Electrical
Design Standard

No. DP-09

Ver. 1.0

Date: 17 November 2016

Revision	Description	Released By	Date
0.1	First draft	J de Villiers	6/05/2016
1	First release	J de Villiers – Principal Engineer, Standards	17/11/2016

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

Table of contents

DEFINITIONS AND ABBREVIATIONS 6

1. INTRODUCTION 10

2. STANDARD DOCUMENTS OVERVIEW 10

3. QUALITY CONTROL AND QUALITY ASSURANCE 11

4. GENERAL ENGINEERING DOCUMENT SUBMITTAL REQUIREMENTS 11

5. REFERENCED STANDARDS 12

6. MATERIALS 13

7. HEALTH AND SAFETY 14

8. ASSET CAPTURE 14

9. ELECTRICAL DESIGN 14

ED1 GENERAL ELECTRICAL DESIGN CONSIDERATION 14

ED1.1 Equipment installation locations 14

ED1.2 Energy minimisation 14

ED1.3 Reliability of operation 15

ED1.4 Harmonics and Voltage distortion in the power supply system 15

ED1.5 Emergency stop 15

ED1.6 Isolation and interlock 15

ED1.8 Earthing 16

ED1.8.1 Main earth bar 16

E1.8.2 Structural earth 16

E1.8.3 Earth continuity conductors 16

E1.8.4 Bonding 16

E1.8.5 Lightning earth 16

ED1.9 Junction boxes 16

ED1.10 Seismic actions 16

ED2 POWER TRANSFORMERS - MEDIUM AND HIGH VOLTAGE 16

ED2.1 General 16

ED2.2 Design considerations for procurement 17

ED3 SWITCHBOARDS, DISTRIBUTION AND CONTROL CENTRES 18

ED3.1 Switchboard layout 18

ED3.2 Switchboard electrical requirements 18

ED3.3 Outdoor switchboards 18

ED3.4 Generator connections 18

ED3.5 Switchboard specific requirements 18

ED3.6 Drawings 19

ED4 UNINTERRUPTABLE POWER SUPPLIES (UPS) 19

ED4.1 UPS function 19

ED4.2 UPS configurations 19
ED4.2.1 Type 1 – Single UPS Unit 20
ED4.2.2 Type 2 – Dual Parallel Redundant 20
ED4.2.3 Type 3 – Dual Independent with or without Static Transfer Switches 20
ED4.2.4 Environmental Conditions 21
ED4.2.5 Minimum Technical Requirements 22
ED4.3 Modes of operation 23
ED4.4 Battery selection 23
ED4.5 Battery testing 24
ED4.6 Supplier equipment technical assessment 24
ED4.7 UPS locational requirements 24
ED4.8 UPS Electrical Protection 24
ED4.8.1 UPS Supply Circuit Breaker Sizing 24
ED4.8.2 Manufacturers Information for design input 24
ED4.8.3 Output Circuit 25
ED4.9 Motor Loads 25
ED4.9.1 Motor Characteristics 25
ED4.9.2 Guidelines to the application of motor loads 26
ED4.9.3 Minimum UPS sizing with motor loads 26
ED4.9.4 Protection considerations with motor loads 26
ED4.10 UPS load Distribution Board schedules 26
ED4.11 UPS status reporting 27
ED4.11.1 Hardwired outputs 27
ED4.12 Serial Communication 27
ED4.12.1 UPS Operating Information 27
ED4.12.2 UPS Fault Information 28
ED4.12.3 UPS Battery Test Initiation 28
ED5 ELECTRICAL ACTUATORS 28
ED5.1 Type and service application 28
ED6 MOTOR STARTERS 28
ED7 MOTORS 29
ED7.1 Motor control 29
ED7.1.1 Local control 29
ED7.1.2 Auto Control 29
ED7.5.5 Anti-condensation heaters 29
ED7.8 Temperature detectors 29
ED8. ELECTRICAL CABLES 29
ED9 FIBRE OPTIC 29
ED9.1 Carrier duct 29

ED9.2 Draw pits ... 30
ED10 CATHODIC PROTECTION ... 30
ED10.1 Impressed current anode groundbeds ... 30
ED10.2 Sacrificial anode groundbeds ... 30
ED10.3 Electrical hazard analysis ... 30
ED10.4 Test points ... 30
ED10.3.1 Test Point locations ... 30
ED10.3.2 Test stations (Test Point enclosures) ... 31
ED10.3.3 Ground access at test points ... 31
ED10.3.4 Test Point Cabling ... 31
ED10.3.5 Interference test points ... 31
ED10.5 Cabling and Connections ... 31
ED11. CABLE IDENTIFICATION ... 31
ED11.1 Cable numbering ... 31
ED11.2 Cable type designation ... 32
ED11.3 Cable numbering example ... 32
ED11.4 Wire numbering ... 33

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.
FIK	Flange insulating kit or flange isolation kit.
Hazard	Potential source of harm.
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.

Watercare
An Auckland Council Organisation

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 minimum design requirements and a consistency for Watercare electrical infrastructure. Compliance with current New Zealand legislation, the recognised standards and consideration to site specific constraints shall form the basis of the design. Any part of this standard that cannot be met must be highlighted in the design report for Watercare's consideration. Design work shall be completed by persons competent and professionally registered in their field of design.

1.2 Applicability

This standard applies to all electrical design work for infrastructure delivered or vested to Watercare. The minimum design level 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

The final design report, inclusive of the calculations and design output shall be supported by a design producer statement. It is the designer's responsibility to ensure compliance with the building code, Watercare standards, legislative requirements and that the desired performance requirements are met.

4. General engineering document submittal requirements

- Consents and legal transfers
- Preliminary design report
- Calculations
- Functional description
- Detail design report
- Material specification
- Producer statements
- Equipment tag lists
- HAZOP records

- Specific design drawings
- O&M manual
- Standard operating procedures

5. Referenced standards

5.1 General

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

5.2 Standards list

The designer must be familiar with the electrical construction standard.

