stainless steel corrosion resistant tags permanently affixed adjacent to the instrument by means of 316 stainless steel screws or rivets.

6.1.9 Transmission

All instruments shall be capable of transmitting the output signal by loop powered 4-20mA analogue current loop. The output signal shall be linear with a proportional increase in the measured variable. Each transmitter shall be fitted with a configurable local indicator. The indicator shall be integral to the transmitter assembly. The local indicator shall display the measured value in engineering units.

Signal transmission shall be HART protocol compatible. A series resistor of 250 ohms shall be connected within the signal loop located adjacent to the instrument to allow connection of a Hart configurator/ calibrator. Consideration to minimum operating voltage (loop power instruments) and total loop resistance shall be consider when adding series resistance.

6.1.10 Surge Protection

Provide lightning surge protection to instrument loops > 5m installed in field locations. Direct mount the protection device on the instrument or install modular protection enclosed in a cubicle within 1m of the instrument. Provide modular protection at the PLC, RTU, receiving device loop.

Protection: Multi stage 10kA max discharge surge current for an 8/20 micro-second pulse (8 micro-second rise time, 20 micro-second exponential decay time) for line-to-line and line-to-earth transients and arranged to fail to the short circuit condition.

6.2 Magnetic Flowmeters

6.2.1 Arrangement

Arrangement of full bore flowmeters, in pits, direct buried, bypassed or non-bypassed shall be considered specific to each application. Where practicable, the preferred location of flowmeters shall be above ground level or within a facility substructure e.g. pump station pump pit. Where not practicable the standard arrangements shall be as follows unless directed otherwise.

Waste Water Treatment Plants including Class-A,C Treatment

Preference for all flowmeters to be installed in pits.

Bypass of flow meters where immediate replacement of the flow meter is required and/or where the process flow cannot be readily isolated.

Potable Water Pumping / Distribution including Class-A,C

Preference for all flow meters to be direct buried.

Bypass of flow meters where immediate replacement of the flow meter is required and/or where the process flow cannot be readily isolated.

Waste Water Pumping / Distribution

Preference for all flowmeters to be installed in pits.

Bypass of flow meters where immediate replacement of the flow meter is required and/or where the process flow cannot be readily isolated.

6.2.2 Pit Considerations

Considerations to the feasibility of flowmeters installed in pits include.

- Criticality of flowmeter and ease of replacement.
- Size of pit to accommodate flowmeter, reducers, dismantling joints and worker access.
- Water table level.
- Drainage. Immersed flowmeters shall be coated with a petrolatum based mastic.
- Trafficable areas.
- Location to other services.
- Direct buried flowmeters <1.2m depth (measured to flowmeter underside) pit optional.
- Direct buried flowmeters >1.2m depth (measured to flowmeter underside) pit mandatory.

6.2.3 Supply Voltage

The flowmeter supply voltage shall be 24VDC.

6.2.4 Verification

After installation a verification test (wet) and report shall be conducted on each electromagnetic flowmeter. The test shall verify the installation and flowmeter are functioning within defined factory test values to ensure flowmeter accuracy. The verification shall consist of a transmitter test, flowmeter insulation test and flowmeter sensor magnetism test.

6.3 Pressure Instruments

6.3.1 Gauges

Pressure gauges shall be industrial Bourdon tube gauges, or Scaffer diaphragm gauges, and shall be suitable for the service specified. The scale range shall be approximately twice the normal operating pressure.

Gauges shall have a nominal diameter of 150mm and shall be fitted with a 10mm (3/8 BSP) threaded connection.

6.3.2 Pressure Transmitters

Pressure transmitters shall include but not limited to the following.

- Minimum reference accuracy of ±0.004% of calibrated span.
- Stability ±0.20% of upper range limit for 10 years
- Ability to measure either gage or differential pressure.
- Transmitter output, 4–20 mA dc/Digital HART Protocol
- Process connection 316L SS , 1/2'" NPT female
- To include operator interface with buttons
- Stainless steel mounting bracket with SS bolts
- 8 x 6 character display. Ability to configure measured value in mWG
- Polyurethane aluminum housing
- All transmitters to be fitted with block and bleed

Pressure transmitter process fittings shall be arranged to either SEW standard drawing E-PRV-STD-005, E-WP-STD-005 or E-WT-STD-005.

Transmitters fitted with a flange connection or flange remote seal in non-potable, solids or viscous applications shall be fitted with a flushing ring to eliminated medium formed deposits or blockages.

6.4 Measurement Units

Instruments, protective devices and indicating devices shall be calibrated in the following metric units.

Parameter	*Unit Name*	*Symbol*
Pressure	Kilopascals	kPa
Pressure (Water Applications)	Metres Water Gauge	mWG
Level	Metres	m
Flow (Site)	Litres/second	l/s
Flow (Telemetry Host)	Mega litres/day	Mld

6.4.1 Accuracy

Unless otherwise specified, all instruments shall have a measuring accuracy of ± 0.5% of range.

6.4.2 Calibration

Conduct calibration of instruments against a reference instrument, test pressure or standard. Calibrate instrument at 0, 25, 50, 75 and 100% of nominated range.

Provide a calibration report for each function indicating instrument uncertainty, error and adjustment.

Calibrated measurements are to be compared against the manufacturer's specification.

Provide manufactures calibration certificates stating the instrument compliance against the instrument specification.

6.4.3 Ranges

Unless otherwise specified the instrument range shall be from zero (0) to 1.5 times the expected maximum measurement value.

6.4.4 Instrument Zero Reading

Provide instrument zero readings referenced to a known relative level. Relative levels include cover level, bottom level, pipe centre line or invert level.

7. Electric Motors

7.1 General

The requirement applies to single-speed three-phase squirrel-cage type, induction motors for general use, totally enclosed fan cooled with a rated voltage up to and including 400V.

Excluded from the scope of this specification are motors for use in hazardous locations, where additional specific features are required.

7.2 Minimum energy performance standard

Three-phase cage induction motors with ratings in the range from 1 kW to 185 kW shall be high efficiency motors and shall comply with the Minimum Energy Performance Standard (MEPS) requirements of AS 1359.5 Tables A3 or B3.

7.3 Load characteristic

The motor shall have a maximum continuous shaft power rating 10% greater than the maximum required power of the driven load and shall be sufficient to accelerate the driven machine and motor to the design full speed and to perform the specified repeated number of starts, within the limits of temperature rise of the motor.

7.4 Direction of rotation

Electric motors shall be capable of bi-directional operation at maximum continuous rated output without modification.

7.5 Degree of protection

The minimum degree of protection for electrical parts of non-submersible motors shall be IP56 in accordance with AS 60529. Submersible motors shall be IP68 and shall be fitted with moisture detection sensors for both the motor winding and oil chamber.

7.6 Temperature rise

To maintain insulation life, motors shall be provided with a minimum Class ‘F’ insulation operating under a Class ‘B’ temperature rise and class ‘H’ insulation operating under a Class ‘F’ temperature rise.

Insulation Class B Maximum winding Temperature 130°C

Insulation Class F Maximum winding Temperature 155°C

Insulation Class H Maximum winding Temperature 180°C

7.7 Thermistors / Resistance Temperature Detectors

PTC thermistors shall be fitted for all motors rated over 5.0kW and up to 75kW with RTDs fitted for motors greater than 75kW.

7.8 Anti-condensation

Anti-condensation heaters shall be fitted to motors which remain inoperative for >12 hours and are subject to cold temperature or high humidity. The heater shall operate when the motor is turned off to ensure and the motor temperature is held above the surrounding dew point, typically 5-10°C above ambient.

7.9 Vertical Mounting

Motors mounted vertically exposed to rain or installed where exposed to falling condensate shall be fitted with a protection cover over the fan shroud.

7.10 Connection

Motor winding configurations shall be terminated within the motor terminal box permitting a 3-wire cable connection only.

8. Electric Valve Actuators

8.1 General

The requirement applies to electric valve actuators excluding the associated external gearbox and/or pedestal and stem extension.

8.2 Actuator Features

Actuator features shall include but not limited to the following.

- Protection class of actuator, including motor, shall be IP 68.
- Unless specified otherwise, the actuator shall be suitable for operating at 3 phase, 415Volt AC (+/- 10%), 50Hz (+/- 2%) power supply.
- Actuators must be selected to provide sufficient torque and duty required for safe valve operation. Actuator output torque must be available at 90 % of nominal voltage.
- All control signals, communication signals as well as main power supply must be wired to a multi pin plug and socket allowing quick disconnection in the event of maintenance or repair.
- Provide a remote hand stations where actuators are mounted in areas that contravene OH&S.
- Provide an anti-condensation heater inside the actuator, suitable for continuous operation. An alarm signal shall be provided in the event of an anti-condensation heater failure.
- Actuators must be equipped with a hand wheel for manual operation.
- Local controls shall consist of push buttons OPEN-STOP–CLOSE–RESET, lockable selector switch LOCAL-OFF-REMOTE.
- Wireless Bluetooth interface for actuator setup and retrieving operational diagnostic information.
- LCD graphic display to view actuator configuration, torque profiles, status, service alarms, name plate data and operational logs accessible. Display clearly visible under all lighting conditions.
- LCD display and controls fitted with a factory fit cast vandal proof cover
- Industrial ethernet using Profinet co
- mmunication protocol
- 4-20mA valve position output signal, internally powered.
- 4-20mA valve torque output signal, internally powered.
- Common fault relay output.
- Hart communications protocol.
- Provide a spare actuator drive coupling (& serial number) for each unique actuator valve assembly.

8.3 Actuator Commissioning

Actuator operational configuration shall be performed by the actuator vendor.

Relevant configuration files shall be downloaded from the actuator and forwarded as part of the Final Commissioning Submission.

9. Battery Backed Up Power Supplies

Battery backed up power supplies normally fall in to two categories:

1) 240V AC charged batteries which supply 24V DC power to all control, instrumentation, protection and communications devices at both Network Facilities and Treatment Plants. These are referred to as **DC Power Supplies.** Where a 48V or 12V DC supply is required, it shall be provided via a connection to the 24V DC Power Supply system with a 24V to 12V DC or 24V to 48V DC converter, and
2) Treatment facility 240V AC charged batteries which supply uninterruptable power to critical 240V AC devices such as SCADA clients, servers and computers used to operate the plant. These are referred to as **Uninterruptable Power Supplies (UPS)**.

Typically, Treatment Plants will have both a DC Power Supply and a UPS, with the DC Power Supply supplied by the UPS.

In either case, the battery backed up power supply shall when fully charged, on loss of mains supply be capable of supplying the connected load for 4 hours back up time on full load to 80% depth of discharge. The battery storage capacity required shall be calculated based on the expected demand with all IO on and at the worst case (i.4-20mA loops at 20mA and all outputs on). Calculations on the storage capacity are to be approved to SEW.

9.1 DC Power Supplies

All batteries used in DC Power Supplies shall be 12V.

Network Facility DC power supplies shall typically be integrated into the main switchboard. In such cases, the DC battery charger, battery(s) and DC power supply shall be contained within the controls compartment of the main switchboard.

Treatment Plant DC power supplies shall typically be provided as an off the shelf self-contained unit in a single cabinet, separate from other switchboards.

9.2 Battery Enclosures

Larger batteries (ie: $\geq$ 50 A hr) shall be separately installed from electronic components in a ventilated enclosure. The layout of batteries inside enclosures shall be such that all battery terminals and cells are easily accessible for examination of the electrolyte level, topping up, cleaning and replacement.

9.3 UPS General

UPS systems are typically only required at Treatment Plants and shall be used to supply continuous bumpless power to SCADA clients, servers and computers used to operate the plant.

UPS systems shall typically be provided as an off the shelf self-contained unit in a single cabinet, separate from other switchboards.

All printed circuit boards shall be conformal coded.

A Low Voltage Disconnect (LVD) function shall be incorporated into the unit to protect the batteries against excessive discharge. Upon activation of the Low Battery alarm and when the mains supply is unavailable, the PLC and other connected devices will initiate a orderly shutdown of the connected equipment where possible.

In the event of battery bank failure provision of D.C. voltage at specified level shall remain available to the D.C. load circuits direct from the charger.

9.4 UPS Static Bypass

A static bypass switch shall be provided to affect an automatic no-break transfer of load from the UPS supply to the bypass supply in the event of an equipment malfunction or overload.

Following operation of the static bypass switch due to an overload, the load shall be automatically restored to the UPS when normal conditions return. For any other cause, restoration to normal conditions shall require manual operation. Transfer of load to the automatic bypass shall be inhibited when the UPS output is not in synchronism with the bypass supply.

9.5 UPS Maintenance Bypass

A manual maintenance bypass switch shall be provided for online transfer of the load from the UPS to mains supply for maintenance purposes. The maintenance bypass shall be interlocked with the static bypass such that the maintenance bypass is only operable when the static bypass is in service and the 2 supplies can be connected in synchronisation.

