MECHANICAL AND ELECTRICAL

ELECTRICAL CONSTRUCTION STANDARD

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Watercare

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Version history

Revision	Description	Released By	Date
1.0	First release	J de Villiers	17/11/2016
2.0	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
3.0	Format change, new sections; updates to existing content	W. Strydom	22/09/2025

Summary of Changes

Version	Section	Description of revision
3.0	Document	Updated document format, including wording edits and numbering
	1.7	Updated list of applicable referenced standards and documents
	1.3.1	Updated wording regarding qualifications
	1.4.2	Section added on recycling of materials
	2.1.3	Added examples of certified testing authorities
	2.1.6	Multiple amendments
	2.1.7	Multiple amendments to sub-sections
	2.1.8	Reference added to Material Supply Standard and included requirement for RCD protected circuits.
	2.1.9.1	Multiple amendments including updated to specify 'single phase socket outlets' for offices
	2.3.2	Updates QA/QC template 'site testing – ESC/CoC'
	2.4.2	Included reference to seismic design requirements, building code and NZS 4219.
	2.6.3	Added reference to applicable Watercare standards
	2.7.2	Included reference to seismic design requirements, building code and NZS 4219.
	2.8.1	Multiple amendments to sub-sections
	2.9.1	Added requirement that fixings for cable supports to be mounted outwards
	2.9.2	Included reference to Nema 16, material preference for cable trays, minimum size for bonding conductor
	2.9.3.1	Specified additional capacity of conduits, expansion joints for straight runs
	2.9.3.5	Updated to reference standard AS/NZS 61386
	2.9.3.6	Section on 'trenched conduits' added
	2.9.4	QA/QC template updated
	2.11	Section on cathodic protection reduced to reference new Watercare Cathodic Protection Standard (ESF-500-STD-704)
	2.12.7	Table on indicator lamp colours updated
	2.13	Reference to Watercare's Code of Practice for commissioning added
	2.13.1	Multiple amendments
	2.13.3	Pre-commissioning requirements updated
	2.13.5	Minimum FAT requirements added

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Definitions and abbreviations

ac	Alternating current electricity.
Bond cable	Conductor cable used to ensure electrical
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 15º from dropping vertical
3 - >2.5mm tools or thick wires etc.	**3** – Water falling as a spray up to an angle of 60º 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.

1. Preamble and general design requirements

1.1 Introduction

1.1.1 Purpose

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.

1.1.2 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.

1.1.3 'Must' versus 'Shall' versus 'Will'

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

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

1.2 Standard documents overview

1.2.1 Relationship of Watercare standards

Watercare standards are comprised of codes of practice, design standards, standard design drawings, construction standards, and asset and material standards.

The Watercare standards detail requirements, which can be additional to nominated national standards, international standards and industry best practice. These shall be used 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:

1.2.2 Design standards

The Watercare design standards detailed, set a level of design for particular types of infrastructure based on operational areas and associated risks. The design standards provide the minimum criteria when:

- Establishing standard design drawings
- Interfacing design between standard drawings and specific designs
- Establishing the correct sizing of components to meet the baseline parameters of the standard drawings
- Developing tailored designs

1.2.3 Design drawings

Standard design drawings support the requirements of the design standards. Minimum and maximum criteria are set, and specific standard details are shown.

1.2.4 Asset and material standards

Asset standards describe the requirements for asset as-builts creation, asset numbering, asset capture, production of operational manuals and documentation. Material standards describe the minimum compliance requirements of materials and products supplied for asset acceptance. Often selected materials will have limitations of applicability and requirements specific to the operating environment and infrastructure classification. Section 2 describes the minimum requirements applicable to this standard. Additional requirements may be specified based on a specific design.

1.2.5 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, focus on proven methods and best practice to ensure quality is maintained. Further, they are used to achieve the design life of the infrastructure and ensure 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.

1.2.6 Project specific specification

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

1.2.7 Design-build projects

Design-build projects (also known as design & construct) shall follow the minimum requirements set out in all the above standards.

1.3 Quality control and quality assurance

1.3.1 Qualifications

All “prescribed electrical work” as defined by the NZ Electrical Regulations (2010) shall be undertaken only by an electrical contractor licensed under the New Zealand Electricity Regulations. All employees of the Contractor undertaking prescribed electrical work on the site shall be licensed under the appropriate class of registration for the work being undertaken. Proof of registration and a current practicing license must be provided to Watercare prior to starting any work. Refer to Watercare’s compliance statement policy available on our website.

1.3.2 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 1.3.5.

An electrical Certificate of Compliance (COC) and an Electrical Safety Certificate (ESC) for each part of the work 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.

1.3.3 Dispensations

Any departure from the standards for the works shall not compromise quality, whole of life performance, safety, operation and maintenance, and regulatory requirements including health and safety and environmental requirements. Any proposed departure shall be evaluated by completing an Application for Dispensation from / relating to the applicable standard and by demonstrating that the departure complies with the requirements and applicable certification by providing proof of quality documentation.

1.3.4 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.

1.3.5 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.

1.4 Materials

1.4.1 Material standards

Materials shall include all equipment, machinery, components, or products used to complete the works.

All materials necessary for the work shall be supplied in accordance with Watercare's Material Supply Standard (ESF-500-STD-601) and meet all applicable water standards. Materials shall be new and suitable for their intended purpose and performance requirements.

Machinery and equipment shall be in a good, maintained condition and safe.

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

1.4.2 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

1.4.3 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, Standard for producing CAD and geospatial drawings, 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.*

1.5 Asset information

Asset information shall be progressively captured and supplied in accordance with the requirements of Watercare's Asset Recording standards. These standards shall be followed for new, upgraded or decommissioned assets.

1.6 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.