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 (safety) Regulations
AS/NZS 3000 Australian/New Zealand Wiring Rules
NZ Electricity Act
NZ Building Act
NZ Building Code
NZ Health and Safety at Work Act
NZ Radio Interference Regulations
AS/NZS 1768 Lightning Protection
AS/NZS 1680 Part 2.4 Interior lighting - Industrial tasks and processes
AS/NZS 1158 Lighting for roads and public spaces
AS 1939 (IEC529) Ingress Protection (IP)
AS/NZS 2053 Conduit Fittings for Electrical Installations
AS/NZS 2430.3 Classification of Hazards Area
IEC 61300-3-35 NZ Electrical Codes of Practice

Harmonics

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

Emergency stop

AS/NZS 4024 safety of machinery

Switchboards, Distribution and Control centres

ANSI/IEEE C62.41.2 Surge Protection
AS/NZS 3439 Low Voltage Switchgear and Control Assemblies

Uninterruptable power supplies

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

Motors

AS1359 series of standards on rotating electrical machines
AS/NZS1359 series of standards on rotating electrical machines

Electrical cables

AS/NZS 5000.1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV
AS/NZS 5000.2 Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V
AS/NZS 5000.3 Electric cables - Polymeric insulated - Multicore control cables
AS/NZS 3008.1.2 Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical New Zealand conditions

Fibre optic

IEC 61300-3-35 Fibre Optic Interconnecting Devices and Passive. Components – Basic Test and Measurement Procedures
AS/NZS ISO/IEC 14763.3:2012ISO/IEC 14763-3:2006 Information technology – Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling
AS/NZS 3080 Telecommunications installations – Generic cabling for commercial premises
AS/NZS ISO/IEC 24702:2007 Telecommunications Installations – Generic Cabling - Industrial Premises
AS/ACIF S008 and S009 Requirements for customer cabling product
IEC 60793 Optical Fibres
IEC 60794 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

Cathodic protection

AS/NZS 4853 Electrical hazards on metallic pipelines
AS2832.1 Cathodic Protection of Metals, Part 1: Pipes and cables
AS2239 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. Watercare has two materials lists that categorises materials as either an accepted material or a standardised material.

The designer shall consider in his design incorporating materials from the standardised material list. Alternatives to material on the accepted materials list may be proposed and demonstrated to comply with Watercare's material standards. A materials schedule shall be completed as part of the design supporting Watercare's minimum requirements and identifying specific requirements over and above the minimum standard.

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: materials that are a selection of, or single material, 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, availability of spare parts, etc.

6.3 Recycled and reused materials

The designer shall consider the interaction and connection to existing infrastructure. All extensions on existing materials and equipment shall be with new material unless specified otherwise by the design brief.

7. Health and Safety

The design shall be founded on the principles of Watercare's Safety in Design guidelines (obtainable from Watercare), and comply with New Zealand legislative requirements or referred best practice.

8. Asset capture

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

9. Electrical design

ED1 General electrical design consideration

ED1.1 Equipment installation locations

General requirements when determining the location for electrical equipment:

- Equipment shall be readily accessible
- Avoid areas that require Traffic Management Plans, is classed as a hazardous area or a confined space
- The installation shall allow easy access for maintenance and removal as required by the equipment supplier
- Equipment shall not be located in areas that are subject to leaks, spills or direct sunlight. Alternatively equipment shall be housed and protected as appropriate for that specific area
- High voltage and low voltage equipment shall be separated

Field mounted equipment excluding in-line and close-coupled devices shall be mounted as follows:

- Wall mounted cabinets approximately 1.2m above ground or standing access levels
- Separated from plant infrastructure (e.g. moving equipment, pipe lines and cable support)
- Transmitters or local controllers shall be located in an accessible location as close as possible to the primary process connection
- Equipment shall not cause any obstruction to walkways, trip hazard, headroom or loss of access to other plant items
- Equipment shall not obstruct plant that is regularly serviced or operated
- Indicators, switches and displays shall be plainly visible and accessible from the access level
- Field mounted equipment shall be housed in 316 stainless steel boxes with an IP65 rating in corrosive atmospheres. Cable and process entries shall be at the bottom of the box

ED1.2 Energy minimisation

Energy consumption shall be considered as part of the design when specifying equipment and control. The following conservation measures shall be included in the design:

- Power factor correction at the switchboard to ensure system power factor is 0.96 lagging, but no more than 0.98 lagging, during normal operation
- Load balancing across phases
- Automatic control of lighting using timers and/or sensors as appropriate for the operating area
- Use of LED lighting
- Correct sizing of electrical devices

- Material selection of high efficiency
- Load distribution over operational time to reduce peaks
- Reduce harmonics over the full operating range of equipment to comply with NZECP 36
- Sharing civil design considerations to reduce heating or cooling requirements

Note: *Watercare is moving towards becoming energy neutral. Design and selection of equipment shall take this direction into consideration.*

ED1.3 Reliability of operation

Component criticality shall be identified and provided with adequate redundancy. Criticality shall be assigned in consultation with Watercare. Equipment shall be field operable using field push buttons in the event of failure of the automatic operation.

Equipment related to a particular process shall be grouped together and located in the same switchboard. Switchboards shall be allocated for particular process areas.

ED1.4 Harmonics and Voltage distortion in the power supply system

The impact of harmonics on the power supply network shall be identified. The design shall identify the distortion on the existing system (where present) and the new design in order to meet the limits set by regulation (Electrical Safety Regulation and IEC61000) and the electricity supplier to NZECP 36.

ED1.5 Emergency stop

Emergency stops shall be to Watercare standard design templates that require emergency stops to be:

- Monitored
- Fitted to all motors
- A latching push button suitably located in the vicinity of the motor
- The stop button located on the cell door of the motor controller for submerged pumps
- When the button is released the motor shall not restart and automatic control shall not be available
- The emergency stop system shall interrupt the voltage supply to the motor through a contactor or circuit breaker

The removal of run signals in variable frequency drives, soft starters or other controllers is not accepted for interrupting the supply

The reset shall be by the same reset function as for any other trip.

ED1.6 Isolation and interlock

Drive stations shall be isolated with a padlock in the off position.

The following interlocks shall be hardwired:

- All emergency stops
- All latched stops
- Thermal overload and protection relays
- Suction safety and delivery safety switches for pumps
- Guard switches
- Pull wire, electronic shear pin and break switches
- High or low pressure protection
- High or low flow protection

Start, stop and emergency stop local buttons shall not be used for equipment isolations.

ED1.8 Earthing

The earthing system shall be designed in accordance with AS/NZS3000.

ED1.8.1 Main earth bar

The main earth shall be driven earth electrode(s) of sufficient number and capacity to carry the calculated fault current for the tripping time required. Each bar shall be oversized by 20% to allow for future connections.

Where more than one earth electrode is required, the main earth shall form a ring circuit. For outdoor installations the main earth bar shall be located within the switchboard.

The main earth bar shall be directly connected to the installed earth electrodes and the supply transformer earth.

E1.8.2 Structural earth

The building housing the main switchboard and any structural steel associated with the building shall have the earth bar connected as per AS/NZS3000 with minimum two 35mm^2 copper earth conductors configured to achieve low earthing impedance.

E1.8.3 Earth continuity conductors

An instrument earth bar shall be provided as a single earth point for instrument bonding and instrument field wiring screens. The instrument earth shall be bonded to the main earth bar with a minimum 35mm^2 copper earth conductor.

