General Electrical Construction Standard

No. EC

Ver. 2.1

Date: 27 July 2021

Revision	Description	Released By	Date
0.1	First draft	J de Villiers	02/03/2016
1	First release	J de Villiers – Principal Engineer, Standards	17/11/2016
2	Updated format. Amended to include construction requirements across all sites	J de Villiers	25/03/2020
2.1	Minor updates	J de Villiers	27/07/2021

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Summary of changes

Version	Section	Description of revision
2	Complete	Renumbered sections and paragraphs
		Added sections and alignment between previous general standards and plant electrical standards
	Part A	Updated preamble for consistency with other Watercare construction documents. Updated referenced standards
	Part B, section 5	New section on instrumentation installations
	Part B section 7	Added section on VSD drive installation
	Part B, section 9	Added section on cable support and protection
2.1	Part B, 1.7.2 h)	Updated reference of earth rod size and material to AS/NZS3000
	Part B, 1.13	Added minimum general QA/QDC
	Part B, 3.9	Update QA/QC template
	Part B, 8.4	New section on cable terminations

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Definitions and abbreviations

ac	Alternating current electricity.
Bond cable	
Bypass mode of operation	The load is supplied via the bypass path only and will be affected by bypass supply voltage and frequency variations.
Cadweld	Refer thermite welding.
Cell	Refer to Reference Electrode.
Competent person	A person who is qualified because of a specific knowledge, training and applicable experience that is familiar with the Health and Safety at Work Act and conversant in identifying and taking corrective action to potential dangers in the workplace.
Controlling authority	Person(s) in a position of responsibility that is authorised to make a decision on changes, provide access and provide direction.
Continuity bond cable (cathodic protection)	Bond cable (as defined by AS/NZS3000) carrying current across an insulating fitting, or potentially insulating fitting, such as a gibault joint or line-valve.
Continuity of load power	Availability of the power supplied to the load with voltage and frequency within steady state and with distortion and power interruptions within the limits specified for the load.
CP	Cathodic protection.
CP System	Distinct section of protected pipeline(s) electrically isolated from other sections, and including all cathodic protection plant connected to the pipeline(s). This may include several transformer/rectifiers or sacrificial groundbeds.
dc	Direct current electricity.
dc energy storage	Single or multiple banks (typically batteries) that provide a time dependent back-up power source.
ELS	Epoxy lined steel. In this standard, ELS is also used to refer to any pipe that has an internal dielectric coating or liner.
ESF	Watercare's engineering standards framework is the single point of access for current standards that allows engineering work to comply with the requirements under the Watercare Bylaw.
Engineer	In reference to quality control check sheets templates, a suitably qualified and experienced person to witness and sign-off on the quality and compliance of the work being audited.
FIK	Flange insulating kit or flange isolation kit.
Hazard	Potential source of harm.
ICT	Information and communications technology.

IJ / IF	Insulating joint and insulating flanges. Includes any coupling that is installed with the intention of creating electrical isolation between two sections of pipe. Insulating flanges are the most common type of insulating joints used by Watercare.
Impressed current	Cathodic protection where current is driven by a transformer/rectifier.
Infrastructure	Facilities in an operational capacity that is managed by a controlling authority.
IP	Ingress Protection rating, comprising of two numbered code:

First digit: Solids	Second digit: Liquids
0 - Not protected	**0** – Not protected
1 - >50mm, any large surface of the body but not deliberate contact	**1** – Dripping water, vertically falling drops
2 - >12.5mm Fingers or similar objects	**2** – Dripping water when tilted to 15° from dropping vertical
3 - >2.5mm tools or thick wires etc.	**3** – Water falling as a spray up to an angle of 60° from vertical
4 - >1mm most wires, screws, etc.	**4** – Splashing water from any direction
5 – Dust protected but not entirely prevented, satisfactory protection against contact	**5** – Water jets by nozzle up to 6.3mm from any direction
6 – Dust tight, no ingress of dust, complete protection against contact	**6** – Powerful water jets up to 12.5mm nozzle from any direction
	7 – Immersion up to 1m to a defined time
	8 – Immersion beyond 1m

IR	Insulation Resistance.
Junction Box	Field mounted enclosure for connecting field instrumentation to central control panels via multicore cables.
Maintenance bypass switch	A switch designed and installed to isolate an uninterruptable power supply for maintenance purposes whilst maintaining continuity of load power via an alternate path.
Materials	Materials include all equipment, machinery, components or products used to complete the works

Metallic foreign structures	Includes steel, ductile iron, cast iron, and reinforced concrete pipelines; metal sheathed cables, metal reinforced concrete structures and any equivalent structure that contains metal that may be detrimentally affected by variations in soil potential along or around its surface.
MPO (MTP)	Standard fibre optic connectors.
Native/Static potentials	Natural pipe to soil potential of the pipe, measured before energisation of the cathodic protection system.
Potential monitoring cable	Cable used for measurement of structure potentials only, and not intended to carry current beyond that required for such measurements.
PF	Power factor.
PVC	Polyvinylchloride.
Reference electrode	Copper sulphate, zinc or other calibrated electrode or cell for making connection to ground for measurement of pipe to soil potential. May be portable or buried permanently.
Risk	Combination of the probability of the harm caused by a hazard and the impact or severity that may result.
Static bypass	An alternative supply path to the uninterruptable power supply load. This is normally internal to the uninterruptable power supply via an electronic power switch.
Static transfer switch (STS or ESL)	An electronic switch that automatically transfers the load from one supply to a second supply if the first supply fails or is out of tolerance. The electronic switch typically transfers the supply to the load in less than one half cycle (<10ms) and this transfer normally does not affect the load.
Supply changeover switch or (ATS)	A switch which automatically transfers the load from one supply to a second supply if the first supply fails or is out of tolerance. A supply changeover switch is normally mechanical and results in a loss of supply to the load during changeover.
Surge Diverter / Lightning Arrestor	Heavy duty gas discharge devices that pass lightning electrical surges.
SMOF	Single mode optical fibre.
Specific drawings	Drawings created to inform specific construction requirements from design basis that are not captured by the standards drawings.
Standby or 'Off-line' (UPS)	In normal mode the load is supplied with the alternating current input power. When the ac input supply is out of tolerance, the unit activates the battery inverter and the load is transferred to the inverter directly or via the uninterruptable power supply switch.
Test Point	Location on a pipe where pipe to soil, and other cathodic protection parameters are measured. Includes the test station, cabling, connections and any other structures that enable access for cathodic protection measurements to be taken.

Test Station	Enclosure containing potential monitoring cable terminations. Refer to junction box for enclosures containing only bond cable terminations.
Thermo weld	Refer thermite weld.
Thermite welding	Method for welding a cable connection to a pipe or other structure using a small explosive charge.
TR	Transformer/rectifier. Refers to a direct current power supply that drains electric current from a Watercare pipeline in order to provide cathodic protection.
Uninterruptible power supply (UPS)	A combination of converters, switches and energy storage (normally batteries) that make up a power system for maintaining power to a load without interruption in the event of power failure.
UPS Double conversion (with bypass)	Where continuity of load power is maintained by a uninterruptable power supply inverter with energy from the rectifier in its normal mode of operation or from energy storage in its battery mode of operation. The output voltage and frequency are independent of input voltage and frequency conditions. Under temporary or continuous overload conditions, the load is temporarily supplied with power via the alternative bypass path, in which case the load may be affected by input supply voltage and frequency variations.
UPS Line Interactive	In normal mode the load is supplied with conditioned power via a parallel connection of the ac input and the uninterruptable power supply inverter. The inverter is operating to provide output voltage conditioning. When the ac input supply is out of tolerance the inverter and battery maintain continuity of power and disconnect the ac input supply to prevent back feed from the inverter.
UPS Normal mode of operation	The stable mode of a uninterruptable power supply when supplied under the following conditions: • the alternating current mains is present and within tolerance • the battery system is charged or under recharge • the phase lock is active • the load is within its given range • the output voltage is within its given tolerance • the bypass is available and within tolerance
UPS Parallel redundant system	An uninterruptable power supply with a number of paralleled load sharing uninterruptable power supply units which, upon failure of one or more uninterruptable power supply units, can take over powering the full load with the remainder.
UPS rectifier	The components that convert the alternating current voltage input (from mains) to a direct current voltage.
UPS inverter	The components that convert direct current voltage back to an alternating current voltage.
UPS unit	A complete uninterruptable power supply consisting of inverter, rectifier and direct current energy storage. It may operate with

	other uninterruptable power supply units to form a parallel or redundant uninterruptable power supply.
Utility	A public agency, organisation or entity that is licensed to operate and maintain infrastructure for a public service.

Part A – Preamble and general requirements

1. Introduction

1.1 Purpose and Scope

This standard provides the minimum requirements for electrical construction work acceptable to Watercare. Additional clauses must be added to contracts where specific site constraints exist. Alternative requirements may only be used on written approval from Watercare. Construction work shall be completed by persons competent in their work possessing the minimum skill and competency level required by this standard.

1.2 Applicability

This standard applies to all electrical construction work for infrastructure delivered or vested to Watercare. The level of workmanship and quality shall be demonstrated to meet this standard as required by the Watercare compliance policy.

1.3 'Must' versus 'Shall' versus 'Will'

Where the verbs must, shall and will (or its past tense forms) are used they describe a requirement for compliance with the statement in which it is used.

'Shall' and 'must' expresses a mandatory condition or action. 'Will' is used to prescribe a performance outcome or intent.

2. Standard documents overview

2.1 Relationship of Watercare standards

Watercare standards comprise of codes of practices, design standards, standard design drawings, construction standards, and asset and material standards.

The Watercare standards sets are requirements additional to nominated national standards, international standards and industry best practice to meet, and in some cases exceed legislative requirements, to accomplish long term operability and good asset management practices to benefit our customers. The interface of these standards with each other and the project specifications are as follows:

2.1.1 Design standards

The design standard sets a level of design for particular types of infrastructure based on operational area and associated risk. The design standards provide the minimum criteria for:

- Establishing standard design drawings
- Interface design between standard drawings and specific design
- Establishing the correct sizing of components to meet the baseline parameters of the standard drawings
- The basis for developing tailored designs

2.1.2 Design drawings

The standard design drawings support the requirements of the design standard. Specific standard details are shown on the drawings.

2.1.3 Asset and material standards

The asset standards describe the requirements for asset creation, asset numbering, asset capture, production of manuals and operational documentation. Material standards describe the minimum compliance requirements of materials supplied for asset acceptance. Often selected materials will have

limitations of use and requirements specific to the operating environment and infrastructure classification. Section 6 describes the minimum requirements applicable to this standard. Additional requirements may be specified based on the specific design.

2.1.4 Construction standards

Construction standards prescribe the methods and requirements for workmanship to be employed when constructing works in accordance with the design requirements, standard drawings and bespoke designs. To achieve the best outcome the construction requirements focusses on proven methods and best practice to ensure quality is maintained to achieve the design life of infrastructure and that maintainability, health and safety and environmental requirements are met. Where construction standards are used or referred to in contracts they form part of the specification of the contract.

2.1.5 Project specific specification

These specifications identify site/project specific requirements that are not covered by the normative construction standards or standard design drawings identified during specific design.

2.1.6 Design build projects

Design build projects shall follow the minimum requirements set out in the standard documents for design and construction.

3. Quality control and quality assurance

3.1 Qualifications

All “prescribed electrical work” as defined by the NZ Electrical Regulations (2010) shall be undertaken only by an electrical Contractor licensed under New Zealand Electricity Regulations. All employees of the Contractor undertaking prescribed electrical work on the site shall be licensed under the appropriate category. Proof of registration must be provided. Refer to Watercare’s compliance policy available on our website.

3.2 Auditing during construction

A construction management plan shall identify the quality control points. This standard includes a number of quality control/assurance templates that highlight key compliance checks to be carried out during construction. These quality control templates shall be completed as part of the construction work together with any project specific record keeping requirements for Watercare. The templates provided are the minimum checks that need to be completed and in some instances are required to be completed more than once depending on the type of installation. See Section 4.

An electrical Certificate of Compliance (COC) and an Electrical Safety Certificate (ESC) for each part of the works shall be provided. The ESC is to be issued immediately following livening and testing of the installation at a point where the electrical installer has designated the equipment safe to operate.

In addition all work classified as high risk prescribed electrical work, as per Electricity Safety Regulations 2010, must be tested by a registered electrical inspector and a Record of Inspection (ROI) must be provided by the Contractor.

Where required for building act compliance a producer statement shall be provided. Watercare will apply for the code compliance certificate on receipt of the necessary producer statements.

All completed works shall be provided with a Watercare compliance statement CS3. Refer to Watercare’s compliance policy available on our website.

3.3 Change orders affecting quality

Any change orders for the works shall not compromise quality, safety and regulatory requirements. Any proposed change shall be evaluated against the applicable standard and be demonstrated to comply with the applicable certification and proof of quality documentation.

4. General engineering document submittal requirements

All construction work shall have an accepted construction management plan before any work can commence. This document shall identify the overall planning, coordination and control of the construction activities from start to finish.

4.1 Quality control templates

The completed quality control or quality assurance sheets shall be provided during the identified stages in the construction management plan. All the applicable quality controls shall be completed and signed-off before Watercare will accept the assets.

Items noted as “required” on the QA/QC sheets must be provided or completed and items noted “As specified” is the quantity or requirements that are specified in the particular clauses of construction or referenced standard (whichever takes priority). Certification blocks that are greyed out with “N/A” defines that the items do not apply to the particular party for certification, or that there is no documentation required for the items.

The QA/QC templates shall be certified to confirm that all actions have been completed by each individual.

4.2 Documents for commissioning or livening of electrical works

The prerequisite for construction work that requires progressive commissioning or livening is to provide sufficient supporting documentation to prove the safe and effective operation of the parts. Refer to the Watercare code of practice for commissioning. The deliverables shall include, but are not limited to:

- Preliminary as-built drawings (redline mark-ups)
- Signed off pre-commissioning test results
- Draft operations and maintenance (O&M) manual
- Residual risks register
- Commissioning plan
- Signed electrical Certificate of Compliance (CoC), Electrical Safety Certificate (ESC) and Record of Inspection (ROI) if required by the regulations

At completion of the construction work the following minimum documentation is required in its final format for handover to Watercare:

- Post construction residual risk register
- O&M manual
- Design drawing sets (pdf), as-built drawings (AutoCAD) and survey data
- Asset register
- Compliance statement for construction CS3
- Producer statement where required
- Construction completion report
- Quality control records

Specific details of the content of the above documents and templates are available from Watercare’s Data and Asset Information standard, Material supply standard, CAD manual and Compliance policy.