1.7 Referenced standards

This standard makes reference to legislation, national, international and Watercare's standards. It is the obligation of users of this document to ensure they comply with the legislation, as well as the cited version or if not cited, the latest version of these standards. Watercare seeks to update this document whenever standards are revised or replaced, however it is expected that the cited version or if not cited the latest recognised replacement by the standard's governing body is adopted until such time that this document can be amended.

1.7.1 Standards list

This standard must be read in conjunction with the legislation, national, international and Watercare's standards. A general list of relevant documents is identified below but this is not an exhaustive list. Where conflict or ambiguity exists, Watercare shall be consulted to confirm the document or clause(s) that take precedence.

1.7.1.1 Legislation

- NZ Health and Safety at Work Act
- NZ Building Act
- NZ Building Code
- NZ Electricity Act
- NZ Electricity (safety) Regulations
- NZ Electrical Codes of Practice

1.7.1.2 Watercare standards

- DP - 10 Safety in Design guide
- ESF-500-STD-401: General plant layout and equipment selection principles
- ESF-500-STD-601 - Material Supply Standard
- ESF-500-STD-502 – Standard for producing CAD and geospatial drawings
- AI - Data and Asset Information standard series
- ESF-500-STD-702 (DP-09) – Electrical design standard
- ESF-700-STD-801 (COP-03) - Code of Practice for commissioning
- Watercare's Standard Electrical Drawing Sets

1.7.1.3 National and international standards

General:

- AS 2067 Substations and high voltage installations exceeding 1 kV a.c.
- AS/NZS 3000 Electrical installations (Known as Australian/New Zealand Wiring Rules)
- NZ Radio Interference Regulations
- AS/NZS 1158 Lighting for roads and public spaces
- AS/NZS 1680 Part 2.4 Interior lighting - Industrial tasks and processes
- AS/NZS 1768 Lightning Protection
- AS 1939 (IEC529) Degrees of protection provided by enclosures for electrical equipment (IP code)
- AS/NZS 2293.1 Emergency lighting and exit signs for buildings
- AS/NZS4024 Safety of machinery set
- 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

- AS/NZS IEC 60947 Low-voltage switchgear and controlgear
- AS/NZS 61386 Conduit systems for cable management
- IEC 62305 Protection against lightning
- NZS 1170 Structural design actions
- NZS 4219 Seismic performance of engineering systems in buildings
- NZS 5807 Code of Practice for Identification by Colour, Wording and other coding

Distribution transformers:

- AS/NZS 60076 Power transformers
- IEC 60296 Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment
- AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

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
- AS/NZS 61439 Low Voltage Switchgear and Control Assemblies

Generator connections

- AS/NZS 3010 electrical installations – Generating sets

Harmonics

- NZECP 36 New Zealand electrical code of practice – Harmonic levels
- AS/NZS 61000 Electromagnetic compatibility

Uninterruptable power supplies

- BS EN 62040 Part 3 Uninterruptible power systems (UPS) Part 3: Method of specifying the performance and test requirements
- IEC 62310 Static transfer systems (STS)

Motors

- AS/NZS 1359 series of standards on 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 5000.1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV
- AS/NZS 5000.2 Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V
- AS/NZS 5000.3 Electric cables - Polymeric insulated - Multicore control cables
- AS/NZS 3008.1.2 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
- AS2832.1 Cathodic protection of metals, part 1: pipes and cable
- AS2239 Galvanic (sacrificial) anodes for cathodic protection

2. Electrical construction

2.1 General electrical installation

2.1.1 Material delivery and handling

a) Materials and equipment shall be delivered to the site with the manufacturer's labelling intact and with SDoC, certificates of compliance, safety certificates, etc., 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

2.1.2 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 2.1.5 below.

c) Fixings and restraints shall ensure that the equipment withstands seismic loading without excessive stress, distortion 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 requires servicing or operation.

2.1.3 Hazardous areas

a) Equipment installations within hazardous areas shall employ protection techniques in compliance with the hazardous area classification as defined by AS/NZS 60079.

b) All equipment including cable and glands shall be certified by a recognised testing authority i.e. IECEx or ANZEx. ATEX certified equipment is not acceptable. 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.

2.1.4 Protection and finishes

a) 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.

2.1.5 Dissimilar metals

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

2.1.6 Junction boxes and field control stations

a) Junction boxes are enclosures for junctioning of cables only and house no control or protective equipment e.g. switches, breakers, relays etc.

b) All junction boxes shall be PVC or grade 316 stainless steel and classified to IP65 or better and mounted securely. Where PVC junction boxes are exposed to UV light, they shall be manufactured of a UV stabilised material. Junction boxes shall contain cables and terminals only.

c) All junction boxes shall have drain/breather plugs fitted.

d) Field control stations are generally small enclosures that house basic control and/or indication equipment e.g. switches, breakers, relays, local displays etc., but are not switchboards, control panels or junction boxes. Refer to Watercare's Material Supply Standard (ESF-500-STD-601) section 13.13 for switchboard and control panel requirements.

e) Field control stations shall be 316 stainless steel metal clad enclosures rated to a minimum of IP65 and be provided with a hinged door.

f) All live exposed parts within the field control station must be protected from direct contact with the field control station door open.

g) Junction boxes/field control stations that are required to be fully waterproof shall have nylon washers installed with the cable glands and gland adapters.

h) Heat dissipation shall be allowed for in the design of the field control station such that any devices do not overheat.

i) All field control stations housing pneumatic equipment shall be vented at the bottom of the box and fitted with a port protector/silencer.

j) An earthed metal gland plate for cable glands shall be installed in the bottom of every metal junction box and field control station.

k) Cables shall only enter the bottom of the enclosure. Unused entries shall be plugged with an approved product that retains the IP rating of the enclosure.

l) All terminals shall be numbered and trunking provided on both sides of the terminals. The trunking shall be grey slotted PVC, with a minimum of 20% spare capacity and be spaced a minimum of 35mm from each side of the terminals.

m) All junction boxes and field control stations shall be labelled in accordance with Section 2.12 of this standard.

n) Refer to the 'Wiring and terminations' and 'Identification' sections in 13.13.4 of Watercare's Material Supply Standard (ESF-500-STD-601) for additional requirements.