E1.8.4 Bonding

Metallic ducts, cable trays, cable ladders, handrails, pipework, benches and sinks, taps and partitioning members, shall be bonded as per AS/NZS3000. The minimum size of the bonding conductor shall be 6mm^2.

E1.8.5 Lightning earth

Aerial mounting masts shall be earthed through a separate earth electrode mounted as close as practical to the mast. The earth conductor between the earth electrode and the mast shall be the most direct route without sharp bends.

ED1.9 Junction boxes

An earthed gland plate for the cable glands at the bottom of every junction box shall be specified.

ED1.10 Seismic actions

The design shall consider any seismic actions in accordance with AS/NZS 1170 that may impact on the installation or components.

ED2 Power transformers - medium and high voltage

ED2.1 General

Transformers shall be located in a transformer yard or inside a suitably vented masonry room with suitably sized containment provided for oil filled transformers.

The transformer shall be mounted on a concrete pad or plinth in accordance with the specific drawings. The transformer shall be on a ground level above the 1 in 100 year flood level with easy truck access for maintenance. A minimum clearance of 1000mm shall be provided around the transformer enclosures.

Transformer rooms shall have concrete floors with cable trenches. In-filled floors are not accepted.

High or Medium Voltage Transformers shall monitor:

- Low oil level

- High Pressure
- High Temperature

Transformer alarms for the above conditions must be hardwired to feeder circuit breakers ensuring the circuit breaker trips if an alarm condition is present. Feeder circuit breakers can be located inside an 11kV switch board or 11kV ring main unit.

Power transformers shall be a three winding, three phase core-type transformer and shall be capable of delivering rated kVA through the complete tapping range.

ED2.2 Design considerations for procurement

The following shall be considered when preparing specifications for the procurement of transformers:

- Type of transformer required:
    - Separate winding transformer
    - Auto-transformer
    - Booster transformer
- Specific handling, assembly and installation requirements
- Restrictions on dimensions and mass
- Dry or oil-immersed type. If oil-immersed type, consider mineral oil or synthetic insulating liquid. If dry type the degree of protection required
- Type of oil preservation system
- Indoor or outdoor
- Expected seismic activity at the installation location
- Single or three-phase unit.
- Number of phases in the system.
- Frequency
- Cooling method
- For multi-winding transformers the required power-loading combinations stating, the active and reactive outputs separately
- Individual winding power and voltage rating. Depending on the cooling method the lower power values are to be stated with the rated power
- For a transformer with tappings identify:
    - Which winding is tapped
    - The number of tappings
    - The tapping range or tapping step
    - State if 'off-circuit' or 'on-load' tap-changing is required
    - For tapping range exceeding ±5% specify the maximum and location of the current tapping, and the type of voltage variation
- Highest voltage for equipment (Um) for each winding with respect to the insulation
- Method of system earthing for each winding
- Insulation level for each winding
- Connection symbol and neutral terminals if required for any winding
- Details of auxiliary supply voltage for other equipment
- Fittings required
- Identify the side from which meters, rating plates, oil-level and other indicators are visible.

The following additional items shall be specified if required:

- Insulation clearances and terminal locations on the transformer for any special space restrictions
- If a lightning impulse voltage test is required, specify if testing needs to include chopped waves to IEC 60076-3
- Stabilising winding and the method of earthing
- Short-circuit impedance, or impedance range. For multi-winding transformers any impedances that are specified for particular pairs of windings with relevant reference ratings if percentage values are given

- Tolerances on voltage ratios and short-circuit impedances
- Whether a generator transformer is to be connected to the generator directly or through switchgear and if it will be subjected to load rejection conditions
- If the transformer is to be connected directly or by a short length of overhead line to gas-insulated switchgear
- The altitude above sea-level if in excess of 1000m
- Special ambient temperature conditions or restrictions to circulating cooling air
- Provide details for load current wave shape distortion or unbalanced three-phase loading where anticipated
- Whether the transformer will be subjected to frequent overcurrent
- Details of intended regular cyclic overloading or other exceptional service conditions
- Identify how a transformer with alternative winding connections should be changed and connected ex-works
- Short-circuit characteristics for other connected equipment and possible limitations affecting the transformer design
- Vacuum resistance of the transformer tank and the conservator if a specific value is required.
- Any special tests not covered by section 10 of this standard

ED3 Switchboards, Distribution and Control centres

ED3.1 Switchboard layout

Switchboards shall be front access only, free standing and of modular construction. The use of double sided switchboards must be approved by Watercare during design.

Shipping breaks are required if the switchboard is greater than three metres long or if there are access limitations on site. Single boards longer than three metres require approval by Watercare.

The switchboard design shall take into account the seismic shear force to be applied horizontally through the centre of gravity of the switchboard at minimum 0.5X the total mass of switchboard. This shall be reviewed with the civil design against the site specific conditions. The shear force may act in any direction. Anchorage of the switchboard shall sustain the shear force and induced overturning moment.

ED3.2 Switchboard electrical requirements

Provision shall be made to adequately support all incoming and outgoing cables against mechanical stress.

Main switchboards with an incoming isolator greater than 80A shall have a power meter installed with an RS485 Modbus or Ethernet IP adaptor module.

The main switchboard shall have three phase surge protection installed including a surge diverter which complies with ANSI/IEEE C62.41.2 Cat A, Cat B, Cat C standards. Electronic equipment shall be protected by surge filters. The diverters and filters shall each provide auxiliary digital outputs connected to the site PLC/DCS to indicate the status of each unit. The surge diverter unit shall be maintainable by way of replaceable cartridges.

ED3.3 Outdoor switchboards

Outdoor switchboards shall be housed in a pillar box arrangement designed with powder-coated marine grade aluminium or stainless steel 316 with ingress protection of minimum IP65.

ED3.4 Generator connections

The generator connection for a switchboard shall be via an externally mounted connection enclosure. Refer to the Watercare General Electrical Construction standard for fitting details.

ED3.5 Switchboard specific requirements

Specific requirements for switchboards are as follows unless otherwise specified in the design brief.

Item	Detail	Notes
Service Conditions	Indoors, with adequate ventilation	
Cable Entry (Incoming Supply Cables)	Bottom entry	
Cable Entry (Outgoing Cables)	Bottom entry	
Access	Front Only	
Shipping Break	Required if switchboard >3m or access limitations prevail	
Supply Voltage (V)	400V 3 phase, 4 wire	Classification in AS3439.1
Supply Frequency (Hz)	50 Hz	Classification in AS3439.1
Fault Level (kA)	25 kA Minimum. Engineer to confirm larger sizes	Classification in AS3439.1
Fault Duration (sec)	1 second	Classification in AS3439.1
Diversity	1	Classification in AS3439.1
Ambient Temperature	0 - 40 °C	
Relative Humidity	Up to 90%	Damp conditions
Segregation	Form 2, 3 & 4a (No terminals in wire way except for Neutral and Earth Bars)	Classification in AS3439.1
Degree of Protection	IP54 or better	Live parts, ingress of foreign bodies (dust) & liquids (water spray)

ED3.6 Drawings

Watercare has produced a standard set of electrical design drawings as templates to be used as the format for all design work. Copies of these drawings are available from Watercare in AutoCAD format.