***Note** – The above listed documents are required for general electrical works. Where specific infrastructure is constructed and this standard is supplemented by the specific standard associated with a component, the additional requirements are provided in the specific standard.*

5. Referenced standards

5.1 General

This standard refers to a number of national and international standards. It is the obligation of users of this document to ensure they make use of the latest version of these standards. Watercare pursues to update this document where standards are replaced however it is expected that the latest recognised replacement by the applicable standard governing body is adopted until such time that this standard can be amended.

5.2 Standards list

This standard must be read in conjunction with the Watercare, national and international standards listed below. Where conflict or ambiguity exists this standard shall take precedence. Where there is conflict between referenced standards, the higher level of standard shall take precedence.

5.2.1 Watercare standards

MS - Material supply standard

7363 - Watercare CAD manual

AI - Data and Asset Information standard

EC – General electrical construction standards

COP-03 Code of Practice for commissioning

5.2.2 National and international standards

General

NZ Electricity Act

NZ Building Code

NZ Health and Safety at Work Act

NZ Radio Interference Regulations

NZ Electricity (safety) Regulations

AS/NZS 3000 Electrical installations (Known as Australian/New Zealand Wiring Rules)

IEC 62305 Protection against lightning

AS 1939 (IEC529) Degrees of protection provided by enclosures for electrical equipment (IP code)

AS/NZS 2053 Conduits and fittings for electrical installations

AS/NZS 60079 part 0 Equipment – General requirements

part 10 Explosive atmospheres – Classification of areas

part 14 Electrical installations design, selection and erection

part 17 Electrical installations inspection and maintenance

part 25 Intrinsically safe electrical systems

Switchboards, Distribution and Control centres

ANSI/IEEE C62.41.2 Recommended practice on characterization of surges in low voltage (1000V and less) AC power circuits

IEC 600439 Low voltage switchgear and controlgear assemblies

Uninterruptable power supplies

BS EN 62040 Uninterruptible power systems (UPS)

IEC 62310 Static transfer systems (STS)

Motors

AS/NZS1359 Parts 5 and 102.3 Rotating electrical machines

AS 1359 Part 114 Rotating electrical machines – General requirements – Vibration measurements and limits

NEMA MG1 part 31, or IEC 60034-25

Electrical cables

AS/NZS 5000 part 1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV

part 2 Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V

part 3 Electric cables - Polymeric insulated - Multicore control cables

AS/NZS 3008 part 1.2 Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical New Zealand conditions

Fibre optic

IEC 61300-3-35 Fibre Optic interconnecting devices and passive components – Basic test and measurement procedures

AS/NZS ISO/IEC 14763 part 3 Telecommunications installations – Implementation and operation of customer premises cabling - Testing of optical fibre cabling

AS/NZS 3080 Information technology – Generic cabling for commercial premises

AS/NZS ISO/IEC 24702 Telecommunications Installations – Generic Cabling - Industrial Premises

AS/ACIF S008 and S009 Requirements for customer cabling product

IEC 60793 (set) Optical Fibres

IEC 60794(set) Optical Fibre Cables

TIA/EIA-455-41 Compressive loading resistance of fibre optic cables

TIA/EIA-455-25 Impact testing of optical fibre cables

TIA/EIA-455-104 Fibre optic cable cyclic-flexing test

Telcordia GR-326 Generic requirements for single mode and multi-mode optical connectors and jumper assemblies

ITU-T / G.650.3 Test methods for installed single mode optical fibre cable links

DURA –LINE (June 2010) Duct Laying Guidelines. Duct Handling and Installation. Duct Laying Field Practices

DURA-LINE Duct Integrity Testing

Cathodic protection

AS/NZS 4853 Electrical hazards on metallic pipelines

AS 2832 part 1 Cathodic protection of metals - Pipes and cables

AS 2239 Galvanic (sacrificial) anodes for cathodic protection

6. Materials

6.1 Material standards

All materials necessary for the work shall be supplied in accordance with Watercare's material standards and as specified by the designer. Materials shall be new and suitable for their intended purpose and performance requirements.

Where no product is nominated it shall be referred to the designer and Watercare for acceptance.

6.2 Recycled or reused materials and prohibited material

Recycled material and material reuse shall not be accepted unless specifically approved by Watercare. The following materials shall not be used under any circumstances:-

- Cadmium or cadmium plating
- Chromium plating
- Untreated exposed copper or copper based alloys, with the exception of copper busbars and cabling exposed ends which shall be tin plated
- Electroplated zinc coated carbon steel
- Asbestos
- Cupronickel
- PCBs or other similar hazardous materials

7. Health and Safety

All work shall be conducted in accordance with the requirements of the Health and Safety at Work Act 2015. Watercare requires that all contractors undergo a Health and Safety induction programme provided by Watercare prior to any work progressing. Health and safety is the responsibility of every person.

The minimum health and safety requirements set out by Watercare must be adhered to and the documentation and procedures must be of an acceptable standard as below:

- Describe the processes to assure compliance with systems, good practice and legislation.

- Provide information to demonstrate that the Health and Safety Management System can manage specific hazards and meeting Watercare minimum requirements. Regulations, approved codes of practice and industry standards or guidelines should be referenced as the basis for hazard controls.
- Provide a Health and Safety Management Plan which addresses controls and unique high risk activities or components of the work.
- Demonstrate the proposed risk controls are adequate and identify alternatives to further reduce risk. Where administrative controls are used, it must be demonstrated that these are sufficient, robust and how they will be properly managed.
- Provide the names of Health and Safety staff and their responsibilities.
- Verify that all workers have received appropriate training for managing the hazards and risks and undertaking the work safely.
- Conduct and record site specific inductions.
- Where work is on an existing Watercare facility or asset an Access Authority is required before work can start.

8. Asset capture

Asset information shall be progressively captured and supplied in accordance with the requirements of Watercare's data and asset information standard.

Part B – Electrical construction

1. General electrical installation

1.1 Material delivery and handling

a) Materials and equipment shall be delivered to the site with the makers' label intact and with certificates of compliance as required, and all data sheets.
b) Materials and equipment shall be inspected to ensure that they are correct, complete and undamaged before proceeding with installation.
c) Materials and equipment shall be stored in accordance with the manufacturer's requirements and protected from damage.
d) Redundant equipment including switchboards and cables shall remain the property of Watercare unless otherwise noted. Redundant equipment shall be decommissioned and stored on site pending the removal of the reusable components by Watercare. The remainder shall be disposed of responsibly.

1.2 Support brackets and fixings

a) Refer to Watercare's general mechanical construction standards for bolting and fixing requirements.
b) Fixings shall have equivalent or better corrosion resistance than the material to which they are joined or held. Galvanic action must be prevented, also see section 1.5 below.
c) Fixings and restraints shall ensure that the equipment withstands seismic loading without excessive stress or displacement in accordance with the NZ Building Code and NZS 4219.
d) Electrical equipment shall not be fixed to handrail systems or process pipework.
e) Equipment shall not cause any obstruction to walkways, trip hazards, headroom, or loss of access to other plant items.
f) Equipment shall not obstruct plant that is requires servicing or operation.

1.3 Hazardous areas

a) Equipment installations within hazardous areas shall employ protection techniques appropriate for hazardous area classification as defined by AS/NZS 60079.
b) All equipment including cable and glands, shall be certified by a recognised testing authority. The examination, testing and certification of the installation shall be documented in the verification dossier in accordance with AS/NZS 60079.
c) Where safety barriers are specified they shall be installed in accordance with the appropriate equipment suppliers' instructions.

1.4 Protection and finishes

Materials, equipment and fixings shall be protected against corrosion, deterioration and absorption of moisture. The protection measures shall be provided as specified by the designer.

1.5 Dissimilar metals

Dissimilar metals shall be protected from electrolysis by insulating washers or gaskets, insulating unions, bituminised felt or similar approved method appropriate to the application.

1.6 Junction boxes and field control stations

a) All junction boxes shall be grade 316 stainless steel and classified to IP65 or better, mounted securely and with a covering protruding over the top seal.
b) Field control stations shall be 316 stainless steel metal clad with an enclosure rating of IP65 to AS 60529.
c) All live exposed parts within the field control station must be protected from direct contact with field control station door open.
d) All junction boxes shall have drain/breather plugs fitted.
e) Boxes that are required to be fully waterproof shall have nylon washers installed with the cable glands and gland adapters.
f) All boxes housing pneumatic equipment shall be vented at the bottom of the box and fitted with a port protector/silencer.

g) An earthed gland plate for cable glands shall be installed in the bottom of every metal junction and field control station box.
h) Terminal rails and individual DIN mounted terminals shall be provided for all terminations. Strip connectors are not acceptable.
i) Cables shall enter from the bottom of the enclosure. Unused entries shall be plugged with an approved product.
j) All terminals shall be numbered and trunking provided on both sides of the terminals. Trunking shall be grey slotted PVC, with a minimum of 20% spare capacity.
k) All junction boxes and field control stations shall be labelled in accordance with section 12 of this standard.

1.7 Earthing

1.7.1 General

a) Earthing shall be installed as per the drawings, in compliance with NZ Electricity Regulations, New Zealand Standard AS/NZS 3000 and any special requirements of the electrical supply.
b) Measure and record the earth resistance and impedance of every earthing system.

1.7.2 Electrodes, main earth and main earth bar

a) All main earth bars shall be tinned copper.
b) The main earth bar for an indoor incoming supply shall be provided in the MCC rooms and/or Transformer pits at a suitable location.
c) For outdoor installations the main earth bar shall be located within the switchboard.
d) All connections to the main earth bars shall be accessible and shall be removable for testing purposes.
e) The main earth bar shall be installed on insulated mounts and used as the connection point for:
   - Supply transformer earth (if installed)
   - Main earth (to earth electrodes)
   - Main switchboard earth
f) The earth bar shall be as sized by the designer and spaced from the support wall to provide a robust, efficient and electrically sound installation. Earth system sizing must ensure equipment protection operates as intended and earth loop impedance values do not inhibit protection from operating.
g) Each Main Earth bar and Main Earth conductors shall be oversized by 20% to allow for future connections.
h) Earth electrodes shall be selected in accordance with AS/NZS3000. Where more than one earth electrode is required, the main earth shall form a ring circuit.
i) Earth grids shall be formed by connecting these earth electrodes with bare copper conductors buried at a depth not less than 450 mm.
j) A proprietary exothermic welding system such as Cadweld shall be used for the bonding between earth electrodes and bare copper conductors.

1.7.3 Structural earth

a) A ‘Wricon’ or an accepted equivalent shall be installed on each building’s reinforcing to provide earth connection points.
b) The connections to the reinforcing shall be made by exothermic welding. The welds shall be inspected before covering.
c) Two ‘Wricon’ building reinforcing connections are required at different locations for every building re-enforcing connection point so that one can be disconnected for testing when required.
d) Earth connections for equipment shall be positioned against the foundation to avoid accidental damage and not to cause a tripping hazard.

1.7.4 Earth continuity conductors

Earth continuity conductors shall be installed with power supply wiring to all electrical equipment as per AS/NZS3000.

1.7.5 Bonding

Metallic ducts, cable trays, cable ladders, handrails, pipework, benches and sinks, taps and partitioning members shall be bonded to the earth bar as per AS/NZS3000.

1.7.6 Lightning protection

Lightning protection shall be installed to IEC 62305. A separate earth electrode shall be exothermically welded as close as practical to aerial masts.

1.8 Lighting

Luminaires shall be installed as detailed on the specific drawings. Alternative luminaires require Watercare approval.

1.9 Power outlets

1.9.1 Socket outlets

a) Socket outlets shall be mounted 300 mm above finished floor level, 200 mm above benches and 1400 mm above finished floor level in plant rooms and outdoors unless specified otherwise.
b) Socket outlets in office areas shall be 3-pin 10A white polycarbonate and flush mounted unless otherwise specified.
c) In all other areas, socket outlets and switches shall be PDL56 type with round pin connections (i.e. as per old Reyrolle Pattern plug connection). Mounting shall be directly to walls or in flush boxes or white polycarbonate mounting blocks as shown on the drawings.
d) Where perimeter trunking is installed, socket outlets shall be mounted in the top section.
e) Three phase switched socket outlets shall be surface mounted.
f) Weatherproof socket outlets shall be surface mount type to minimum IP56 rating.

1.9.2 Fixed outlets

a) In office areas, fixed outlets shall be installed for such items as hot water cylinders, auto doors, roller shutter doors and hand dryers.
b) Fixed outlets shall be mounted 1400 mm nominal above finished floor level, 500 mm above benches or as shown on the drawings.
c) Fixed outlets for single, three phase connections, or fixed outlets in plant rooms, shall be of an approved polycarbonate surface mounted type and be switched with neon indication to show power is on.

1.9.3 Outdoor power distribution

a) Outdoor power enclosure distribution must be:
    - Wall mounted
    - Minimum IP56
    - Yellow high impact polycarbonate enclosure
    - Fastening with stainless steel fixtures
    - Contain switchable unit isolator
    - All circuits protected by RCD.

- Unit protected by over current and short circuit protection
- Installed as per manufacturer's instructions.

1.10 Wiring and terminations

a) Each conductor of control wiring shall be identified at each termination with ferrules or other approved method giving the wire number. Self-adhesive labels will not be accepted for this work.
b) For labelling specific to wires, refer to section 12.4. The Grafoplast system shall be used for labelling cable terminations.
c) Each conductor of power wiring or cabling shall be permanently identified at each end of the appropriate phase, neutral or earth colour code.
d) All wiring shall be fitted with crimp pins/lugs as appropriate before terminating.
e) Each terminal at each terminal block and relays shall be permanently identified.
f) All DIN mount rail terminals shall be screw type to fit TS35 DIN rail.
g) All power and earthing cabling requiring crimp lugs or links, lugs and links must be fitted as per industry best practice. There shall be no exposed conductor from excess stripping of insulation to fit lugs or links.
h) Cable terminations must be tightened to the manufacturer specified sequence and torque setting. The torque wrench or driver must be calibrated.
i) Cable lugs must be correctly sized to ensure full surface contact.
j) Following termination, heat shrink sleeving of the same colour as the conductor insulation must be fitted. Heat shrink must fully cover joint where conductor is exposed as it enters links or lugs.
k) For each cable, a 316 stainless steel or aluminum (silver anodized) tag punched with the cable number as shown on the drawings shall be provided at each end.
l) Each cable tag shall be attached to its cable with cable ties at the point where the cable emerges from the connected panel or equipment.
m) Lettering shall be 3mm in height and shall be in English.

