General Electrical
Construction Standard

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Reviewers:
Ryan McMahon – Senior Electrical Engineer, Watercare
Robert Xu – Electrical Engineer, Watercare
Luke Mainwaring – Senior Commissioning Engineer, Watercare
Ali Nicholls – Asset Specialist – Electrical, Watercare
Geof Stewart – Manager Asset Strategy, Watercare
Andrew Deutschle – Operations controller (re. Cathodic Protection), Watercare

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Definitions and abbreviations

ac	Alternating current electricity.
Bond cable	Cable intended to carry current.
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 thermit weld.
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	Bond cable 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. The quality control checks do not relieve the requirement for producer statements to be signed by a suitable engineering professional attesting that the works have been constructed in accordance with this standard.
FIK	Flange insulating kit or flange isolation kit.
Hazard	Potential source of harm.
ICT	Information and communications technology.

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

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

IR	Insulation Resistance.
Junction Box	Field mounted enclosure for connecting field instrumentation to central control panels via multicore cables.
Maintenance bypass switch	A switch designed and installed to isolate an uninterruptable power supply for maintenance purposes whilst maintaining continuity of load power via an alternate path.
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 thermit weld.
Thermit weld	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 system (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. Introduction

1.1 Purpose and Scope

This standard has been developed to provide the minimum standard of electrical construction work acceptable to Watercare. Additional clauses must be added to contracts where specific site constraints exist. This general electrical construction document must be supplemented with standards applicable to the specific operational area (see Section 2). The content of this standard may not be changed or amended. Equivalent or alternatives may only be used on written approval from Watercare. Construction work shall be completed by persons competent in their work possessing a minimum skill and competency level required from this standard.

1.2 Applicability

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

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

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

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

2. Standard documents overview

2.1 Relationship of Watercare standards

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

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

2.1.1 Design standards

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

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

2.1.2 Design drawings

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

2.1.3 Asset and material standards

The asset standards describe the requirements for asset creation, asset numbering, asset capture, production of manuals and operational documentation. Material standards describe the minimum compliance requirements of materials supplied for asset acceptance. Often selected materials will have limitations of use and requirements specific to the operating environment and infrastructure classification. Section 6 describes

the minimum requirements applicable to this standard. Additional requirements may be specified based on the specific design.

2.1.4 Construction standards

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

2.1.5 Project specific specification

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

2.2 Review and approval of construction standards

Section 2.2 is provided for information only.

Watercare updates standards from time to time. Users of this document should ensure that the latest version is used. Suggestions for improvement of this standard will be welcomed. They should be sent to: **Principal Engineer - Standards, Watercare Services Limited, Private Bag 92521, Wellesley Street, Auckland 1141.**

Alternatively place feedback electronically at: Engineering Standards Framework

2.2.1 Watercare's engineering standards framework

The Watercare standards are provided in the online engineering standards framework (ESF). The system provides guidance to the end user to find the applicable standards for the operational area in which design, construction or maintenance is performed. The system ensures that the latest versions of standards are available. The standards are uncontrolled when copied or printed.

2.2.2 Governance of standards

Changes to standards are made under a governance structure to evaluate any change or improvements against factors such as Health and Safety, legislative compliance, standards, best practice and reliability.

2.3 Design build projects

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

3. Quality control and quality assurance

3.1 Auditing during construction

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

3.2 Change orders affecting quality

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

4. General engineering document submittal requirements

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

4.1 Quality control templates

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

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

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

4.2 Documents for commissioning or livening of electrical works

The prerequisite for construction work that requires progressive commissioning or livening is to provide sufficient supporting documentation for the safe and effective operation of the parts. This documentation set shall comprise of:

- Preliminary as-built drawings (redline mark-ups)
- Signed off pre-commissioning test results
- Process/piping and instrumentation diagrams (P&ID)
- Draft operations and maintenance (O&M) manual
- Residual risks register
- Commissioning plan
- Signed electrical certificate of compliance and Electrical safety certificate

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 certificate
- Engineering producer statements
- Construction completion report
- Quality control certificates
- Signed electrical certificate of compliance and Electrical safety certificate

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

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

5. Referenced standards

5.1 General

This standard makes reference to a number of national and international standards. The latest version of these standards shall be used at all times.

5.2 Standards list

This standard must be read in conjunction with the national and international standards listed below. Where conflict or ambiguity exists this standard shall take precedence.

General

NZ Electricity Act
NZ Building Code
NZ Health and Safety at Work Act
NZ Radio Interference Regulations
NZ Electricity (safety) Regulations
AS/NZS 3000 Electrical installations (Known as Australian/New Zealand Wiring Rules)
AS/NZS 1768 Lightning Protection
AS 1939 (IEC529) Degrees of protection provided by enclosures for electrical equipment (IP code)
AS/NZS 2053 Conduits and fittings for electrical installations
AS/NZS 60079 part 0 Equipment – General requirements
part 10 Explosive atmospheres – Classification of areas
part 14 Electrical installations design, selection and erection
part 17 Electrical installations inspection and maintenance
part 25 Intrinsically safe electrical systems

Switchboards, Distribution and Control centres

ANSI/IEEE C62.41.2 Recommended practice on characterization of surges in low voltage (1000V and less) AC power circuits
AS/NZS 3439 Low voltage switchgear and controlgear assemblies

Uninterruptable power supplies

BS EN 62040 Uninterruptible power systems (UPS)
IEC 62310 Static transfer systems (STS)

Motors

AS/NZS1359 Parts 5 and 102.3 Rotating electrical machines
AS 1359 Part 114 Rotating electrical machines – General requirements – Vibration measurements and limits

Electrical cables

AS/NZS 5000 part 1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV
part 2 Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V
part 3 Electric cables - Polymeric insulated - Multicore control cables
AS/NZS 3008 part 1.2 Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical New Zealand conditions

Fibre optic

IEC 61300-3-35 Fibre Optic interconnecting devices and passive components – Basic test and measurement procedures
AS/NZS ISO/IEC 14763 part 3 Telecommunications installations – Implementation and operation of customer premises cabling - Testing of optical fibre cabling
AS/NZS 3080 Information technology – Generic cabling for commercial premises
AS/NZS ISO/IEC 24702 Telecommunications Installations – Generic Cabling - Industrial Premises
AS/ACIF S008 and S009 Requirements for customer cabling product
IEC 60793 (set) Optical Fibres
IEC 60794(set) Optical Fibre Cables
TIA/EIA-455-41 Compressive loading resistance of fibre optic cables
TIA/EIA-455-25 Impact testing of optical fibre cables

TIA/EIA-455-104 Fibre optic cable cyclic-flexing test
Telcordia GR-326 Generic requirements for single mode and multi-mode optical connectors and jumper assemblies
ITU-T / G.650.3 Test methods for installed single mode optical fibre cable links
DURA –LINE (June 2010) Duct Laying Guidelines. Duct Handling and Installation. Duct Laying Field Practices
DURA-LINE Duct Integrity Testing

Cathodic protection

AS/NZS 4853 Electrical hazards on metallic pipelines
AS 2832 part 1 Cathodic protection of metals - Pipes and cables
AS 2239 Galvanic (sacrificial) anodes for cathodic protection

6. Materials

6.1 Material standards

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 standards. Materials shall be new and suitable for their intended purpose and performance requirements.