ED4 Uninterruptable power supplies (UPS)

ED4.1 UPS function

Standby and line interactive UPS systems are not suitable for Watercare applications and only double conversion UPS's shall be used. Note that some double conversion UPS units can also be operated in a line interactive mode.

ED4.2 UPS configurations

To assist the designer, three standard UPS configurations have been developed:

a) Type 1 – Single UPS unit;
b) Type 2 – Dual parallel redundant; and
c) Type 3 – Dual independent with/without static transfer switches.

Where a proposed configuration differs from the three identified types above, the design and application of the UPS shall be reviewed under a specific hazard and operability (HAZOP) review. Refer to Watercare standard drawings for the type configuration layouts.

Where low criticality equipment is supplied from the UPS a single UPS configuration Type 1 is appropriate. The Type 3 configuration is the most secure of the three standard types, however when fitted to existing installations, the changes required to implement this arrangement may be cost prohibitive. For configurations based on these installations, a Type 2 configuration may be considered. Determination of the UPS load criticality requires Watercare approval.

ED4.2.1 Type 1 – Single UPS Unit

Type 1 UPS configuration consists of a single UPS unit. The input and output of the UPS shall be connected to a maintenance bypass cabinet. The maintenance bypass cabinet shall incorporate a maintenance bypass switch plus isolators for UPS rectifier supply, bypass supply and UPS output. The maintenance bypass switch will include an early break auxiliary contact to force the UPS to static bypass before the maintenance bypass switch main contacts close.

Where alternative supplies to a site are available, a supply changeover switch shall be incorporated on the input supply to the UPS.

ED4.2.2 Type 2 – Dual Parallel Redundant

The Type 2 UPS configuration comprises two UPS units operating in a parallel redundant mode. The input and output of the UPS units shall be connected to a single maintenance bypass cabinet. The maintenance bypass cabinet shall incorporate a single maintenance bypass switch plus individual isolators for each UPS unit rectifier supply, bypass supply and UPS unit output. The maintenance bypass switch shall have three positions:

a) Position 1 – ‘Normal’. The load is supplied from the UPS units
b) Position 2 – ‘Transfer’. The UPS output and the maintenance bypass supplies are paralleled to prevent load supply interruption during transition to the ‘maintenance bypass’ mode
c) Position 3 – ‘Bypass’. The maintenance bypass supply provides supply continuity to the load. Note that this position also allows the UPS units to be tested in parallel mode during maintenance before connection to the load

The maintenance bypass switch shall include an early break auxiliary contact to force both UPS units to static bypass before the maintenance bypass main switch contacts close.

Where alternative supplies are available at the site, a supply changeover switch shall be incorporated to provide a common independent bypass supply to the UPS units. Only a common (same phase) bypass supply to the UPS in a parallel configuration is acceptable. This is to avoid potential phasing or paralleling conflicts through the internal UPS unit internal static transfer switches.

Each UPS unit in a dual parallel redundant configuration shall be capable of supplying the full UPS load independently. The parallel UPS units shall incorporate a communications link that controls synchronism and load sharing between the UPS units.

ED4.2.3 Type 3 – Dual Independent with or without Static Transfer Switches

Type 3 UPS configuration has two UPS units operating independently. The input and output of each UPS unit shall be connected to its own maintenance bypass cabinet. The maintenance bypass switch shall include an early break auxiliary contact to force the UPS unit to static bypass before the maintenance bypass switch main contacts close.

The output of each UPS unit shall supply its own UPS output distribution board comprising miniature circuit breakers with ‘B’ type trip curves.

Equipment provided with dual power supplies shall be connected with a supply from each UPS output distribution board. Typical dual supply equipment includes DCS and server cabinets.

Return to Contents

Single input equipment which is duplicated shall be connected to separate UPS distribution boards i.e. its duplicate supplied from the other UPS distribution board.

This does not eliminate the risk where one of the duplicated pieces of equipment is out of service at the same time as the UPS supplying its duplicate fails. Where this risk to plant operation is unacceptable, each item of equipment will be supplied from a separate static transfer switch. Each static transfer switch shall be powered from both UPS distribution boards.

Multiple process units may be arranged in groups within a process area e.g. filters or clarifiers. These systems may also be designed such that a single point of failure makes the whole group unavailable. In this case a single static transfer switch may be used to supply all the equipment in that group.

Where non-duplicated single input loads are to be connected to a dual independent system, static transfer switches shall be installed. These shall be located downstream of the UPS output distribution boards.

ED4.2.4 Environmental Conditions

The designer shall assess the environmental operating conditions for the UPS installation. These conditions include but are not limited to:

Condition	**Requirement**
Site Elevation	>1.5m to <200m (Above mean sea level)
Location	Indoor in ventilated environment. Preferably in a climate controlled purpose built room.
Corrosive Gas Presence	Low levels of hydrogen sulphide, chlorine, fluoride and other gases may be present at some sites
Ambient Air Temperature	Maintained at 20˚C ±3˚C
Relative Humidity Maximum: Minimum:	 95 % 0 %
Seismic Loadings Design Codes	 NZS 4219: 2009: Seismic performance of engineering systems in buildings.
IP Rating	Minimum IP21

Watercare An Auckland Council Organisation

ED4.2.5 Minimum Technical Requirements

- The minimum UPS capacity rating shall be 10kVA
- Each UPS unit shall have the ability to separate the static bypass input from the rectifier input
- The maximum load on the UPS shall not exceed 75% of the UPS rating

AC Input to UPS

Parameter	Requirement
Voltage Configuration Rectifier	400VAC nominal, three phase 4-wire plus ground. Tolerance on input voltage to be ±20% without switching to battery supply.
Voltage Configuration Bypass	≤ 20kVA. 230VAC nominal, single phase 2-wire plus ground. >20kVA. 400VAC nominal, three phase 4-wire plus ground. Tolerance on bypass voltage to be ±15% of nominal output voltage for static bypass switch operation.
Input Frequency	45Hz to 55Hz without switching to battery supply.
Input Current Distortion	Sinewave <3% total harmonic disturbance of current (THDi) maximum at 100% rated load.
Input Power Factor	Equal to or greater than 0.99 at 100% rated load, 0.97 at 50% rated load (lagging).
Inrush current	Limited by soft start and not exceeding rated input current (In).