9.6 UPS Indications

The following indications shall be provided on the UPS unit as a minimum:

- Mains on
- Charger on float
- Charger on charge
- Charger on boost
- Inverter on
- Static bypass on
- Maintenance bypass on
- UPS fault
- Overload
- Battery volts low

Monitoring voltage free contacts shall be made available to interface to the PLC/RTU system. Any of the above alarms are to be able to be assigned to the configurable contacts.

9.7 UPS Indicating instruments

The following operating values be provided via individual meters or an LCD display:

- Inverter output AC volts
- Inverter output AC amps
- Inverter output frequency
- Battery charger DC volts
- Battery charger DC amps
- Rectifier input AC volts

9.8 Commercial Grade UPS Units < 5kVA rating

It is acknowledged that for small ratings full industrial grade units are not cost effective in the longer term and thus commercial grade units are acceptable. Concessions from the previous clauses apply to UPS units of rating less than 5kVA.

10. Data Networks

10.1 General

10.1.1 Spare Capacity

The data networks shall be designed to cater for future expansion of the plant. Future expansion is integral to allow for plant modifications during the design process, modifications during commissioning, allowance for future plant upgrades and provision for future control system renewals.

Item	*Requirement*
Minimum Subnet & Programming Ports	Minimum of 1 port per VLAN5 on each network switch shall be allocated for programming use
Spare Network Switch Ports	25% minimum spare ports per switch (Total ports used includes ports allocated for programming)
Minimum Fibre Cores	Minimum number of fibre cores shall be 12 cores per fibre type (i.e. for both fibre types of Single-Mode and Multi-Mode)
Minimum Spare Fibre Cores	50% minimum spare fibre cores
Minimum Copper Cables	Minimum number of Cat 6 structured cables between points shall be 4 If practical e.g. 1 Cat 6 cable used run 4 2 Cat 6 cables used run 4 3 Cat 6 cables used run 6
Structured Cabling	50% minimum spare – If practical – Cat 6 structured cabling should be blue
Network switch ports	Cisco IE4000 switch ports 1 to 4 are to be reserved for fibre SFPs – South East Water approval to use for other. Cisco IE4000 switch ports 5 to 8 are to be reserved for PoE devices - South East Water approval to use for other. All other Cisco IE4000 switch ports to be used as assigned by South East Water. Dust caps must be fitted to all spare or unused ports. Cisco IE4010 Ports 12 and 24 are allocated for ether-channelling

If more than 12 fibre cores are required to cover spares or initial requirements another 12 core fibre cable shall be run.

10.1.2 Topology

Fibre optic ring topology shall be designed to ensure a redundant physical path is taken for each section of the ring.

To achieve this all fibre optic cables must form part of a ring topology and no other fibre optic cables in the ring shall be run through the same physical route. The redundant paths shall be in

separate conduits with at least 2 metres separation up to the termination points. South East Water allows the following exceptions to be on spurs or non-redundant physical rings.

- Cameras
- Weather Stations
- Temporary Construction Site Offices

Any other exceptions including secondary rings shall be approved by South East Water.

See Appendix E Data Networks **Topology Terms Examples** section for a diagram showing examples of a main fibre ring, secondary fibre ring and a fibre spur.

Fibre optic patch panels shall match the type of fibre cable used (OM1 for OM1, OM4 for OM4).

10.1.3 Switch Configuration

The South East Water supplied network switches that will be deployed around the treatment plant will have multiple VLANs.

- ICS VLAN
- HMI VLAN
- Corporate VLAN
- Profinet VLAN
- VoIP VLAN
- IO VLAN

South East Water will configure the network switches and provide IP addresses where required. When available network switch alarm contact shall be wired to the PLC (Closed contact equals OK).

Cisco switch alarm contact shall close on power up if alarm conditions are OK and open if alarm condition exists.

10.1.4 Communications Infrastructure

Daisy chaining of Ethernet devices is not permitted e.g. between variable speed drives.

The design should incorporate fibre optic cabling between Ethernet switches. The Contractor will be required to supply and install the fibre network interface modules in these switches (LC SFPs) see approved equipment schedule in Appendix A for details. The LANs shall include an optical fibre self-healing ring topology consisting of components that are industrially hardened.

The fibre ring LAN, including cables, components and switches shall be capable of full duplex 1000 Mbps. Copper network cables for communication between racks and peripheral equipment shall be Cat 6, structured cabling.

Ethernet switches mounted in control panels shall be Cisco industrial DIN rail mounted switching as per standard network equipment list in Appendix A.

Ethernet switches mounted in server racks shall be Cisco 19 inch as per standard network equipment list in Appendix A.

Any OEM equipment which has non-standard switches shall be replaced with structured cabling to the closest ICS network switch or replaced with a switch as per standard network equipment list in Appendix A. Structured cabling runs shall be only used when run is less than 20 metres and inside the same building.

The contractor will be responsible to supply and install the FOBOT's in the rack unit as required in various locations around the treatment plant, see approved equipment schedule in Appendix A. The FOBOT shall use LC connectors and terminate all of the cores of the fibre optic cable.

The design of the fibre optic network shall minimise the potential for physical damage, in particular damage caused to unprotected cables in pits during maintenance activities. The design shall incorporate some type of physical protection or segregation to provide protection.

Within the plant, heavy-duty PVC conduits shall be used for buried connections between pits and conform to relevant Australian standards.

Fibre optic cables running underground shall have termite and rodent proof sheaths. The use of steel wire armoured or similar fibre optic cables such as e.g. external underground loosetube all dielectric rodent proof optical cable from Prysmian Australia PTY LTD. Patch panels shall be compatible with cable used. Patch panels shall be DIN mount in cabinets or control panels and 1RU 19 inch mount in server cabinets.

10.1.5 Public Communications Infrastructure

Public communication infrastructure, e.g. Telstra NextG, maybe required to provide interlocks to remote assets or plant. South East Water will provide the IPWAN and IT infrastructure equipment and South East Water will configure the devices. If required, this equipment will be detailed in the job specific specification.

10.1.6 Wireless Devices

Due to the security implications of license free wireless networks, the SCADA system shall not employ any form of license free wireless connectivity other than wireless devices such as Bluetooth keyboards and mice.

10.1.7 Network Device Security

All unused services and ports on any installed network devices shall be disabled e.g. the FTP service on port 21 of a new PLC CPU device Ethernet LAN RJ45 port should be disabled if not used).

All default user name and/or passwords in devices shall be changed from factory settings to ones assigned by South East Water.

User names and/or passwords for devices and services will be provided by South East Water with the assigned IP addresses.

Security checks will be completed for new devices by South East Water on handover.

10.2 19 Inch Server Racks

19 inch racks and associated equipment shall be selected from the approved equipment schedule in Appendix A. All 19 inch racks shall have at least 50% spare space when installed.

10.2.1 19 Inch Rack Locations and layout

19 inch racks shall be located in an air-conditioned room and shall have thermostatically controlled ventilation fan(s) installed in the top.

When deciding the location of a 19 inch rack, the noise generated by equipment shall be considered (avoid placing the racks in areas that people spend long periods working in close proximity to the racks, e.g. offices or labs).

Layout and connection of equipment in 19 inch racks shall be as shown in Appendix E server rack layout.

10.2.2 19 inch Rack Network Switch Power supplies

Rack mounted network switches in19 inch cabinets shall have 2 separate power supplies.

1 x 240VAC Non UPS Based and 1 x 240VAC UPS based.

Power supplies shall be selected from the approved equipment schedule in Appendix A.

10.3 Control Panels Network Equipment

10.3.1 Indoor

- Cabinet or panel shall have a filtered vent and thermostatically controlled fan.
- Cabinet or panel shall have a condensation heater with thermostat control.
- Cabinet or panel shall be lockable with a standard South East Water cabinet lock.
- Network equipment shall be DIN rail mounted.

10.3.2 Outdoor

- Cabinet or panel shall have a filtered vent and thermostatically controlled fan.
- Cabinet or panel shall have a condensation heater with thermostat control.
- Cabinet or panel shall be stainless steel and have a double skinned roof if outdoors (preferable the whole cabinet or panel is double skinned).
- Cabinet or panel shall be lockable with a South East Water padlock if outdoors.
- Network equipment shall be DIN rail mounted.

10.3.3 Cabinet or Panel Network Switch Power supplies

Network switches in cabinets or control panels where practicable shall have 2 separate power supplies.

Din mounted switches in control panels shall have:

1 x 48VDC Non UPS based

1 x 24VDC UPS based.

The 24 VDC power supply to switches where practicable shall be battery or UPS backed.

48 volt DC power supplies are backup and to allow the Cisco switches to provide power for existing or future PoE (Power over Ethernet) devices.

Power supplies shall be selected from the approved equipment schedule in Appendix A.

48 VDC power supplies shall have 50% spare capacity and be a minimum of 5 amps on the DC secondary side.

10.4 Documentation

Below is a list of some of the documents that will need to be updated / provided to South East Water. The format shall be as per section 1.4 of this document (Electrical Equipment and Installation Specification AM2714).

South East Water will provide a list of existing drawings and documents that will be required to be updated.

- Pit fibre route drawings reference (CAD and PDF).
- Network topology drawings (CAD and PDF).
- Single line drawings for network device power supplies (CAD and PDF).
- PLC IO drawings for network device digital alarms (CAD and PDF).
- IT Topology overview Visio drawing.
- Controls (SCADA) IP address spreadsheet (Excel) and IP Schema will be updated by South East Water IT Department.
- Fibre optic AND Copper cabling test sheets.
- Data sheets located at the end of SCADA standards document - South East Water Treatment Plant PLC SCADA Standard Specification Master.
- Equipment manuals – operation and maintenance.
- Recommended spare parts list.
- Software.
- South East Water network checklist in Appendix E.

10.5 Installation Requirements

10.5.1 General

Installation of all cables shall follow installation standards in this document (Electrical Equipment and Installation Specification AM2714).

The order of precedence of documents shall be as follows;

- Legislative and AS/NZS Standards
- Job specific specifications
- Job specific drawings
- Standard South East Water specifications (This document)
- Other standard South East Water specifications
- Standard drawings

Fibre optic cables and structured copper cabling shall be terminated in a patch panel located either in an existing 19 inch server rack or control cabinet / panel.

South East Water IT approval is required for any new racks cabinets or patch panels

10.5.2 Removal of Redundant Network Related Equipment

All redundant cables and network equipment shall be removed if replaced.

e.g.

Fibre optic and copper cables.

Fibre optic and copper patch leads and patch panels.

Network switches.

Redundant power supplies, fuses, circuit breakers and wiring.

10.5.3 Identification

All equipment and cables shall be identified by means of labels.

Label types shall follow standards in this document.

Building name used on labels shall match the buildings external label.

Cabinet or Control panel name used on labels shall match the label on the outside of the cabinet or control panel.

Patch panel name used on labels shall match the label on the patch panel.

See information below and Appendix E tables E and F for labelling conventions to be used.

First patch panel in each cabinet or control panel should be labelled Patch Panel A.

Next patch panel would be Patch Panel B then C etc.

Each new cabinet or control panel would start at Patch Panel A again.

10.6 Fibre Optic

10.6.1 Fibre Optic Cable

All fibre optic network cable routes must be submitted to South East Water for written approval.

Fibre optic cable shall be either a multimode fibre of minimum OM4 capacity or a single mode fibre.

For fibre optic cable runs less than 500 metres multimode OM4 should be used if suitable for the application.

For fibre optic cable runs greater than 500 metres single mode fibre must be used if suitable for the application.

All terminations of the fibre shall be “LC” type. All fibres including spares in a fibre optic cable shall be terminated at each end in the patch panel. Boots shall cover the unused fibres at the patch panel. Fibre optic cables shall be rodent proof such as e.g. external underground loose tube all dielectric rodent proof optical cable from Prysmian Australia PTY LTD.

10.6.2 Fibre Optic Patch Leads

Fibre optic patch leads shall be selected to match colour standards for grade of fibre Appendix E Table C. When patching directly between 2 fibre cable patch panels, the patch lead shall be labelled with original source and destination building and cabinet. All fibre optic patch leads in cabinets are to be run free inside existing ducting and follow manufacturer prescribed recommendations and minimum bend radius. Patch leads shall be installed to the closest metre in length – minimum amount laying in ducts or tied up. If patch leads need to be cable tied, it shall be done loosely with Velcro straps. Fibre optic patch leads that are run between cabinets need to be labelled with destination Cabinet or Control Panel Name – Patch Panel Name.

Patch leads that are run between cabinets shall also be protected by PVC fixed / flexible conduit for vermin and physical protection or fibre patch leads used shall be stainless steel armoured type. Installation standards in this document shall be followed.

Fibre optic patch leads shall be LC duplex connector at the network switch or patch panel.

Connector at the device if possible should also be LC.

See Table C in Appendix E for patch lead colour standards and selection.

Patch cables to devices within cabinets shall be labelled at each end with the same label, as shown in appendix E table D

10.6.3 Fibre Optic Cable Identification

Fibre optic cables (FOC) termination points (patch panels) shall be labelled at each end with the cable destination.

Example labelling of source and destination FOC at patch panel termination points.

E.G. Cable Number – To Building Name – Cabinet or Control Panel Name – Patch Panel Name

E.G. Cable from RWTP Building - Network Cabinet - Patch Panel A to Blower Building - PLC 102 Control Panel - Patch Panel A.