1.11 Cables support identification

a) Exposed cables, cable trays, conduits and catenary wire shall be identified in accordance with NZS 5807. Refer to section 12. Identification lettering and banding shall be applied at the following locations:
   - For buried runs and concealed runs (including in floors and walls) - where the service disappears/reappears
   - For concealed runs in ceiling spaces - every 2,500 mm or part thereof.
   - For exposed runs - every 10 m or part thereof.
b) The identification on the band shall consist of stenciled lettering 25mm high.
c) Where these supports are required to be painted the identification band colour shall extend along the entire length of the support.

1.12 Workmanship

a) The entire installation shall be undertaken in a tidy and efficient manner.
b) The work shall be installed in accordance with manufacturer instructions and any specific requirements noted.
c) Work shall be planned to maintain unobstructed access to equipment.
d) All workmanship shall as a minimum:
   - Be in accordance with best industry practice
   - Comply with the Contract documents
   - Be carried out by appropriately qualified and experienced tradesmen and supervised apprentices
   - Be carried out under the constant supervision of a competent foreman
e) All major equipment installations shall be checked by a qualified and trained representative of the manufacturer, or his agent.

f) All labour and materials required to clean, treat, shim, grout, adjust, alter, support or do any other work on materials and equipment which the manufacturer, or their agent, may consider necessary to achieve a satisfactory installation shall be provided.

1.13 QA/QC template

Minimum mandatory tests:

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Visual inspection	Conducted visual inspection as required by AS/NZS3000		Required	Required
2	Main earth and bonding conductors	Continuity test		Required	Required
3	Protective earth conductors	Loop impedance test, or continuity/ resistance test		Required	Required
4	Insulation resistance			Required	Required
5	Polarity of main supply and sub-circuits			Required	Required
6	Revenue Metering and Correct circuit connectors			Required	Required
7	Protective devices (CBs, RCDs, etc.) verification			Required	Required
		Sign-off			

2. Power transformers

2.1 Installation requirements

a) Warning signage shall be provided on transformer doors stating: “DANGER – HIGH VOLTAGE”.
b) The bund holding volume shall be sufficient for the size of the transformer being installed. For civil construction requirements refer to Watercare’s general civil construction standard.
c) See section 13.4 of this standard for testing requirements. The testing of indoor transformers shall include the operation of the ventilation system.

3. Switchboards, distribution centres and control centres

3.1 General

Refer to Watercare material supply standard for the construction and supply of switchboards, distribution centres and control centres

3.2 Internal wiring and cabling

a) Power and CT secondary wiring shall have a minimum cross sectional area of 2.5mm^2 and be of stranded flexible copper high temperature PVC panel wire, unless otherwise specified. Matching terminals and shorting links shall be provided for all CT secondary circuits.
b) Control wiring shall be stranded flexible copper high temperature PVC panel wire of minimum 0.75 mm^2 matching the current requirement.
c) Control wiring connected to the DCS/PLC I/O module terminations shall be minimum 0.5mm^2. The wiring must be terminated in rail mounted terminal blocks mounted in the same cubicle.
d) Control and power wiring shall be enclosed in slotted PVC ducts. Wiring not enclosed in ducts shall be loomed together neatly. Cable ties at 150mm centers shall be used. For looming, adhesive tape is not acceptable.
e) The cable ducting shall be sized for 30% over-capacity and the cables shall not exert pressure or cause deformation of the enclosure.
f) The distance between cable ducting and equipment shall be minimum 35mm to allow wire termination.
g) No more than two conductors shall be terminated both sides of each terminal. Wire termination shall be with suitable ferrules or crimp lugs. Soldered connections are not permitted.
h) Termination on devices shall be shrouded to prevent contact with live parts
i) Terminal blocks shall be DIN rail mounted with supports and identification accessories. The termination blocks shall allow the following:
    - Testing of circuits connected to the terminal
    - Linking of adjacent terminals
    - Screw-clamp type connections
    - Cross-linking facilities where terminals are associated with current transformers. This facility shall allow the current transformer to be short-circuited
    - Isolation functionality where the terminals are associated with voltage monitoring circuits
    - Segregation barriers between extra low voltage and low voltage terminals
    - 20% spare capacity
j) All unused terminals of equipment shall be wired to the terminal blocks for spare use and labeled individually as spare.
k) Refer to section 12 for labelling, colour coding and identification.

3.3 Equipment labelling

a) Equipment shall be identified in accordance with the labels on the design drawings. All major fixed components within the switchboard including switches, relays and circuit breakers shall be labelled.
b) Both ends of each wire shall be identified with a Grafoplast system of ferrules, crimp pins and markers.
c) Switchboards shall be provided with labels detailing the following information (Refer section 12):
    - Plant asset number (tag name)
    - Manufacturer's name
    - Switchboard's form factor, serial number and the year of manufacture
    - Applicable standards
    - Degree of protection
    - Rated operating voltage
    - Rated frequency
    - Main busbar continuous current rating
    - Main busbar short circuit capacity

3.4 Switchboard specific requirements

Requirements for switchboards are listed in Watercare's material supply standard and as otherwise specified in the design brief.

3.5 Control, indication and instrumentation

Control switches, pushbuttons, lamp indicators and instrumentation shall be labelled as per the drawings. Indicator lamps shall be high intensity LED type. Refer to section 12.7 or push buttons and lamp indication colours.

3.6 Radio installation requirements

a) A gland suitable for co-axial cable shall be installed in the control cubicle gear plate for routing the radio antenna cable to the exterior of the building.
b) The lightning arrestor shall be installed as close as possible to the exit gland of the radio antenna cable and connected to the main earth busbar with 6mm^2 insulated copper PVC earth cable.

3.7 Generator connections

a) The generator connection shall be mounted externally to the switchboard.
b) The generator connection enclosure shall be IP66 rated 316 stainless steel with a lockable hinged panel at the bottom for the generator cable entry.
c) A split rubber barrier shall be fitted over the generator cable entry point to provide touch protection.
d) Connection stabs for the three-phases, neutral and earth shall be provided in the generator connection enclosure.
e) Cabling shall be provided to connect the generator connection with the main switchboard generator circuit breaker or changeover switch.
f) A mechanical interlock shall be provided between the main incomer and changeover switch.
g) A suitable generator cable entry point into buildings must be approved by a suitably qualified civil engineer.

3.8 Outdoor switchboards

a) Outdoor switchboards shall be housed in a pillar box constructed of powder coated marine grade aluminium or 316 stainless steel.
b) All doors shall have wind stays to keep the door(s) in a fixed position when open.
c) A flush mounted lock shall be provided keyed to Watercare requirements.
d) The pillar box shall include a pedestal for mounting the switchboard and a gland plate to separate the switchboard from the pedestal. All cables shall enter the pillar box from the bottom.
e) IP ratings for this equipment are as follows:
    - Switchboards not requiring vents for equipment cooling shall have a minimum IP65 rating.
    - Switchboards requiring vents for equipment cooling shall have a minimum IP55 rating.

3.9 QA/QC template

ENSURE THE MAIN SITE SWITHBOARD IS NOT LIVENED UNTIL THE FOLLOWING IS CARRIED OUT AND DOCUMENTED

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Factory Testing	Provision of factory acceptance test sheets - both visual inspection and test sheets (by switchboard builder)		Required	Required
2	Factory Testing – ESC/CoC	Provision of ESC (electrical safety certificate) – by switchboard builder		Required	Required
3	Site Testing	Provision of site acceptance test sheets (by switchboard builder) – NOTE: REASSEMBLY & MODIFICATION OF SWITCHBOARDS IS TO BE COMPLETED BY THE MANUFACTURER		Required	Required
4	Site Testing – ESC/CoC	Provision of ESC after site assembly & testing (electrical safety certificate) – by switchboard builder		Required	Required
5	Material Supply Standard Check	Cross-check switchboard supplied on site complies with WSL Material Supply standard checklist (MS-01)		Required	Required
6	Pre-commissioning checks	Cross-check switchboard compliance with Code of Practice (COP-03) for checks and **hold points**		Required	Required
7	Revenue Metering and livening (ESC/CoC & ROI)	Provision of ESC and ROI (record of inspection) of metering and mains connection **PRIOR TO LIVENING**		Required	Required
		Sign-off			

4. Uninterruptable power supplies (UPS)

4.1 UPS Room

a) The UPS manufacturer's minimum clearance distances shall be observed and allowance shall be made for access to complete battery testing.
b) UPS systems shall not be installed underneath water, process or chemical lines.
c) The room ventilation shall be fitted with replaceable fan input filters.

4.2 UPS Mounting

UPS units shall be restrained to resist movement and from toppling over as per the design.

4.3 UPS Cabling

a) Flexible multi-strand cables shall be used between the UPS unit and the maintenance bypass cabinet. The cables shall have sufficient length to allow the UPS unit to be accessed and repetitively moved for maintenance purposes without causing significant cable stress.

b) UPS cabling shall follow the manufacturer's guidelines noting maximum rectifier and bypass input currents. Attention shall be paid to the maximum permissible cable size for termination at the UPS.

Note: *For three phase output UPS systems the neutral current can be higher than the phase currents during bypass operation.*

4.4 UPS Neutral and earthing

a) The UPS neutral connection to the earth shall only be at one location.
b) The earthed end shall be as close as possible to the source.
c) Unless the UPS system has transformer isolation, no earth and neutral link shall be at the UPS output or output distribution boards.
d) The neutral shall not be switched or disconnected by the UPS except where UPS output transformers are used.

4.5 UPS maintenance

The UPS equipment manufacturer's maintenance guidelines shall be included in the system operation and maintenance manual. The frequency of testing shall be defined.

4.6 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Installation process	Clear access, not located below water or chemical lines	N/A	Required	Required
		Secured and restrained	N/A	Required	Required
2	Cabling	Sufficient length provided for removal and maintenance	N/A	Required	Required
		Confirm size and rating as per design	N/A	Required	Required
		Neutral to earth connection confirmed as one location	N/A	Required	Required
3	Maintenance	Documentation provided	Required	Required	N/A
		Sign-off			

5. Instrumentation

5.1 Name plates and tag plates

a) Instruments shall have 316 Stainless steel nameplates with the following minimum manufacturer's information engraved:
- Serial number
- Model number
- Manufacturer
- Date of manufacture
- Hazardous area classification code
- Operating Specifications as appropriate

b) Equipment tag numbers shall be shall be made from 316 stainless steel and hooked to the instruments with a ring or chain made from the same material. The tag plates shall be engraved with the equipment number as referenced on the instrument data sheet.

c) Nameplates and equipment tags shall be fixed to instruments in a position that can be easily read once installed.

5.2 Installation and mounting

a) Equipment with openings in enclosure shall be vermin proofed with corrosion resistant metallic screens of maximum 3mm by 3mm openings.

b) All outdoor electrical equipment that is fitted with operator interface screens or controls for operator adjustment shall be protected from direct sunlight in all directions.

c) The instruments shall be installed to the supplier's details for position and orientation so as not to affect accuracy.

d) All process connections shall be to the supplier's specification.

e) Pneumatic solenoid valves and regulators shall be housed in suitable 316 stainless steel enclosure adjacent to the valves that they control.

f) All instruments shall be installed with isolating and vent valves as required wherever possible to facilitate removal and servicing with minimal process disruption.

5.3 Power supply and earthing

a) Power supply to instruments shall be 230 VAC at 50 Hz UPS supply or 24V DC supplied from DCS/PLC cabinets.
b) Any special requirements for instrument power supply or earthing shall be referred to Watercare for instruction.
c) Grounding connections shall be provided independently for each transducer, transmitter and indicator.

6. Motors

6.1 Fault indication

a) All faults available from the motor control circuit shall be monitored as individual inputs to the control system.
b) A single common fault lamp shall be hardwired to illuminate at any fault signal.

6.2 Circuit breakers

a) Motors shall be supplied through individual circuit breakers of appropriate size for the motor and the future short circuit rating of the site.
b) Each circuit breaker shall be fitted with an extended rotary handle to the front of the switchboard door. The extended handles shall provide a single isolation point for the motor and be labelled.

6.3 Anti-condensation heaters

a) The heaters shall be wired to a separate terminal block within the motor terminal box.
b) A miniature circuit breaker or fuse shall be connected to the load side circuit of the motor isolator/breaker, allowing the heater to be isolated with the motor.
c) VSD anti-condensation heating (dc injection) shall not be used in place of heaters.

6.4 Motor vibration and noise

a) The operating speed of rotating elements shall be below and far removed from the critical resonant speeds.
b) Operating vibration levels of rotating equipment shall be in accordance with AS1359.

Note: *Apart from the acceptance of the vibration limits during factory tests, Watercare requires vibration tests on installed equipment. Refer to the Watercare general mechanical construction standard.*

c) Noise levels of shall not exceed 80dB and if not met must be referred to the designer for a resolution.

6.5 Terminal enclosures

a) An earth terminal shall be provided within the main motor terminal enclosure. Terminals shall be permanently marked and firmly mounted.
b) A permanent wiring label stating the maximum thermistor voltage shall be displayed on the terminal box.
c) Heater terminals shall be shrouded and separated from the main terminals with a fixed insulated barrier greater than 3mm thick.
d) A separate terminal closure may be provided for the heater terminals with a permanent rating plate displaying the heater rated voltage and power.
e) A gland plate shall be provided to enable the cable connections.

6.6 Motor installation

The mounting plinth or frame shall be fabricated to match the motor frame dimensions. Refer to the general mechanical standard for installation and alignment requirements.

6.6.1 Insulation resistance

a) The insulation resistance of the motor shall be measured between phases and each phase to the frame before energising.

Nominal rating of equipment (Volts)	Minimum test voltage (DC)	Minimum IR (Megohms)
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

b) The insulation resistance shall be measured at the terminals within the supply switchboard.
c) Resistance values shall be recorded and submitted for acceptance by Watercare. If any of the readings are lower than 1.5 megohms, the motor shall not be energised and must undergo evaluation by the motor supplier**.**

6.6.2 Winding resistance

Winding resistance shall be measured and recorded at the motor terminals and the supply switchboard.

6.7 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Fault indications	All connected; Common fault lamp provided	N/A	Required	Required
2	Circuit breakers	Load rating confirmed as appropriate	N/A	Required	Required
		Rotary pivot arm connected to front panel	N/A	Required	Required
		Breaker provided per motor	N/A	Required	Required
3	Heaters	Connected on load side of motor circuit breaker	N/A	Required	Required
		VSD (if installed) anti-condensation **not** installed in lieu of heater	N/A	Required	Required
4	Vibration and noise	Limitation confirmed per limits set out in AS 1359.114	Required	Required	Required
5	Insulation resistance	Measured at > 1.5 megohm. When lower insulation measured the motor may not be energized	N/A	Required	Required
6	Winding resistance	Document winding resistance measurements	Required	Required	Required
		Sign-off			

7. Variable Speed Drives

7.1 Cabling

a) Cables shall be installed as designed to suit the VSD range and reducing the transmission of electromagnetic interference.
b) The cable shall minimise capacitance of the power conductors and have an electrically balanced construction including split earths and a copper screen. Refer to section 8.
c) Note the following material requirements shall apply:
- The construction shall be 600/1000 volt XLPE insulated conductor and shall comply with AS/NZS 5000.1.
- Maximum 90°C continuous rating.