AC Output

Parameter	Requirement
Voltage configuration	≤ 20kVA. 1 x 230VAC single phase, 2 wire plus ground >20kVA. 400VAC nominal, three phase 4-wire plus ground
Voltage tolerance	± 5% (zero to 100% to zero load steps)
Voltage Distortion	± 2% total harmonic distortion (THD) maximum – 100% linear load ± 4% total harmonic distortion (THD) maximum – 100% non-linear load (BS EN 62040-3)
Load power factor range	0.8 lagging to 0.9 leading
Load unbalance	100%
Overload capability	125% load – 10 minutes 150% load – 60 seconds If the overload limits or times are exceeded, the UPS will transfer the load to bypass supply via the internal static bypass transfer switch.
Short circuit capability	Inverter: 3xIn for 100ms Bypass: 20xIn for 100ms
Battery Recharge Time	Time required to recharge the batteries to 90% of their full capacity following complete discharge and with the UPS operating at a load of 75% of rated capacity, shall not exceed 8 hours.

UPS Efficiency

The overall efficiency (AC-DC-AC, on-line mode) shall not be less than the figures shown in the table below:

Load %	100%	75%	50%	25%
Efficiency %	95%	95%	93%	92%

Measurement with linear load (PF = 0.8 inductive)

Noise

The audible noise generated by the UPS system during normal operation shall not exceed 60dBA measured at 1 metre from the surface of the UPS.

Conformal Coating

UPS printed circuit boards shall be factory coated to ensure protection against moisture, dust, chemicals and temperature extremes.

ED4.3 Modes of operation

The UPS system shall be designed to operate as a true double conversion system where the UPS output is independent of supply (utility/generator) voltage and frequency variations. The following modes of operation shall apply:

- **Normal** – The critical AC load is continuously supplied directly by the UPS inverter. The UPS input rectifier derives power from the utility or generator AC source and supplies DC power to the inverter. A separate but integral battery charger shall maintain a ripple free float-charge voltage to the battery
- **Battery** –The critical AC load is supplied by the inverter which obtains power from the battery in the event of AC input failure. There shall be no interruption in power to the critical load at failure or restoration of the utility or generator AC source.
- **Recharge** – At restoration of utility or generator AC power after a power outage, the input rectifier shall automatically restart and resume supplying power to the inverter and the battery charger shall commence recharging the battery. The UPS input rectifier shall provide a soft start on the return of the utility or generator AC power.
- **Automatic Restart** – At restoration of utility or generator AC power, after an AC power outage and after a complete battery discharge, the UPS module shall automatically restart and resume supplying power to the connected load via the inverter.
- **Internal Static Bypass** – The static bypass shall provide alternative power to the connected AC load and be capable of operating in the following manner:
    - **Automatic** –In the event of a UPS failure, the faulty UPS unit shall perform an automatic transfer of the connected AC load to the bypass source supply via its internal static bypass switch. There shall be no interruption in power to the load upon UPS failure or restoration.
    - **Manual** – Should the UPS unit need to be taken out of service for maintenance or repair, full electrical isolation of the UPS unit shall be obtained, without disruption to the load, by manual operation of an integral wrap-around maintenance bypass switch.

ED4.4 Battery selection

For Type 1 – Single UPS units and Type 3 - Dual Independent UPS configurations, minimum battery back-up time for each unit shall be 60 minutes at the maximum anticipated load.

For Type 2 – Dual Parallel redundant, each unit shall be capable of a minimum battery back-up time of 60 minutes at the total maximum anticipated load.

The maximum anticipated load is defined as the current UPS load with 25% additional capacity for future UPS load increases. Each UPS unit shall incorporate a redundant battery system comprising independent parallel battery strings such that on the failure of one string, power to the load shall still be maintained during a mains power failure.

ED4.5 Battery testing

The UPS unit shall include a full automatic battery testing and battery fault reporting scheme. The automatic battery test shall only be initiated under Watercare controlled conditions.

The UPS unit shall include the facility to start an in-built battery test through the serial communication link from the site control system.

ED4.6 Supplier equipment technical assessment

A guide is provided in the Watercare material supply standard to assist the designer in making a selection on the UPS for each application.

ED4.7 UPS locational requirements

UPS systems shall be located within a dedicated room that is a dry, dust and chemical free environment. Sufficient clearance to the manufacturer's requirements shall be provided around the UPS for access and battery testing. UPS systems shall not be placed underneath lines carrying liquid or in the vicinity of gas or other detrimental environmental conditions.

The effect of air conditioning failure or excessive room temperature shall be considered and mitigated by room temperature monitoring and alarming. The UPS room shall be pressurised with monitored clean air. Additional options include active carbon filtering or a closed loop air conditioned sealed environment.

ED4.8 UPS Electrical Protection

Selection and co-ordination between the UPS protection devices shall be considered as UPS systems offer limited fault capacity to its output circuits. Fault discrimination is required to avoid the potential for one device overload to isolate all UPS loads. The overload can cause the UPS to be damaged or bypassed.

ED4.8.1 UPS Supply Circuit Breaker Sizing

The UPS manufacturers' installation manual shall be consulted for the appropriate rectifier input and bypass supply circuit breaker sizes.

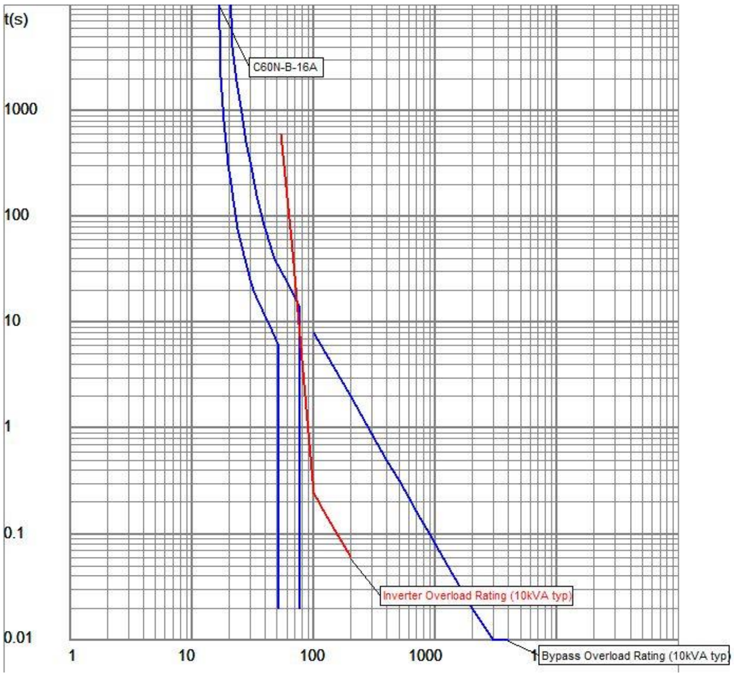
ED4.8.2 Manufacturers Information for design input