(At the RWTP End) Label E.G. FOC 12 - To Blower Building - PLC 102 Control Panel - Patch Panel A

(At the Blower End) Label E.G. FOC 12 - To RWTP Building - Network Cabinet - Patch Panel A

Fibre optic cable (FOC) number labels shall also be applied on the inside and outside any panel or cabinet at the cable entry point.

E.G. **FOC 12** for **F**ibre **O**ptic **C**able 12.

Fibre optic cables shall also be clearly labelled in each pit with the Cable number.

E.G. **FOC 12** for **F**ibre **O**ptic **C**able 12.

10.6.4 Fibre Optic Testing

See Appendix E Fibre Optic Testing for details on fibre test requirements.

South East Water network checklist must also be completed for handover.

10.7 Copper

10.7.1 Copper Cable

All copper network cable routes must be submitted to South East Water for written approval.

Where copper Cat 6 structured cables exit a building, gel filled poly Cat 6 shall be run and lightning arrestors installed at each end. Equipment selection as per standard network equipment list in Appendix A.

Any copper cables running between panels shall be Cat 6 and terminated at each end in a South East Water approved patch panel. See standard network equipment list in Appendix A for South East Water approved patch panel types. Cable colour for Cat 6 structured cabling should be blue.

Terminations at patch panels shall be to TIA568A.

Patch panels shall be labelled with the source and destination. See Cat 6 patch lead labelling appendix E table D.

10.7.2 Copper Patch Leads

All Cat 6 patch leads are to be run free inside existing ducting and follow manufacturer prescribed minimum bend radius. Patch leads shall be installed to the closest metre in length – minimum amount laying in ducts or tied up. If patch leads need to be cable tied, it shall be done loosely with Velcro straps. Copper patch leads should not exit the cabinet or be run between cabinets. Structured Cat 6 cabling shall be run to the closest managed network switch and equipment location and terminated in a patch panel at both ends. Cat 6 patch leads shall be selected to match colour standards for network type as per Appendix E table D. Patch cables to devices within cabinets shall be labelled at each end with the same label, as shown in appendix E table D.

10.7.3 Copper Cat 6 Cable Identification

RJ45 Cat 6 copper termination points (patch panels) shall be labelled at each end with the cable destination.

Example labelling of source and destination RJ45 Cat 6 copper cables at patch panel termination points.

E.G. To Building Name – Cabinet or Control Panel Name – Patch Panel Name – Port Range

E.G. 12 RJ45 Cat 6 copper cables from RWTP Building - Network Cabinet - Patch Panel A to RWTP Building - PLC 104 Control Panel - Patch Panel A.

(At the Network Cabinet End) Label E.G. **To RWTP - PLC 102 Control Panel - Patch Panel A – Port 12 to Port 24**

(At the - PLC 104 Control Panel End) Label E.G. **To RWTP - Network Cabinet - Patch Panel A – Port 12 to Port 24**

Cat 6 Cable (C6C) number labels shall also be applied on the inside and outside of any panel or cabinet at the cable entry point. If a group of cables are run from and to the same source / destination points they can be labelled as a group.

E.G. **C6C 4-15** for **C**at **6 C**ables **4 to 15.**

E.G. **C6C 4** for **C**at **6 C**able **4**.

If Cat 6 cables if run external to buildings they shall also be clearly labelled in each pit with the cable number.

E.G. **C6C 4-15** for **C**at **6 C**ables **4 to 15**.

10.7.4 Copper Testing

See Appendix E - Copper CAT 6 Testing for details on CAT 6 structured cable test requirements.

South East Water network checklist must also be completed for handover.

11. Inspection, Testing and Completion

The contractor shall develop an ITP during the design process which details all tests and procedures to be completed through fabrication and installation. It shall at least include plans for Factory Acceptance Testing (FAT), Site Acceptance Testing (SAT), Instrument Calibration, Communications Cable testing and Performance Testing.

Tests shall ensure all equipment operates correctly, safely, and efficiently and meets the correct operation in accordance with the drawings, specifications and manufacturer's requirements.

The ITP shall be submitted to SEW during the design process with no testing to commence until the ITP has been approved in writing by SEW.

Notice shall be given to South East Water's superintendent or nominated representative to witness key stages of construction (important ITP milestones, FAT, SAT, Performance Testing). Nominally 5 working days' notice shall be given unless otherwise negotiated.

All tests shall be witnessed and signed off by an SEW representative.

11.1 Key References

- AM2755 Testing, Commissioning and Handover Plan
- AM2775 Watershed Collection Details (Equipment data sheets)
- AM2522 O&M Manual and Operating Training Specification
- Appendix C – Commissioning Inspection Test Sheet.
- Appendix D – Consumer / Submain, Motor, DC Supply Test Results.
- Appendix E – Instrument Calibration Record
- Appendix F Section 18.7 – Fibre Optic Testing
- Appendix F Section 18.8 – Copper CAT 6 Testing

11.2 Installation & Transition Management Plan

The Contractor must develop an Installation & Transition Management Plan (ITMP) that details the transition planning to either commission a new plant or transition an existing plant from its current control system to the new control system. The plan is to also include rollback plans in the event the cutover cannot be completed.

11.3 Inspection

Inspection during construction shall ensure all equipment is assembled and installed compliant to relevant standards, regulations, manufacturer's guidelines and the requirements of this specification. Inspection shall at least consist of:

- Installation of underground electricity supply mains prior to backfill.
- Installation of underground conduits prior to backfill. Inspect points can be prepared if immediate backfill is required.
- Installation of conduits under concrete or asphalt prior to laying.
- Site electrical inspection conducted by a South East Water nominated registered electrical inspector.
- Visual inspection for construction, finish and standard of work

- Inspection for consistency with design and specifications
- Complete check of wiring and terminations

Photographs of all inspections undertaken shall be included as part of the ITP record.

11.4 Factory Acceptance Testing (FAT)

Prior to delivery of equipment to site, all preassembled equipment shall be tested in accordance with the approved FAT contained within the ITP.

The FAT shall reference the FDS such that the testing replicates the actual operating scenarios. FAT shall be conducted using as much of the “real world” equipment as possible to accurately simulate operating conditions. Prior to FAT, the Contractor shall advise what parts of the testing or equipment will be simulated.

Ensure all solid state devices are protected from excessive voltage or current during testing.

All documentation listed section 11.6 and section **Error! Reference source not found.** shall be made available at the time of FAT.

Equipment shall not be delivered to site until FAT has been completed, fully documented, witnessed and verified in writing by an SEW representative.

The following tests and activities shall be undertaken as a minimum:

- Insulation resistance tests on wiring.

  Carry out insulation resistance tests on the switchboard assembly prior to energisation, to verify the IR readings. Demonstrate >1000 mega Ohm resistance using 1kV megger, with all submains connected.
- Conductance testing: Millivolt drop tests on busbar joints.
- Point to point checks of all input, output and circuit wiring.
- Fault loop impedance tests.
- Testing of interfaces to other equipment
- Functional tests using externally connected simulated circuits and or equipment. Operate and functionally test relays, PLC digital and analogy input outputs, protection, interlocking, metering, indications, switches, ATS systems, thermostats, ventilation and anti-condensation devices. Test all controls, processes, interlocks & protection circuits in reference to the FDS.
- Adjust power supply nominated output voltages.
- Check and adjust settings of motor starting devices.
- Check Current Transformers for polarity and connection.
- Check termination and gland provisions to ensure that they are suitable for cables to be installed on site. Mechanically check clamps, fixings and terminations.
- Full functional testing of local Human Machine Interfaces with reference to the FDS
- Complete testing of all alarms referencing the SAL
- Verification of the range, units, failure mode and deadbands of tags referencing the SDM
- Set settings of protection devices.
- Earth system continuity and resistance tests.
- Continuity and resistance of incoming neutral.

- Polarity.
- Power Factor.
- Phase Sequence.
- Verify operation of residual current devices.
- Confirmation that circuit protective devices are sized and adjusted to protect installed circuits.

11.5 Site Acceptance Testing (SAT)

Following completion of FAT and site installation works, SAT shall be conducted. Where testing involves signals from and commands to field devices these shall be done to/from the completed field device installation as far as practical to minimise the amount of simulation required.

There shall be no soft or PLC simulation during SAT.

The following tests and activities shall be undertaken as a minimum:

- Functional tests of all instrumentation, control, interlock, process, protection and communications in all modes of operation (eg: manual, automatic and remote operation) in reference to the FDS.
- Demonstrate operation of all IO by initiation from the alarm / status source i.e. float, pressure switch, motor overload, limit switch.
- Check correct display of all IO and equipment operation on any local HMI display, South East Water remote SCADA device and the South East Water SCADA Host in reference to the FDS and site alarm list (SAL).
- No-line load tests for any standby generators and UPS's.
- Motor insulation resistance, winding resistance and running load current (if not completed in FAT).
- Process instrumentation equipment verification challenged at 0, 25, 50, 75 and 100% of the calibrated measurement range (if not completed in FAT). Refer Appendix E for Instrument Calibration record requirements.
- Position accuracy checks for all actuators and valves (if not completed in FAT).
- Electromagnetic flowmeter verification test and report.
- Thermographic scan of all main switchboards, sub-assemblies, distribution load centres, motor drives, motors and cable terminations operating under designed loads. Lighting and general purpose outlets excluded. Scan performed by persons accredited with a Level I Infrared Thermography Certification (IRT Cat 1 or equivalent that complies with ISO-18436, ASNT SNT-TC-1A) or higher. Provide a formalised report indicating equipment scanned, defects and corrections.
- OSI PI historian data verification
- Testing of interfaces to other equipment
- Functionality and signal testing of all communication networks
- Testing of all emergency stops, limit switches and safety devices

11.6 Final Submissions

Prior to final performance testing, submit:

- Reports indicating results obtained during pre-commissioning (ITP, FAT and SAT results) indicating compliance or non-compliance with the requirements.
- A full list of telemetry digital and analogy points clearly identifying successful indication and transmission. The list shall indicate Tag No, Description, Status Value, Analog Span, Applied Offset and relevant Engineering Units.
- All software source code and equipment software settings where relevant.
- As-built drawings, operation and equipment maintenance manuals, spare parts schedule, authorities and utilities approvals.
- Submit a final commissioning program (Performance Testing) which outlines the operational specifics to demonstrate the operation of the plant to satisfy the Principal Of Operation.
- Provide valve actuator supplier commissioning setup documentation indicating valve position, direction, speed, open / close position limits, actuator torque set point, alarm outputs, HMI, fail position, manual lever operation
- A complete list of all settings applied to each item of equipment and instrumentation. Include instrument calibration, ranges, instrument relative offsets (i.e. level to mAHD). Refer Appendix E.
- Signed Certificates of Electrical Safety (if applicable) shall be submitted to the SEW representative on satisfactory completion of any work associated with the connection, or modification of AC power supplies.

The various versions of these documents shall be clearly identified. For designated tests, including pre-delivery tests, submit reports or certificates in a form suitable for inclusion in the operation and maintenance manuals.

11.7 Certificates of Electrical Safety

Signed Certificates of Electrical Safety (if applicable) shall be submitted to the SEW representative on satisfactory completion of any work associated with the connection, installation or modification of AC power equipment.

11.8 Cleaning

Prior to final commissioning, clean the following:

- Switch rooms.
- Luminaries.
- Insides of switchboard, switchgear and control gear assemblies, contactors and the like. Adjust as necessary.
- Control escutcheons.
- Face plates of services outlets and panels.

11.9 Completion

A number of electrical equipment related activities which are required to be completed are described within other South East Water Standards. These include:

- Performance Testing (to validate hydraulic, operational and process conformance). Primarily described within AM2755 Testing, Commissioning and Handover Plan.
- As Constructed Drawings.
  Primarily described within AM2488 2D and 3D Drafting.

- Operations and Maintenance Manuals and Training
  Primarily described within AM2522 O&M Manual and Operating Training Specification.
- Submission of Datasheets
  Primarily described within AM2775 Watershed Collection Details.

11.10 Spare Parts

Unless otherwise specified, only the following spares shall be provided for network facilities: water pumps, dosing pumps, sewer pumps, vent fans and odour filters. All network spares shall be labelled with their facility and location and sent to SEW store at Lynbrook.

The following process shall be adopted for the provision of Spare Parts for treatment plant projects:

1) During the tender phase, the Contractor shall assess the items which pose a significant risk to the operation of the project assets, list these items in the tender response and provide a provisional total unit price against each item and a provisional total price for these items.
2) In their tender response, the Contractor shall provide a “mark up” rate (percentage additional cost on top of the manufacturer’s cost) to cover:
   - Consultation with treatment plant operations,
   - Procurement,
   - Packaging, handling and delivery to the spares storage area on site,
   - Checking receipt, marking and numbering in accordance with the spare parts schedule,
   - Referencing equipment schedules in the operation and maintenance manuals; and
   - Painting, greasing and packing to prevent deterioration during storage.
3) Once all items have been purchased and at least 4 weeks before the date for final commissioning, the Contractor shall consult with treatment plant operations on the spares already available and provide a schedule of recommend further spares required. All custom made items shall be included, eg: spare fans. This schedule shall include for each spare: the item description, recommended quantity, manufacturer’s current unit price and marked up cost to South East Water.
4) South East Water will consider the recommendation and advise on new spares required.