7.2 Enclosure

a) Access for operation and maintenance shall be from front only.
b) Floor standing VSDs shall be mounted on a steel plinth.

8. Electrical cables

8.1 General cable installation

a) Cables shall be new unless otherwise specified.
b) Cables shall be installed to AS/NZS 3000 and AS/NZS 3008.1.2 Electrical Installations – Selection of Cables.
c) Cables shall be mechanically anchored without tension at the position of termination with the ends finished to the gland manufacturer's recommendations. Metallic glands shall be earthed to equipment or switchboards.
d) Glands installed with steel wire armoured (SWA) cables in non-conducting enclosures shall be provided with an internal earthing washer and connected to a suitable earth connection.
e) Cables shall not be installed where they may be subjected to damage due to subsequent work e.g. nailing of linings.
f) Cables shall not be strapped to pipework or directly mounted to walls or structures.
g) Cables shall not be embedded directly in concrete or plaster. Cable runs through block walls, concrete slabs or similar shall be protected within PVC conduit.
h) Cables shall be protected where they pass through any openings, gaps and holes by ensuring that surrounding surfaces are smooth and free of sharp edges and that holes are bushed where required with close fitting plastic bushes.
i) Entries to buildings and to equipment in exterior locations shall be sealed to prevent ingress of gases, water and vermin.
j) Where cables pass through fire rated walls or floors, a fire barrier or fire rated sealing compound shall be used.
k) Where possible instrument cables shall follow a separate route from, and shall not be run parallel to, large power cables or motor cables.
l) Single core cables shall be run in trefoil with the neutral conductor adjacent to the phase conductors.
m) Single core cables forming part of a three phase system shall be held in trefoil formation by approved cable clamps and be capable of resisting the forces arising from the short circuit current.
n) Trefoil groups of parallel conductors shall each comprise one conductor of each phase.
o) Cable entries to equipment shall be made through glands, sleeves, or bushes in accordance with manufacturers' instructions.
p) Care shall be taken during installation of cables to prevent cuts or abrasion damage to cable sheaths.
q) Ducts shall be cleaned before installation of cables. Dry lubricant shall be applied to cables during drawing into ducts to prevent scuffing of cable sheaths.
r) Lengths shall be such that any cable runs required are without joints. Cables shall not be jointed without prior approval of Watercare. Where joints have been permitted they shall be accessible and in proprietary junction boxes or made with proprietary jointing kits to the approval of Watercare.
s) Cabling to generators, motors, mechanical plant, or crossing seismic joints shall provide for vibration and movement by allowing cable slack or loops. The fixed cabling shall be terminated in a junction box and the final connections shall be completed with a flexible cable.
t) Vertical cable rises exceeding 6 metres shall have loops or offsets to avoid differential movement between cable cores and sheath.
u) TPS flat cables shall not be used in any installation except those classified as office or domestic type wiring installations.
v) Cables installed into enclosed PVC ducts shall be pulled together with a draw wire dedicated for the next or future cable installation.

8.1.1 Twisting and bending

a) Cables shall be installed to avoid twisting and to ensure the bending radius is less than the manufacturer's recommendation.
b) In addition the to manufacturer's minimum bending radius, the following minimum radii apply:

Cable Type	Radius
Unarmoured	6 times the overall outside diameter of the cable
Armoured	12 times the overall outside diameter of the cable

8.1.2 Cable fittings

Cable fittings shall be of the correct size to terminate cables. Proprietary crimping tools shall be used to the manufacturer's requirements.

8.1.3 Cable end sealing

a) The exposed cable end left on the drum shall be sealed against moisture ingress.
b) Installed cables shall be sealed against moisture ingress up to the termination.
c) Unused cores of a multicore cable shall be grouped neatly and the ends covered with heat shrink sleeve.

8.1.4 Cable identification

a) For each cable, a stainless steel or aluminum (silver anodized) tag punched with the cable number as shown on the drawings shall be provided at each end and at each cable joint.
b) Each cable tag shall be attached to its cable with cable ties, at the point where the cable emerges from the connected panel or equipment.
c) Lettering shall be 3mm in height.
d) The Grafoplast system shall be used for labelling cable terminations.

8.2 Underground Cabling

a) Refer to Watercare general civil construction standards for civil excavation and reinstatement requirements. Backfilling material shall be free of stones, debris, rubbish, etc., and shall be placed, and thoroughly compacted in 200mm layers. The surface shall be made good to match the surrounding ground.
b) Underground cables shall be run in suitable ducts that must be sealed at both ends and exposed protected from direct sunlight.
c) A cable marker strip shall be placed during backfilling along the full buried length of cables at the depth shown on the drawings. Refer to the Watercare general civil construction standard for marker strip colouring.
d) The minimum depths for laying underground cables shall be so 600mm for LV cables and 900mm for HV cables.
e) Conduits or ducts shall be provided for road crossings or runs under buildings at the depths shown on the drawings. Long radius sweeps or bends shall be used for all changes of direction.
f) A slack section of cable shall be left at each side of a road or traffic way to allow for settlement of the road without stretching the cable.
g) Plaques shall be provided to identify the points at which buried cables enter the ground and fixed to the structures or external walls of buildings from which the cables enter the ground.

8.3 Cable Jointing

a) Cable joints will only be permitted with the prior written approval by Watercare. The jointing technique may require to be demonstrated at no cost to Watercare.
b) Joints shall be carried out using proprietary jointing kits and shall comply with the manufacturer's instructions. The joint enclosure shall be compatible with the location or environment where the joint is made and prevent ingress of moisture or attack by vermin.

c) Cables shall be supported so that no weight or stress is transferred to the joint. The support method must be approved by Watercare.
d) Cable joints that are approved are conditional to the following:
   i. Cable joints shall be 'in-line', staggered and located on the cable support
   ii. Use epoxy cable jointing kits for cables ≥ 10mm^2. Glue-lined thick wall heat shrink may be used when approved by Watercare
   iii. For power cable conductors < 10mm^2 use a glue lined thin walled heat shrink on each core with a heavy walled glue lined heat shrink encompassing the entire cable joint
   iv. For control cables a thin walled heat shrink on each core with a heavy walled glue lined heat shrink encompassing the entire cable joint. Numbered cores shall remain the same throughout the length of the jointed cable
   v. The cable core rotation for both the existing and new cables shall be matched to minimise the profile of the cable joints

8.4 Cable terminations

a) For up to 33kV cables.
b) Terminations shall be supplied in accordance with completed schedules of the Watercare materials supply standard and provided with test certificates.
c) Methods for achieving environmental seal and managing induced voltages shall be submitted with full details for review.
d) Lugs should preferably be screwed connectors with shear head bolts instead of compression lugs.
e) For TR-XPLE / XPLE insulated cables the lugs shall be bi-metallic or tinned aluminium for phase conductors and tinned copper or brass lug for screen wires.
f) Lugs shall have a clearance hole suitable for 12mm bolt for cable terminations up to 300mm² and a clearance hole suitable for a 16mm bolt for larger cables.
g) For conductors up to 400mm² terminating to open bushings, the lug palms must not exceed 35mm in width and have a clearance hole suitable for a 12mm bolt.

8.5 Redundant cables

Redundant cables shall be disconnected and removed. If the cables cannot be removed then:

   i. Disconnect the cable at both ends
   ii. Make the cable safe by capping the end with a heat-shrink cap
   iii. Label the cable as redundant at both ends with a unique identifier

8.6 Cable length

Cable shall be manufactured and supplied in a single length unless the length exceeds a standard drum length. Cable joints shall be on approval by Watercare.

8.7 Conductors

a) Copper conductor multicore cables shall be used throughout the installation unless otherwise specified.
b) Single core aluminium conductor cables may be used for mains and sub-mains larger than 70mm^2.
c) Aluminium conductors must be terminated with bimetallic lugs.
d) Aluminium surfaces for mechanical jointing shall be prepared and jointed with oxidation inhibiting and jointing compound.
e) Unused cores of multicore cables shall be grouped neatly and the ends covered by a heat-shrink sleeve.
f) Parallel conductors shall be on identical routes and be of equal cross sectional area and length.
g) Trefoil groups of parallel conductors shall be arranged as per the requirements of Appendix D in AS/NZS3008.

8.8 Un-armoured cable

Un-armoured cable shall be installed in appropriate trunking, or in a conduit, or on cable support unless otherwise accepted by Watercare.

8.9 PVC cable construction application

a) PVC cables shall be constructed as follows:

Cable type	Construction
Un-armoured cables	PVC insulated PVC sheathed
Armoured cables	PVC insulated PVC bedded / armoured / black extruded PVC outer sheath
Earth continuity conductor cables	PVC insulated PVC bedded / armoured Copper earth continuity wire in armour / black extruded PVC outer sheath
Single core cables	PVC insulated and unsheathed (for installation in wire ways and switchboards)

b) Armouring for multi-core cables shall consist of one layer of galvanised steel wire.
c) Armouring for single-core cables shall have non-magnetic wire.
d) Aluminium strip or tape armouring shall not be used.

8.10 Cross linked polyethylene cable construction application

a) The cross linked polyethylene cable shall comprise of:
   i. High conductivity annealed or hard-drawn stranded copper conductors
   ii. A stress equalising layer of extruded semi-conducting cross-linked polyethylene
   iii. Extruded cross-linked polyethylene insulation
   iv. A conducting compound applied over a semi-conducting coating or a layer of extruded semi-conducting compound applied directly to the dielectric
b) An extruded PVC sheath shall protect the collective metallic screen of annealed copper tape enclosing all the cores and inter-spatial filler.
c) Armoured cables shall have bedding of a continuous waterproof layer of PVC. The galvanised steel wire armour shall be enclosed in an outer sheath of PVC.

8.11 Cable route planning

a) Cables shall be installed in the planned cable corridors, or when unspecified to minimise the effects of electric and magnetic fields on equipment. Cable crossovers shall be minimised.
b) Single core cables for three phase systems shall be installed in trefoil formation with the neutral conductor adjacent to the phase conductors. Cables shall be held in place by approved cable clamps. Such cable installations shall be capable of resisting the forces arising from the prospective short circuit current.
c) Cabling shall allow for vibration and movement by utilising cable slack or loops. To allow for relative movement or extreme vibrations situations, fixed cabling shall be terminated in a junction box and the final connections completed with a flexible cable.
d) High voltage cables shall be separated from low voltage and extra low voltage cables and services in separate floor trenches, pipes or metal channels. A minimum spacing of 600 mm shall be maintained.
e) Extra low voltage cables not exceeding 50Vac, or 120V ripple free dc, shall be separated from power cables by at least 300mm. A physical barrier shall be provided between power cables and cables for other services in building ducts.

8.12 Instrument cables

a) Instrument signal and power cables shall be arranged to only cross at right angles, thereby avoiding interference from electrical power supply voltage drops or spikes.
b) To ensure that each cable has only a single voltage level, extra low voltage and low voltage shall not utilise the same cable. Watercare must provide approval for variations to this requirement.
c) Analogue signal cables shall include an individual and overall screen. Screened instrument cables shall be earthed at one end only and be electrically continuous from its source to the instrument. The earthed end of the cable shall be as close as possible to the source. Cable screen drain wires shall be insulated and connected to a low impedance earth, preferably an instrument earth bar. Instrument cable screens shall terminate at junction boxes through insulated terminals to prevent earth loops.
d) Instrument field cables shall have minimum 300mm spare length at the instrument end, neatly supported below the instrument.
e) Instrumentation cables stacked on a cable supports shall not be more than two cables high. Refer to section 9 for stacking restrictions on other cables.

8.13 Data highways (communication cables)

a) Data highway cables shall be run individually in 20mm conduit where there are no cable supports.
b) Dual redundant data highway cable systems shall be installed on separate routes between device locations.

8.14 Cable glands

a) Glands specific to the cable application shall be installed to the manufacturer's recommendation and instructions.
b) A minimum of 50mm straight cable shall be provided prior to the cable entering a gland.
c) The glands for steel wire armoured cables shall be made of nickel-plated bronze or brass and provided with ISO threads.
d) The glands for VSD cables shall provide a 360° ground connection for the VSD screen.

8.15 Cable gland accessories

a) Suitable accessories shall be provided with glands to be used on earthed continuity conductor-armoured cables to facilitate a bolted lug connection.
b) Grooves cut into the barrel or cone bush to accommodate the earth continuity conductors are not acceptable.
c) Gland shrouds shall be made of non-deteriorating neoprene or similar approved rubber that is resistant to water, oil and sunlight. The shrouds shall fit tightly around the glands and cable.