The UPS manufacturer's installation manual shall be consulted for the appropriate ratings for the UPS units. The ratings used to determine the correct output protection devices are:

- The maximum i^2t rating of the static bypass. This is the maximum thermal rating of the electronic power switches within the internal static bypass. The internal static bypass is normally connected to a utility supply (or generator) with a fault current level significantly higher than the UPS inverter. Most UPS internal static bypass switches will automatically open if its thermal rating is exceeded to prevent damage to the static bypass. A maximum fault level is normally also stated (max kA level).
- The maximum i^2t rating of the inverter. This is the maximum thermal rating of the UPS inverter. The rating is normally stated in battery mode with the rectifier supply isolated. If the inverter is overloaded the UPS will automatically switch to static bypass to assist in clearing the overload. This will only occur if the bypass supply is available and within tolerance. If the bypass supply is not available (e.g. utility power failure) the output overload must be cleared by the inverter on battery supply. The overload must be cleared before the inverter shuts down on over-temperature and isolates the complete UPS load.
- Overload allowed by the inverter. This is the short term overload rating of the inverter. This is normally stated at 10 minute and 1 minute duration as a percentage of the maximum rated current. The maximum rated current can be calculated from the nominal apparent power divided by the nominal output voltage for single phase output UPS systems.

ED4.8.3 Output Circuit

The correct selection of output circuit breakers for a given UPS installation will involve plotting the overload characteristics of the inverter and the internal static bypass. The characteristic of the UPS output circuit breakers must coordinate with the UPS. A typical example is provided by the following graph to assist the designer.



The output circuit breaker tripping characteristic (C60N-B-16A in the above example) must be graded below the inverter overload rating. The bypass overload rating is considerably higher than the inverter but the output circuit breaker sizing is to be designed on the basis that the bypass is not available.

'B' trip curve circuit breakers shall be used for UPS output circuit breakers.

Note: *'B' type instantaneous trips operate at three to five times the breaker rated current. It should be noted that 'C' curve miniature circuit breakers are more commonly used in industry and more readily available, however their instantaneous trip operation is at five to ten times the breaker rated current, making them less suitable for coordination with low fault current devices such as a UPS.*

ED4.9 Motor Loads

This section includes evaluation of the motor starting characteristics, UPS output capability, and the UPS load and protection requirements.

ED4.9.1 Motor Characteristics

Where motor loads are required to be supported by a UPS, the following information is to be obtained from the motorised equipment supplier:

- Motor characteristics including motor type, phasing (single or three), running current and running power factor
- Motor starting characteristics. Including motor starting current (locked rotor current), motor starting time and preferably a time current starting characteristic

Note: *Unlike a three phase induction motor a single phase motor generates no starting torque and must be started by external means. There are several types of single phase motor including split-phase, capacitor start/induction run and capacitor start/capacitor run. Each has different starting torques and starting currents that must be taken into consideration during design.*

ED4.9.2 Guidelines to the application of motor loads

The following guidelines are provided to assist in the application of motor loads to a UPS system:

1. Obtain the loaded motor running and starting characteristics
2. Calculate the minimum UPS size based on the motor starting characteristics and the maximum UPS running load
3. Review UPS inverter and motor protection by evaluating the running and starting motor current against the inverter and protection circuit breaker time/current characteristics
4. Review the nature of the electrical load on the UPS. Regardless of the suitability and sizing of the UPS system, the starting of motors on a UPS has the potential to affect sensitive electrical loads
5. Determine or specify the control system characteristics with respect to:
   - Motors starting after a power outage
   - Multiple motors starting concurrently
6. Interlocking shall be provided to prevent concurrent starts
7. Review the proposed motor loading with the UPS equipment supplier
8. Consideration should be given to the practical testing. This should ensure motor loads are supported by the UPS under all operating conditions and without risk to the UPS or other loads

ED4.9.3 Minimum UPS sizing with motor loads

The following formula is provided **for UPS systems with single phase output** to determine the minimum UPS size based on the loaded motor characteristic.

$$P_U = \frac{P_L + (I_S * E_L)}{0.75}$$

Where:

P_U = minimum required UPS sizing in VA

P_L = remaining maximum UPS running load in VA

I_S = motor starting (or locked rotor current) in amps

E_L = inverter output voltage

ED4.9.4 Protection considerations with motor loads

The starting characteristics for the motor shall be plotted against the UPS output inverter overload characteristics to ensure a suitable margin exists between the UPS sourcing capability and the motor demand. A typical plot of the UPS output characteristics is shown in section ED4.8.3. The motor circuit protection shall also be plotted and similarly verified.

ED4.10 UPS load Distribution Board schedules

A load schedule for each UPS distribution board shall be developed as a specific detail drawing. The drawing shall be within the appropriate functional description document for the installation.

The UPS Distribution Board schedule shall include:

- UPS tag name and UPS kVA rating
- UPS make, model and battery capacity
- Distribution board circuit numbering
- Distribution board circuit breaker rating and trip curve type
- The tag and description of load connected to each circuit
- Output circuit cable size
- The anticipated maximum load rating of each circuit. This will generally be the VA rating of each connected load.

ED4.11 UPS status reporting

The status of the UPS shall be monitored by Watercare's control system for the site. The monitoring medium shall utilise hardwired outputs and serial communication.

ED4.11.1 Hardwired outputs

Remote monitoring of each UPS unit shall consist of volt free 24Vdc rated relay contacts for each signal. The following minimum status of each UPS unit shall be provided:

1. UPS General Alarm (failsafe – opens on a fault). The general alarm will initiate on any of the following conditions:
    - Input or bypass supply failure or supply is out of the acceptable range (voltage and/or frequency)
    - UPS running on battery
    - UPS is in internal bypass mode (load not on inverter)
    - UPS battery is low
    - UPS fault has occurred
2. Mains Supply Failure. A positive signal contact opening conveys to the control system that the power supply to the UPS has failed. The UPS connected load is now supplied by the UPS battery supply. This is an alarm condition.
3. On Internal Bypass. A positive signal contact opening conveys to the control system that the UPS is in bypass. Whilst in bypass the load is not protected if a power outage should occur. There is also no power conditioning for the control equipment and instrumentation. UPS bypass can occur either by initiation through local manual operator control, or if the UPS has faulted, or has been overloaded. This is an alarm condition.
4. UPS Battery Low. A positive signal contact opening conveys to the control system that the UPS battery capacity is low. If the mains supply is not reinstated within a timely manner, the supply to critical loads will be lost. This is an alarm condition.