Spares shall be provided as per this section unless otherwise approved by South East Water.

11.11 Warrantees

The principal contractor shall be named as the warrantee. The contractor shall register equipment with manufacturers as necessary. Retain copies delivered with components and equipment.

Commencement of warranty periods shall commence at final commissioning at acceptance of installation. Warranty periods to end at expiry of defects liability period (52 weeks) unless specified otherwise.

If installation is not by manufacturer, and the product warranty is conditional on the manufacturer's approval of the installer, submit the manufacturer's written approval of the installing firm.

12. Decommissioning

Unused equipment, switchboards, cables and supporting structures shall be decommissioned or removed as identified within the indented project Scope Of Works.

The site documentation shall be updated depicting removal or status information.

- Cable schedules.
- Equipment schedules.
- Single line diagrams.
- Control schematics
- Piping & Instrumentation diagrams.
- Service plans.

Unless otherwise specified unused protection devices shall be removed.

Items not removed and inoperative shall be made safe by the following means, but not limited to.

- Disconnect equipment so that it cannot become energized.
- Remove unused cable glands and fill penetrations with stop ends.
- Effectively seal conduits with polyurethane polymer expandable foam fill.
- Replace switchboard panels where panel mounted equipment is removed to retain the relevant IP.
- Label equipment with status information affixed appropriately, refer section 2.6 Labels.

Unless otherwise specified all redundant cables shall be removed. Where cables are left in situ, for example cannot be removed or are left intentionally a South East Water M&E Electrical representative shall be notified with and the following information:

Site No	Location Start Description	Approx. Length
Site Name	Location End Description	Termination Type
Reporting Contractor Company	Type of & Size of Cable	Rectification Photo of Start
Reporting Contractor Employee	Cable Depth	Rectification Photo of End
Reason Left In Situ	Associated Drawing Numbers	

The cable conductors shall be terminated in a manner that provides a minimum degree of protection of IP 2X in accordance with AS 60529 Degree Of Protection and be labelled with unique reference tag as assigned by East Water M&E Electrical representative. The reference tag shall include the cable operational status i.e. spare, immovable, reserved etc.

Cable termination methods shall include.

Within switchboards – terminate cable ends to DIN mounted screw terminals or cover cable ends with resin heat shrink sleeve and affix to cables, termination and status information of cables, refer 2.2.3 Cable Markers.

Within cable trenches or pits – cover cable ends with resin heat shrink sleeve or cover cable ends within a polycarbonate termination enclosure appropriately glanded.

13. Appendix A – Approved Equipment

To maintain standard site equipment an approved list of equipment is provided as follows. A status condition is given against each item indicating the prerequisite level. New items of the latest generation of the approved product shall be used.

“Firm” means that the requirement is a preferred requirement of South East Water, however South East Water would be willing to consider varying the requirement if there is substantiation that the proposed variance will produce an equal or superior outcome. A Firm status is a Fixed status until such time as approval from South East Water is given to vary the requirement.

“Fixed” means that this is a mandatory requirement of South East Water.

“Flexible” means that South East Water does not have mandatory or preferred requirements for the particular aspect of the project.

“N” column indicates the product is relevant to Network facilities.

“TP” column indicates the product is relevant to Treatment Plants.

Description	Requirement	N	TP	Status
Ethernet Switch	Low density switching; Cisco IE3000-4TC (4 ports available + additional 2 uplink ports; fibre or copper)		Y	Fixed
	Medium density switching; Cisco IE3000-8TC (8 ports available + additional 2 uplink ports; fibre or copper)		Y	Fixed
	High density switching; Cisco IE4000-4GC4GP4G-E (Maximum flexibility, 8 ports available & PoE, Gigabit all ports + Additional 4 uplink ports; fibre or copper) High density switching in 19 inch racks; Cisco IE-4010-4S24P		Y	Fixed
Operator interface panel	C-more EA3-T6CL	Y		Fixed
	GE Automation- Quickpanel		Y	Fixed
Programmable Logic Controller (PLC)	GE Fanuc		Y	Fixed
	RX3i 12 slot universal base - Part No IC695CHS012		Y	Fixed
	RX3i 24VDC power supply, 40 watts - Part No IC695PSD040		Y	Fixed
	CPE330 2 slot CPU, 1.1Ghz, 64 Mbyte – Part No IC695CPK330		Y	Fixed
	Ethernet Module – Part NoIC695ETM001		Y	Fixed
	RX3i Local Expansion Module – Part NoIC695LRE001		Y	Fixed
	RX3iSerial Communications Module(2ports) – Part No IC695CMM002		Y	Fixed
	Direct Logic Koyo 105 F1-130DR (Sewer High Level Backup System)	Y		Fixed
Flow Switch	IFM Efector SI5000 or SA5000 (Not to be used as a flowmeter)	Y	Y	Flexible
Flowmeter (Magnetic)	Siemens SITRANS FM MAG 5100W flow tube.MAG 6000, IP67 (NEMA 4x/6) Polyamid signal convertor, 24 VDC complete with add-on bus module for HART communication	Y	Y	Fixed
Level Sensor (Hydrostatic)	Vegawell 52 c/w Hart & VegaDIS82 Adjustment Unit	Y	Y	Firm
Level switch	MJK	Y	Y	Firm

Description	Requirement	N	TP	Status
Pressure Switch	United Electric Controls	Y	Y	Firm
Pressure Gauge	Wika - Stainless Steel, Metres Water Gauge, 160mm dia.	Y	Y	Firm
	Floyd - Stainless Steel, Metres Water Gauge, 150mm dia.	Y	Y	Firm
Pressure Transmitter	Rosemount 3051 – Digital display, Hart comms. Push button,	Y	Y	Fixed
Signal Convertor	Red Lion IAMA3535	Y	Y	Firm
Temperature Sensor	Siemens SITRANS TF	Y	Y	Firm
	Rosemount 248	Y	Y	Firm
	Prominent	Y	Y	Firm
	WTW	Y	Y	Firm
	E&H	Y	Y	Firm
	Hatch	Y	Y	Firm
pH	Siemens (Evoqua)	Y	Y	Firm
	Prominent	Y	Y	Firm
	WTW	Y	Y	Firm
	Rosemount	Y	Y	Firm
	E&H	Y	Y	Firm
	Hatch	Y	Y	Firm
Turbidity	Hatch	Y	Y	Firm
EC	Prominent	Y	Y	Flexible
	E&H	Y	Y	Flexible
ORP	E&H	Y	Y	Flexible
UVT	Real Tech	Y	Y	Firm
Free / Total Chlorine	Siemens (Evoqua)	Y	Y	Firm
Flowmeter (Magnetic)	Siemens SITRANS F M MAG 5100 W 7ME6520-3TN12-2AA1 Complete with IP67 / NEMA 4X/6, Polyamid enclosure & display, 11-30V DC/11-24V 7ME6910-1AA30-1AA0	Y	Y	Fixed
	ABB WaterMaster	Y	Y	Fixed
Level Sensor (Hydrostatic)	Vegawell 52 c/w Hart & VegaDIS82 Adjustment Unit	Y	Y	Firm
Level switch	MJK	Y	Y	Firm
Temperature Sensor	WTW	Y	Y	Flexible
	Rosemount	Y	Y	Flexible
Total Suspended Solids	WTW	Y	Y	Flexible
pH	MJK	Y	Y	Flexible
	WTW	Y	Y	Flexible
EC	Honeywell (Technology must be non-contact toroidal)	Y	Y	Flexible
	Yokogawa (Technology must be non-contact toroidal)	Y	Y	Flexible
NH3	ChemScan	Y	Y	Firm
NO3	ChemScan	Y	Y	Firm
Turbidity	Hatch 1720E	Y	Y	Firm
DO	WTW	Y	Y	Flexible
ORP	WTW	Y	Y	Flexible

Ammeters	Crompton Parkinson	Y	Y	Flexible
	NHP	Y	Y	Flexible
Hour run meter	NHP	Y	Y	Flexible
Contactors	Sprecher and Schuh	Y	Y	Firm
Contactor Overload	Sprecher and Schuh Electronic CEP7	Y	Y	Firm
Electronic motor protection relay	Sprecher and Schuh	Y	Y	Firm
	Siemens	Y	Y	Firm
Indicator Lamps	NHP LED BA9s, Separate Termination Block and Globe	Y	Y	Firm
Motor junction box (wet well)	NHP Fibox IP68 (Clear Lid)	Y	Y	Flexible
Potentiometer	Kraus & Naimer CA10 NZV049FT202 FH	Y	Y	Flexible
Push buttons	NHP	Y	Y	Firm
Relays	NHP Finder	Y	Y	Firm
Relay Bases	NHP Finder 4 pole 94.04	Y		Firm
Selector switches	Kraus & Naimer	Y	Y	Firm
Soft Starter	Danfoss MCD500	Y	Y	Fixed
Solenoid Valves	Goyen	Y	Y	Firm
	Danfoss EV Series	Y	Y	Firm
Terminals	Weidmuller W Series - Screw Connection Terminal	Y	Y	Firm
	Telemechanique Linergy TR - Screw Connection Terminal	Y	Y	Firm
Thermistor relay	Sprecher and Schuh RT7 24-240V AC-DC	Y	Y	Firm
Time delay relay	Syrelec	Y	Y	Firm
Variable speed drive	Danfoss VLT Aqua Drive	Y	Y	Fixed
Circuit breakers	Terasaki	Y	Y	Firm
	Schneider Electric - Merlin Gerin	Y	Y	Firm
Main switch	Merlin Gerin,	Y	Y	Firm
	Kraus and Naimer	Y	Y	Firm
	Terasaki	Y	Y	Firm
Generator set Controller	DSE 7320 MKII	Y	Y	Fixed
Harmonic Filter - Active	Danfoss – For Units Greater than 100A units – (IP54 Minimum) - Schaffner Ecosine	Y	Y	Firm
	Sinexcel	Y	Y	Firm
Power Meter	Schneider Electric – PowerLogic, PM8240 (panel mounted)	Y		Flexible
	Siemens SENTRON PAC3200- (1) with Profinet optional module (preferred), or (2) with Modbus TCP (no Profinet) up to 100m away, or (3) with Modbus RTU & RS485 optional module (no Profinet) b/w 100 and 1200m away		Y	Flexible
Miniature circuit breaker (MCB)	Schneider	Y	Y	Firm
	Terasaki	Y	Y	Firm
Moulded-case circuit breaker	Terasaki MCB DTLDC	Y	Y	Firm
	Schneider	Y	Y	Firm
Phase failure relay	Crompton 252-PSGW-SBBX-C5-T1-IA	Y	Y	Firm

Phase Sequence Indicator (Panel Mount)	Crompton 243-12P IME RQ72SE	Y	Y	Firm
Source Transfer Switch	Merlin Gerin UA Controller, IVE Interlock	Y	Y	Fixed
Surge Arrester (Electricity Supply)	Cirprotec PSM Series Pluggable	Y	Y	Firm
Surge Arrester (Equipment)	Novaris SFD Series	Y	Y	Firm
Surge Arrestor (Instrument Loop)	Novaris SL420-G	Y	Y	Firm
Surge Arrestor (Telemetry Arial)	Polyphaser IS- B50LN-C1 Novaris CN-FF-90-M1	Y	Y	Firm
Surge Arrestor (Network Cat 6)	Novaris RJ45-POE Weidmuller VDATA CAT6 006D10V1	Y	Y	Firm
Uninterruptable Power Supply (Treatment plants Only)	Socomec ITYS Pro 20kVA UPS – Circuit boards to be conformal coated from factory.	Y	Y	Fixed
UPS Surge Filter	Eaton ESFi 63A 3 Phase Input Surge Filter Wall Mounted	Y	Y	Firm
Voltmeter	Crompton 244-01Q-SW7	Y	Y	Flexible
UPS	Socomec ITYS Pro 20kVA		Y	Firm
Batteries	Yuasa (12 V Lead Acid)	Y	Y	Flexible
	Panasonic (12 V Lead Acid)	Y	Y	Flexible
DC Battery Charger	Meanwell DR UPS40 (*40 A*)	Y		Firm
DC to AC Invertor	Victron Energy – Phoenix Inverter	Y	Y	Fixed
DC Power Supplies	Meanwell SDR range (*10 to 40 A*)	Y		Firm
Integrated 24V DC Power Supply	Dyne Industries LADDP100-30 (30A supply, required with minimum 150Ahr battery capacity)		Y	Fixed
Power DC Convertor	Puls CD5.121 24V-12V	Y	Y	Firm
Power Supplies 48V DC	Weidmuller PROmax 240W 48V 5A	Y	Y	Firm
Antenna	High Gain Cellular Antenna RFI COL2194	Y	Y	Firm
Digital Modems	Digi WR44R (SEW issued)	Y	Y	Fixed
Remote Telemetry Unit (RTU)	Kingfisher II	Y	Y	Fixed
19 inch server racks	APC, Minimum 40 RU, Painted Black	Y	Y	Flexible
Rack PDU AP8859	APC 2G, Metered, ZeroU, 20A/208V, 16A/230V, (18) C13 & (2) C19	Y	Y	Fixed
19 Inch Rack Power Isolators	Clipsal 56 Series	Y	Y	Firm
19 Inch Rack accessories	Cable management, shelves etc	Y	Y	Flexible
19 Inch Copper RJ45 Patch Panels	Belden 24 port Cat 6. Belden 2 x 12 port LC connector	Y	Y	Firm
19 Inch Fibre Patch Panels	Belden MIP Range OM4 OS2 LC fibre and RJ45 Cat 6	Y	Y	Firm
Din Fibre and Copper Patch Panels	Ruggedized 1000Mb Cisco if 100Mb Named brand	Y	Y	Firm
SFPs	Moxa MGate MB3280	Y	Y	Firm