8.16 QA/QC template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Cable length	No joints – single length	N/A	Required	Required
2	Conductors	Multi-core copper for cabling < 70mm^2	N/A	Required	Required
		Unused cores grouped and heat shrink sleeved	N/A	Required	Required
3	Un-armoured cable	Trunked in conduit or cable support.	N/A	Required	Required
4	Instrumentation cable	Lay lines to cross power cables at right angles	N/A	Required	Required
		ELV and LV using separate cables	N/A	Required	Required
		Minimum 300mm spare length at cable ends	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
		Cable depth maximum 3 on cable supports	N/A	Required	Required
5	Communication cables	Min 300mm separation from power cables	N/A	Required	Required
		Installation individual in 20mm conduit	N/A	Required	Required
		Dual redundancy installed in separate cable paths	N/A	Required	Required
6	Glands	Installed to manufacturer requirements and appropriate to the operating environment	N/A	Required	Required
		Minimum 50mm straight cable allowance before entering gland	N/A	Required	Required
		Cables are not under tension	N/A	Required	Required
7	Bending and twist	Within maximum allowed for cable type	N/A	Required	Required
8	Cable ends sealed	Heat shrink	N/A	Required	Required
9	Identification	Cables tagged and identified	N/A	Required	Required
		Sign-off			

9. Cable support and protection

9.1 General

a) All cable trays and support fittings for the project shall be new, of similar material and finish and sourced from the same manufacturer.
b) Cable support systems shall be complete with matching proprietary bonds, ties, reducers, expansion joints and jointing accessories which shall be employed as appropriate at junctions, changes of level, changes of direction, and changes of size. Metallic cable support systems shall be bonded to earth and shall be made electrically continuous using, where necessary, earth continuity straps between sections.
c) Fixings and fastenings shall be of a material appropriate to the parts being fixed, the loads imposed and the locations involved. Bolts, screws, nuts, washers and other fixing components shall be stainless steel or galvanized to match the adjacent material. Refer to the Watercare mechanical construction standard.
d) Cable support systems shall be run level, in a single plane, straight and parallel with building lines to produce a tidy installation. Joints and accessories shall fit closely and shall be correctly matched.
e) Sharp edges shall be rounded. Cut ends and cut-outs in cable support systems shall be neat and square. Cut edges shall be protected against corrosion.
f) Cable support systems shall not be fixed to handrail systems or process pipework and support mechanisms for electrical equipment must remain independent from these. This includes cable support systems.
g) Where cable support systems cross seismic joints appropriate allowance shall be made for the movement of the support system.
h) Cables shall be adequately supported at all points and shall be neatly fixed with clips, saddles, cleats or ties as appropriate in accordance with the manufacturer's written instructions.
i) Cables shall be neatly arranged on trays or in trunking.
j) Twisting, bunching, excessive slack, or excessive tightness shall be avoided.
k) Where cables join or leave trays, unnecessary crossovers and tangling of cables shall be avoided.

l) Cables shall not be brought out above the top level of cable ladder side rails except where cable ladders are surface mounted.
m) Cables to be fixed to cable ladders/trays using ultraviolet light resistant plastic ties where required.

9.2 Cable trays and ladders

a) Cable ladders and trays shall be constructed of heavy duty aluminium (as defined in Nema).
b) Sweeps and bends should be installed at all right angled junctions.
c) Where cable ladder is joined by fish plate with single bolt, then a suitable earth strap shall be installed.
d) Cable support brackets and trays shall be installed free of sagging. The maximum horizontal deflection is 25mm over a 6m length.
e) Cable supports shall be installed to follow the lines of the building.
f) The supports shall be suspended below overhead structures or impingements by minimum 300mm. Brackets and hangers must be constructed to permit easy installation and removal of cables from the ladder or tray.
g) Each support for overhead structures shall consist of two galvanised steel hanger rods of minimum 10mm diameter on each side of the cable support and a galvanised steel unistrut cross-member underneath.
h) Brackets shall be compatible with the tray or ladder material. Cable runs on the cable tray shall be laid in the channel, not strapped underneath the tray.
i) The cables shall be neatly secured with clamps, saddles or cable ties. The restraint method shall be suitable for fault conditions. 24mm^2 single core and larger cables shall be clamped.
j) Cables other than instrumentation cable shall not be stacked more than 3 high.
k) Process lines must not be supported on cable trays.
l) Dissimilar materials shall be isolated against galvanic corrosion.
m) The cable support shall be electrically isolated and bonded to earth. Where cable support is not continuous, bonding across both sides of the cable support is required at:
   - Hinged joints
   - Expansion joints
   - Discontinuous sections
n) The bonding cable size shall be determined based on the protection setting of the circuits on the cable support. The table below is a guide for minimum bonding cable sizes:

Minimum Bonding Cable Size

Setting of circuit over current device (Amps)	Minimum cable support bonding cable size (mm^2)	Bonding cable size for each side of cable support (mm^2)
<=63	6	6
63-149	25	16
150-299	50	25
300-399	70	35
400-499	95	50
500-630	120	70
=>500	120	70

o) Outdoor cable supports shall be fitted with gable covers suitable to the environment. The covers shall have a minimum 15° peak to allow run-off.

9.3 Conduits

9.3.1 Conduit general

a) The minimum size of conduit shall be 20 mm. Unless otherwise specified, conduit shall be one size larger than required by regulation for the number of conductors to be drawn in.
b) Conduit boxes with removable covers shall be provided with draw cable after the conduit system has been installed.
c) Conduit boxes shall be of appropriate size for intersecting conduits. Multiple single boxes shall not be used.
d) Conduit length shall be installed with a conduit box at least every 40m and expansion joints at least every 20m.
e) Avoid drawing cables around more than two 90-degree bends by appropriately spacing the boxes.
f) Typical bends radii are given below:
   - 20mm conduit: 80mm
   - 25mm conduit: 100mm
   - 32mm conduit: 130mm
   - 40mm conduit: 160mm
   - 50mm conduit: 200mm
g) Conduits installed in roof spaces must be parallel and at right angles to the building's structural elements.
h) Above ground conduit shall be supported in saddles with spacer-bar at appropriate spacing and load rating. The maximum distance between the saddles shall be 1m and within 100mm on each side of a conduit box or fitting.
i) Saddles and fixings shall be stainless steel. Fixings into concrete shall be made using Nylon "rawl-plugs". Wood or fibre "rawl-plugs" shall not be used.
j) Flexible conduit shall only be used in short lengths where rigid conduit is unsuitable. At the conduit termination an appropriate cable gland be used and a length of heat shrink applied covering the end of the flexible conduit and the gland.
k) Conduits must:
   - Be kept at least 160 mm clear of steam or hot water pipes.
   - Not be run on the ceiling of underground chambers or on removable covers.
   - Not be run across access ways or floors in positions that will cause a trip hazard.
   - Not be installed over seismic joints without provision for movement equal to the width of the joint gap.
l) A double offset shall be used where conduits change level. Conduit shall be run in straight, symmetrical lines.
m) Moisture and dirt ingress shall be prevented by suitable drainage points and plugs. Conduits shall be cleaned before installing cables.
n) Conduit for any circuit shall be erected complete before any cable is drawn in.
o) Conduits which penetrate walls or floors of fire resisting construction shall be treated in the following or equivalent approved manner:
   - Seal all PVC conduit penetrations with firestop collars.
   - Seal all steel conduit penetrations with PYROSAFE SVT universal bulkhead system and pack any gaps with FYREFYBA ceramic fibre.
   - For small penetrations with gaps less than 10mm seal with fire resistant foaming sealant.

9.3.2 Chasing of conduits

a) The outer face of conduits shall be more than 10 mm back from the finished plastered surface.
b) Powered machines shall be used for chasing in walls.
c) Face bricks shall not be chased, unless accepted by Watercare.

9.3.3 Conduit in concrete

a) The conduit shall be installed in position before the concrete is cast and extend minimum 100mm beyond the finished concrete where it protrudes.
b) Conduit runs in groups or large concentrations shall be spaced minimum one conduit diameter width apart.
c) Penetrations through the concrete shall be watertight and sealed.

9.3.4 Metallic conduit

a) The use of metallic conduits requires approval by Watercare.
b) Screwed joints shall be painted with 2 layers of Zinc galvanising paint after installation.
c) Interior surfaces of conduits shall be free of sharp protrusions. Open ends shall be provided with solid brass bushes.
d) Damaged galvanizing shall be repainted with two layers of Zinc galvanising or as otherwise specified.
e) Conduit shall be bushed and fixed on the inside of the box or appliance in which it is terminated.
f) Running joints shall be provided with lock-nuts to ensure that connections are secure.
g) The conduits shall be electrically continuity bonded to earth. Conduit systems shall not be relied upon for earth continuity.

9.3.5 PVC conduit

a) PVC conduit must be installed to the manufacturer's recommendations.
b) Conduit colours:
   - PVC conduit colour shall be orange for below ground complying with AS/NZS 3000. Conduit shall be heavy duty as defined in AS/NZS 2053. Watercare still require installation of “mag slab” mechanical protection in addition to installation of heavy duty conduit even though this is not a requirement in AS/NZS3000.
   - Grey high impact PVC to AS/NZS 2053, UV stabilised conduit, shall be used above ground and areas subject to UV exposure.
   - Flexible conduits and fittings shall be "black Technoflex” or equivalent and be a minimum IP56.
c) Dry lubricant shall be applied to cables during pulling in of PVC sheathed or covered cables to prevent welding or scuffing of cable sheaths.
d) All conduit joints, fittings and adapters shall be glued. All conduit ends shall be sealed.
e) PVC conduit shall only be used in temperatures below 50°C and where it cannot be mechanically damaged.
f) Straight runs greater than 10 metres exposed to sunlight shall have expansion joints.

9.3.6 MDPE conduit

a) Communications ducting “sub-duct” shall be green MDPE and used for telecommunications cabling only.
b) Joints in the sub-duct shall be made using PE compression fittings.

9.3.7 Support and fixings

a) Steel supports, frames, hangers and fixings shall be hot dip galvanized mild steel to AS/NZS 4534 (all parts as applicable), or stainless steel as specified.
b) Conduit saddles and fixings shall be stainless steel.
c) All fixings to concrete or masonry in water retaining structures shall be by Hilti HVA or Chemset Fixings. Expanding type fixings shall not be used. Fixings in other structures may be by Ramlock/Rawlbolts/Hilti/Dynabolts or by cast in fixings such as bolts or Unistrut. Terrier and powder charged fixings shall not be used. Staple guns and staples shall not be used for fixing cables.
d) Fixings to structural steelwork shall be by clamping only. If welding or drilling is required prior approval shall be obtained from the designer.

e) Cable support systems shall be installed in accordance with the manufacturer's recommendation to give a maximum between support deflection of 10 mm when carrying the final number of cables installed, plus a 20% allowance for spare capacity.

9.3.8 Wire way trunking

a) Wire-way trunking shall be completed with fit for purpose accessories.
b) Partitions may be perforated or solid.
c) Wire-way trunking shall be of suitable material for the site conditions and more than 1.2mm thickness. Sharp edges shall be de-burred.
d) Vertical cable in trunking shall be fitted with insulated cable supports at intervals not exceeding 2.5 metres.
e) The cover-plates on channels up to 75mm width shall be of the snap-in type. Cover-plates on larger trays shall be fixed by means of screws.
f) Knockouts for conduits shall be provided in the sides of all trunking.
g) Conduit connections to wiring channels shall either be terminated direct to the channel using screwed or bushed entry or by means of a conduit box and through a hole in the back of the channel.
h) The trunking supports shall be spaced to avoid sagging between supports.
i) All metallic trunking shall be earthed in accordance with the AS/NZS3000.

9.3.9 Trenched conduits

a) This section shall be read in conjunction with the general civil construction standard. Also refer to section 9.2 above.
b) The width of the cable trench shall be as required for the number of cables to be laid but shall not be less than 300mm wide.
c) Bedding shall be minimum 75mm thick.
d) Cable marking tape shall be laid after the first 150mm cover layer.

9.4 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Cable support	Support brackets space at minimum 300mm	N/A	Required	Required
		Deflection limited to 25mm per 6m	N/A	Required	Required
		Cable support bonding to correct size	N/A	Required	Required
		Heavy duty aluminium	N/A	Required	Required
2	Cable conduit	Support saddles space at minimum 1000mm	N/A	Required	Required
		Expansion joints provided at minimum 25m intervals and conduit boxing provided at minimum 40m intervals	N/A	Required	Required
		Appropriate anchor size used. – Wood or fibre plugs are not allowed	N/A	Required	Required
3	Buried cable	Min 75mm bedding and 300mm width	N/A	Required	Required
		Cable marker tape installed	N/A	Required	Required
		Sign-off			

10. Fibre optic

a) All installation contractors and staff must have appropriate licenses and certification to perform work on Watercare fibre optic infrastructure. All installation contractors must be Certified Partners.
b) Both blown tube fibre and loose tube fibre cabling are used across Watercare; if not evident in the design, confirm the method for a particular installation with Watercare.

10.1 General duct installation

a) Micro duct and 32mm ducting can be installed into existing duct lines.
b) Ducting must be cut with fit for purpose ratchet shears. Cutting with a saw is not permitted.
c) Sufficient slack should be hauled through to allow for the duct to be cut. The duct should be cut back twice the length of the pulling grip or "sock".
d) The duct bending radius shall not exceed the manufacturer's specification.
c) Ducts in manholes shall be arranged to maximise bending radius and avoid cutting across the centre of the manhole.
d) When ducts are jointed in manholes, a duct overlap of minimum 600mm shall be allowed.

10.1.1 Carrier duct

a) Carrier duct shall be located as specified with a minimum bending radius of two metres for bends.
b) The bending radius may be reduced on approval from Watercare in situations where the minimum radius causes installation difficulties.

10.1.2 Couplers

Push fit couplers shall be used for jointing ducts. The internal edges of the duct joints shall be bevelled and the swarf removed.

10.1.3 Duct end caps

End caps shall be installed on the ends of ducts during, and after construction. Uninstalled duct shall always be capped.

10.1.4 Tracer wire

a) Buried ducts shall have an integrated external tracer wire.
b) Sufficient length must be provided to allow the tracer wire to be jointed.
c) The tracer wire insulation must not be damaged when stripped off the pipe to make the connection.
d) The joint shall be soldered and covered with glue lined heat shrink.

10.1.5 Draw pits

Draw pit spacing shall consider the type of cable, installation conditions and the number of bends. Line valves or air valve chambers may be used as draw pits with prior approval from Watercare.

***Note**: Supplier literature states that a stretch of 2.2km can be blown in one increment. Obtaining this level of performance is dependent on the quality of blowing equipment available, the number of bends and length of run7*

10.1.6 Testing of ducts

Refer to Section 13.7.1.

10.2 Specific duct installation methods

10.2.1 Open trench duct installation

a) The trench shall be clear of stones and sharp objects. Refer to Watercare's general civil construction standard including:
   - Bedding shall be minimum 100mm surround material covering minimum 100mm over the top of the duct.
   - A warning tape shall be laid at 150mm above the duct before final backfilling is completed.

10.2.2 Mole ploughing

a) Where ground conditions dictate, pre-ploughing is recommended to ensure there are no obstacles in the plough route.
b) During installations with a plough, care should be taken to ensure:
   - Pre-plough is performed correctly and obstacles avoided
   - The correct amount of duct is on site for the planned length to be installed
   - The feeding of ducts are done smoothly without sudden bursts
   - The plough is kept at an even depth
   - Ensure there is no tension build up. This will cause retraction later

10.2.3 Reinstating ground after trenching/ploughing

Refer to Watercare's general civil construction standard.

10.2.4 Directional drilling

Refer to the Watercare general civil construction standard for horizontal directional drilling requirements. Tension on the duct shall not exceed the duct manufacturer's specification.