Watercare lists a number of pre-evaluated materials as either an accepted material or a standardised material.

6.2 Accepted and standardised materials

- Accepted material: materials that have been evaluated for use or a specific function in an operational area, but does not imply exclusive use. Materials not on this list require evaluation against Watercare's materials standards prior to being used.
- Standardised material: A selection of materials that shall be exclusively used for a specific operational area or function. In some instances materials under this list are provided under commercial agreements that ensure long term serviceability, component compatibility or availability of spare parts.

6.3 Recycled and reused materials

Recycled material and material reuse shall not be accepted unless specifically approved by Watercare.

7. Health and Safety

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

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

- Describe the processes to assure compliance with systems, good practice and legislation.
- Provide information to demonstrate that the Health and Safety Management System is capable of managing 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 adequate training for managing the hazards and risks and undertaking the work safely.
- Conduct and record site specific inductions.
- Where work is on an existing Watercare facility or asset an Access Authority is required before work can start.

8. Asset capture

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

9. Electrical construction

E1 General electrical installation

E1.1 Material delivery and handling

Materials and equipment shall be stored in accordance with the manufacturer's requirements and protected from damage.

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 exposed of responsibly.

E1.2 Support brackets and fixings

Refer to Watercare's general mechanical construction standards for bolting and fixing requirements.

E1.3 Junction boxes

The junction box shall be classified to IP65 or better, mounted securely and with a covering protruding over the top seal.

Boxes that are required to be fully waterproof or are installed in potentially explosive areas shall have nylon washers installed with the cable glands and gland adapters.

Boxes housing pneumatic equipment shall be vented at the bottom of the box and fitted with a port protector/silencer.

An earthed gland plate for cable glands shall be installed in the bottom of every metal junction box.

Junction boxes shall be labelled in accordance with section E9 of this standard.

Terminal rails and individual DIN mounted terminals shall be provided for all terminations. Strip connectors are not acceptable. All terminals shall be numbered and trunking provided on both sides of the terminals. Trunking shall be grey slotted PVC, with a minimum of 50% spare capacity.

Cables shall enter from the bottom of the junction box. Unused entries shall be plugged with an approved product.

E1.4 Earthing

Earthing system installation shall comply with AS/NZS3000. Measure and record the earth resistance and impedance of every earthing system.

E1.4.1 Main earth bar

The main earth bar for an indoor incoming supply shall be of tinned copper. The main earth bar shall be installed on the internal wall of the switchroom, on insulated mounts and used as the connection point for:

- Supply transformer earth (if installed)
- Main earth (to earth electrodes)
- Main switchboard earth

The earth electrode shall be copper coated mild steel or stainless steel rod. Connections to the earth electrode shall be made by exothermic welding (cadweld).

E1.4.2 Structural earth

A 'Wricon' or an accepted equivalent shall be installed between the building reinforcing and the main earth bar. The connections to the reinforcing shall be made by exothermic welding (cadweld). The welds shall be inspected before covering.

E1.4.3 Earth continuity conductors

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

E1.4.4 Bonding

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

E1.4.5 Lightning earth

Lightning conductors shall be installed to AS/NZS1768. A separate earth electrode shall be exothermically welded as close as practical to aerial masts.

E1.5 Lighting

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

Fittings installed at plant facilities shall have minimum IP56 rating.

E1.6 Socket outlets

Outlets shall be mounted 300 mm above finished floor level, 200 mm above benches and 1400 mm above finished floor level in plant rooms unless specified otherwise.

Socket outlets shall be mounted to walls, or in flush boxes, or white polycarbonate mounting blocks to the positions shown on the specific drawings. Perimeter trunking socket outlets shall be mounted in the top section.

Three phase switched socket outlets shall be surface mounted. Weatherproof socket outlets shall be surface mount type to minimum IP56 rating.

E1.7 Workmanship

Only one apprentice or assistant per qualified tradesman is allowed. The entire installation shall be undertaken in a tidy and efficient manner.

The work shall be installed in accordance with manufacturer instructions and any specific requirements noted. Work shall be planned to maintain unobstructed access to equipment.

E2 Power transformers

For civil construction requirements refer to Watercare's general civil construction standard. See section 10 of this standard for testing requirements.

E2.1 Installation requirements

Warning signage shall be provided on transformer doors stating: "DANGER – HIGH VOLTAGE".

All bunds shall be tested for leak tightness using a water test. The holding volume shall be sufficient for the size of the transformer being installed.

The transformer shall only be commissioned after testing. The testing of indoor transformers shall include the operation of the ventilation system.

E3 Switchboards, Distribution centres and Control centres

E3.1 Equipment labelling

Equipment shall be identified in accordance with the labels on the design drawings. All major fixed components within the switchboard including switches, relays and circuit breakers shall be labelled.

Both ends of each wire shall be identified with a Grafoplast system of ferrules, crimp pins and markers.

Switchboards shall be provided with labels detailing the following information (Refer section E9):

- Plant asset number (tag name)
- Manufacturer's name
- Manufacturer's type designation, serial number and the year of manufacture
- Applicable standards
- Degree of protection
- Rated operating voltage
- Rated frequency
- Main busbar continuous current rating
- Main busbar short circuit capacity

E3.2 Internal wiring and cabling

Power and CT secondary wiring shall have a minimum cross sectional area of 2.5mm^2 and be of stranded flexible copper high temperature PVC panel wire, unless otherwise specified. Matching terminals and shorting links shall be provided for all CT secondary circuits.

Control wiring shall be stranded flexible copper high temperature PVC panel wire of 0.75 mm^2 matching the current requirement. Control wiring connected to the DCS/PLC I/O module terminations shall be 0.5mm^2. The wiring must be terminated in rail mounted terminal blocks mounted in the same cubicle.

Control and power wiring shall be enclosed in slotted PVC ducts. Wiring not enclosed in ducts shall be loomed together neatly. The cable ducting shall be sized for 30% over-capacity and the cables shall not exert pressure or cause deformation of the enclosure. The distance between cable ducting and equipment shall be minimum 35mm to allow wire termination. Wiring must be terminated in rail mounted terminal blocks. Large cables are exempted.

No more than two conductors shall be terminated both sides of each terminal. Wire termination shall be with suitable ferrules or crimp lugs. Soldered connections are not permitted.