2.1.7 Earthing

2.1.7.1 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.

2.1.7.2 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 suitably convenient location.

c) For outdoor installations the main earth bar shall be located within the switchboard.

d) All connections to the main earth bar 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:

i. Supply transformer earth (if installed)

ii. Main earth (to earth electrodes)

iii. 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 shall be electrically sized in accordance with the standards and oversized mechanically by 20% to allow for future connections.

h) Earth electrodes shall be selected in accordance with AS/NZS 3000. Where horizontal earth electrodes or more than one vertical earth electrode is required, the main earth system shall form a ring circuit.

i) Where the earthing system utilises buried bare copper conductors, the conductors shall be treated as per buried cables, i.e. at a depth not less than 500 mm.

j) A proprietary exothermic welding system e.g. Cadweld, shall be used for connecting earth electrodes and copper conductors.

2.1.7.3 Structural earth

a) The building housing the main switchboard and any structural steel associated with the building shall be earthed with a minimum of two 35mm^2 copper earth conductors. For portal framed steel buildings, each end frame and every second frame are to be earthed as a minimum.

b) Concrete slabs with steel reinforcement shall be earthed with a minimum of one 70mm^2 Wricon. Reinforcing within concrete slabs used for buildings and/or supporting electrical equipment shall be earthed by a minimum of two 70mm^2 Wricons. The Wricon(s) shall not be welded directly to the structural steel but instead welded to a sacrificial reinforcing bar, or bar arrangement, which is wire tied to the reinforcing proper at regular intervals.

c) Wricons shall be vertically positioned against the foundation to avoid accidental damage and arranged so as not to cause a tripping hazard.

2.1.7.4 Instrument earth

a) Refer to the 'General requirements' Section in 13.13.4 of Watercare's Material Supply Standard (ESF-500-STD-601), for additional requirements.

2.1.7.5 Earth continuity conductors

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

2.1.7.6 Bonding

a) Metallic ducts, building steel work, portal frames, concrete reinforcing, cable trays, cable ladders, handrails, pipework, benches and sinks, taps and partitioning members shall be bonded together and to the earth bar as required by AS/NZS3000.

2.1.7.7 Lightning protection

a) Lightning protection shall be installed as per the design and to IEC 62305. A separate earth electrode shall be exothermically welded as close as practical to aerial masts.

2.1.8 Lighting

a) Luminaires shall be installed as detailed on the specific drawings. Refer to the 'Luminaires' Section in 13.13.2 of Watercare's Material Supply Standard (ESF-500-STD-601), for additional requirements.

b) Alternative luminaires require Watercare approval. All lighting circuits shall be RCD protected in accordance with AS/NZS 3000.

2.1.9 Power outlets

2.1.9.1 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) Single phase 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 series or Lifeguard types. Single phase socket outlets shall be flat pin 15 Amp rated. 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) Socket outlets located outdoors or in damp areas shall be of the surface mount type with a minimum IP56 rating.

g) All general-purpose socket outlets shall be RCD protected in accordance with AS/NZS 3000.

2.1.9.2 Permanent connection units

a) In office areas, permanent connection units shall be installed for such items as hot water cylinders, auto doors, roller shutter doors and hand dryers.

b) Permanent connection units shall be mounted at the heights shown for socket outlets.

c) Permanent connection units for single 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.

2.1.9.3 Outdoor power distribution

Outdoor power enclosure distribution must be:

a) Wall mounted

b) Minimum IP56

c) Fastening with stainless steel fixtures

d) Contain switchable unit isolator

e) Arranged so that all circuits are protected by RCD.

f) Unit protected by over current and short circuit protection

g) Installed as per manufacturer's instructions.

2.1.10 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 2.12.

c) All wiring shall be fitted with crimp pins/lugs as appropriate before terminating.

d) Each terminal at each terminal block shall be permanently identified.

e) All DIN mount rail terminals shall be screw type to fit TS35 DIN rail.

f) All power and earthing cabling crimp lugs or links must be fitted as per industry best practice. There shall be no exposed conductor between the lug and the cable insulation. Following termination, heat shrink sleeving of the same colour as the conductor insulation shall be installed to cover the cable insulation and lug/link barrel.

g) Bolted cable terminations must be tightened using the manufacturer's specified sequence and torque setting. The torque wrench or driver must be calibrated.

h) Cable lugs must be correctly sized to ensure full surface contact.

2.1.11 Workmanship

a) All work for the entire installation shall be undertaken in a tidy and professional manner. The Contractor shall coordinate with other trades and services to ensure the most efficient use of site resources.

b) All works shall be installed in accordance with manufacturer's instructions and any specific contract requirements.

c) Work shall be planned to maintain unobstructed access to existing site equipment.

d) All workmanship, shall as a minimum:

- Be in accordance with best industry practice
- Comply with the Contract documents
- Be carried out under the constant supervision of a competent foreman
- Be carried out by appropriately qualified and experienced tradesmen and supervised apprentices

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.

2.1.12 QA/QC template – General electrical installations

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			

2.2 Power transformers

2.2.1 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 plus 20%. For civil construction requirements refer to Watercare’s general civil construction standard.

c) See Section 2.13.4 of this standard for testing requirements. The testing of indoor transformers shall include the operation of the ventilation system.

2.3 Switchboards

2.3.1 General

Refer to Watercare’s Material Supply Standard (ESF-500-STD-601) for the construction and supply of switchboards (e.g. power distribution centres, distribution boards, etc.) and control panels.