10.3 Handling cable drums

a) When loading or unloading drums, use a fork lift or lift the drum through the drum centre hole. Drums must not be rolled when offloading.
b) Lift the drum from the flange side when using a fork lift, making sure that the fork grips both flanges of the drum without touching the duct or cable
c) When drums through the centre hole an appropriate lifting frame shall be used with no lateral pressure on the drum flanges.
d) Drums with product must always be kept upright, resting on the flange rim and secured to prevent from rolling. Do not store the drum in direct sunlight or extreme temperatures.
e) Unroll cable or duct from the top of the drum using a drum stand or jinker in the direction of the arrow indicated on the drum.

10.4 Cable installation

a) Cable tensile hauling loads, bending radius and operating temperatures shall not exceed the manufacturer specification.

Note: *Tensile ratings, loads bending radius etc. vary with cable fibre count.*

b) Pre-terminated cables shall be laid, not hauled. MTP/MPO cables are to be laid only. Hauling of pre-terminated cables shall be on approval of Watercare and requires a protective hauling assembly to protect the connectors and fibre during the installation process.
c) Minimum 15m of excess cable shall be allowed at each end for enclosure management and termination. All cables shall enter the enclosure.

d) The bending radius for air blown fibre shall be the greater of 20 times the diameter of the cable or the manufacturer's stated radius.

10.5 Cable breakout, fusion splicing and terminations

10.5.1 Cabling tools

Cable sheaths and tube shall be removed using proprietary tools. Knives or pliers shall not be used for this purpose.

10.5.2 Central strength member

The cable gland and central strength member clamp shall be used to secure the cable.

10.5.3 Fibre coils in Splice Cassette

a) Minimum 1.5 fibre coils are required within the splice cassette.
b) Excess fibre shall be coiled around the 30mm direction columns.
c) All fibre must be located in the fibre channel.

10.5.4 Change of direction in Splice Cassette

Reversing the direction of pigtails or fibres after entry to the splice cassette shall be through the 30mm fibre redirection columns provided in the splice cassette only.

10.5.5 Unterminated fibres in Splice Cassette

Unterminated (dark) fibres must be left in the dark fibre storage area in the splice cassette. Unused fibres must not be left in the fibre channel.

10.5.6 Securing Splice Cassette

Splicing cassettes must be secured to the base of the enclosure with the screws provided.

10.5.7 Securing pigtails and tubes

a) Pigtails and tubes must be secured in the splicing cassette using fibre clamps.
b) Tubes and pigtails at the organiser entry points shall have protective oversleeving.
c) Cable ties are acceptable for loose tubes, but not on pigtails or on fibres directly.

10.5.8 Splice Protectors

Splice protectors must be installed in the splice cassette combs after heat shrinking. The splice must be fitted with a splice protector housed in a splice cassette.

10.5.9 Splicing position

Coupler panels shall be spliced in from the bottom up allowing future expansion.

10.5.10 Splice loss

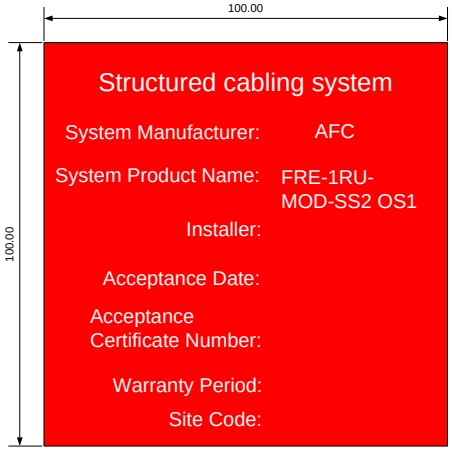
There shall be less than 0.1dB loss per splice.

10.6 Labelling

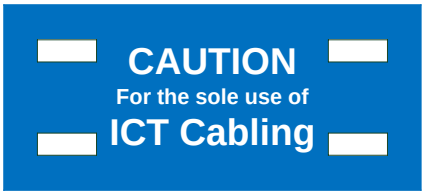
a) Labels shall be machine printed in black with the font minimum 8 mm high.

b) A label shall be installed on every communications equipment enclosure displaying the manufacturer's warranty number and details.

Example below:



c) Every enclosure shall be labelled with the location, inter-connect rack location and corresponding enclosure information.
d) Core numbers shall be identified.
e) Cable pathways shall be labelled to identify the pathway for the sole use of information and communications technology (ICT) cabling.
f) Labels shall be installed less than 4m apart, at key intersections and be visible. Example below:



10.7 Cable management

10.7.1 Vertical cable management

If vertical cable management is not installed into racks then vertical cable management rings shall be installed.

10.7.2 Cable ties

Velcro ties are to be used on all tight buffered or MTP/MPO cables. Plastic cable ties may only be used on the un-stripped portion of loose tube cables.

10.7.3 Installation of cables

Other cables shall not be installed on top of fibre optic cables. This is to prevent micro-bends and pressure points in the fibre cable.

10.7.4 Horizontal cable management

a) Fibre optic cable including patch cords must be arranged to the closest point horizontally and transition into vertical cable management.
b) Fibre optic cables shall not be run in front of other installed equipment.

10.8 Record keeping

a) As built records shall be completed to the requirements of Watercare data and asset information standards, including:
   - A photograph from coupler to coupler must be taken and recorded as part of the final documentation submitted to Watercare
   - Joint locations measured from Kerb lines, boundaries and fence lines where possible or a GPS location point.

10.9 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Qualification	Certified to complete fibre installation	Required	Required	Required
2	Duct installation	Bending radius not exceeded	N/A	Required	Selected
		Connection details through pits adhered to; no sharp edges or sharp turns	N/A	Required	Required
		Bedding surround 100mm of the fibre duct.	N/A	Required	Required
		Warning tape installed over top of bedding	N/A	Required	Selected
		Duct integrity tested in accordance with Section 13	Required	Required	Required
3	Cable installation	15m additional length left at each draw end for cable termination	N/A	Required	Required
		Un-used fibre placed in cassette dark storage area, not in duct.		Required	Required
		Cable and equipment labels installed	N/A	Required	Selected
		Only Velcro ties used	N/A	Required	Selected
4	Record keeping	Records provided	Required	Required	Required
		Sign-off			

11. Cathodic protection

a) Refer to the Watercare general mechanical installation standard for flange installation requirements.
b) Electrical isolation shall be installed as shown in the specific drawings.

11.1 Surge protection of insulating joints

a) Insulating joints shall have a lightning arrestor installed across the insulated joint to protect the joint.
b) If a polarisation cell, PCR or equivalent is specified then a lightning arrestor shall be installed as well.
c) Where the insulating joints are adjacent to a valve, the arrestor shall be connected to the outside pipe flanges, not to the valve body.

11.2 Cathodic protection power supplies (TR's)

a) TRs shall be mounted on a concrete plinth that complies with the concrete structure requirements in Watercare's general civil construction standard and the following:
   - Extend beyond the side of the TR cabinet by a minimum of 100mm
   - Concrete thickness of minimum 150mm and have 12mm reinforcing at mid-level of the plinth
   - Sloped from the centre of the plinth to 1:100 – if the TR base is an open frame
   - Sloped from the side of the TR cabinet of 1:100 – if the TR base is enclosed and sealed against water ingress
   - Provided with minimum 4x 50NB uPVC penetrations for earth peg and cables

11.3 Impressed current anode groundbeds

a) Impressed current anodes shall:
   - Have individual cables brought up to a junction box from all anodes
   - Be rated for 50 years operation at the design current
   - Be located as per the drawings

11.4 Sacrificial anode groundbeds

a) Sacrificial anodes shall:
   - Be supplied and installed packaged in gypsum bentonite backfill in a calico bag
   - Backfill shall be well wetted prior to backfill
   - Have individual cables brought up to a junction box from all anodes
   - Have a junction box designed to allow easy access to cable terminals. Terminals shall be brass or stainless steel bolts and/or bus bars, except where mounted in instrumentation control boxes with DIN rail mounts.
   - Be rated for minimum 25 years operation for magnesium and 50 years for zinc
b) Anodes installed in the pipe trench shall be installed in the bottom corner of the trench resting on native soil. Where anodes are installed outside the trench it shall be in native soil
c) Anodes shall not be laid on scoria, bedding sand or other free draining material.
d) The anode bed may be connected temporarily to ensure operation. Following the check, the anode bed must be disconnected until pre-commissioning has been completed or as otherwise specified by Watercare.

11.5 Permanent buried reference cells

a) The installation arrangement shall be as shown on the specific drawings. The cells shall:
   - Be supplied and installed in packaged in gypsum bentonite backfill in a calico bag
   - Backfill shall be thoroughly wetted prior to backfill

11.6 Continuity bonding

a) Un-welded joints within buried cathodically protected sections of pipeline shall be bridged with a continuity bond cable.
b) The bond cable shall be:
   - As short as practicable to reduce voltage drop
   - Located such that there are no mechanical joints between the connection point and the pipe being bonded

11.7 Test points

a) A drop tube or soil access box must be provided for a test point that will be surrounded by surface pavement.
b) Drop tubes shall be installed with minimum 300mm native soil in the base. In cases where native soil is too hard to be compacted in the tube or too free draining to enable contact, the fill shall be:
   - For corrosion coupons: Washed sand
   - Buried references and other installations: 50% gypsum / 50% bentonite mix
c) Fill shall not be scoria, gravel or a similar free draining material.

11.7.1 Test point cabling

Test points terminating in a test station shall have two cables connected separately to the structure and terminated separately in the test station, one for potential monitoring the other as a bond cable, regardless of whether bonding is required.

11.7.2 Interference test points

a) Interference test points shall be installed as close as practicable to the crossing point of two services in an accessible location.
b) Where the test station is 3m or more from the crossing a permanent zinc reference shall be installed mid-way between the protected pipe and the crossing service, ensuring that the cell is no closer than 100mm from either.

11.8 Corrosion coupons and electrical resistance probes

a) The test station foot shall be buried in the pipe trench in the same bedding and surround material as the pipe, facing down towards the pipe invert.
b) Wherever practicable a drop tube shall be provided. Configuration options in order of preference are:
   i. Single unit with probe foot directly below test station, with a drop tube in the test station connected to the foot
   ii. Probe foot with drop tube and flush access box buried separately near test station
   iii. Probe foot buried with permanent zinc reference (supplied with the probe) and no drop tube
c) The manufacturer's installation methodology shall be followed, except that the fill in the drop tube shall comply with section 11.7.

11.9 Cabling and connections

a) Cables shall be installed as continuous single length cables without splices or joints.
b) Cables shall be installed in conduit.
c) Cable and connections shall be tested following installation to ensure continuity.
d) Buried cable connections shall be tested prior to recoating connections and backfilling.

11.9.1 Cable Connections to Pipeline and Other Structures

a) Connections to pipework shall be made in accordance with the Watercare standard drawings.
b) Cable connections to the pipeline shall be made in chambers or above ground unless otherwise noted.
c) Buried connections shall be thermit welded or cadwelded, except where a foreign service owner specifies otherwise for connections to their service or structure.

11.9.2 Cable size and insulation

a) The following minimum conductor sizes shall apply:

Conductor	Size
Potential monitoring (no current)	4mm^2
Test point bond cables (impressed systems)	16mm^2
Test point bond cables (sacrificial systems)	6mm^2
Continuity bond cables (not for earthing)	16mm^2
Anode junction box to TR or test station	16mm^2
Impressed current anodes (individual)	16mm^2
Sacrificial anodes (individual)	6mm^2

b) Continuity bond cables shall as short as practicable to avoid unnecessary voltage drop in the cable.
c) Bond cables for earthing purposes shall comply with relevant regulations.
d) Cable insulation type shall be appropriate to the location.

11.9.3 Cable insulation colours

Unless shown otherwise in the specific drawings, cable colours shall be:

Cable use	Colour
Protected pipes in the main CP system	Black
Other Watercare pipework (protected or not)	White
Customer or foreign pipes or structures	Blue
Permanent references	Yellow
Sacrificial anodes	Red (may be TPS inner layer)
Impressed anodes	Red or Black
Continuity cabling for CP	Black
Earthing	Green/Yellow

11.10 Equipment labelling and identification specific to cathodic protection

a) Labels shall comply with the general requirements in section 12 except as altered in this section. Equipment to be labelled are:
   - Insulating flanges
   - Test stations
   - Junction boxes
   - TRs

b) Equipment labels on TRs, pillar and wall mounted test stations and junction boxes shall be Satin Metalphoto 25x90x0.8, with the following text:

WATERCARE

CATHODIC PROTECTION SITE ###

Phone: 09 442 2222

c) Equipment labels for Flush test stations shall be as above with the following text:

CP SITE

WATERCARE

###

d) All equipment labels shall incorporate a CP Site ID number, represented by'###' above. CP Site ID's should be indicated on design drawings. If not specified, the contractor shall request issue of the numbers from Watercare.