Terminal blocks shall be DIN rail mounted with supports and identification accessories. The termination blocks shall allow the following:

- Testing of circuits connected to the terminal
- Linking of adjacent terminals

- Screw-clamp type connections
- Cross-linking facilities where terminals are associated with current transformers. This facility shall allow the current transformer to be short-circuited
- Isolation functionality where the terminals are associated with voltage monitoring circuits
- Segregation barriers between extra low voltage and low voltage terminals
- 25% spare capacity

Refer to Section E9 for labelling, colour coding and identification.

E3.3 Control, indication and instrumentation

Control switches, pushbuttons, lamp indicators and instrumentation shall be labelled as per the drawings. Indicator lamps shall be high intensity LED type.

Refer to section E9 for push buttons and lamp indication colours.

E3.4 Radio installation requirements

A gland suitable for co-axial cable shall be installed in the control cubicle gear plate for routing the radio antenna cable to the exterior of the building.

The lightning arrestor shall be installed as close as possible to the exit gland of the radio antenna cable and connected to the main earth busbar with 6mm^2 insulated copper PVC earth cable.

E3.5 Generator connections

The generator connection shall be mounted externally to the switchboard. The generator connection enclosure shall be IP66 rated 316 stainless steel with a lockable hinged panel at the bottom for the generator cable entry. A rubber split barrier touch protection shall be fitted over the generator cable entry point. Connection stabs for the three-phases, neutral and earth shall be provided in the generator connection enclosure.

Cabling shall be provided to connect the generator connection with the main switchboard generator circuit breaker or changeover switch. A mechanical interlock shall be provided between the main incomer and changeover switch.

A suitable generator cable entry point into buildings must be approved by a suitably qualified civil engineer to prevent any structural damage.

E3.6 QA/QC template

Quality / Control		**Measurement**	**Certification**		
			Document supplied	Site supervisor witness	Engineer witness
1	Earthing	Welds inspected before covering the welds	N/A	Required	Required
2	Wiring	Minimum cross sectional area checked against current requirement	N/A	Required	Required
		Trunking capacity 50% remain	N/A	Required	Required
		Ducting capacity 30% remain	N/A	Required	Required
		Un-ducted wiring loomed	N/A	Required	Required
3	Indication	Correctly labelled and coloured	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
		Indicator lamps high intensity LED	N/A	Required	Required
		Layout confirmed	N/A	Required	Required
4	Glands and connections	Suitable for cable type	N/A	Required	Required
		IP66 rated	N/A	Required	Required
		Sign-off			

E4 Uninterruptable power supplies (UPS)

E4.1 UPS Room

The UPS manufacturer's minimum clearance distances shall be observed and allowance shall be made for access to complete battery testing. UPS systems shall not be installed underneath water, process or chemical lines.

The room ventilation shall be fitted with replaceable fan input filters.

E4.2 UPS Mounting

UPS units shall be restrained to resist movement and from toppling over.

E4.3 UPS Cabling

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.

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.*

E4.4 UPS Neutral and earthing

The UPS neutral connection to the earth shall only be at one location. The earthed end shall be as close as possible to the source. Unless the UPS system has transformer isolation, no earth and neutral link shall be at the UPS output or output distribution boards.

The neutral shall not be switched or disconnected by the UPS except where UPS output transformers are used.

E4.5 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.

E4.6 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Installation process	Clear access, not located below water or chemical lines	N/A	Required	Required
		Secured and restrained	N/A	Required	Required
2	Cabling	Sufficient length provided for removal and maintenance	N/A	Required	Required
		Confirmed size and rating as appropriate	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			

E5 Motors

E5.1 Fault indication

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

E5.2 Circuit breakers

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

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

E5.3 Anti-condensation heaters

Anti-condensation heaters shall raise the motor temperature to 6°C above ambient and operate continually, unless otherwise noted. The heaters shall be wired to a separate terminal block within the motor terminal box.

A miniature circuit breaker or fuse shall be connected to the load side circuit of the motor isolator/breaker, allowing the heater to be isolated with the motor.

VSD anti-condensation heating (dc injection) shall not be used in place of heaters.

E5.4 Motor vibration and noise

Motors and couplings shall be accurately balanced to remove end-thrust and to eliminate noise and vibration when running.

Dynamic balancing shall be undertaken by the removal of parent metal in a manner that does not affect the structural strength of the rotating element. The use of solder or similar deposits for balancing is not accepted. The operating speed of rotating elements shall be below and far removed from the critical resonant speeds.

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.*

Noise levels of shall not exceed 80dB.

E5.5 Temperature detectors

Motors larger than 5.5kW and/or used in variable speed applications shall be protected against excessive temperature with protectors terminated in the terminal box.

E5.6 Terminal boxes

An earth terminal shall be provided within the main motor terminal box. Terminals shall be permanently marked and firmly mounted.

A permanent wiring label stating the maximum thermistors voltage shall be displayed on the terminal box.

Heater terminals shall be shrouded and separated from the main terminals with a fixed insulated barrier greater than 3mm thick. A separate terminal box may be provided for the heater terminals with a permanent rating plate displaying the heater rated voltage and power. A gland plate shall be provided to enable the cable connections.

E5.7 Motor installation

Standard frame motor sizes shall be used to ease replacement. 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.

E5.7.1 Insulation resistance

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

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

The insulation resistance shall be measured at the terminals within the supply switchboard.

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**.**

E5.7.2 Winding resistance

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

E5.8 QA/ QC template

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

E6. Electrical cables

E6.1 General

Cables shall be new. Cables shall only be reused where specified. The installation shall be clean, tidy appearance and conform to AS/NZS3000 and AS/NZS3008.

E6.2 Redundant cables

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

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

E6.3 Cable length

Cable shall be manufactured and supplied in a single length unless the length exceeds a standard drum length. Cable joints shall be approved by the designer.

E6.4 Conductors

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

Single core aluminium conductor cables may be used for mains and sub-mains larger than 70mm^2. Aluminium conductors must be terminated with bimetallic lugs. Aluminium surfaces for mechanical jointing shall be prepared and jointed with oxidation inhibiting and jointing compound.

Unused cores of multicore cables shall be grouped neatly and the ends covered by a heat-shrink sleeve.

Parallel conductors shall be on identical routes and be of equal cross sectional area and length. Trefoil groups of parallel conductors shall be arranged as per the requirements of Appendix D in AS/NZS3008.

E6.5 Un-armoured cable

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

E6.6 PVC cable construction application

PVC cables shall be constructed as follows:

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

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

An earth continuity conductor shall be provided within the armouring in accordance with AS/NZS3000, or when specified.