2.3.2 QA/QC template - Switchboards

ENSURE THE MAIN SITE SWITCHBOARD 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	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
3	Site Testing – ESC/CoC	Provision of ESC/COC after site assembly & testing (electrical safety certificate/certificate of compliance) – by electrician after testing and prior to livening		Required	Required
4	Material Supply Standard Check	Cross-check switchboard supplied on site complies with WSL Material Supply standard checklist.		Required	Required
5	Pre-commissioning checks	Cross-check switchboard compliance with Code of Practice (COP-03) for checks and **hold points**		Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
6	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			

2.4 Uninterruptable power supplies (UPS)

2.4.1 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.

2.4.2 UPS Mounting

UPS units shall be restrained in accordance with seismic design requirements, the NZ Building Code, and NZS 4219.

2.4.3 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.*

2.4.4 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.

2.4.5 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.

2.4.6 QA/QC template – Uninterrupted power supply (UPS)

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			

2.5 Instrumentation

2.5.1 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 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.

2.5.2 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 strictly in alignment with the supplier's specifications 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 a 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.

2.5.3 Power supply and earthing

a) Power supplies to instruments shall be 230 Vac at 50 Hz UPS supply or 24 Vdc 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.

2.6 Motors

2.6.1 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 for any fault signal.

2.6.2 Circuit breakers

a) Motors shall be supplied through individual circuit breakers of appropriate size for the motor and the short circuit rating of the site.

b) Each motor circuit breaker shall be labelled and fitted with an extended rotary handle through to the front of the switchboard door. The extended handle shall provide a single isolation point for the motor and control circuitry.

2.6.3 Anti-condensation heaters

Refer to the Electrical Design Standards (ESF-500-STD-702) and Material Supply Standard (ESF-500-STD-601) for anti-condensation heater requirements in motors.

2.6.4 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.

2.6.5 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.

2.6.6 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.

2.6.6.1 Insulation resistance

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

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.

2.6.6.2 Winding resistance

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

2.6.7 QA/QC template - Motors

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			

2.7 Variable Speed Drives

2.7.1 Cabling

a) Cables shall be installed to suit the VSD and in a manner that reduces 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 2.8.

c) Note the following material requirements shall apply:

d) The construction shall be 600/1000 volt XLPE insulated conductor and shall comply with AS/NZS 5000.1.

2.7.2 Enclosure

a) Access for operation and maintenance shall be from the front only.

b) Floor standing VSDs shall be mounted on a galvanized steel plinth.

c) Mechanical restraints shall be installed to meet seismic requirements, the NZ Building Code, and NZS 4219.

2.8 Electrical cables

2.8.1 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 for 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, hand rails 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 extra low voltage cables shall follow a separate route from, and shall not be run parallel with low or high voltage 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 as defined in AS/NZS 3008.1.2

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. As a minimum, this means bevelling/smoothing edges of cable support and the internal radius of conduits.

q) Ducts shall be cleaned before installation of cables. Cable manufacturer approved lubricant shall be applied to cables during drawing into ducts to prevent damage to 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.

2.8.1.1 Twisting and bending

a) Cables shall be installed to avoid twisting and to ensure the bending radius complies with the manufacturer's recommendation.

2.8.1.2 Cable fittings

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

2.8.1.3 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.

2.8.1.4 Cable identification

a) For each cable, a cable label with the cable name as defined on the drawings/schedules shall be provided at each end and at each cable joint.

b) The cable label shall be:

- PVC with black lettering on a white or yellow background. If the label is in any way exposed to UV it must be made of a UV stabilized material. The label shall be affixed to the cable with black cable ties.
- Stainless steel (silver anodized) engraved with the cable name. The label shall be affixed to the cable with stainless steel wire.
- Aluminium (silver anodized) engraved with the cable name. Aluminium labels must not be used where corrosive chemicals are present. The label shall be affixed to the cable with aluminium wire.

c) 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. If where the cable emerges the label is inaccessible, e.g. under a floor mounted switchboard, at height etc., a label shall also be affixed in an accessible location e.g. inside the panel, at ground level etc.

- Lettering shall be minimum 3mm in height.
- The Grafoplast system shall be used for labelling cable terminations.

2.8.2 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 any exposed sections protected from degradation by UV.

c) The internal edges at the ends of each duct shall be bevelled and smoothed to prevent damage to cables being drawn in.

d) 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.

e) The minimum depths for laying underground cables shall be so 600mm for LV cables and 900mm for HV cables.

f) 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.

g) 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.

h) 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.

2.8.3 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:

- Cable joints shall be 'in-line', staggered and located on the cable support
- For cables ≥ 10mm^2 use epoxy cable jointing kits. Glue-lined thick wall heat shrink may be used when approved by Watercare
- For cable with conductors between 4mm^2 and 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
- For cables less than 4mm^2 use 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
- The cable core rotation for both the existing and new cables shall be matched to minimise the profile of the cable joints

2.8.4 Cable terminations

a) Terminations shall be supplied in accordance with completed schedules of the Watercare materials supply standard and provided with test certificates.

b) Methods for achieving environmental seal and managing induced voltages shall be submitted with full details for review.

c) Lugs should preferably be screwed connectors with shear head bolts instead of compression lugs.

d) For TR-XLPE / XLPE insulated cables the lugs shall be bi-metallic or tinned aluminium for phase conductors and tinned copper or brass lug for screen wires.

e) 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.

f) 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.

2.8.5 Redundant cables

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

- Disconnect the cable at both ends
- Make the cable safe by capping the end with a heat-shrink cap
- Label the cable as redundant at both ends with a unique identifier
- Mark the redundant cable on a drawing using the unique identifier

2.8.6 Cable length

a) Cable shall be manufactured and supplied in a single length unless the length exceeds a standard drum length. Cable joints shall be undertaken with the written approval of Watercare.