11.11 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Surge protection	Lightening arrestor installed. Not connected to valve or isolated fitting bodies.	N/A	Required	Required
2	Cabling	QA completed as per section 9	Required	Required	Required
		Correct cable size and colour used	N/A	Required	Required
3	Anodes	Position confirmed exactly as per the specific drawings – captured co-ordinates	Required	Required	Required
4	Reference cell	Installed in bentonite fill, ground wetted when placing	N/A	Required	Required
5	Isolation and bonding	Joints and fitting/component isolation inspected for bonding. Flange isolation confirmed as per the mechanical construction standard	N/A	Required	Required
6	Coupons and resistance probes	Drop tube provided. Backfill same material as pipe bedding	N/A	Required	Required
7	Electrical hazard analysis	Analysis completed. Any issues rectified	Required	Required	Required
8	Labelling	Equipment and cables labelled	N/A	Required	Required
		Sign-off			

12. Colour coding, Identification and labels

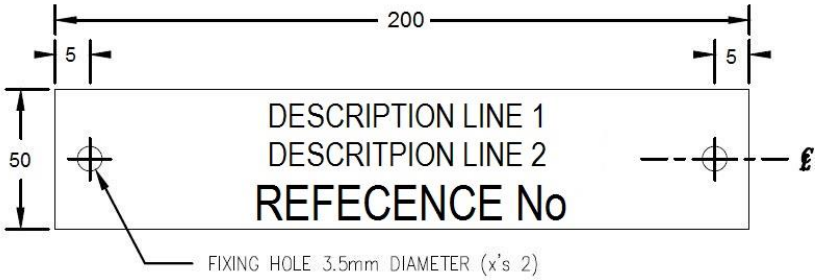
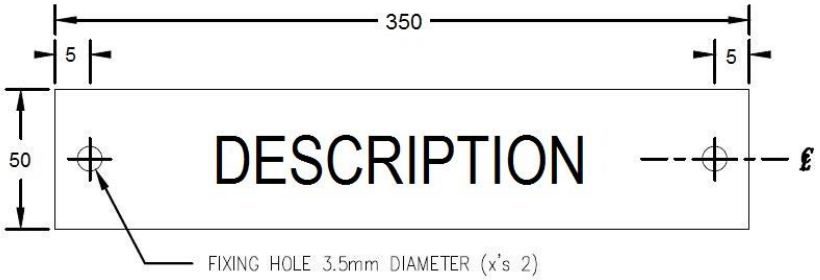
12.1 Equipment number

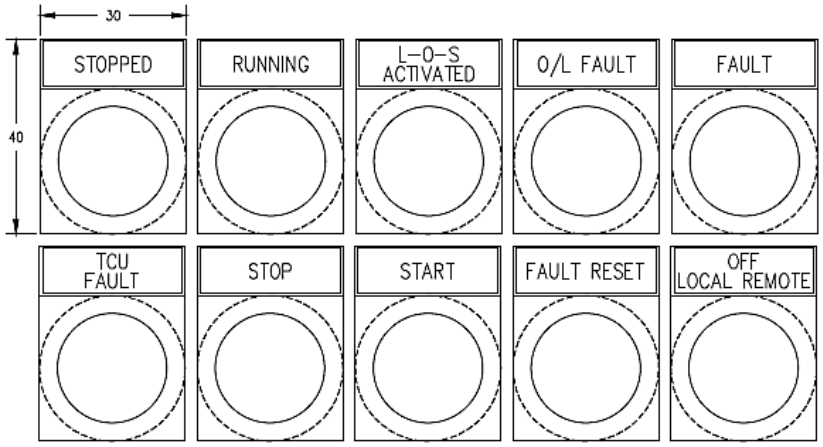
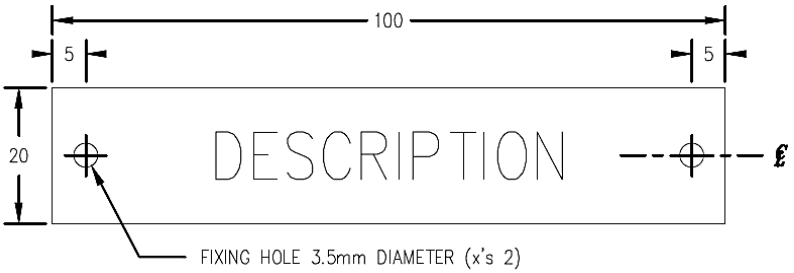
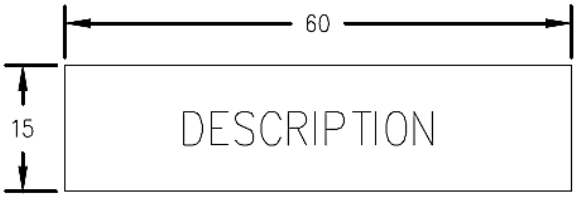
The equipment number is referenced to the site, area and function, and is assigned during the production of the Process and Instrument Diagram drawing and the Functional Description in accordance with the Watercare data and asset information standards.

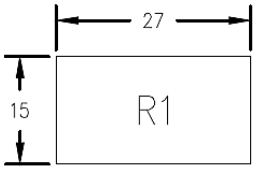
12.2 Labels - general

a) Labelling and identification of equipment, services and the like shall be in accordance with NZS 5807 and to the Watercare data and asset information standard
b) Every plant item shall be fitted with a label displaying the tag number and function.
c) The label shall be permanently attached to the equipment or in close proximity in a visible location.

12.2.1 Switchboard specific label examples

Label Type "A" 1. Material: 1.6mm Plastic 2. Colour White – Background Black – Letters 3. Letter height 7mm – Description line & 10mm – Reference No 4. Application On doors for cell descriptions (General)	
Label Type "B" 1. Material: 1.6mm Plastic 2. Colour White – Background Black – Letters 3. Letter height 25mm 4. Application Main label	

Label Type "C" 1. Material: ZBY-0102 (0.85x8x27mm) 2. Colour White – Background Black – Letters 3. Letter height 3mm 4. Application Push buttons selector switches	
Label Type "D" 1. Material: 1.6mm Plastic 2. Colour White – Background Black – Letters 3. Letter height 7mm 4. Application General	
Label Type "E" 1. Material: 1.6mm Plastic 2. Colour White – Background Black – Letters 3. Letter height 4mm 4. Application General	

Label Type "F" 1. Material: 1.6mm Plastic 2. Colour White – Background Black – Letters 3. Letter height 4mm 4. Application Relays & Misc.	
Label Type "X" 1. Material: 1.6mm Plastic 2. Colour Red or Yellow – Background White or Black – Letters 3. Letter height As required 4. Application All Danger, advisory & caution labels	DANGER – HIGH

12.3 Cable colours

The outer sheath colour of cables shall be the normal manufacturer's colour or as otherwise specified. The outer sheath colour of intrinsically safe cable shall be light blue.

12.4 Cable numbering

Cables shall be numbered as identified on the specific drawings.

12.5 Wire labelling

a) The Grafoplast system shall be used for labelling wiring terminations. Wiring and terminal numbers shall be according to the specific drawings.

Example 1:

WS113	**W** (ELV)	**S** (Analogue Signal)	**113** (wire number)
H160A	**H** (LV-AC)	**160** (wire number)	**A** (device)

b) Numeral

i. The number starts at 001 for the first wire of a particular function in a facility and follows sequentially for other wires of the same function in that facility.
ii. The number shall follow the wire through all continuously connected terminations as if the wire was a continuous length. The number changes at the terminal of a new device e.g. at a fuse or relay.

c) Device Identifier
i. Wires for devices within a set or bank shall be identified using a suffix letter after the number. Starting at A for the first device in the set and continuing alphabetically for devices following.
ii. For each set or bank of devices the number preceding the suffix shall be unique.

Example: Dose pumps for both the fluoride process area and the caustic process area may be identical sub systems.

Example 2:

Fluoride Pumps

Pump 1:

Wire number low voltage H160A; K250A

Extra low voltage control WL113A; WK220A

Pump 2:

Wire number low voltage H160B; K250B

Extra low voltage control WL113B; WK220B

12.6 Wire colour coding

12.6.1 Colours for low voltage busbars and main connections

Wire Type Connection	Colour
Single Phase Supply	Red or Brown (live conductor)
3 phase 3 wire	Red/White/Blue
Neutral	Black or light blue
Earth	Green (or Green with a Yellow stripe)
Thermistor	White
Current Transformers	Yellow
dc supply Positive (110v) (1)	Red with white tracer
dc supply Negative (110v) (1)	Blue with white tracer
Common	Black

(1) If the positive or negative dc rail is the common rail then this shall be clearly marked as such within the panel.

12.6.2 Colours for extra low voltage wiring within panels and switchboards

Wire Type Connection	Colour
dc supply voltage positive supply	Grey
dc supply voltage negative (Vdc common)	Purple
Analogue loop positive (4-20mA)	White
Analogue loop negative (4-20mA)	White (black in a paired cable)
Digital loop (control)	Orange

12.6.3 Colours specific to Mangere Waste Water Treatment Plant

Table below shall be used for Mangere Waste Water Treatment Plant only to replace applicable colours in section 12.6.1 and 12.6.2 above.

Wire Type Connection	Colour
+ 24 vdc	Red
0 vdc	Black
Analogue control circuits (4-20mA)	White
240 vac control circuits	Brown
220v Neutral	Blue
110 vac control circuits	Grey
110 v Neutral	Grey
Protective earth	Green/Yellow
Instrument earth	Green

12.7 Push button and indicator lamp colour coding

This defines the colours for push buttons and indicator lamps to be used in Watercare:

12.7.1 Push button colours

Stop push button	Black	
Start push button	White	
Reset push button	Amber / Yellow / Orange	
Open push button	White	
Close push button	White	
Emergency Stop push button	Red / Yellow Background	

12.7.2 Indicator (led) lamp colours

Note: Lamp indicators on existing sites shall follow the existing site convention. ***Adequate layers of protection shall be used such as labelling and machine safety lockouts to not purely rely on signal colours alone.***		
Running	Red	
Stopped	Green	
Tripped / Fault	Amber / Yellow / Orange	
Auto available	White	
Open	White	
Closed	White	
Alarm	Amber / Yellow / Orange	

The type of push buttons and indicator lamps are described in the Watercare material supply standard.

13. Testing and commissioning

13.1 General pre-commissioning checks and tests

a) Testing and pre-commissioning check sheets shall be completed for all electrical, control and instrumentation items. Pre-commissioning tests shall include as a minimum:

- A visual inspection confirming equipment is installed in accordance with the specification, drawings and manufactures recommendations and ensuring are certifications are relevant.
- Point to point testing and unique identification test of all conductors in all cables.
- Insulation resistance.
- Phase rotation testing (mandatory before disconnection and after reconnection of MCCs, DBs etc.).
- Equipment is safe to operate and circuit breakers, overloads, protection equipment, safety devices and interlocks have been properly set and are all in working order.
- Instruments used for testing are suitable for the purpose and have been calibrated by a recognised laboratory within the last 12 months, or as required by the instrument manufacturer.
- Equipment operation and functional tests.
- Certification of the contractor's commissioning personnel being competent in the relevant fields.

b) Watercare or a representative to be present at inspections and tests and shall be informed of the testing 48 hours in advance.

c) A Certificate of Compliance and Electrical Safety Certificate shall be provided on completion of the testing before Watercare can take ownership and operate the system.

13.2 Cable testing

The insulation test (a) must be performed prior to any high voltage tests

a) Insulation resistance test of primary insulation with DC voltage up to 5kV:
   - An insulation test of the primary insulation should be carried out with an resistance tester with a minimum DC voltage of 2.5kV for 1.9/3.3 kV cabled, or
   - 5kV for cables above 1.9/3.3 kV and up to 19/33 kV.
   - The resistance measured should be after 1 minute of voltage application and must be greater than the calculated values. (New cable range from 2,400 MΩ/km to 18,000 MΩ/km at 20°C).

   Note: If the insulation resistance test is using a Megger Type BM 25 or equivalent then the following tests should be considered:

   - A 10 minute polarisation index test, or
   - A 5 minute step voltage test.

b) High voltage AC test after installation:
   - A high voltage AC test should be applied for 24 hours with the normal operating voltage.
   - A reduced time test can be achieved by a very low frequency (VLF) HV AC test:
     - Maximum VLF voltage for new cable is 2.7 to 3 times the cable operating voltage for minimum 15 minutes, where possible 30minutes is recommended.
     - Existing or aged cables, the VLF voltage should be a maximum of 2.3 times the cable operating voltage for 15 minutes.

13.3 Pre-commissioning of Switchboards, Distribution and Control centres

Pre-commissioning checks and tests shall be completed to the manufacturer's recommendations.

13.4 Power transformers

All transformers will be tested in accordance with 'routine tests' to IEC 60076. Alternative testing standards require Watercare approval.

13.5 Factory acceptance testing (FAT)

13.5.1 Switchboard FAT

a) A switchboard FAT shall be completed and witnessed by Watercare. This shall be undertaken prior to the switchboards leaving the manufacturer's premises. Incomplete switchboards shall not be tested.
b) All protection shall be set and tested in the factory via primary or approved secondary current injection test.

13.5.2 Software FAT

a) The FAT shall be an offsite bench test using the same make and model for hardware and software as that being installed on site. Additional simulation software (PLC and SCADA) will be required to mimic field equipment and provide realistic process system feedback e.g. pump running status, alarms, levels etc. Alternative testing methods may be considered on approval from Watercare.
b) The software FAT shall be witnessed by Watercare. The FAT shall only proceed when the following is supplied to Watercare:

- Screen shots of all graphics
- Signed off internal test sheets
- A FAT agenda
- Proposed FAT test sheets (for approval)

c) The testing shall include as a minimum:

- Operation and layout of all graphics
- Referencing and linking of graphics and all screen based controls
- Operation and function of the plant control system in comparison with the functional description, SFCs, flow charts etc.
- Interlocking
- Alarms and indication for all plant, communications systems etc.
- Logging and trending of plant parameters
- Shut down and restart operability
- Remote connection monitoring and configuration

d) This FAT shall include full step-by-step test for the integration of the radio system onto Watercare's network in coordination with Watercare.

13.6 Cathodic protection testing

Test stations, TRs, and junction boxes shall be visually inspected for:

- Labelling
- Cable colours
- Cable sizes checked

13.6.1 Insulating joints

Insulating joints, monolithic insulating joints and other site specific alternatives shall be tested for adequate electrical isolation or the presence of electrical shorts between joint sides. Isolating joints shall be tested:

a) Prior to installation, and
b) After the pipeline is commissioned or filled with water.

At both stages the joints shall be inspected for signs of incorrect installation or damage. Tests shall be recorded and issued to Watercare. Any readings outside the standard shall be remedied and re-tested.

1. Pre-Installation insulation test in workshop or store

The first test shall check the insulation of the joint as supplied or fabricated and assembled. The test method shall be one of:

Test method	Pass Standard
Resistance meter or multimeter	> 1 megohm
500 V 'Megger' type tester*	> 1 megohm
Radio frequency insulation tester (RF-IT)	Full scale

*500V 'Megger' type, or other high voltage testers must not be used on mag-flow meter insulating flanges, or on any pipework connected to instrumentation.

2. Post-Installation insulation test

a) The final test shall check the insulation of the joint with the pipeline operating or at least charged with water. The test equipment shall be:

Test equipment	Pass Standard
Radio frequency insulation tester (RF-IT)	33% (1/3) of Full Scale

b) The test shall be carried out according to the RF-IT supplier's instructions.
c) For pipes of 300mm internal diameter and larger, two or more measurements shall be taken at equal distances around the circumference of the joint (at approximately 1m spacing around the circumference).
d) The minimum number of tests shall be:

Pipe Diameter (ID, mm)	Number of tests
100 - 250	1
300 - 550	2
600 - 800	3
900 – 1000	4
1200-1500	5
1700	6
1900	7

3. Locating the cause of a short or partial short

a) On insulating flanges the following tests shall be carried out to determine the cause of the failed test:

1. Measure the resistance/insulation of each bolt using either an RF-IT or a resistance meter, if no bolt is shorted, then:
2. Measure insulation of flange at points around the flanged joint using the RF-IT to find where the insulation is weakest

b) If a bolt is found to cause the short it shall be removed and inspected. If the cause is due to a coating defect the bolt-hole must inspected for burrs and misalignment and the bolt replaced. The flange joint shall be retested. Refer to the general mechanical construction standard for bolt replacing procedures.
c) For monolithic insulating joints, and other non-flanged insulating joints the manufacturer's instructions shall be followed for testing and repair.