E6.7 Cross linked polyethylene cable construction application

The cross linked polyethylene cable shall comprise of:

i. High conductivity annealed or hard-drawn stranded copper conductors
ii. A stress equalising layer of extruded semi-conducting cross-linked polyethylene
iii. Extruded cross-linked polyethylene insulation
iv. A conducting compound applied over a semi-conducting coating or a layer of extruded semi-conducting compound applied directly to the dielectric

An extruded PVC sheath shall protect the collective metallic screen of annealed copper tape enclosing all the cores and inter-spatial filler.

Armoured cables shall have bedding of a continuous waterproof layer of PVC. The galvanised steel wire armour shall be enclosed in an outer sheath of PVC.

E6.8 Cable route planning

Cables shall be installed in the planned cable corridors, or when unspecified to minimise the effects of electric and magnetic fields on equipment. Cable crossovers shall be minimised.

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.

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.

- High voltage cables shall be separated from other cables and services in separate floor trenches, pipes or metal channels. A minimum spacing of 600 mm shall be maintained.
- Low voltage cables shall be separated from extra low voltage cables by at least 300mm. An earthed metallic bonded partition shall be used otherwise.
- Extra low voltage cables not exceeding 50Vac, or 120V ripple free dc, shall be separated from power cables by at least 300mm. A physical barrier shall be provided between power cables and cables for other services in building ducts.

E6.9 Instrument cables

Instrument signal and power cables shall be arranged to only cross at right angles, thereby avoiding interference from electrical power supply voltage drops or spikes.

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.

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

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

Instrumentation cables stacked on a cable supports shall not be more than two cables high. Refer to section E6.19.1 for stacking constraints on other cables.

E6.10 Data highways (communication cables)

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

E6.11 Cable glands

Glands specific to the cable application shall be installed to the manufacturer's recommendation and instructions.

A minimum of 50mm straight cable shall be provided prior to the cable entering a gland.

The glands for steel wire armoured cables shall be made of nickel-plated bronze or brass and provided with ISO threads.

The glands for VSD cables shall provide a 360° ground connection for the VSD screen.

E6.12 Cable gland accessories

Suitable accessories shall be provided with glands to be used on earthed continuity conductor-armoured cables to facilitate a bolted lug connection.

Grooves cut into the barrel or cone bush to accommodate the earth continuity conductors are not acceptable.

Gland shrouds shall be made of non-deteriorating neoprene or similar approved rubber that is resistant to water, oil and sunlight. The shrouds shall fit tightly around the glands and cable.

E6.13 Cable installation

Cables shall be installed to AS/NZS 3000 and AS/NZS 3008.1.2 Electrical Installations – Selection of Cables.

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.

Glands installed with steel wire armoured (SWA) cables in non-conducting enclosures shall be provided with an internal earthing washer and connected to a suitable earth connection.

E6.14 Cable jointing

Cable joints not noted on the design require Watercare approval and are conditional to the following:

i. Cable joints shall be 'in-line', staggered and located on the cable support
ii. Use epoxy cable jointing kits for cables ≥ 10mm^2. Glue-lined thick wall heat shrink may be used when approved by Watercare
iii. For power cable conductors < 10mm^2 use a glue lined thin walled heat shrink on each core with a heavy walled glue lined heat shrink encompassing the entire cable joint
iv. For control cables a thin walled heat shrink on each core with a heavy walled glue lined heat shrink encompassing the entire cable joint. Numbered cores shall remain the same throughout the length of the jointed cable
v. The cable core rotation for both the existing and new cables shall be matched to minimise the profile of the cable joints

E6.15 Twisting and bending

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

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

E6.16 Cable fittings

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

E6.17 Cable end sealing

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

E6.18 Cable identification

Cables shall be identified at each end and at each cable joint in accordance with Section E9.

E6.19 Cable support and protection

E6.19.1 Cable trays and ladders

Cables shall be supported on a cable ladder, cable tray, or in a conduit and must not be attached directly to walls, pipes or structures.

Cable support systems shall be installed in accordance with the manufacturer's recommendations and in compliance with the earth bonding requirements in AS/NZS 3000. All cable trays and support fittings for the project shall be new, of similar material and finish and sourced from the same manufacturer.

Cable support brackets and trays shall be installed free of sagging. The maximum horizontal deflection is 25mm over a 6m length. Cable supports shall be installed to follow the lines of the building.

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 cables from the ladder or tray.

Support from overhead structures shall have two galvanised steel hanger rods of minimum 10mm diameter on each side of the cable support and a galvanised steel unistrut cross-member underneath.

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.

The cables shall be neatly secured with clamps, saddles or cable ties. The restraint method shall be suitable for fault conditions. Minimum 24mm^2 single core and larger cables shall be clamped.

Cables other than instrumentation cable shall not be stacked more than 3 high. Refer to section E6.9 for instrumentation cable specific requirements.

Process lines must not be supported on cable trays.

Dissimilar materials shall be isolated against galvanic corrosion.

The cable support shall be electrically isolated and bonded to earth. Where cable support is not continuous, bonding across both sides of the cable support is required at:

- Hinged joints
- Expansion joints
- Discontinuous sections

The bonding cable size shall be determined based on the protection setting of the circuits on the cable support. Table E6.1 below is a guide for minimum bonding cable sizes:

Table E6.1 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

Outdoor cable supports shall be fitted with covers suitable to the environment. The covers shall have a minimum 15° peak.

E6.19.2 Conduits

Conduit boxes with removable covers shall be provided with draw cable after the conduit system has been installed. Conduit boxes shall be of appropriate size for intersecting conduits. Multiple single boxes shall not be used.

Avoid drawing cables around more than two 90-degree bends by appropriately spacing the boxes. Conduit length shall be installed with a conduit box at least every 40m and expansion joints at least every 20m.

Conduits installed in roof spaces must be parallel and at right angles to the building's structural elements.

Above ground conduit shall be supported in saddles with spacer-bar at appropriate spacing and load rating. The maximum distance between the saddles shall be 1m and within 100mm on each side of a conduit box or fitting.

All saddles and fixings shall be stainless steel. Fixings into concrete shall be made using Nylon "rawl-plugs". Wood or fibre "rawl-plugs" shall not be used.

Flexible conduit shall only be used in short lengths where rigid conduit is unsuitable. At the conduit termination an appropriate cable gland be used and a length of heat shrink applied covering the end of the flexible conduit and the gland.

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.

A double offset shall be used where conduits change level. Conduit shall be run in straight, symmetrical lines.

Typical bends radii are given below:

- 20mm conduit 80mm
- 25mm conduit 100mm
- 32mm conduit 130mm
- 40mm conduit 160mm
- 50mm conduit 200mm

Moisture and dirt ingress shall be prevented by suitable drainage points and plugs. Conduits shall be cleaned before installing cables.