ED4.12 Serial Communication

An RS485 Modbus protocol serial communication port shall be provided for remote monitoring of the status of each UPS unit by the site control system. All UPS system status, alarms and data shall be available for remote monitoring including battery condition.

ED4.12.1 UPS Operating Information

The following table lists the minimum operating information to be displayed for each UPS unit through the site control system.

Parameter	Units
Input Voltage L1	Volts
Input Voltage L2	Volts
Input Voltage L3	Volts
Input Frequency	Hertz
Bypass Voltage	Volts
Bypass Frequency	Hertz
Output Voltage	Volts
Output Frequency	Hertz
Ambient Temperature	Degrees C
Battery Time Remaining	Minutes

ED4.12.2 UPS Fault Information

The following table lists the minimum fault information to be displayed for each UPS unit through the site control system.

Parameter	Explanation
Bypass Active	Indicates that the UPS has switched to internal bypass either through an inverter fault, inverter overload or manual initiation.
Inverter on Battery	Indicates that the UPS is running on battery due to rectifier fault or rectifier supply failure.
Low Battery Voltage	Indicates battery voltage is low. If the mains supply is not reinstated shortly, the supply to UPS load will be lost.
Input Power Supply Fail	Indicates the rectifier input supply has been lost or is out of tolerance.
Bypass Supply Fail	Indicates the bypass input supply has been lost or is out of tolerance (voltage or frequency)
Battery Fault	UPS automatic battery test indicates a battery problem.
Rectifier Fault	UPS has detected a fault in the rectifier.
Inverter Fault	UPS has detected a fault in the inverter.
Over-temperature	Indicates that the UPS unit is operating above the normal expected operating temperature.

ED4.12.3 UPS Battery Test Initiation

Manual initiation of the UPS battery test shall be through the site control system and be security protected.

ED5 Electrical actuators

Wherever practicable, actuators shall not be installed in environments where they may be directly exposed to wastewater or a corrosive atmosphere such as wastewater wetwells.

Actuators shall be installed in locations and environments that are easily accessible for maintenance and replacement.

ED5.1 Type and service application

The actuator shall be suitable for purpose, configured to:

- a quarter turn butterfly valve, or
- rising spindle penstock or gate valve, or
- non-rising spindle penstock or gate valve.

ED6 Motor starters

Motor starters shall utilise Watercare's standard motor starter diagrams as a basis for motor control.

Motor control shall be via direct on-line (DOL), soft starters or variable speed drives (VSD). Motors 15kW and larger shall be provided with assisted start arrangements (soft starters or VSDs) and not DOL.

Star-delta starters are not accepted.

Primary motor control and indication shall be provided by hardwired signals connected directly to the PLC/DCS. A communication link shall be used in conjunction with the hardwired I/O to provide additional motor control/status information to the DCS/PLC/SCADA system.

Power factor correction shall be provided for motors larger than 5kW. Power factor correction capacitors shall be rated at 525Vac. Correction may be by static capacitors or part of a site wide automatic correction system.

ED7 Motors

ED7.1 Motor control

ED7.1.1 Local control

Local manual control should not rely on the health/functionality of the station controller. The motor should run if the manual-off-auto switch is in the manual position and the start button depressed.

Field start/stop station may be incorporated if considered necessary best practice.

ED7.1.2 Auto Control

Under automatic operation i.e. with the manual-off-auto switch selected to the auto position, the DCS/PLC will be in full control to start and stop the motor at any time it is required.

In Automatic operation the primary motor control and indication hardwired I/O signals shall be:

Digital Inputs	Digital Outputs
Running	Start/Stop
Fault(s)	Auto available/not available
Auto selected	-
Emergency-stop operated	-
Analogue Inputs	**Analogue Outputs**
Motor current	Speed reference (for VSDs only)

ED7.5.5 Anti-condensation heaters

Anti-condensation heaters shall be provided on all motors with a rating over 10kW.

ED7.8 Temperature detectors

Motors larger than 5.5 kW and all motors used in variable speed applications shall be protected against excessive temperature rise using protection devices terminated in the terminal box.

ED8. Electrical cables

The type of cable support chosen shall accommodate the type of cables to be carried (size and weight). Cable support shall be designed to allow for a future growth of at least 30% of installed cable.

Cable trays shall be aluminium or stainless steel. The thickness shall not be less than 1.5mm for dry locations and 2.5mm for damp locations.

Wire-way trunking shall be manufactured of stainless steel, aluminium, plastic or galvanised steel plate as required for site conditions and be a minimum thickness of 1.2 mm.

Refer to the Watercare electrical construction standard for cable types, sizes and minimum spacing. Cable corridors shall be designed and not left up to the installer to resolve.

ED9 Fibre optic

ED9.1 Carrier duct

A minimum bending radius of two metres shall be allowed for blowing the fibre through the carrier duct.

Watercare
An Auckland Council Organisation

ED9.2 Draw pits

To enable easy blowing/drawing in of the fibre, draw pits shall be provided at the beginning, end and nominal intervals throughout the cable/duct run. The designer is to sign off on the placement and entry of all draw pits.

ED10 Cathodic protection

ED10.1 Impressed current anode groundbeds

The design for large systems shall avoid positioning anodes within 50m of metal structures of any kind including reinforced concrete. The designer shall inspect the site before installation of the anode ground bed to ensure that there are no metal structures that are not shown on the design drawings. Exceptions may only be made if the metal structures are explicitly part of the CP design or with written permission from Watercare.

ED10.2 Sacrificial anode groundbeds

The design for small systems shall avoid positioning anodes within 3m of metal structures of any kind including reinforced concrete. The designer shall inspect the site before installation of the anode ground bed to ensure that there are no metal structures that are not shown the design drawings. Exceptions may only be made if the metal structures are explicitly part of the CP design or with written permission from Watercare.

ED10.3 Electrical hazard analysis

A risk analysis of electrical hazards shall be carried out as specified in AS4853 - Electrical hazards on metallic pipelines, for all metallic water pipelines that:

- Are longer than 300m, and
- Have high voltage cables, within 150m of the pipeline(s) for a total aggregate distance of 300m or longer, or
- Have high voltage system pylons, transformer earth beds or similar earth discharge structures within 50m of a pipeline chamber or exposed pipe section, or
- Have high voltage system pylons, transformer earth beds or similar earth discharge points within 10m of the pipeline.

High voltage means 11kV or higher, and includes electrified railway networks.

Refer to Watercare material standards for suitable suppliers to complete the analysis.