Modbus Gateways	12 core rodent proof armoured OM4 or SM	Y	Y	Firm
Fibre Optic Cable	LC connector standard inside cabinets Armoured if run outside cabinets	Y	Y	Firm
Fibre Optic Patch Leads	*TBA*	Y	Y	Firm
Light, public external	Sylvania JLA9901L22	Y	Y	Firm
Light, Switchboard	Arlec Slimline Cabinet Light UC0074	Y	Y	Firm
Limit Switch (Switchboard Door)	Element14 - Reed Switch 1447651 – Normally Open Element14- Magnet 1447652	Y	Y	Firm
Terminal Strips	Weidmüller Type SAKR	Y	Y	Firm
Actuators	Rotork IQ4 series or Limitorque, with manufacturer provided display covers	Y	Y	Firm
Ventilation Fan	Lineo V0 Range In-line mixed flow fans	Y		Firm
Motors	*IES min, IE4 if practical, ABB, Toshiba, Siemens, Weg*	Y	Y	Flexible

14. Appendix B – Equipment Identification

General

This requirement is primarily directed to Treatment Plant facilities where equipment identification and labelling is considerable.

Equipment Assignment

South East Water assigns unique asset identification prefixes and numbers associated with installed mechanical and electrical equipment such as pumps, motors, blowers, fans, valves, actuators, instruments and the alike. The identification prefix and number is utilised within South East Water's maintenance services and equipment information systems. To provide conformity with these systems and identification of installed equipment the following process shall be followed.

1. The principal designer shall produce an asset listing of all significant maintainable equipment. Examples of significant maintainable equipment include PLCs, HMIs, RTUs, VSDs, soft starters, main isolators, UPSs, harmonic filters, power factor correction units, valve actuators, motors, compressors, fans, pressure transmitters, analysers, flowmeters, level transmitters and the alike. Examples of insignificant equipment include control relays, fuses, control transformers, power supplies, lighting, control switches, ammeters, indicators and the alike.
2. Against each item on the asset list South East Water shall assign a unique asset prefix, number and description.

Example Plant Effluent Flowmeter FMR 1 01

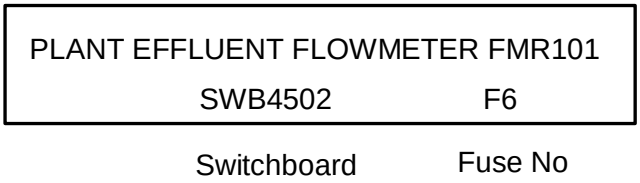
Prefix (Flowmeter Description Number)

3. All design drawings, site equipment labels, SCADA tags, HMI labels, O&M manuals and the alike shall use the assigned asset numbers and descriptions.

Site Equipment Labels

Significant maintainable equipment shall be identified by a label in accordance with the assigned asset prefix, number and description. Additionally for ALL electrically supplied equipment external to switchboards shall include within the label the source of supply.

Example 1 - Flowmeter.



Example 2 - General Purpose Outlet (note no allocated asset ID).

SWB4502 CB17

Refer Section 2.6 Labels for material, size and fixing details.

Electrical Isolation

Continuity of equipment labels shall be adopted to identify electrical connection between the supply source and the end equipment (nominally equipment installed external to the switchboard) to ensure no confusion during electrical isolation. The controlled piece of equipment i.e. pump motor, valve actuator, compressor, fan etc. shall dictate the label's first row of text at each device within the electrical connection.

Example:

Equipment	*Equipment Label Prefix and Asset Number*
WAS Pump 1 Circuit Breaker (located at SWB450 position 6)	WAS PUMP 1 MTR4550
Was Pump 1 Motor Variable Speed Drive (*mounted external to switchboard)	WAS PUMP 1 MTR4550 STARTER STR4750 SWB4500 CB6
WAS Pump 1 Motor Isolator (field isolator)	WAS PUMP 1 MTR4550 SWB4500 CB6
WAS Pump Motor (field mounted)	WAS PUMP 1 MOTOR MTR4550

*note if drive mounted within switchboard line 3 of label not required.

Electrical switchboards shall also be labelled to ensure appropriate isolation information is communicated between switchboards.

Example

CONTROL ROOM LIGHT & POWER SWB6430 SWB6425 CB2

Proprietary Plant

Equipment not specifically itemised within the design drawings that are supplied as a proprietary package such as generators, dosing skids and analyser panels shall be identified with a single equipment label.

15. Appendix C – Site Acceptance and Inspection Test Sheet

Date:	Site ID:
Location:	
Inspected by :	
Contractor:	

SECTION 1: APPLICATION AND FUNDAMENTAL PRINCIPLES				
No.		**AS3000**	**Y**	**N**
1.1	Ensure that all electrical insulation and electrical enclosures provide effective protection against direct contact with live parts in normal operation.	*1.5.4*		
1.2	Ensure that all electrical insulation and electrical enclosures, double insulation and/or isolation transformers provide effective protection against indirect contact with live parts under fault conditions	*1.5.5*		
1.3	Ensure exposed conductive parts be located behind an insulating barrier that provides a degree of protection not less than IPXXB or IP2X and which shall be removable only by use of a tool.	*1.5.5.4*		
1.4	Protection provided against thermal effects, e.g. enclosure, guarding or screening of flammable materials, hot surfaces and parts that may cause physical injury.	1.5.8		
1.5	Ensure that unused cables are protected against unwanted voltages by suitable termination at both ends in the same manner as is required for live conductors.	1.5.11.4		
1.6	Ensure that where electrical cables and/or equipment penetrate fire barriers, that effective protection is provided to prevent spread of fire.	1.5.12		
1.7	Ensure that electrical equipment and accessories are safe to use. There is no damage that could impair safe operation. Unused electrical equipment is safely disconnected.	1.7		
1.8	Ensure that all electrical equipment intended to be installed within an installation complies with required standards.	1.9		
SECTION 2: GENERAL ARRANGEMENT, CONTROL AND PROTECTION				
2.1	Ensure that switchgear is correctly selected and installed to provide isolation, fault protection, accessibility and arranged without affecting other parts of the installation.	2.1		

2.2	Ensure each circuit that requires a neutral shall incorporate a neutral conductor labelled to identify the associated active conductors.	2.2.1		
2.3	Ensure that the current carrying capacity of consumer's mains and sub-mains is correct.	2.2.2		
2.4	Ensure that main switch(s) are fitted and clearly labelled.	2.3.3		
2.5	Ensure that isolation and switching devices are fitted to protect against injury from mechanical movement in electrical devices and motors.	2.3.6		
2.6	Ensure that correct protective overload devices are fitted, especially for max circuit lengths as per Appendix B5.	2.5		
2.7	Ensure that the fault current ratings for RCD/MCB's are appropriate.	2.5.4.5		
2.8	Ensure that correct residual current devices are fitted.	2.6.1		
2.9	Ensure the switchboard is installed correctly, including restricted locations and exit facilities are considered.	2.9.2		
2.10	Ensure that emergency exits are provided.	2.9.2.2		
2.11	Ensure that neutral bars, earth bars, and active links are fitted and correctly terminated.	2.9.4		
2.12	Ensure that switchboards and their electrical equipment are clearly labelled.	2.9.5		
2.13	Ensure that switchboard wiring is correctly terminated.	2.9.6		
SECTION 3: SELECTION AND INSTALLATION OF WIRING SYSTEMS				
3.1	Ensure that cables are protected against external influences.	3.3		
3.2	Ensure that electrical equipment is protected against external influences.	3.3		
3.3	Ensure that switchboards are protected against external influences.	3.3		
3.4	Ensure that cables are protected against external influence.	3.3.1		
3.5	Ensure that the current carrying capacity of circuit wiring is correct in accordance with AS3008.1	3.4		
3.6	Ensure that wiring connections are correct and under no undue pressure.	3.7		
3.7	Ensure that all connections, joints and terminations in earthing conductors are correct.	3.7		
3.8	Ensure that the cable cores are identified.	3.8		

3.9	Ensure that all electrical equipment is connected, supported and fixed, in an acceptable manner and protected from damage.	3.9		
3.10	Ensure that there is adequate support and fixing for cables.	3.9.3		
3.11	Ensure that cables are segregated from other services and electrical installations.	3.9.8		
3.12	Ensure that underground wiring is installed correctly.	3.11		
3.13	Ensure that aerial installation conditions are correct.	3.12		
3.14	Underground Location Diagram	3.11.4.6		
SECTION 4: SELECTION AND INSTALLATION OF APPLIANCES AND ACCESSORIES				
4.1	Ensure that isolation and switching devices are fitted to protect against thermal effects produced by motors, room heaters , water heaters, etc.	4.2		
4.2	Ensure that switching devices for socket outlets are installed as required. Rating, location, IP and isolation.	4.4.4		
4.3	Ensure motor isolation and appropriate interrupt rating.	4.4.4		
SECTION 5: EARTHING ARRANGEMENTS AND EARTHING CONDUCTORS				
5.1	Ensure that all the earthing conductors are the appropriate size and colour.	5.3		
5.2	Ensure that the MEN connection is installed correctly.	5.3.5		
5.3	Ensure that the earth electrode is installed correctly.	5.3.6		
5.4	Ensure that the creation of an earthed situation that may require earthing of additional electrical equipment is addressed.	1.4.44		
5.5	Ensure a permanent label is attached to the main earthing conductor at the earth electrode: WARNING: 'MAIN ELECTRICAL EARTHING CONDUCTOR—DO NOT DISCONNECT'	5.5.1.3		
5.6	Ensure that earthing in outbuildings and detached portions of an electrical installation comply with standards, especially neutral connection.	5.5.3.1		
5.7	Ensure that all the equipotential bonding conductors are the appropriate size and colour.	5.6		
5.8	Ensure circuit loop impedance and protection devices provide protection under earth fault loop conditions.	5.7		
SECTION 6: DAMP SITUATIONS				
6.1	Particular installation conditions for socket outlets around showers and other fixed water containers. There will not be any socket outlets fitted within Zones 0, 1 and 2. Socket outlets installed in a Zone 3 area must be protected by an approved method.	6.2.4.2		

6.2	Particular installation conditions for the selection and installation of electrical equipment for hose down areas. The correct degree of protection shall be provided.	6.7.4.2		
6.3	Particular installation conditions for switches and other accessories around showers and other fixed water containers. There will not be any switches or accessories fitted in a Zone 0 area. Switches and accessories fitted within Zone 1, 2 and 3 areas will be protected by an approved method.	6.2.4.3		
6.4	Particular installation conditions for other electrical equipment around showers and other fixed water containers. The correct degree of protection required for each Zone will be provided for all other electrical equipment.	6.2.4.5		
SECTION 7: SPECIAL ELECTRICAL INSTALLATIONS				
7.1	Ensure that emergency wiring systems are installed correctly.	7.2.7		
7.2	Ensure electricity generation systems are installed correctly.	7.3		
7.3	Particular installation conditions for the selection and installation of electrical equipment for separated and protected extra low voltage installations.	7.5		
7.4	Ensure electrical equipment installed in hazardous areas comply	7.8		
SECTION 8: VERIFICATION				
8.1	Visual inspection and compliance.	8.1		
8.2	Mandatory tests of continuity of earthing, insulation resistance, polarity, correct circuit connections, impedance and operation of RCDs. Refer APPENDIX PART D – Consumer / Submain, Motor, DC Supply Test Results.	8.3.3		

16. Appendix D – Consumer / Submain, Motor, DC Supply Test Results

Date:	**1. CONSUMER-SUBMAIN SWITCHBOARD TEST RESULTS**						
Mandatory testing shall be carried out in accordance with AS/NZS 3000:2007 clause 8.3.							
AS/NZS 3017:2007 sets out some of the common test methods required to test that a low voltage electrical installation complies with AS/NZS 3000:2007.							
Address / location:			**Site ID:**		**Company Name:**		
Registered Electrical Workers name:			**Signature:**		**Licence No.**		
Switchboard / distribution board No:		**PSC[b] at Main Switch: kA**			**All live parts screened from touch without use of tool: (IP2X < 12mm) Yes / No**		
Incoming voltage (if supply avail.): RØ V, WØ V, BØ V.			**Electricity Meter No**	**Phase Failure (%)**	**Phase Failure Delay (s)**		
Test Equipment:	**Type:**	**Serial No.**	**Calibration date:**	**Type:**	**Serial No.**	**Calibration date:**	
	Type:	**Serial No.**	**Calibration date:**	**Type:**	**Serial No.**	**Calibration date:**	