Chasing of conduits

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

Conduit in concrete

The conduit shall be installed in position before the concrete is cast and extend minimum 100mm beyond the finished concrete where it protrudes. Conduit runs in groups or large concentrations shall be spaced minimum one conduit diameter width.

Penetrations through the concrete shall be watertight and sealed.

Metallic conduit

The use of metallic conduits requires approval by Watercare. Screwed joints shall be painted with 2 layers of Zinc galvanising paint after installation.

Interior surfaces of conduits shall be free of sharp protrusions. Open ends shall be provided with solid brass bushes.

Damaged galvanizing shall be repainted with two layers of Zinc galvanising or as otherwise specified.

Conduit shall be bushed and fixed on the inside of the box or appliance in which it is terminated.

Running joints shall be provided with lock-nuts to ensure that connections are secure.

The conduits shall be electrically continuity bonded to earth. Conduit systems shall not be relied upon for earth continuity.

PVC conduit

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

Conduit colours:

- PVC conduit colour shall be orange for below ground complying with AS/NZS 3000.
- Grey PVC, UV stabilised conduit, shall be used above ground and areas subject to UV exposure.

Dry lubricant shall be applied to cables during pulling in of PVC sheathed or covered cables to prevent welding or scuffing of cable sheaths.

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

PVC conduit shall only be used in temperatures below 50°C and where it cannot be mechanically damaged.

Straight runs greater than 10 metres exposed to sunlight shall have expansion joints.

MDPE conduit

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

E6.19.3 Wire way trunking

Wire-way trunking shall be completed with fit for purpose accessories needed to complete the installation. Partitions shall be perforated or solid. Wire-way trunking shall be of suitable material for the site conditions and more than 1.2mm thickness. Sharp edges shall be de-burred.

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.

Knockouts for conduits shall be provided in the sides of all trunking.

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.

The trunking supports shall be spaced to avoid sagging between supports. All metallic trunking shall be earthed in accordance with the AS/NZS3000.

E6.19.4 Cable trenching

This section shall be read in conjunction with the general civil construction standard. All electrical aspects shall conform to the relevant sections of AS/NZS 3000.

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. Bedding shall be minimum 75mm thick. Cable marking tape shall be laid after the first 150mm cover layer.

E6.20 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Cable length	No joints – single length	N/A	Required	Required
2	Conductors	Multi-core copper for cabling < 70mm^2	N/A	Required	Required
		Unused cores grouped and heat shrink sleeved	N/A	Required	Required
3	Un-armoured cable	Trunked in conduit or cable support.	N/A	Required	Required
4	Instrumentation cable	Lay lines to cross power cables at right angles	N/A	Required	Required
		ELV and LV using separate cables	N/A	Required	Required
		Minimum 300mm spare length at cable ends	N/A	Required	Required
		Cable depth maximum 2 on cable supports	N/A	Required	Required
5	Communication cables	Min 300mm separation from power cables	N/A	Required	Required
		Installation individual in 20mm conduit	N/A	Required	Required
		Dual redundancy installed in separate cable paths	N/A	Required	Required
6	Glands	Installed to manufacturer requirements and appropriate to the operating environment	N/A	Required	Required
		Minimum 50mm straight cable allowance before entering gland	N/A	Required	Required
		Cables are not under tension	N/A	Required	Required
7	Bending and twist	Within maximum allowed for cable type	N/A	Required	Required
8	Cable ends sealed	Heat shrink	N/A	Required	Required
9	Identification	Cables tagged and identified	N/A	Required	Required
10	Cable support	Support brackets space at minimum 300mm	N/A	Required	Required
		Deflection limited to 25mm per 6m	N/A	Required	Required
		Cable support bonding to correct size	N/A	Required	Required
11	Cable conduit	Support saddles space at minimum 1000mm	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
		Expansion joints provided at minimum 25m intervals and conduit boxing provided at minimum 40m intervals	N/A	Required	Required
		Appropriate anchor size used. – Wood or fibre plugs are not allowed	N/A	Required	Required
12	Buried cable	Min 75mm bedding and 300mm width	N/A	Required	Required
		Cable marker tape installed	N/A	Required	Required
		Sign-off			

E7 Fibre optic

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.

E7.1 General duct installation

Micro duct and 32mm ducting can be installed into existing duct lines. Ducting must be cut with fit for purpose ratchet shears. Cutting with a saw is not permitted.

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".

The duct bending radius shall not exceed the manufacturer's specification.

Ducts in manholes shall be arranged to maximise bending radius and avoid cutting across the centre of the manhole. When ducts are jointed in manholes, a duct overlap of minimum 600mm shall be allowed.

E7.1.1 Carrier duct

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

E7.1.2 Couplers

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

E7.1.3 Duct end caps

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

E7.1.4 Tracer wire

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

E7.1.5 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.*

E7.1.6 Testing of ducts

Refer to Section 10.4.

E7.2 Specific duct installation methods

E7.2.1 Open trench duct installation

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.

E7.2.2 Mole ploughing

Where ground conditions dictate, pre-ploughing is recommended to ensure there are no obstacles in the plough route.

During installations with a plough, care should be taken to ensure:

- Pre-plough is performed correctly and obstacles avoided
- The correct amount of duct is on site for the planned length to be installed
- The feeding of ducts are done smoothly without sudden bursts
- The plough is kept at an even depth
- Ensure there is no tension build up. This will cause retraction later

E7.2.3 Reinstating ground after trenching/ploughing

Refer to Watercare's general civil construction standard.

E7.2.4 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.

E7.3 Handling cable drums

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.

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

When drums through the centre hole an appropriate lifting frame shall be used with no lateral pressure on the drum flanges.

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.

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.

E7.4 Cable installation

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.*

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.

Minimum 15m of excess cable shall be allowed at each end for enclosure management and termination. All cables shall enter the enclosure.

The bending radius for air blown fibre shall be larger than 20 times the diameter of the cable.

E7.5 Cable breakout, fusion splicing and terminations

E7.5.1 Cabling tools

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

E7.5.2 Central strength member

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

E7.5.3 Fibre coils in Splice Cassette

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

E7.5.4 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.

E7.5.5 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.

E7.5.6 Securing Splice Cassette

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

E7.5.7 Securing pigtails and tubes

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

E7.5.8 Splice Protectors

Splice protectors must be installed in the splice cassette combs after heat shrinking.

E7.5.9 Splicing position

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

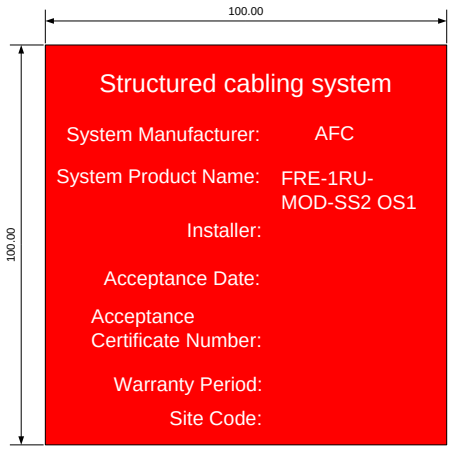
E7.5.10 Splice loss

There shall be less than 0.1dB loss per splice. The splice must be fitted with a splice protector housed in a splice cassette.