2.8.7 Conductors

a) Copper conductor multicore cables shall be used throughout the installation unless otherwise specified.

b) Explicit approval in writing from Watercare is required for use of aluminium conductors.

c) Aluminium conductors must be terminated with bimetallic or tinned aluminium 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.

2.8.8 Un-armoured cable

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

2.8.9 Cable route planning

a) Cables shall be installed in the planned cable corridors 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) Low voltage cables shall be separated from extra low voltage cables i.e. those not exceeding 50Vac, or 120V ripple free dc, by at least 300mm. A physical barrier shall be provided between low voltage cables and cables for other services in building ducts.

2.8.10 Instrument cables

a) Extra low voltage (instrument) cables shall be arranged to cross low voltage and high voltage cables at right angles, thereby minimizing electrical interference

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 the screen shall be electrically continuous from its source to the instrument. The earthed end of the cable shall be as close as possible to the source of the signal. The cable screen's drain wires shall be insulated and connected to a low impedance earth, preferably an instrument earth bar. Cable screens shall terminate at junction boxes through insulated terminals to prevent earth loops.

d) Instrument field cables shall have minimum of 300mm spare length at the instrument end, neatly supported below the instrument.

e) Instrumentation cables shall not be stacked more than three cables high on cable supports. Refer to Section 2.9 for stacking restrictions on other cables.

f) Cables terminated at instruments that are buried or installed in underground enclosures shall be potted where the instrument has this capability. The instrument manufacturer's procedures/products shall be explicitly followed/used in these cases.

2.8.11 Communication cables

a) Communications cables can be installed on ELV cable support. Where there are no ELV cable supports communication cables shall be run individually in 20mm conduit. In both cases, communication cabling shall be separated from LV and HV cables by a minimum of 300mm.

b) Dual redundant communication cable systems shall be installed on separate routes between device locations.

2.8.12 Cable glands

a) Glands specific to the cable application shall be installed in compliance with the manufacturer's recommendations and instructions.

b) A minimum of 50mm of straight cable shall be provided prior to the cable entering a gland. The cable shall enter the gland in direct alignment with the bore of the gland i.e. not at an angle.

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.

2.8.13 Cable gland accessories

a) Only manufacturer recommended accessories shall be used with cable glands and terminations. Where cables utilise the armour/screen as an earth continuity conductor, an earthing ring with a bolted lug connection shall be used at both ends.

b) Steel or nickel-plated glands used on wastewater treatment plants or pump stations shall be protected from H2S deterioration. The protection shall be in the form of Denso tape (or approved equivalent) wrapped around the gland and cable.

2.8.14 QA/QC template – Electrical cables

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	Protected in conduit or cable support.	N/A	Required	Required
4	Instrumentation cable	ELV cables to cross LV and HV cables at right angles	N/A	Required	Required
		ELV and LV use separate cables	N/A	Required	Required
		Minimum 300mm spare length at cable ends	N/A	Required	Required
		Cable depth maximum 3 on cable supports	N/A	Required	Required
5	Communication cables	Min 300mm separation from LV 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 glands	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			

2.9 Cable support and protection

2.9.1 General

a) All cable trays and support fittings 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. These 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 and size 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 handrails or process pipework. Fixings for cable support systems must be mounted outwards to minimise the likelihood of damage during cable installation.

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 shall be fixed to cable ladders/trays using ultraviolet light resistant plastic ties where required.

2.9.2 Cable trays and ladders

a) Cable ladders shall be compliant with Nema 16.

b) Cable tray shall be constructed of galvanized steel or aluminium.

c) Sweeps and bends should be installed at all right-angled junctions.

d) Where cable ladder is joined by fish plates with a single bolt, then a suitable earth strap shall be installed.

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.

f) Cable supports shall be installed to follow the lines of the building.

g) 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.

h) Each support for overhead structures shall typically 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.

i) 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.

j) The cables shall be neatly secured with clamps, saddles or cable ties. The restraint method shall be suitable for fault conditions. 240mm^2 single core and larger cables shall be clamped.

k) Cables shall not be stacked more than 3 high.

l) Process lines must not be supported on cable trays.

m) Dissimilar materials shall be isolated against galvanic corrosion.

n) Metal cable support shall be bonded to earth. Where the cable support is not continuous, bonding across (both sides of) the cable support is required at:

- Hinged joints
- Expansion joints
- Discontinuous sections

o) The minimum size of the bonding conductor shall be 6mm^2.

p) The bonding cable size shall be determined based on the site's prospective fault current and protection settings. The designer is to confirm to the contractor the minimum size to be used.

Table 2.1: *Guide to 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

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

2.9.3 Conduits

2.9.3.1 Conduit - general

a) The minimum size of conduit shall be 20 mm. Unless otherwise specified, conduit shall be one size larger than required by the standards for the number of conductors to be drawn in with an additional 20% spare capacity.

b) Conduit boxes with removable covers shall be provided with draw wires 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 boxes shall be installed at least every 40m and expansion joints at least every 20m. Straight runs exposed to sunlight shall have expansion joints every 10 metres.

e) Avoid drawing cables around more than two 90-degree bends by appropriately spacing the boxes.

f) Typical bend 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 with and at right angles to the building's structural elements.

h) Above ground conduits shall be supported by saddles at appropriate spacings and load ratings. The maximum distance between the saddles shall be 1m and within 100mm on each side of a conduit box or fitting. The saddle spacing shall prevent visible sagging of the conduit at completion.

i) Saddles and fixings shall be stainless steel. Fixings into concrete shall be made using Nylon anchors with stainless steel pins/screws. 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 shall 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.

2.9.3.2 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 approved in writing by Watercare.