ED10.4 Test points

ED10.3.1 Test Point locations

Test points shall be designed for the following locations:

- SCADA monitored sites
- Line valves
- Scour valve outlet chambers
- Pipe ends
- Insulating joints
- Crossings of other steel pipelines (including existing Watercare mains), except where the foreign steel pipe is less than 30m in length
- Rail crossings
- Major road crossings
- Geographic features where potentials and corrosion rates can be expected to be at variance to other parts of the pipeline, including; estuary verges, major river crossings, swamps, etc.
- The following maximum separations shall apply, if none of the features listed in this section exist in the specified lengths of pipe:
    - Rural: 3000m
    - Semi-rural: 1500m

- Suburban: 1000m
- CBD/high density: 500m

ED10.3.2 Test stations (Test Point enclosures)

Test stations must be installed in easily accessible locations that do not expose technicians to any undue risks, require confined space entry or traffic management. Test stations shall be located in order of preference:

- Inside a instrumentation control / SCADA boxes, or
- In a standard Watercare pillar station, or
- In a standard Watercare TUDS pit, or
- A bolt welded to the pipe

ED10.3.3 Ground access at test points

Drop tubes shall be designed with a minimum of 300mm (vertical) of native soil in the base where no direct access to native soil is available.

ED10.3.4 Test Point Cabling

For all test points with cables terminated in a test station each monitored structure shall have two cables connected separately to the structure, and terminated separately in the test station. In most cases these are expected to be a potential monitoring cable and a bond cable. In the case where it is unlikely that there will ever be a need to bond the structure then two potential monitoring cables shall be installed.

ED10.3.5 Interference test points

Interference (also called foreign service) test points shall be located as close as practicable to the crossing point in an easily accessible location that will not expose technicians to any undue risks.

Where the test station is ≥3m from the crossing a permanent zinc reference shall be installed exactly mid-way between the protected pipe and the foreign service, ensuring that the cell is not closer than 100mm from either.

ED10.5 Cabling and Connections

The following minimum conductor sizes shall apply:

- 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), $6mm^2$

Where the cables may be exposed to high chloride levels extra precautions must be taken to ensure the operating life of the cable and terminations. The minimum standard of insulation for impressed anode cable tails and feeder cable(s) is Olex XLPE or equivalent.

ED11. Cable identification

ED11.1 Cable numbering

A cable number is made up of the destination equipment number (excluding the Facility Code) of the device that is connected followed by a cable type designation and a sequential number. When the equipment number is used the dashes (-) are removed from it and a single dash is added before the cable type designation.

Watercare
An Auckland Council Organisation

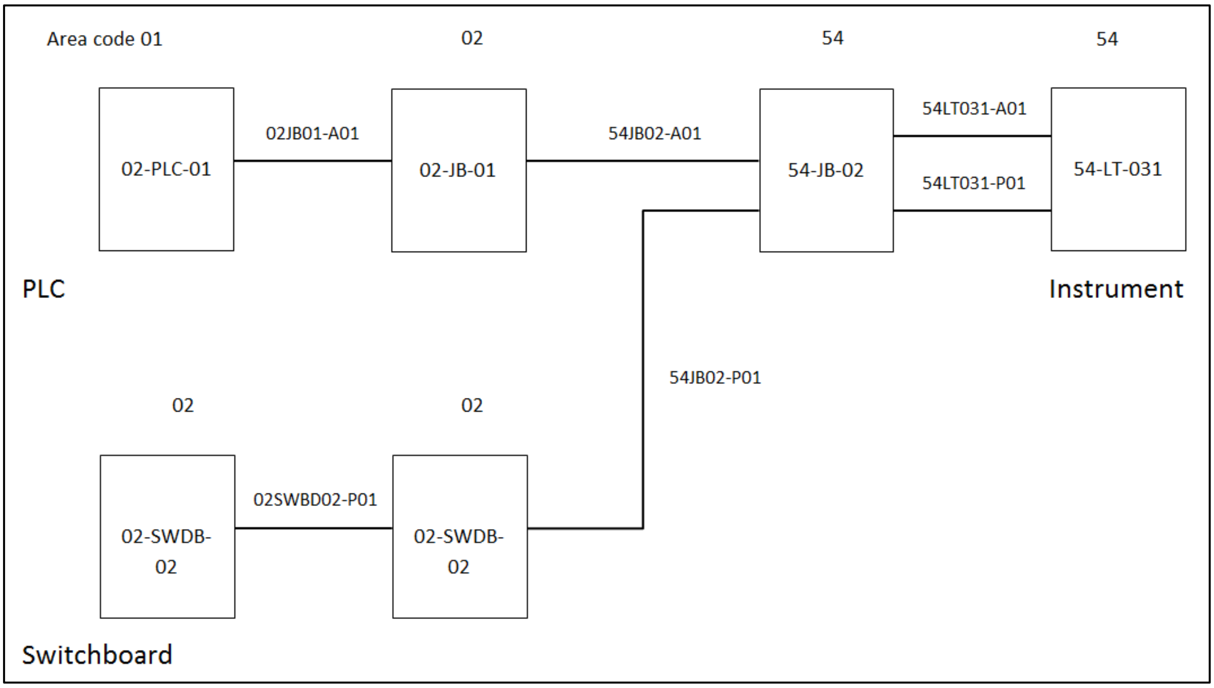
ED11.2 Cable type designation

The cable type shall be defined as follows:

Type Code	Description
P	Shall indicate a power cable carrying 230Vac or 415Vac either switched or continuous. For power cables consisting of multiple single cores, a phase colour identification letter (R or W or B) shall be added to the end, i.e. 06SWBDX01-P01-R (for red phase)
A	Shall indicate an analogue cable carrying extra low level continuous currents or voltages (typically 4-20 mA loop current).
C	Shall indicate a control cable carrying extra low voltage power supply levels and /or switching levels for control purposes.
S	Shall indicate a signal cable carrying serial communications data or other digital levels not exceeding 50Vdc for signalling purposes.

The cable numeral starts at 01 for the first cable of a particular type for a piece of equipment and increases sequentially for other cables of the same type for that piece of equipment.

ED11.3 Cable numbering example



ED11.4 Wire numbering

A wire number is made up of two or three components in an alpha, numeral, alpha string. These are the wire function, numeral and a device identifier (for sets of devices). Refer to the General electrical construction standard for wire colours

The wire function is shown in the table below:

Letter	Wire Function
C	Current Transformers
E	Earthing connections
H	ac
J	dc supplies
K	Closing & Tripping control circuits
L	Alarms & Indications
N	Neutral
R	Interlock
S	Instrument loops
T	Thermistors
U	Spares
W	Extra low voltage
X	Miscellaneous circuits not covered above
Y	Telephone Circuits

Where a wire performs more than one function, the letter for the most important function shall be used e.g. if a wire is part of a control circuit and is also used to provide an indication it shall be labelled “L”.

Where numbering extra low voltage wires the prefix “W” is used before the wire function identifier e.g. WL113, WK12.

Extra low voltage is less than 32Vac or 50Vdc.