MAIN SWITCHBOARD, CONSUMERS MAINS & MAIN EARTH

M.E.N. Connection & Main Switchboard earthing compliant :- Y / N	**Main Switch / Load Limiter**			**Conductor**		**Earth Continuity - ohms**		**Insulation Resistance - Megohms**				**Rotation /Polarity**		**Comments:**
	Type[a]	Current rating *A*	PSC[b] rating *kA*	C.C.C[c] *A*	Size *mm²*	Main earth conductor	EQ bonding conductors[d]	A - E[d]	A - N[d]	N - E	Phase - Phase[d]	Y / N		
						Ω	**Ω**							

SUBMAINS

Circuit ID & no. of Phases	**Over Current Protective Device**			**Conductor**		**Earth Continuity - ohms**		**Insulation Resistance - Megohms**				**Rotation /Polarity**	**Earth fault loop impedance**	**RCD test results**			
	Type[a]	Current rating *A*	PSC[b] rating *kA*	C.C.C[c] *A*	Size *mm²*	Submain earths	EQ bonding conductors[d]	A - E[d]	A - N[d]	N - E	Phase - Phase[d]	Y / N		Push button test	Current trip test - ms	Supply not avail.	No RCD
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**v**				
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**Ω**				

FINAL SUB CIRCUITS

Circuit ID & no. of Phases	**Over Current Protective Device**			**Conductor**		**Earth Continuity - ohms**		**Insulation Resistance - Megohms**				**Rotation /Polarity**	**Earth fault loop impedance**	**RCD test results**			
	Type[a]	Current rating *A*	PSC[b] rating *kA*	C.C.C[c] *A*	Size *mm²*	Protective earths	EQ bonding conductors[d]	A - E[d]	A - N[d]	N - E	Phase - Phase[d]	R/ S		Push button test	Current trip test - ms	Supply not avail.	No RCD
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**Ω**				
						Ω	**Ω**						**Ω**				
						v							**Ω**				

						Ω	Ω						Ω				
						Ω	Ω						Ω				
						Ω	Ω						Ω				
						Ω	Ω						Ω				
						Ω	Ω						Ω				
						Ω	Ω						Ω				

NOTES:

a. Protective device types : Rewirable fuse = rf, HRC fuse = hrc, Circuit breaker = c/b B,C or D, MCB/RCD combo = rcd, Isolator = isol.

b. PSC = Prospective Short-circuit current in kA. Ref: AS/NZS 3000:2007 clause 2.5.

c. C.C.C = Current Carrying Capacity of the conductor after derating in A. Ref: AS/NZS 3000:2007 clause 3.4.

d. Where multiple results are obtained due to multiphase, multiple EQ bonds etc. record the lowest insulation resistance & highest earth resistance readings obtained.

2. MOTOR LOADS									
Motor ID	**Insulation Resistance**			**Currents**		**Windings**			**Rotation**
	MegOhms	MegOhms	MegOhm s	FLC	Running Current	Ohms	Ohms	Ohms	
	R-E	W-E	B-E			U	V	W	Y/N
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	
	Ω	Ω	Ω	A	A	Ω	Ω	Ω	

3. DC SUPPLY	
Battery Voltage	VDC
Battery Charger Output Voltage	VDC
DC Convertor Output Voltage	VDC

17. Appendix E – Instrument Calibration Record

Site ID:	Site Description:	Date:
Instrument Location:		Watershed Tag No:
Instrument Function:		SCADA Tag No:
Make:	Model:	Serial No:
Supplier:		Instrument Supply Voltage:
Calibrated Range to Units		Output to Units
Calibration Check ☐ Re-Range ☐ Verification ☐ Replacement		Instrument Accuracy %
Instrument Datum:	Offset:	Measuring Reference:

CALIBRATION RESULTS

Input	**Desired**			**Pre Cal**			**Post Cal**		
Span %	Input units	Output units	Units	Output Units	Error %	Units	Output units	Error %	Units
0%									
25%									
50%									
75%									
100%									

PRESSURE SWITCH

Contacts	M.O.F Value		B.O.F Value		M.O.R Values		Process Units	Electrical Value/units
	Post	Pre	Pre	Post	Pre	Post		

SCADA VALUES

Tag No	Zero	Full Scale
Office ☐ Plant Computer ☐		

FLOW METER DETAILS

Flow Sensor Model:	Flow Sensor Serial No:	
Sensor Size:	Cal Factor	Insertion Depth:
Sensor Prom Code Number:	Transmitter Serial No:	Flow Direction Uni. ☐ Bi. ☐

CALIBRATION EQUIPMENT

Input:	Serial No:	Calibration Date:
Output:	Serial No:	Calibration Date:

CALIBRATED BY

Technician Name:	Company:	Signature:
Comments:	Pass ☐ Fail ☐ Action Raised ☐ Operator informed ☐	

18. Appendix F: Data Networks

18.1 Table A: Fibre Optic Numbers and Colours

Fibre Optic Cable Core Individual Fibre Number and Colour Standards		
Fibre number and colour	1	Blue
Fibre number and colour	2	Orange
Fibre number and colour	3	Green
Fibre number and colour	4	Brown
Fibre number and colour	5	Slate
Fibre number and colour	6	White
Fibre number and colour	7	Red
Fibre number and colour	8	Black
Fibre number and colour	9	Yellow
Fibre number and colour	10	Violet
Fibre number and colour	11	Rose
Fibre number and colour	12	Aqua

18.2 Table B: Fibre Optic Patch Lead Colours & Types

Fibre Optic Patch Lead Colours and Type		
Fibre Patch Cable Type and Colour	OM1 or 2	Orange
Fibre Patch Cable Type and Colour	OM3 or 4	Aqua
Fibre Patch Cable Type and Colour	Single Mode OS1 OS2	Yellow

18.3 Table C: Copper Patch Lead Colours & Types

Copper Cat 6 Patch Lead Colour Standards		
Controls (PLC SCADA related devices)	Cat 6	Grey
IO and Profinet (Remote IO and Profinet devices)	Cat 6	Dark Green
Security devices (Cameras)	Cat 6	Pink
IT devices (Office PCs and IP phones)	Cat 6	Blue

18.4 Table D: Lead Labels

Fibre Optic and Copper Patch Lead Labels Within the Same Cabinet					
IE4000	**IE3000**	**Stratix**		**4010**	
Gi1/01	Fa1/01	Fa1/01		Gi1/01	Gi1/013
Gi1/02	Fa1/02	Fa1/02		Gi1/02	Gi1/14
Gi1/03	Fa1/03	Fa1/03		Gi1/03	Gi1/15
Gi1/04	Fa1/04	Fa1/04		Gi1/04	Gi1/16
Gi1/05	..	Fa1/05		Gi1/05	Gi1/17
Gi1/06	..	Fa1/06		Gi1/06	Gi1/18
Gi1/07	..	Fa1/07		Gi1/07	Gi1/19
Gi1/08	..	Fa1/08		Gi1/08	Gi1/20
Gi1/09	..	..		Gi1/09	Gi1/21
Gi1/10	..	..		Gi1/10	Gi1/22
Gi1/11	Gi1/01	Gi1/01		Gi1/11	Gi1/23
Gi1/12	Gi1/02	Gi1/02		Gi1/12	Gi1/24

18.5 Table E: Naming Conventions

Network device naming conventions

South East Water Will provide the network devices and names.

xxxxyyyyzzzz

Where the x's are locality:

blin - Blind Bight

bone - Boneo

lang - Lang Lang

mtma - Mt Martha

pake - Pakenham

some - Somers

The y's are purpose:

icsn - Industrial Control Systems Network

step - Sewage TrEatment Plant Corporate Network

corp - CORPorate Network

cctv - IP Camera Network (acronym slightly awry on this one)

tcs1 - TeleCommunication Services MWAN 1

And the z's are device type:

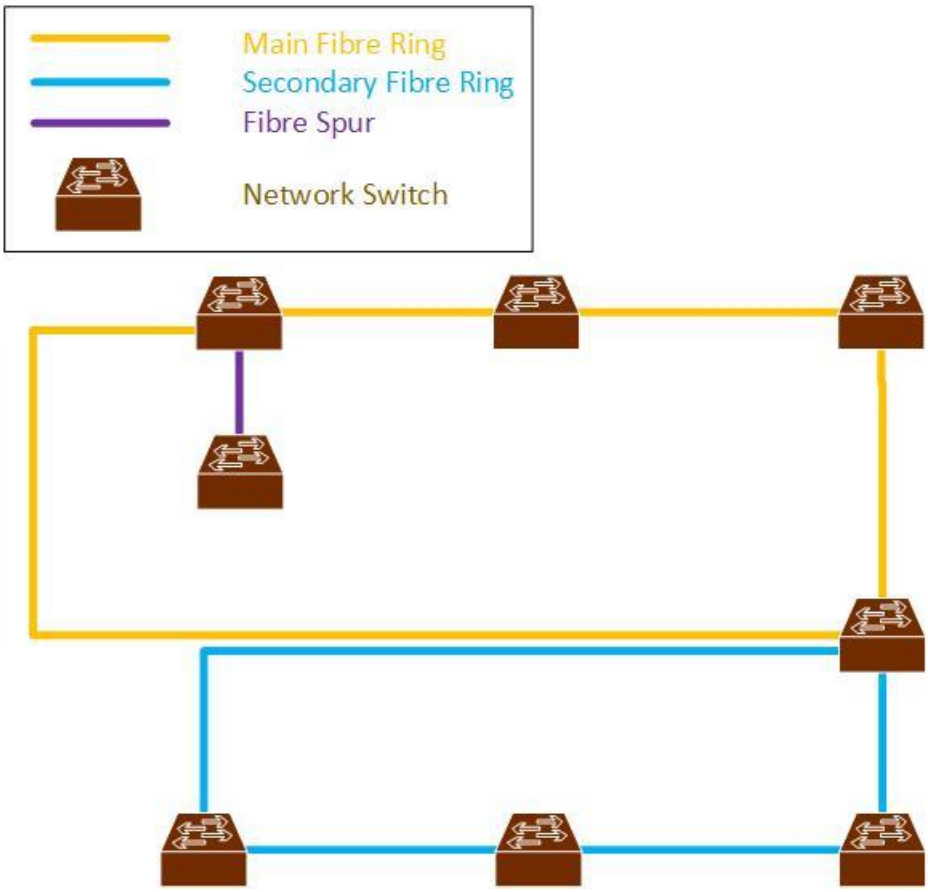
swzz - SWitch number 'zz'

stkz - Switch STacK number ‘z’

fwgz - FireWall Gateway number ‘z’

rtrz - Router number ‘z’

1.1 Topology Terms Examples



18.6 Server Rack Layout

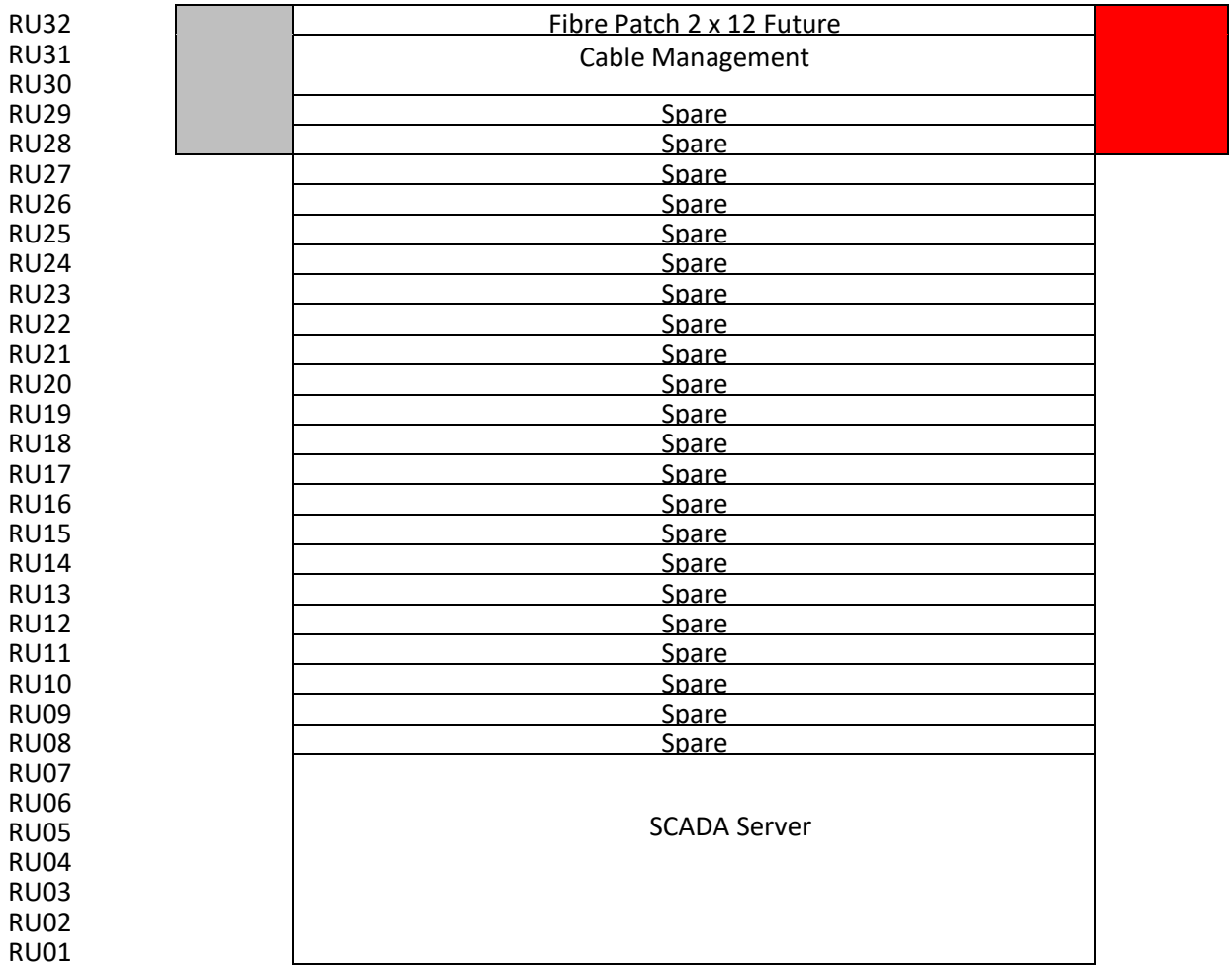
Main Power Isolators must be located on top of the cabinet on the same side as the supplied power rail.