E7.6 Labelling

Labels shall be machine printed in black with the font minimum 8 mm high. A label shall be installed on every communications equipment enclosure displaying the manufacturer's warranty number and details.

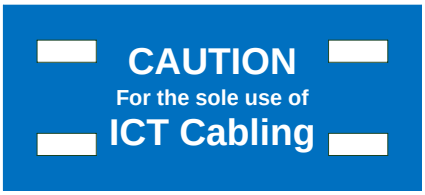
Example below:



Every enclosure shall be labelled with the location, inter-connect rack location and corresponding enclosure information. Core numbers shall be identified.

Cable pathways shall be labelled to identify the pathway for the sole use of information and communications technology (ICT) cabling.

Labels shall be installed less than 4m apart, at key intersections and be visible. Example below:



E7.7 Cable management

E7.7.1 Vertical cable management

If vertical cable management is not installed into racks then vertical cable management rings shall be installed. Care must be taken to properly manage fibre optic cables.

E7.7.2 Cable ties

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

E7.7.3 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.

E7.7.4 Horizontal cable management

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

E7.8 Record keeping

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.

E7.9 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Qualification	Certified to complete fibre installation	Required	Required	Required
2	Duct installation	Bending radius not exceeded	N/A	Required	Selected
		Connection details through pits adhered to; no sharp edges or sharp turns	N/A	Required	Required
		Bedding surround 100mm of the fibre duct.	N/A	Required	Required
		Warning tape installed over top of bedding	N/A	Required	Selected
		Duct integrity tested in accordance with Section 10	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 dark storage area, not in duct.		Required	Required
		Cable labels installed	N/A	Required	Selected
		Only Velcro ties used	N/A	Required	Selected
4	Record keeping	Records provided	Required	Required	Required
		Sign-off			

E8 Cathodic protection

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

E8.1 Surge protection of insulating joints

Insulating joints shall have a lightning arrestor installed across the insulated joint to protect the joint.

If a polarisation cell, PCR or equivalent is specified then a lightning arrestor shall be installed as well.

Where the insulating joints are adjacent to the valve, the arrestor shall be connected to the outside pipe flanges, not to the valve body.

E8.2 Cathodic protection power supplies (TR's)

Installation of Transformer-rectifiers (TR) shall be in accordance New Zealand Electrical Regulations and AS/NZS3000.

TRs shall be mounted on a concrete plinth that complies with the concrete structure requirements in Watercare's general civil construction standard and the following:

- Extend beyond the side of the TR cabinet by a minimum of 100mm
- Concrete thickness of minimum 150mm and have 12mm reinforcing at mid-level of the plinth
- Sloped from the centre of the plinth to 1:100 – if the TR base is an open frame

- Sloped from the side of the TR cabinet of 1:100 – if the TR base is enclosed and sealed against water ingress
- Provided with minimum 4x 50NB uPVC penetrations for earth peg and cables

E8.3 Impressed current anode groundbeds

Impressed current anodes shall:

- Have individual cables brought up to a junction box from all anodes
- Be rated for 50 years operation at the design current
- Be located dimensionally to the specific design

E8.4 Sacrificial anode groundbeds

Sacrificial anodes shall:

- Be supplied and installed packaged in gypsum bentonite backfill in a calico bag
- Backfill shall be well wetted prior to backfill
- Have individual cables brought up to a junction box from all anodes
- Have a junction box designed to allow easy access to cable terminals. Terminals shall be brass or stainless steel bolts and/or bus bars, except where mounted in instrumentation control boxes with DIN rail mounts.
- Be rated for minimum 25 years operation for magnesium and 50 years for zinc

Anodes installed in the pipe trench shall be installed in the bottom corner of the trench resting on native soil. Anodes shall not be laid on scoria, bedding sand or other free draining material. Anodes installed outside the pipe trench shall be installed in native soil

The anode bed may be connected temporarily to ensure operation. Following the check, the anode bed must be disconnected until pre-commissioning has been completed or as otherwise specified by Watercare.

E8.5 Permanent buried reference cells

The installation arrangement shall be as shown on the specific drawings. The cells shall:

- Be supplied and installed in packaged in gypsum bentonite backfill in a calico bag
- Backfill shall be thoroughly wetted prior to backfill

E8.6 Continuity bonding

Un-welded joints within buried cathodically protected sections of pipeline shall be bridged with a continuity bond cable.

The bond cable shall be:

- As short as practicable to reduce voltage drop
- Located such that there are no mechanical joints between the connection point and the pipe being bonded

E8.7 Test points

A drop tube or soil access box must be provided for test point that will be surrounded by surface pavement. Drop tubes shall be installed with minimum 300mm native soil in the base. In cases where native soil is too hard to be compacted in the tube or too free draining to enable contact, the fill shall be:

- For corrosion coupons: Washed sand
- Buried references and other installations: 50% gypsum / 50% bentonite mix

Fill shall not be scoria, gravel or a similar free draining material.

E8.7.1 Test point cabling

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

E8.7.2 Interference test points

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

E8.8 Corrosion coupons and electrical resistance probes

The test station foot shall be buried in the pipe trench in the same bedding and surround material as the pipe, facing down towards the pipe invert.

Wherever practicable a drop tube shall be provided. Configuration options in order of preference are:

a) Single unit with probe foot directly below test station, with a drop tube in the test station connected to the foot
b) Probe foot with drop tube and flush access box buried separately near test station
c) Probe foot buried with permanent zinc reference (supplied with the probe) and no drop tube

The manufacturer's installation methodology shall be followed, except that the fill in the drop tube shall comply with section E8.7.

E8.9 Cabling and connections

Cables shall be installed as continuous single length cables without splices or joints. Cables shall be installed in conduit.

Cable and connections shall be tested following installation to ensure continuity. Buried cable connections shall be tested prior to recoating connections and backfilling.

E8.9.1 Cable Connections to Pipeline and Other Structures

Connections to pipework shall be made in accordance with the Watercare standard drawings. Cable connections to the pipeline shall be made in chambers or above ground unless otherwise noted.

Buried connections shall be thermit welded or cadwelded, except where a foreign service owner specifies otherwise for connections to their service or structure.

E8.9.2 Cable size and insulation

The following minimum conductor sizes shall apply:

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

Continuity bond cables shall as short as practicable to avoid unnecessary voltage drop in the cable.

Bond cables for earthing purposes shall comply with relevant regulations. Cable insulation type shall be appropriate to the location.