2.9.3.3 Conduit in concrete

a) The conduit shall be installed in position before the concrete is cast and shall extend to a minimum of 100mm beyond the finished concrete where it protrudes.

b) Conduit runs in groups or large concentrations shall be spaced a minimum of one conduit diameter width apart.

c) Penetrations through the concrete shall be watertight and sealed.

2.9.3.4 Metallic conduit

a) The use of metallic conduits requires written 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 paint 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 continuous and bonded to earth. However, conduit systems shall not be relied upon for earth continuity.

2.9.3.5 PVC conduit

a) PVC conduit must be installed to the manufacturer's recommendations.

b) PVC conduit shall be heavy duty as defined in AS/NZS 61386.

c) Conduit colours:

- PVC conduit shall be orange for below ground installations.
- PVC conduit colour shall be grey for above ground installation and UV stabilised.
- Flexible conduits and fittings shall be ‘black Technoflex’ or equivalent and be a minimum IP56.

d) All conduit joints, fittings and adapters shall be glued. All conduit ends shall be sealed.

e) PVC conduit shall only be used in ambient temperatures below 50^{o}C and where it is not susceptible to mechanical damage.

2.9.3.6 Trenched conduits

a) This section shall be read in conjunction with the general civil construction standard. Also refer to Section 2.9.2 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 material shall be sand and a minimum of 75mm deep.

d) Mechanical protection of the conduit e.g. 'Magslab' shall be provided even though this is not a requirement in AS/NZS3000.

e) Cable marking tape installation shall be laid in compliance with AS/NZS 3000.

2.9.3.7 MDPE conduit

a) Communications ducting "sub-duct" shall be green MDPE and used for communications cabling only.

b) Joints in the sub-duct shall be made using PE compression fittings.

2.9.3.8 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 316 stainless steel as specified. Site cut sections of mild steel shall be protected from corrosion. Refer to Section 13.10 of the MS Standard for treatment options.

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 recommendations 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.

2.9.3.9 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 a 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 fixings shall be spaced to avoid sagging between supports.

i) All metallic trunking shall be earthed in accordance with the AS/NZS3000.

2.9.4 QA/QC template – Cable support and protection

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Cable support	Support bracket spacing meets design requirements for deflection	N/A	Required	Required
		Cable support bonding to correct size	N/A	Required	Required
		Minimum of NEMA 16 for cable ladder	N/A	Required	Required
2	Cable conduit	Support saddles spaced as per manufacturer's recommendations	N/A	Required	Required
		Expansion joints and conduit boxing provided at minimum required 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			

2.10 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.

2.10.1 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.

2.10.1.1 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.

2.10.1.2 Couplers

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

2.10.1.3 Duct end caps

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

2.10.1.4 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.

2.10.1.5 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 run.*

2.10.1.6 Testing of ducts

Refer to Section 2.13.

2.10.2 Specific duct installation methods

2.10.2.1 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.

2.10.2.2 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 is 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

2.10.2.3 Reinstating ground after trenching / ploughing

Refer to Watercare's general civil construction standard.

2.10.2.4 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.

2.10.3 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.

2.10.4 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.

2.10.5 Cable breakout, fusion splicing and terminations

2.10.5.1 Cabling tools

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

2.10.5.2 Central strength member

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

2.10.5.3 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.

2.10.5.4 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.

2.10.5.5 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.

2.10.5.6 Securing splice cassette

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

2.10.5.7 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.

2.10.5.8 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.

2.10.5.9 Splicing position

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

2.10.5.10 Splice loss

There shall be less than 0.1dB loss per splice.

2.10.6 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.

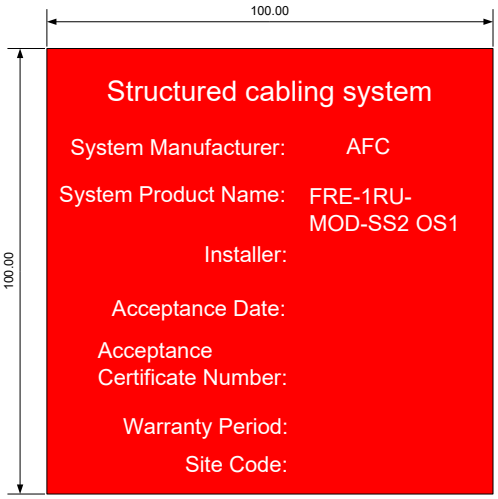


***Figure 2.1**: Example of label on communications equipment.*

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.

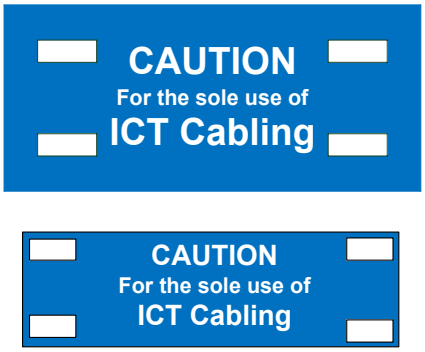


***Figure 2.2**: Example of label positioning*

2.10.7 Cable management

2.10.7.1 Vertical cable management

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

2.10.7.2 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.

2.10.7.3 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.

2.10.7.4 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.

2.10.8 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.

2.10.9 QA/QC template – Fibre optics

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 2.13.	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			

2.11 Cathodic protection

a) Refer to Watercare's Cathodic Protection Standard (ESF-500-STD-704).

b) Refer to the Watercare general mechanical installation standard for flange installation requirements.

c) Electrical isolation shall be installed as shown in the specific drawings.