13.6.2 Cathodic protection power supplies (TR's)

1. Pre-installation inspection

a) TR's are bench tested by the supplier prior to supply, however if the unit has been modified after delivery a bench is mandatory.
b) The TR unit shall be inspected for secure access. Authorised personnel shall be able to access:

- Output setting and level control switches
- Meter faces
- Interrupter controls
- Pipe cable - for current measurement with a clamp and installation of a portable interrupter
- Anode cable for measurement of output voltage with a portable meter

2. Post-Installation Inspection and Testing

a) Following visual inspection the TR may be energised to ensure operation.
b) Following testing the TR must be turned off until pre-commissioning has been completed.
c) The TR will only remain in operation after the CP system commissioning has been completed.

Performance requirements for acceptance:

The following checks shall be carried out:

- Operate TR at maximum output for 5 minutes and check current output is stable
- Operate TR at minimum output (or 1% of maximum output) for 5 minutes and check current output is stable
- Operate at design current for 5 minutes and check current output is stable
- Set interrupter to 12 seconds On, 3 seconds Off, and check that the output voltage does not exceed 50V when the interrupter switches the TR On and Off
- Interruption can be set onsite, and current during off period is <0.001amps
- At maximum voltage the output current is in excess of the design current

13.6.3 Test points

Pipe to soil potential shall be measured for all test point terminals using a 10 megohm or higher resistance multimeter and a copper/copper sulphate electrode.

13.6.4 Cable connections to pipework

1. Testing of cable connection to pipework at time of installation

a) Resistance of electrical cable connections to pipework shall be tested immediately after the connection is made and prior to applying the protective coating.
b) The measurement must be taken between the cable wires and the pipe steel surface.
c) To achieve accuracy the tester may take the measurement as the difference between the measured resistance of the connection and the resistance of the meter leads.
d) The report shall include the calculated resistance, total resistance and the test lead resistance.

Performance requirements for acceptance:

Connection Type	Test method	Pass Standard
All	Resistance meter or multimeter	≤ 0.1 ohm

e) Any connections with resistance greater than the pass standard shall be remade, and retested.

2. Continuity bonds

a) Pipe to pipe resistance shall be measured.

Performance requirements for acceptance:

Connection Type	Test method	Pass Standard
All	Resistance meter or multimeter	≤ 0.1 ohm

b) Any connections where the resistance is greater than the pass standard shall be remade, and retested.

3. Post Installation testing

a) TRs and TPs normally contain two cable connections to pipework. The resistance of cable connections to pipework shall be measured at the test stations and TR(s) by measuring the total resistance of each of these cable pairs.

Performance requirements for acceptance:

Connection Type	Test method:	Pass Standard:
All	Resistance meter or multimeter	< 0.5 ohm

b) Where the measured resistance is greater than the pass standard correct the cause and retest.

13.7 Fibre Optic Testing

13.7.1 Duct integrity testing

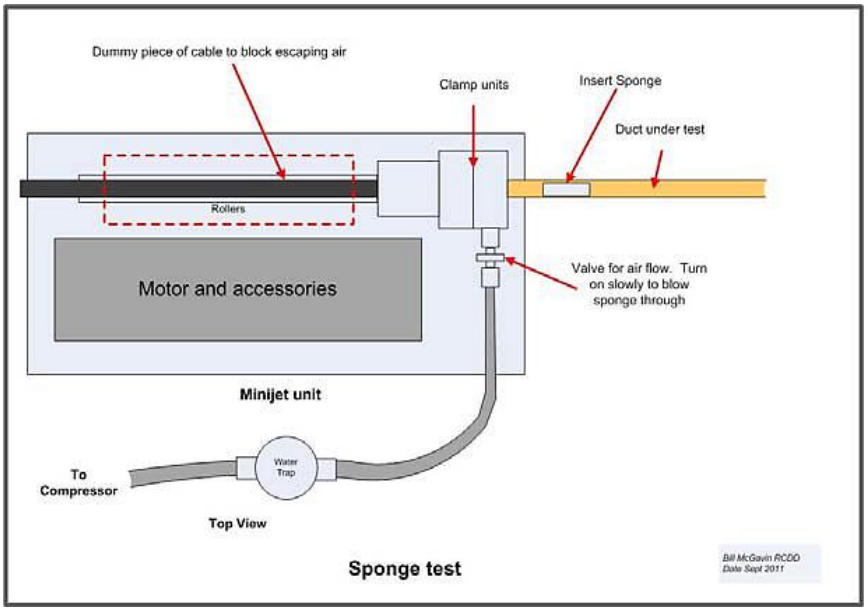
Pre-test procedures:

The technicians selected for duct integrity testing should have at least one year of experience in blowing fibre. The following shall be considered before progressing with duct integrity testing:

- Availability of a complete and clear stretch of between two regeneration/repeater stations
- Availability of Route Survey Reports and the Route Survey Summary Report
- Confirmation of section completeness
- Availability of the a line diagram showing all the coupler points and distances between the couplers, duct overlaps, suspected coupler points and any incomplete portions

Procedure:

1. Ensure that the duct into which cable is to be installed is continuous over the length of the duct by visual inspection
2. Complete an air test to establish duct continuity
3. Blow a sponge through the duct, refer the below, to establish that there are no kinks or blockages in the duct



4. Correct any issues before progressing
5. Verify the duct is rated to withstand the jetting pressure
6. Pressure test the duct
7. Cable installation through jetting under 10 bar pressure

13.7.2 Video inspection and Fibre Optic cleaning

a) Fibre optic connection points shall be inspected and cleaned during installation.
b) All connectors inserted into the network shall be inspected using a 400x video inspection scope and comply with IEC 61300-3-35 using FiberChek2 Software.
c) Certification of compliance to IEC 61300-3-35 is required.

13.7.3 Optical time domain reflectometer (OTDR) testing

All single mode optical fibre must be tested using an OTDR. All Multi-mode Optical Fibre (MMOF) over 300 metres must be tested using an OTDR.

Pre-test procedures:

- The OTDR must have a current calibration certificate (certificate to be provided)
- The OTDR must use the SOR format for file saving
- The OTDR must have an event dead zone of 1 metre or better at a 3ns pulse width
- A near end launch lead must be used on all tests of at least 100m in length
- An electronic copy of traces must be supplied in .PDF and .SOR formats

Guidelines for OTDR Setup:

There are numerous variables in a fibre optic network and the OTDR being used that can change these guidelines. The guideline is to assist in consistency and settings of OTDR traces.

Cable Distance in km	Pulse Width in ns	Range in km	Resolution in m	Averaging Time in seconds
1	10	2	0.25	30
2	25	4	0.25	30

5	50	8	0.5	30
10	100	16	1	30
15	250	32	2	30
20	500	32	2	30
30	500	64	4	30
40	500	64	4	45
50	1000	64	4	45
75	1000	128	8	60
90	2500	128	8	60
120	2500	256	16	60
150	5000	256	16	90
175	10000	256	16	120
200	30000	256	16	120

Procedure:

- Each fibre within the same cable must be tested with the same parameters for pulse width and resolution
- Bi-directional testing must be undertaken on each fibre using 1310nm and 1550nm wavelengths for single mode optical fibre and 850nm and 1300nm for MMOF
- Cursors must be positioned at the start and end of the fibre under test to show cumulative loss and distance

13.7.4 Insertion Loss Testing

All fibre shall be tested using a light source and power metre to the following requirements:

Pre-test procedures:

- The Light Source Power Meter (LSPM) must have a current calibration certificate (certificate to be provided)

Procedure:

- Optical link loss testing shall be according to the LSPM one or three test cord referencing method. The method shall comply with Australian and International Standards depending of the installed configuration of the link i.e. ISO/IEC 14763-3 and AS/NZS 3080
- Dual wavelength bi-directional testing is required under AS/NZS 3080. Bi-directional averaging of test results is not acceptable

13.8 Commissioning

13.8.1 General

a) Refer to the Watercare Code of Practice for Commissioning.
b) The scope of the commissioning shall be to prove:

- Compliance with all statutory requirements such as The Electricity Safety Regulations, AS/NZS3000 and Codes of Practice
- Safe and proper working of the installation in all respects
- The design requirements and correct operation

c) A commissioning programme shall be prepared for each major stage by the contractor for approval Watercare prior to any commissioning commencing.

13.8.2 Cathodic protection specific requirements

The results of the testing shall be complete and accepted prior to commencing the commissioning works.

1. Commissioning procedure

a) Commissioning shall be completed in accordance with:

- The commissioning procedure issued by the designer (if applicable)
- AS2832 Part 1, Section 9

b) The following surveys shall be carried out as a minimum:

- Inspection of CP equipment
- Pre-energising survey
- On/Off test point survey at time of energising
- Interim testing and adjustment if required
- On/Off test point survey following full polarisation of pipeline

2. Pre-energising survey

The following pre-energising testing shall be carried out as per section 9.2 of AS2832 Part 1:

1. Check the effect of current leakage to/from neighbouring CP systems by measurement of pipe to soil potentials. This is achieved by interrupting the neighbouring systems, with the new system off, and measuring if there is any difference between pipe potentials during the On and Off periods. Measurements are to be taken at a minimum of:
    - The insulating joint(s) separating the systems, and
    - The next nearest test points.

   Care must be taken to ensure that the readings are not affected by coating defect IR drop – if no swing, or a positive swing (Off more negative than On) is measured then a second reading must be taken with the half-cell 5m – 20m from the test point or chamber. The positive swing must be included in the survey report, with a description of the location of the half-cell during the measurement.

2. Visually inspect all CP equipment, including:
    - Insulating joints
    - Test points
    - TR's
    - Junction boxes

3. *Post-energising Survey*

The CP system is to be tested and adjusted to afford the best level of protection without causing interference exceeding the limits in AS2832 Part 1. Alternative interference criteria, based on actual protection levels on the foreign structure, may be used, with the approval of Watercare and the other structure owner.

4. *TR operation*

TR's shall be commissioned to manufacturer requirements. Circuit resistance shall be measured across the TR's output range, and the back electro motive force and total loop resistance calculated. Calibrated portable meters shall be used to measure output voltage and current. Summary of method:

1. The TR shall be set to maximum output, both portable and the panel meter readouts shall be recorded.
2. The readings shall be repeated at a minimum of 3 intermediate settings and with the TR turned off.
3. Loop resistance shall be calculated and a linear trend line applied. The gradient shall be reported as the loop resistance and the value at which the trend line crosses the voltage access as the back electro motive force.

5. *Interaction with earthing systems*

Where earthing groundbed(s), PCR(s) or equivalents are connected to the protected pipeline there will be some effect on the accuracy of 'Off' pipe to soil potentials. The commissioning must include measurement of the 'Off' pipe to soil potential at all test points where potentials may be affected. Two surveys will be required:

- The first with the PCR or earth bed interrupted
- The second with the PCR's or earth beds not interrupted

6. *Interference with other Watercare CP systems*

Check the effect of current leakage to/from neighbouring Watercare CP systems by measurement of pipe to soil potentials on those systems. This is achieved by interrupting the CP system being commissioned, and measuring if there is any difference between pipe potentials during the on and off periods on the secondary pipe. Measurements are to be taken at a minimum of:

- The insulating joint(s) separating the systems, and
- The next nearest test points

7. *Commissioning surveys*

The final commissioning survey shall be carried out after full polarisation has been achieved. The length of this period will depend on the coating, insulating joint type and size, and surface area protected. The minimum period between energising and the final survey, shall be the longer of the period in the following table:

Pipe ID (mm)	**Standalone IF's in CLS pipe**			**IF's adjacent to valves**	
	Initial Current (mA)	Polarised Current (mA)	Time to Polarise (months)	Initial Current (mA)	Polarised Current (mA)
≤ 250	10	5	< 1	0	0
310-700	20	10	2	5	2
730-1300	50	20	6	20	10
1500-2000	200	50	12	100	30

The period given here for total system current:

- <200mA: 1 month
- 200mA – 1 amp: 3 months

- 1 amp -5 amps: 6 months
- >5 amps: 12 months

For all systems drawing greater than 1 amp the commissioning procedure must include interim testing and adjustment at a maximum of 3 month intervals.

8. Commissioning Report

A report detailing protection levels and adjustments made shall be submitted to Watercare after completion of each interim CP commissioning survey. The final report shall include results from all the testing including:

- All commissioning results presented in an Excel Spreadsheet. An example format is presented in Appendix A
- Analysis of results
- Summary of protection level
- Summary of interference issues
- Proposed routine test point survey methodology including:
  I. Neighbouring CP systems that must be interrupted for accurate offs
  II. Earthing systems must that be interrupted to measure accurate off, and which test points are affected
  III. Recommendation as to whether neighbouring CP system routines should be modified due to interference from the system being commissioned

14. Appendix A: Example of cathodic protection commissioning reporting sheet

CP Site ID	TP #	TP Name/Location	Mounting	Type	Structure	Facility Code	Terminal	Cable	Commissioning surveys							
									IF and influence checks from other systems*		Natives*	Post Energisation		After 3 months	
									Dates:						
									On	Off		On	Off	On	Off
181	1	Cosseys tunnel outlet portal	Bolt	IF	Portal side of IF	WMCOS	Bolt	-							
					Pipe side of IF	WMCOS	Bolt	-							
182	2	Wairoa River, off Cossey Access Rd	Bolt	Potential	Cosseys 1	WMCOS	Bolt	-							
183	3	Hirst propert AV at top of hill	Pillar	Potential	Cosseys 1	WMCOS	4	Black							
184	4	White / John Hill Rd Corner, left TP	Pillar	IF	Cosseys 1	WMCOS	2	Black							
185	5	White / John Hill Rd Corner, right TP	Pillar		Cosseys 1	WMCOS	2	Black							
					Hunua 4	WMHN4	3	White							
186	6	John Hill Rd, right TP	Pillar	IF	Cosseys 1	WMCOS	2	Black							
					Hunua 2	WMHN2	3	White							
187	7	John Hill Rd, middle TP	Pillar	IF	Cosseys 1	WMCOS	2	Black							
					Hunua 3	WMHN3	3	White							
					Bond current	WMCOS									
188		*John Hill Rd, left TP*	*Pillar*	*IF*	*Hunua 2 upstream*	*WMHN2*	*2*	*Black*							
					Hunua 2 downstream	*WMHN2*	*1*	*White*							
					Hunua 3 upstream	*WMHN3*	*4*	*Black*							
					Hunua 3 downstream	*WMHN3*	*3*	*White*							
								Test Point 7 bond current(amps):							
												Panel Meter	Portable	Panel Meter	Portable
								John Hill Rd TR output volts:							
								Amps:							
								Trail Rd TR output volts:							
								Amps:							