E8.9.3 Cable insulation colours

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

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

E8.10 Equipment labelling and identification specific to cathodic protection

Labels shall comply with the general requirements in Section E9 as altered by this section. Equipment to be labelled is:

- Insulating flanges
- Test stations
- Junction boxes
- TRs

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

WATERCARE
CATHODIC PROTECTION SITE ###
Phone: 09 442 2222

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

CP SITE
WATERCARE
###

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

E8.11 QA/QC template

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Surge protection	Lightening arrestor installed. Not connected to valve or isolated fitting bodies.	N/A	Required	Required
2	Cabling	QA completed as per section E6	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			

E9 Colour coding, Identification and labels

E9.1 Equipment number

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

E9.2 Labels - general

Every plant item shall be fitted with a label displaying the tag number and function. The label shall be permanently attached to the equipment or in close proximity in a visible location.

Field labels shall be black letters on a white background and made of a suitable plastic type material (trafolyte), stainless steel or aluminium as required for the installation environment.

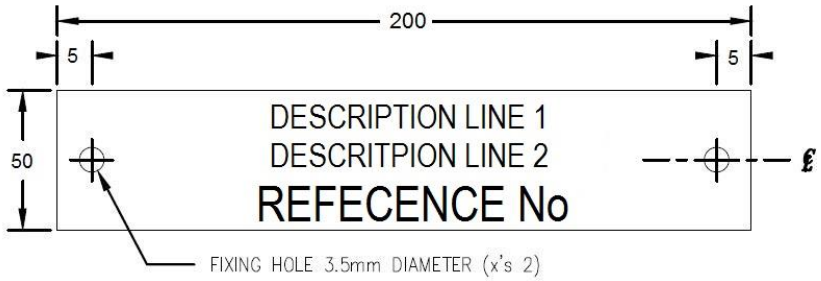
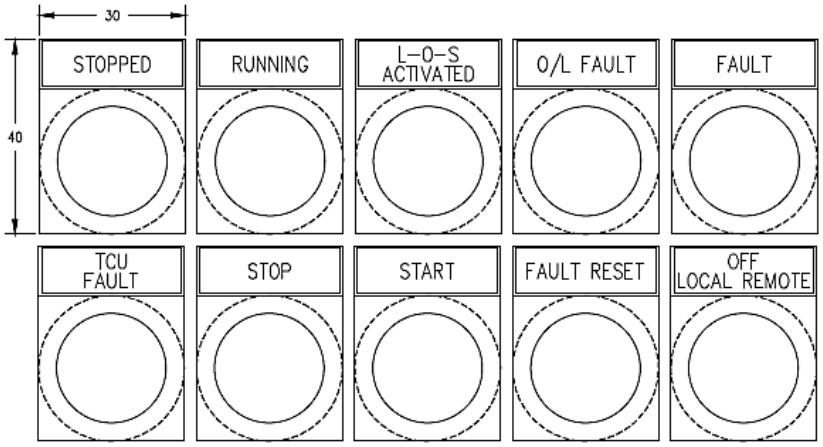
Font shall be Arial. Font width may be compressed to 75% to enable letters to fit onto the label.

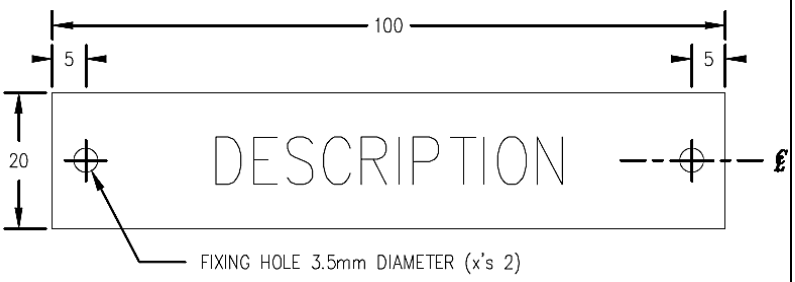
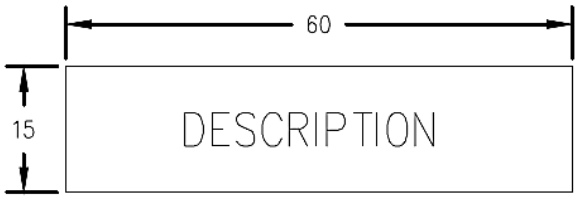
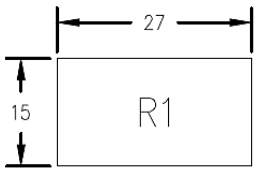
Field mounted instruments including final control elements should have the label on a bracket independent from the instrument.

E9.2.1 Equipment label – examples

Label - Type 1 50mm wide 10mm high for 1 line 5mm lettering Example: Limit switch	99-ZSO013
Label - Type 2 100mm wide 30mm high for 3 lines 22mm high for 2 lines 5mm lettering and 7mm lettering Example: Field instrument tags	LEVEL SWITCH LOW RAW WATER WET WELL 20-LSL402
Label - Type 3 150mm wide 50mm high for 3 lines 35mm high for 2 lines 7mm lettering and 10mm lettering Example: Motor tags	RAPID MIX PUMP 1 RAW WATER MAIN 51-PU01
Label - Type 4 300mm wide 100mm high for 3 lines 70mm high for 2 lines 15mm lettering and 20mm lettering Example: Motor tags	AIR SCOUR BLOWER 1 GAC 56-BL31

E9.2.2 Switchboard 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

E9.3 Cable identification

Cables shall be labelled at both ends with a cable tied plastic marker bearing the cable number as detailed on the cable schedule, refer section E9.2. The Grafoplast system shall be used for labelling cable terminations.

E9.3.1 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 blue.

E9.3.2 Cable numbering

Cables shall be numbered as identified on the specific drawings.

E9.4 Wire labelling

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)

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.

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

E9.5 Wire colour coding

E9.5.1 Colours for low voltage busbars and main connections

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

[1] If the positive or negative dc rail is the common rail then this shall be stated clearly on the drawings and shall be clearly marked as such within the panel.

E9.5.2 Colours for extra low voltage wiring within panels and switchboards

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

E9.6 Push button and indicator lamp colour coding

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

E9.6.1 Push button colours

Stop push button	Black	
Start push button	White	

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

E9.6.2 Indicator (led) lamp colours

Running	White	
Stopped	White	
Tripped / Fault	Amber / Yellow / Orange	
Auto available	White	
Open	White	
Closed	White	
Alarm	Amber / Yellow / Orange	

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

10. Testing and commissioning

This section shall be read with Watercare's code of practice for commissioning.

10.1 General pre-commissioning checks and tests

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

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

Watercare be present at inspections and tests and shall be informed of the testing 48 hours in advance.