All network connections to be at the rear and rear facing.

Servers to be at the front and front facing.

The view below is of a typical layout shown from the front

	Isolator		Isolator
RU42	Power Rail Non UPS at Rear	TOP Fans	Power Rail UPS at Rear
RU41		Spare	
RU40		Spare	
RU39		RJ45 Patch x 24	
RU38		Cable Management	
RU37		Blank Plate	
RU36		Cisco Switch	
RU35		Blank Plate	
RU34		Cable Management	
RU33			



18.7 Fibre Optic Testing

18.7.1 Minimum Requirements

A. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fibre cabling.

B. This Section includes minimum requirements for:

1. *Fibre optic test instruments*
2. *Fibre optic testing*
3. *Identification*
    a) Labels and labelling
4. *Administration*
    a) Test results documentation
    b) As-built drawings

C. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fibre end faces shall also be verified.

D. Testing shall be performed on each cabling link (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.

   1. *Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.*

F. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps.

   1. *Optionally, documentation shall also include optical length measurements and pictures of the connector end face.*

18.7.2 Quality Assurance

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

   1. *ANSI Z136.2, ANS For Safe Use Of Optical Fibre Communication Systems Utilizing Laser Diode And LED Sources*
   2. *ANSI/TIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fibre Cable Plant with full OTDR descriptions*
   3. *ANSI/TIA-526-7-A, Measurement of Optical Power Loss of Installed Single-Mode Fibre Cable Plant*
   4. *TIA-TSB-4979, Practical Considerations for Implementation of Multimode Launch Conditions in the Field*
   5. *ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises*
   6. *ANSI/TIA-568.3-D, Optical Fibre Cabling and Components Standard*
   7. *ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labelling requirements*

B. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

   1. *Manufacturer of the fibre optic cable and/or the fibre optic connectors.*
   2. *Manufacturer of the test equipment used for the field certification or representative.*
   3. *Training organization.*

C. South East Water or their representative shall be invited to witness and/or review field-testing.

   1. *South East Water or their representative shall be notified of the start date of the testing phase five (5) business days before testing commences.*
   2. *South East Water or their representative will select a random sample of 5% of the installed links and shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to South East Water.*

18.7.3 Submittals

A. Manufacturer's catalogue sheets and specifications for fibre optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.

B. A schedule (list) of all optical fibres to be tested.

C. Sample test reports.

18.7.4 Acceptance of Test Results

A. Unless otherwise specified by South East Water or their representative, each cabling link shall be in compliance with the following test limits:

1. ***Optical Loss Testing***

a) Multimode and Singlemode links

1) *The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568.3-D.*

(i) ***Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)***

(ii) ***Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)***

(iii) ***Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)***

(iv) ***Maximum allowable connector_loss = 0.75 dB***
Check your application, may need to reduce the allowable connector loss.

(v) ***Use of Reference Grade connectors in Test Reference Cords.***

(vi) ***Test Reference Cords shall use Reference Grade connectors and the mated loss budget value (first and last) for these cords for Multimode shall be 0.30 dB and for Single-Mode shall be 0.50 dB.***

(vii) ***Splice_Attn (dB) = number_of_splices * splice_loss (dB)***

(viii) ***Maximum allowable splice_loss = 0.3 dB***
Check application limits, may need to reduce the allowable connector loss.

(ix) ***The values for the Attenuation_Coefficient (dB/km) are listed in the table below: Cable may perform better than this,*** *check the datasheet from the vendor and insert values here if desired*

Type of Optical Fibre	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.0	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. ***OTDR Testing***

   a) Reflective events (connections) shall not exceed: **Check application limits, may need to reduce the allowable connector loss/reflectance.**

      1) *0.75 dB in optical loss when bi-directionally averaged*

      2) *-35 dB Reflectance for multimode connections*

      3) *-40 dB reflectance for UPC singlemode connections*

      4) *-55 dB reflectance for APC singlemode connections*

   b) Non-reflective events (splices) shall not exceed 0.3 dB.
   Check application limits, may need to reduce the allowable splice loss

3. *Magnified end face inspection*

   a) Fibre connections shall be visually inspected to IEC 61300-3-35 Edition 1.0 for end face quality.

   b) Scratched, pitted or dirty connectors shall be diagnosed and corrected.

B. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of South East Water.

   Note: High Bandwidth applications such as 10GBASE-SR, FC1200, and 40GBASE-SR4 impose stringent channel loss limits. Where practical, certification should consider loss length limits that

   meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.

D. Performance specification for multimode fibre links at 850 nm.

Fibre Type		Bandwidth	10GBASE-SR		FibreChannel 1200-MX-SN-I		40GBASE-SR4	
	µm	(MHz• Km)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM 1	62.5	200	33	2.5	33	2.4	N/A	N/A
OM 2	50	500	82	2.3	82	2.2	N/A	N/A
OM 3	50	2000	300	2.6	300	2.6	100	1.9
OM 4	50	4700	400	2.9	N/A	N/A	150	1.5
OM 5	50	4700	400	2.9	N/A	N/A	150	1.5

18.7.5 Optical Fibre Testers

A. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

B. Optical loss test set (OLTS)

1. *Multimode optical fibre light source*

   a) Provide dual LED light sources with central wavelengths of 850 nm (±30 nm) and 1300 nm (±20 nm). VCSEL sources are not permitted per ANSI/TIA-526-14-C.

   b) Output power of –20 dBm minimum.

   c) The launch shall meet the Encircled Flux launch requirements of ANSI/TIA-526-14-C.

   d) The test reference cords must demonstrate an insertion loss ≤ 0.15 dB when mated against each other, and this test shall be stored and delivered with the other test results.

   e) Acceptable manufacturers

      1) *Fluke Networks*

2. *Singlemode optical fibre light source*

   a) Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).

   b) Output power of –10 dBm minimum.

   c) The test reference cords must demonstrate an insertion loss ≤ 0.25 dB when mated against each other, and this test shall be stored and delivered with the other test results.

   d) Acceptable manufacturers

      1) *Fluke Networks*

3. *Power Meter*

   a) Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.

b) Power measurement uncertainty of ± 0.25 dB.

c) Store reference power measurements.

d) Save at least 10,000 results to internal memory.

e) PC interface (USB).

f) Acceptable manufacturers

1) *Fluke Networks*

4. *Optional length measurement*

a) It is preferable to use an OLTS that is capable of measuring the optical length of the fibre using time-of-flight techniques.

C. Optical Time Domain Reflectometer (OTDR)

1. *Shall have a bright, colour LCD display with backlight.*

2. *Shall have rechargeable Li-Ion battery for 8 hours of normal operation.*

3. *Weight with battery and module of not more than 4.5 lb and volume of not more 200 in³.*

4. *Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fibre links.*

5. *USB port to transfer data to a PC or thumb drive/memory stick.*

6. *Multimode OTDR*

a) Wavelengths of 850 nm (± 10 nm) and 1300 nm (+ 35 nm / - 15 nm).

b) Event dead zones not to exceed 0.7 m at 850 nm and 1300 nm.

c) Attenuation dead zones not to exceed 2.5 m at 850 nm and 4.5 m at 1300 nm.

d) Distance range not less than 9,000 m.

e) Dynamic range at least 28 dB for 850 nm and 30 dB at 1300 nm.

f) Allow bi-directional testing without moving the OTDR to the far end.

g) Perform on-board bi-directional averaging.

7. *Singlemode OTDR*

a) Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).

b) Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.

c) Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.

d) Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.

e) Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.

f) Allow bi-directional testing without moving the OTDR to the far end.

g) Perform on-board bi-directional averaging.

8. *Acceptable manufacturers*

a) Fluke Networks

D. Fibre Microscope

1. *Field of view 420 µm x 320 µm*

a) Video camera systems are preferred.

b) Camera probe tips that permit inspection through adapters are required.

c) Test equipment shall be capable of saving and reporting the end face image to IEC 613003-3-35.

2. *Acceptable manufacturers*

a) Fluke Networks

E. Integrated OLTS, OTDR and fibre microscope

1. *Test equipment that combines into one instrument an OLTS, an OTDR and a fibre microscope may be used.*

2. *Acceptable manufacturers*

a) Fluke Networks

18.7.6 Identification

A. Labels

1. *As per South East Water Electrical Equipment and Installation Specification AM2714*

18.7.7 Administration

A. Administration of the documentation shall include test results of each fibre link and channel.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows™-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of these test records

18.7.8 General

A. All tests performed on optical fibre cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.

B. All outlets, cables, patch panels and associated components shall be fully assembled and labelled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

18.7.9 Optical Fibre Testing

A. Field-test instruments shall have the latest software and firmware installed.

B. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC and/or a cloud-based service in which the administrative documentation (reports) may be generated.

C. Fibre end faces shall be inspected using a video scope with a field of view not less than 425 µm x 320 µm.

1. *It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.*

D. Testing shall be performed on each cabling segment (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.

F. Testing of the cabling shall be performed using high-quality test reference cords of the same core size as the cabling under test, terminated with reference grade connectors. Reference grade connectors are defined as having a loss not exceeding 0.1 dB for multimode and 0.2 dB for singlemode. The test reference cords for OLTS testing shall be between 2 m and 5 m in length. The length of the launch and tail fibres for multimode OTDR testing shall be at a least 100 m (328 ft.). For singlemode, the length of the launch and tail fibres will depend on the link under test. As a guide, the following table can be used for determining the length of the launch and tail fibres.

Maximum Length of Link (km)		Typical Pulse Width (ns)	Minimum Launch and Tail Cord Length (m)
1310 nm	1550 nm only		
0 to 35	0 to 50	≤ 1,000	130
35 to 45	50 to 65	3,000	400
45 to 50	65 to 75	10,000	1,000
≥ 50	≥ 75	20,000	2400

G. Optical loss testing

1. *Horizontal/Backbone link*

   a) Multimode links shall be tested in one direction at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-C, one-cord reference method, with an Encircled Flux compliant launch.

   b) Singlemode backbone links shall be tested in one direction at 1310 nm and 1550 nm in accordance with ANSI/TIA-526-7-A, Method A.1 (One-cord reference method).

   c) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

H. OTDR Testing

1. *Fibre links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.*

   a) Multimode: 850 nm and 1300 nm.

   b) Singlemode: 1310 nm and 1550 nm.

2. *Each fibre link and channel shall be tested in both directions.*

   a) The launch and tail fibres shall remain in place for the measurement in the opposite direction – failing to do so will result in an increase in measurement uncertainty.

   b) The use of a loop back fibre at the far end with a tail fibre at the near end on the adjacent fibre is permitted for bi-directional testing, so long as the OTDR is able to split the trace automatically into two traces for the two fibres under test.