2.11.1 QA/QC template – Cathodic protection

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 2.8	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			

2.12 Colour coding, Identification and labels

2.12.1 Equipment number

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

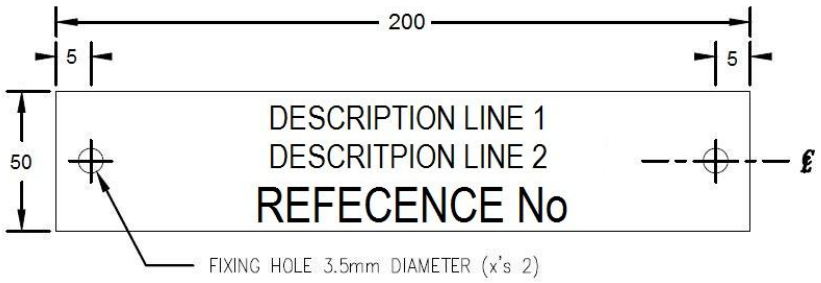
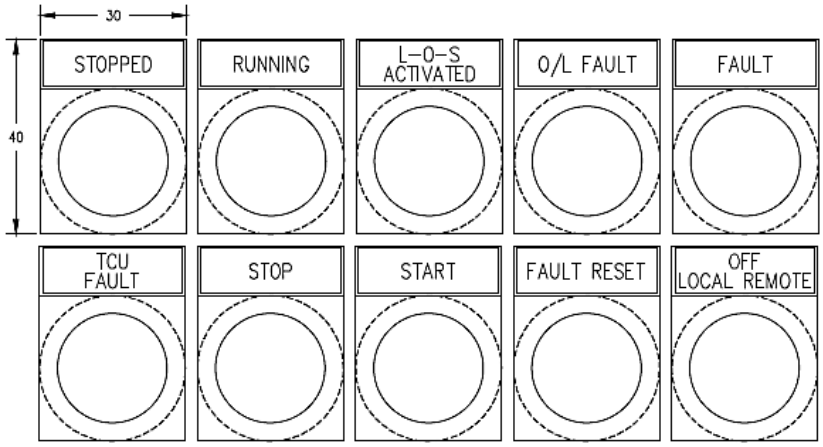
2.12.2 Labels - general

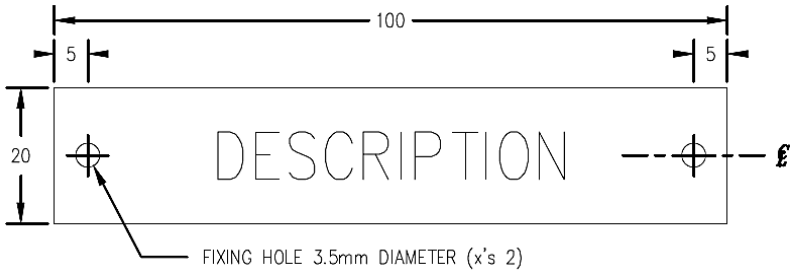
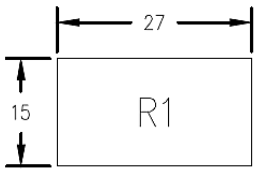
a) Labelling and identification of equipment, services and the like shall be in accordance with NZS 5807. The labelling shall be to the Watercare data and asset information standard

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 installed in close proximity to it, in a clearly visible location.

2.12.2.1 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 VOLTAGE

2.12.3 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.

2.12.4 Cable numbering

Cables shall be numbered as identified on the specific drawings.

2.12.5 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

- 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.
- 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

- 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.
- 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

2.12.6 Wire colour coding

2.12.6.1 Colours for low voltage busbars and wiring within panels and switchboards

Each conductor of power wiring or cabling shall be permanently identified at each end of the appropriate phase, neutral or earth with the appropriate colour code.

***Table 2.2**: Colours for low voltage busbars*

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)
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.

2.12.6.2 Colours for extra low voltage wiring within panels and switchboards

***Table 2.3**: Colours for extra low voltage wiring*

Wire Type Connection	Colour
24Vdc supply voltage positive supply	Grey
Other dc supply voltages positive supply	Pink
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
Thermistors	White
Current Transformer Secondary	Yellow

2.12.6.3 Colours specific to Mangere wastewater treatment plant

***Table 2.4**: Colours for wiring at Mangere wastewater treatment plant (only to replace applicable colours in Section 2.12.6.1 & 2.12.6.2 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

2.12.7 Push button and indicator lamp colour coding

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

***Table 2.5**: Push button colours*

Button type	Colour	Example
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	

***Table 2.6**: Indicator (led) lamp colours*

Indicator type	Colour	Example
Running/Stopped	White	
Tripped / Fault	Amber / Yellow / Orange	
Auto available	White	
Open	White	
Closed	White	
Alarm	Amber / Yellow / Orange	

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.

The type of push buttons and indicator lamps are described in the Watercare's Material Supply Standard (ESF-500-STD-601).

2.13 Testing and commissioning

All testing and commissioning shall be undertaken in accordance with the Code of Practice for Commissioning (ESF-700-STD-801 / CoP-03).

2.13.1 General

a) Proposed testing and commissioning check sheets shall be submitted for approval prior to any testing/commissioning taking place for all electrical, control and instrumentation items. Tests shall include as a minimum:

- A visual inspection confirming equipment has relevant certification and is installed in accordance with:
  - The specifications,
  - The drawings
  - The manufacturer's recommendations
- Point to point testing and unique identification of all conductors in all cables.
- Insulation resistance testing.
- Phase rotation testing (mandatory before disconnection and after reconnection of MCCs, DBs etc.).
- Ductor (joint resistance) testing on all bus bar connections and terminations with a design current rating not less than 630 Amps.
- The Contractor shall measure and record the earth resistance and impedance of the earthing system for:
  - Any new installation

- Installations which have had modifications to the supply transformer, mains cables, main switchboard, supply equipment etc.
- Installations which have had changes to the main earthing system.