A Certificate of Compliance and Electrical Safety Certificate shall be provided on completion of the testing.

10.2 Pre-commissioning of Switchboards, Distribution and Control centres

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

10.3 Power transformers

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

10.4 Factory acceptance testing (FAT)

10.4.1 Switchboard FAT

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.

All protection will be set and tested in the factory via primary or approved secondary current injection test.

Switchboards must by Type Tested (ISO Type 5) with routine test certificates to AS/NZS 3439

10.4.2 Software FAT

A software FAT shall be completed and witnessed by Watercare. The FAT shall only proceed when the following is supplied:

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

The testing shall include as a minimum:

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

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

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

10.5 Cathodic protection testing

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

- Labelling
- Cable colours
- Cable sizes checked

10.5.1 Insulating joints

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

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

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

10.5.1.1 Pre-Installation insulation test in workshop or store

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

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

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

10.5.1.2 Post-Installation insulation test

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

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

The test shall be carried out according to the RF-IT supplier's instructions. 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).

The minimum number of tests shall be:

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

10.5.1.3 Locating the cause of a short or partial short

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

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

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 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.

For monolithic insulating joints, and other non-flanged insulating joints the manufacturer's instructions shall be followed for testing and repair.

10.5.2 Cathodic protection power supplies (TR's)

10.5.2.1 Pre-installation inspection

TR's are bench tested by the supplier prior to supply, however if the unit has been modified after delivery a bench is mandatory.

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

10.5.2.2 Post-Installation Inspection and Testing

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

Performance requirements for acceptance:

The following checks shall be carried out:

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

10.5.3 Test points

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

Performance requirements for acceptance: Refer to section 10.3.4.

10.5.4 Cable connections to pipework

10.5.4.1 Testing of cable connection to pipework at time of installation

Resistance of electrical cable connections to pipework shall be tested immediately after the connection is made and prior to applying the protective coating. The measurement must be taken between the cable wires and the pipe steel surface.

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. 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

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

10.5.4.2 Continuity bonds

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

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

10.5.4.3 Post Installation testing

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

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

10.6 Fibre Optic Testing

10.6.1.1 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 60km between two regeneration/repeater stations
- Availability of Route Survey Reports and the Route Survey Summary Report

- Confirmation of section completeness
- Availability of the a line diagram showing all the coupler points and distances between the couplers, duct overlaps, suspected coupler points and any incomplete portions

Procedure:

1. Ensure that the duct into which cable is to be installed is continuous over the length of the duct by visual inspection
2. Complete an air test to establish duct continuity
3. Blow a sponge through the duct, refer Figure 10.1, to establish that there are no kinks or blockages in the duct

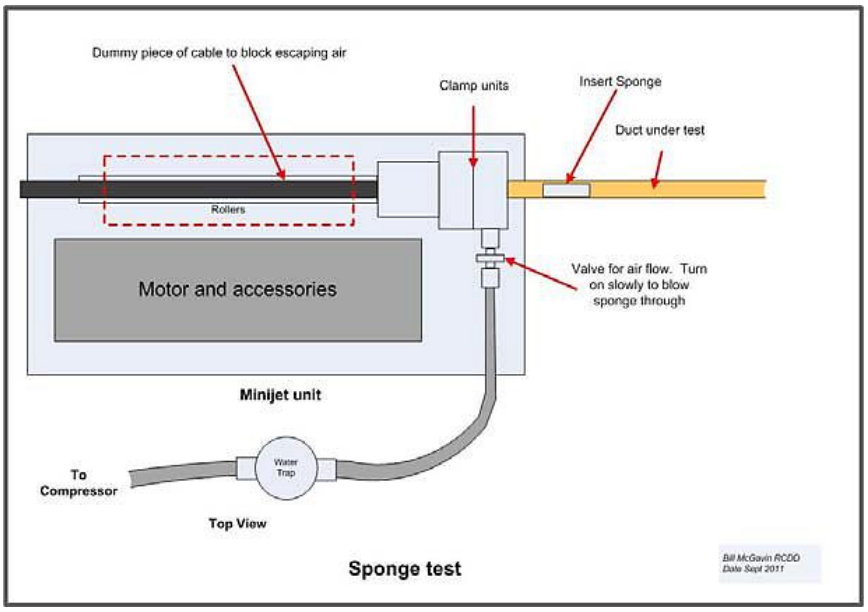


Figure 10.1

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

10.6.2 Video inspection and Fibre Optic cleaning

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

10.6.3 Optical time domain reflectometer (OTDR) testing

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

Pre-test procedures:

- The OTDR must have a current calibration certificate (certificate to be provided)
- The OTDR must use the SOR format for file saving
- The OTDR must have an event dead zone of 1 metre or better at a 3ns pulse width
- A near end launch lead must be used on all tests of at least 100m in length
- All connectors in the network under test and test leads must be inspected and cleaned if required (must comply to IEC 61300-3-35) before inserting launch or recovery lead into the network
- An electronic copy of traces must be supplied in .PDF and .SOR. formats

Guidelines for OTDR Setup:

There are numerous variables in a fibre optic network and the OTDR being used that can change these guidelines.

The guideline is to assist in consistency and settings of OTDR traces.

Cable Distance in km	Pulse Width in ns	Range in km	Resolution in m	Averaging Time in seconds
1	10	2	0.25	30
2	25	4	0.25	30
5	50	8	0.5	30
10	100	16	1	30
15	250	32	2	30
20	500	32	2	30
30	500	64	4	30
40	500	64	4	45
50	1000	64	4	45
75	1000	128	8	60
90	2500	128	8	60
120	2500	256	16	60
150	5000	256	16	90
175	10000	256	16	120
200	30000	256	16	120

Procedure:

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

10.6.4 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)
- All connectors in the network under test and test leads must be inspected and cleaned in compliance with IEC61300-3-35. This must occur before referencing and inserting launch or receive lead into network.

Procedure:

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

10.7 Commissioning

10.7.1 General

Refer to the Watercare Code of Practice for Commissioning.

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

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

10.7.2 Cathodic protection specific requirements

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

10.7.2.1 Commissioning procedure

Commissioning shall be completed in accordance with:

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

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

10.7.2.2 Pre-energising survey

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

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

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

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

10.7.2.3 Post-energising Survey

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

10.7.2.4 TR operation

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

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

10.7.2.5 Interaction with earthing systems

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

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

10.7.2.6 Interference with other Watercare CP systems

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

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

10.7.2.7 Commissioning surveys

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

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

The period given here for total system current:

- <200mA: 1 month
- 200mA – 1 amp: 3 months
- 1 amp -5 amps: 6 months
- >5 amps: 12 months

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

10.7.2.8 Commissioning Report

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

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

11. 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							
					Hunua 1	WMHN1	3	White							
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:							