3. *A launch cable shall be installed between the OTDR and the first link connection.*

4. *A tail cable shall be installed after the last link connection.*

I. Magnified End face Inspection

1. *Fibres shall be inspected using a video scope with a minimum field of view 425 µm x 320 µm to IEC 61300-3-35 Edition 1.0. The following test limits shall be used:*

a) Multimode connectors; Table 6 of IEC 61300-3-35 Edition 1.0

b) Singlemode field polished connectors; Table 5 of IEC 61300-3-35 Edition 1.0

c) Singlemode factory polished connectors; Table 3 of IEC 61300-3-35 Edition 1.0

d) Angled Physical Contact (APC) connectors; Table 4 of IEC 61300-3-35 Edition 1.0

J. Length Measurement

1. *The length of each fibre shall be recorded.*

2. *It is preferable that the optical length be measured using an OLTS or OTDR.*

K. Polarity Testing

1. *Paired duplex fibres in multi-fibre cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568.3-D. The polarity of the paired duplex fibres shall be verified using an OLTS.*

18.7.10 Identification

A. Labelling

1. *Labelling shall conform to the requirements specified by the South East Water Electrical Equipment and Installation Specification AM2714*

18.7.11 Administration

A. Test results documentation

1. *Test results saved within the field-test instrument shall be transferred into a Windows™-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC or cloud unaltered, i.e., "as saved in the field-test instrument". The following formats do not provide adequate protection of these records and shall not be used.*

a) Portable document format (PDF)

b) Word (.doc & .docx)

c) Comma separated values (.csv)

d) Excel separated values (.xls & .xlsx)

e) Text (.txt)

2. *The test results documentation shall be available for inspection by South East Water or their representative during the installation period and shall be passed to the South East Water or their representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.*

3. *The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered in an electronic format, prior to Owner acceptance of the building in the original format used by the cabling vendors' software.*

4. *Circuit IDs reported by the test instrument should match the specified label ID (see of this Section).*
5. *The detailed test results documentation data is to be provided in an electronic database for each tested optical fibre and shall contain the following information*
    a) The identification of the customer site as specified by the end-user.
    b) The name of the test limit selected to execute the stored test results.
    c) The name of the personnel performing the test.
    d) The date and time the test results were saved in the memory of the tester.
    e) The manufacturer, model and serial number of the field-test instrument.
    f) The version of the test software and the version of the test limit database held within the test instrument.
    g) The fibre identification number.
    h) The length for each optical fibre.
    i) The index of refraction used for length calculation when using length capable OLTS.
    j) The backscatter coefficient of the fibre under test when using an OTDR.
    k) Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
    l) Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
    m) The length for each optical fibre as calculated by the OTDR.
    n) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
    o) Optional
        1) *A picture or image of each fibre end-face*
        2) *A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0*

B. Record copy and as-built drawings
    1. *Provide record copy drawings periodically throughout the project as requested by the South East Water Project Manager, and at end of the project in format as specified in South East Water Electrical Equipment and Installation Specification AM2714.*

18.8 Copper CAT 6 Testing

18.8.1 Minimum Requirements

A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.

B. This Section includes minimum requirements for:
    1. Copper cabling test instruments
    2. Copper cabling testing
    3. Identification

a) Labels and labelling

4. Administration
   a) Test results documentation
   b) As-built drawings

C. Testing shall be carried out in accordance with this document.

D. Testing shall be performed on each cabling link. (100% testing)

E. All tests shall be documented.

18.8.2 Quality Assurance

A. All testing procedures and field-test instruments shall comply with applicable requirements of:
   1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
   2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
   3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
   4. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
   5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labelling requirements.

B. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
   1. Manufacturer of the connectors or cable.
   2. Manufacturer of the test equipment used for the field certification.
   3. Training organizations.

C. The South East Water or their representative shall be invited to witness and/or review field-testing.
   1. South East Water or their representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
   2. South East Water or their representative will select a random sample of 5% of the installed links. South East Water or their representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

18.8.3 Submittals

A. Manufacturers catalogue sheets and specifications for the test equipment.

B. A schedule (list) of all balanced twisted-pair copper links to be tested.

C. Sample test reports.

18.8.4 Acceptance of Test Results

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be tested for:
   1. Wire Map
   2. Length
   3. Propagation Delay
   4. Delay Skew
   5. DC Loop Resistance – recorded for information only
   6. DC Resistance Unbalance – recorded for information only
   7. Insertion Loss
   8. NEXT (Near-End Crosstalk)
   9. PS NEXT (Power Sum Near-End Crosstalk)
   10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
   11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
   12. ACR-F (Attenuation to Crosstalk Ratio Far-End)
   13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
   14. Return Loss
   15. TCL (Transverse Conversion Loss) – recorded for information only
   16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in Part 3. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of South East Water or their representative.

18.8.5 Balanced Twisted Pair Cable Testers

A. The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

B. Certification tester
   1. Accuracy
      a) Level III accuracy in accordance with ANSI/TIA-1152
      b) Independent verification of accuracy
   2. Permanent Link Adapters
      a) RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C

b) Twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures

3. Results Storage
   a) Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below
4. Measurement capabilities
   a) Wire Map
   b) Length
   c) Propagation Delay
   d) Delay Skew
   e) DC Loop Resistance
   f) DC Resistance Unbalance
   g) Insertion Loss
   h) NEXT (Near-End Crosstalk)
   i) PS NEXT (Power Sum Near-End Crosstalk)
   j) ACR-N (Attenuation to Crosstalk Ratio Near-End)
   k) PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
   l) ACR-F (Attenuation to Crosstalk Ratio Far-End)
   m) PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
   n) Return Loss
   o) TCL (Transverse Conversion Loss)
   p) ELTCTL (Equal Level Transverse Conversion Transfer Loss)
   q) Time Domain Reflectometer
   r) Time Domain Xtalk Analyzer

C. PC Software
   1. Windows® based.
   2. Must show when 3 dB and 4 dB rules are applied
   3. Re-certification capability, where results must have their Cable IDs suffixed with (RC).
   4. Built in PDF export – no additional third party software permitted.
   5. Built-in statistical analysis.

18.8.6 Identification

A. Labels
   1. As per South East Water Electrical Equipment and Installation Specification AM2714

18.8.7 Administration

A. Administration of the documentation shall include test results of each Permanent Link.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows® -based database utility that allows for the maintenance, inspection and archiving of these test records.

18.8.8 General

A. All outlets, cables, patch panels and associated components shall be fully assembled and labelled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

18.8.9 Balanced Twisted Pair Cable Testing

A. Field-test instruments shall have the latest software and firmware installed.

B. Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

C. Testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.

D. Permanent Link adapters made from twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures.

E. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6 Permanent Link test each day before use to ensure no degradation of the tester or its Permanent Link adapters.

F. Wire Map Measurement

1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:

   a) Continuity to the remote end

   b) Shorts between any two or more conductors

   c) Reversed pairs

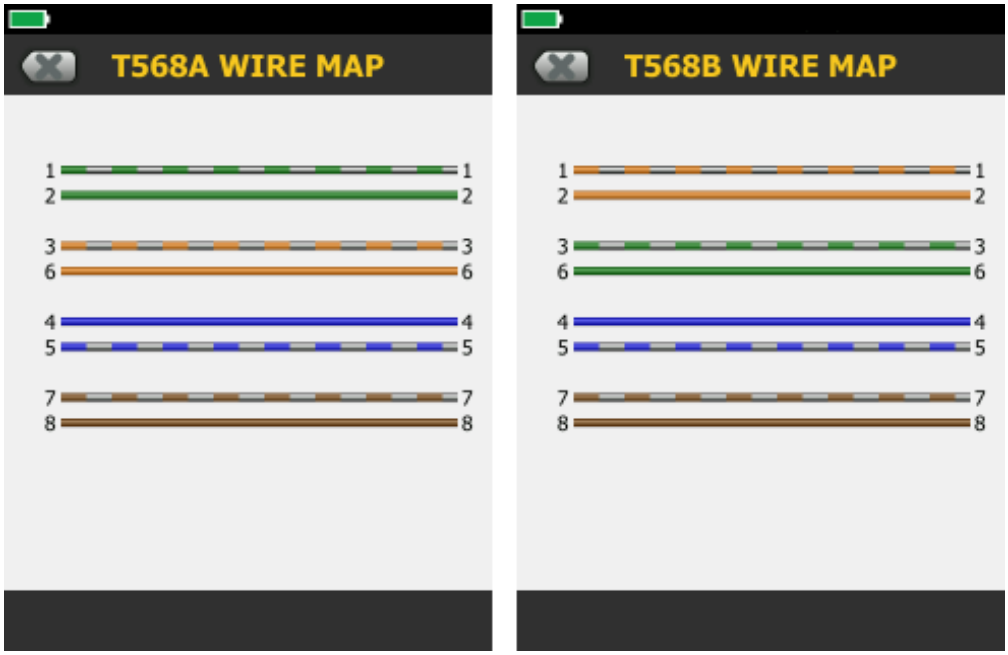
   d) Split pairs

   e) Transposed pairs

   f) Distance to open on shield

   g) Any other miss-wiring

2. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. **T568A scheme is to be used**. The field tester shall document colour scheme used. Examples are given below:



G. Length Measurement
   1. The length of each balanced twisted pair shall be recorded.
   2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
   3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

H. Propagation Delay measurement
   1. Is the time it takes for a signal to reach the end of the link.
   2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
   3. The propagation delay of each balanced twisted pair shall be recorded.
   4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

I. Delay Skew measurement
   1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
   2. The delay skew of each balanced twisted pair shall be recorded.
   3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

J. DC Resistance
   1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
   2. Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.

K. DC Resistance Unbalance
   1. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.

2. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all four pairs.

L. Insertion Loss

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Worst case shall be reported for all four pairs in one direction only.
4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

M. NEXT (Near-End Crosstalk)

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

N. PS NEXT (Power Sum Near-End Crosstalk)

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

O. ACR-N (Attenuation Crosstalk Ratio Near-End)
   1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be calculated in both directions.
   4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 12 possible combinations.

P. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)
   1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be calculated in both directions.
   4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 8 possible combinations.

Q. ACR-F (Attenuation Crosstalk Ratio Far-End)
   1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (24 pair to pair possible combinations)
   4. Both worst case and worst margins shall be reported.
   5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
   6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

R. PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End)
   1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (8 pair possible combinations)
   4. Both worst case and worst margins shall be reported.

5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

S. Return Loss

1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
6. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

T. TCL (Transverse Conversion Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

U. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

18.8.10 Administration

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
2. The test results documentation shall be available for inspection by South East Water or their representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests. The installer shall retain a copy to aid preparation of as-built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered in electronic format prior to South East Water acceptance. This electronic format media shall include the software tools required to view, inspect, and print any selection of the test reports.
4. Circuit IDs reported by the test instrument should match the specified label ID.
5. The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information
    a) The overall Pass/Fail evaluation of the link-under-test
    b) The date and time the test results were saved in the memory of the tester
    c) The identification of the customer site as specified by the end-user
    d) The name of the test limit selected to execute the stored test results
    e) The name of the personnel performing the test
    f) The version of the test software and the version of the test limit database held within the test instrument
    g) The manufacturer, model and serial number of the field-test instrument
    h) The adapters used
    i) The factory calibration date
    j) Wire Map
    k) Propagation Delay values, for all four pairs
    l) Delay Skew values, for all four pairs
    m) DC Resistance values, for all four pairs
    n) DC Resistance Unbalance, values for all four pairs
    o) Insertion Loss, worst case values for all four pairs
    p) NEXT, worst case margin and worst case values, both directions
    q) PS NEXT, worst case margin and worst case values, both directions
    r) ACR-F, worst case margin and worst case values, both directions
    s) PS ACR-F, worst case margin and worst case values, both directions
    t) Return Loss, worst case margin and worst case values, both directions

u) TCL, worst case values both directions

v) ELTCTL, worst case values, both directions.

w) Time Domain Crosstalk data if the link is marginal or fails

x) Time Domain Reflectometer data if the link is marginal or fails

19. Appendix G: Suggested Electrical Contractors

The below tables list companies which have successfully delivered electrical assets to South East Water in the past. This does not guarantee acceptable future performance but indicates that the company understands and has in the past been capable of delivering assets acceptable to South East Water. Companies not on the list that have successfully delivered assets to South East Water are encouraged to contact the owner of this standard if they also wish to also be listed. It is not mandatory that listed contractors be used, however it is advised that only companies such as those listed below that are knowledgeable in this standard be engaged to deliver electrical infrastructure works for South East Water.

Company Name	Contact Name	Contact Email	Contact Phone
Suggest Contractors:			
Lendlease	Peter Bartlett	peter.bartlett@lendlease.com	0419 008 325
Topp Industries	Danny Top	accounts@toppservicesaus.com	0407 344 038
CEI Services	John MacKenzie	John.mackenzie@ceiservices.com.au	03 8777 0923
Jonoco	Noel McKay	noel@jonoco.com.au	03 9540 0311
Ace Electrical	Ashwin Vikash Chand	avchand@acecon.com.au	
Aquatec	Harvey Seeley	hseeley@aquatecenviro.com.au	03 5823 4200
PID	Stuart Bennet	stuart@pidcontrols.com.au	0457 580 477
Suggest Switchboard Fabricators:			
Infinite Controls	Colin Ewart	infinitecontrols@iprimus.com.au	03 8761 6847
CEI Services	John MacKenzie	john.mackenzie@ceiservices.com.au	03 8777 0923
L&I Electrical	Brett Mathers	brett.m@lielectrical.com.au	
SRS Comcell		info@srscomcell.com.au	
Metroid Electrical	Arun Meleppura	arun.m@metroid.net.au	03 5442 5444