- 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 shall be invited to all inspections and tests and shall be informed of the testing at least 48 hours in advance.

c) A Certificate of Compliance, Electrical Safety Certificate and Record of Inspection (if required) shall be provided on completion of the testing before Watercare will accept ownership and operate the system.

2.13.2 HV Cable testing

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

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 insulation resistance tester having a minimum DC voltage of:
  - 2.5kV for 1.9/3.3 kV cable, 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.

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.

2.13.3 Pre-commissioning of switchboards, distribution boards and control centres

Pre-commissioning checks and tests shall be completed to the manufacturer's recommendations. Where the switchboard has been reassembled on site, the manufacturer (or their agent) shall test the board and provide written confirmation of its integrity/functionality. Testing as a minimum shall include:

- Visual inspection
- Continuity
- Insulation resistance
- Contact resistance
- Ductor (joint resistance) testing as applicable.

2.13.4 Power transformers

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

2.13.5 Factory acceptance testing (FAT)

2.13.5.1 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 testing.

c) As a minimum the FAT shall be to prove functionality of equipment, correct implementation of settings, use of compliant equipment and compliance with Watercare standards. The designer shall develop a FAT test sheet and have it approved by Watercare prior to the testing at the manufacturer's premises.

2.13.5.2 Software FAT

a) The software FAT shall be an offsite bench test using the same make and model of 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, flows, etc. Alternative testing methods may be considered with written approval from Watercare.

b) The software FAT shall be witnessed by Watercare. The FAT shall only proceed when the following is supplied to, and approved by, 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 equipment, 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 testing for the integration of the radio system onto Watercare's network, in coordination with Watercare.

2.13.6 Cathodic protection testing

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

- Labelling
- Cable colours
- Cable sizes checked

2.13.6.1 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:

- Prior to installation, and 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 using one of the methods in Table 2.7.

***Table 2.7**: Pre-installation test options for joints.*

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

***Note:** *500V insulation resistance tester, 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.

***Table 2.8**: Test equipment*

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).

***Table 2.9**: Minimum number of tests*

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:

- Measure the resistance/insulation of each bolt using either an RF-IT or a resistance meter, if no bolt is shorted, then:
- 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.

2.13.6.2 Cathodic protection power supplier (TR's)

1. Pre-installation inspection

a) TR's are to be 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 a 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 the TR at maximum output for 5 minutes and check current output is stable
- Operate the 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 less than 0.001amps
- At maximum voltage the output current is in excess of the design current

2.13.6.3 Test points

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

2.13.6.4 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.

2.13.7 Fibre Optic Testing

2.13.7.1 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 duct between two regeneration/repeater stations

- Availability of Route Survey Reports and the Route Survey Summary Report
- Confirmation of section completeness
- Availability of the line diagram showing all the coupler points and distances between the couplers, duct overlaps, suspected coupler points and any incomplete portions.

Procedure:

a) Ensure that the duct into which cable is to be installed is continuous over the length of the duct by visual inspection

b) Complete an air test to establish duct continuity

c) Blow a sponge through the duct, refer the below, to establish that there are no kinks or blockages in the duct

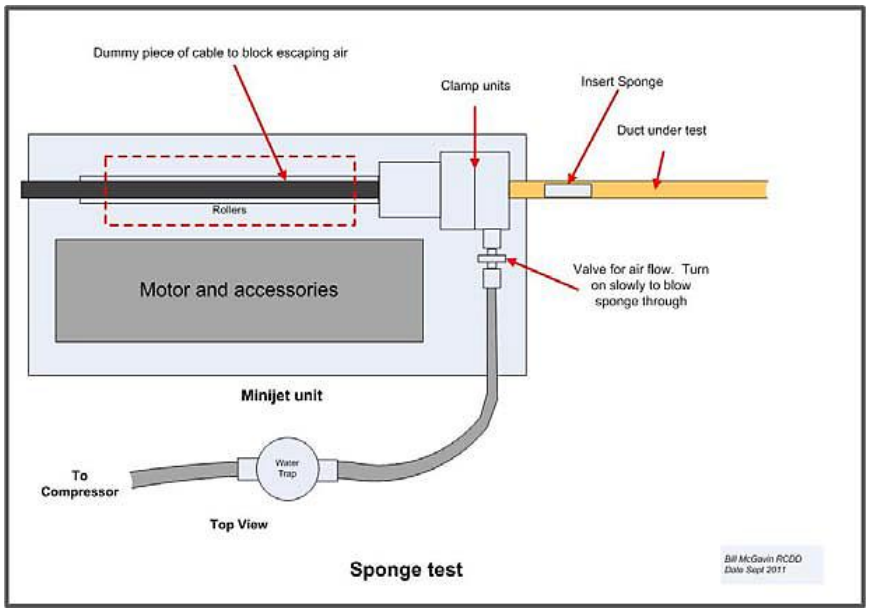


***Figure 2.3**: Illustration of sponge test*

d) Correct any issues before progressing

e) Verify the duct is rated to withstand the jetting pressure

f) Pressure test the duct

g) Cable installation through jetting under 10 bar pressure

2.13.7.2 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 shall comply with IEC 61300-3-35 using FiberChek2 Software.

c) A certificate of compliance to IEC 61300-3-35 is required.

2.13.7.3 Optical time domain reflectometer (OTDR) testing

All single mode optical fibre (SMOF) 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 can change these guidelines.

***Table 2.10**: 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

2.13.7.4 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 in accordance with the LSPM one or three test cord referencing method. The method shall comply with Australian and International Standards depending on 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

2.13.8 Commissioning

2.13.8.1 General

a) 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

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

2.13.8.2 Cathodic protection specific requirements

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

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

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

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.

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.

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

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

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 Table 2.11.

***Table 2.11**: Minimum period between energising and final survey*

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.

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

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:								