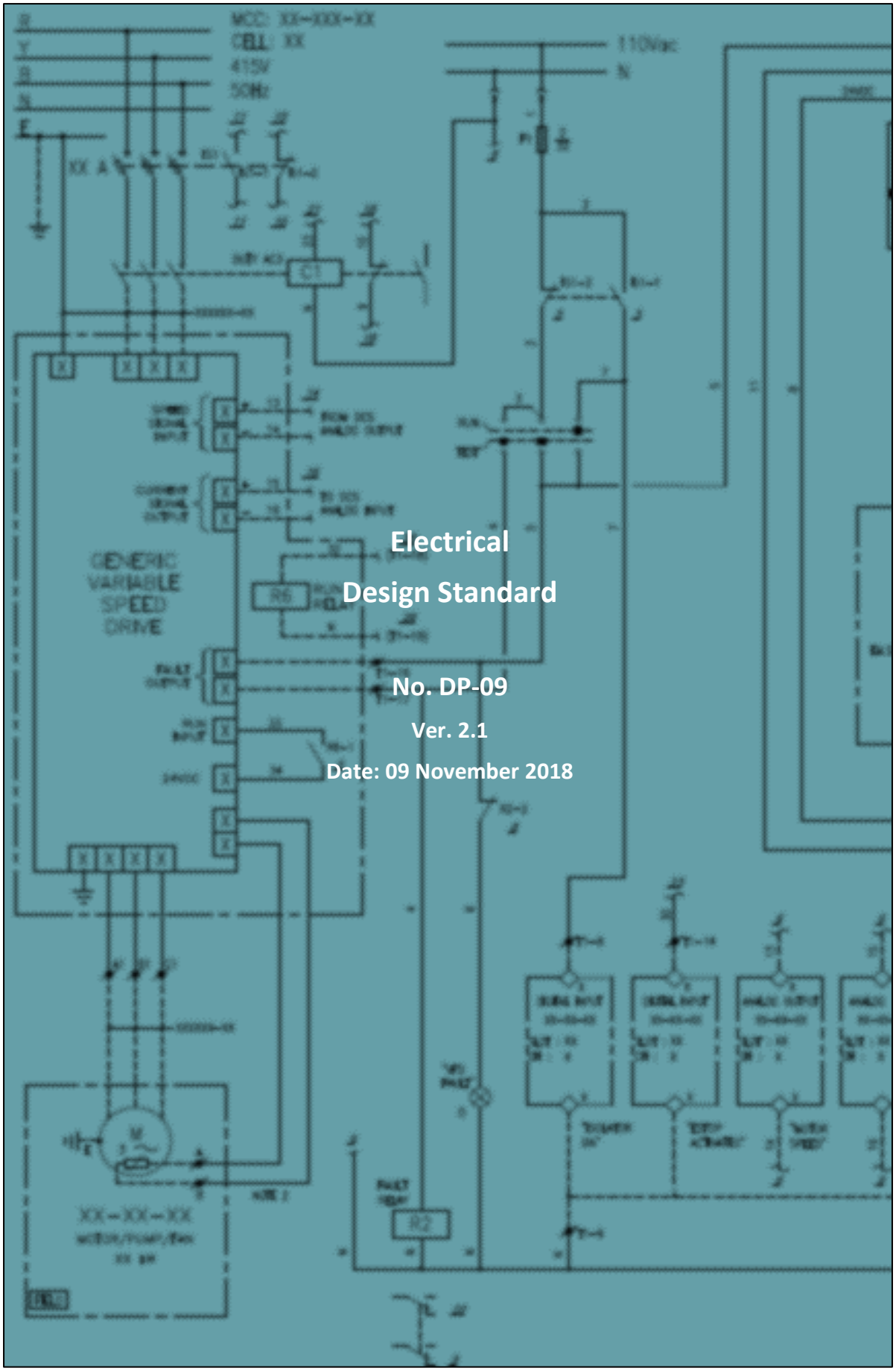

Electrical
Design Standard

No. DP-09

Ver. 2.1

Date: 09 November 2018

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
1.1	Merge document with treatment plant electrical standards – document not published	R McMahon – Senior Electrical Engineer	22/09/2017
2	Updates and review of merged document for first release (not published)	J de Villiers	26/09/2018
2.1	Final review. Included generator connection section	J de Villiers	9/11/2018

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Andrew Deutschle – Operations Controller (re. cathodic protection), Watercare
Ali Nicholls – Asset Specialist – Electrical, Watercare
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Table of contents

Summary of changes

Version	Section	Description of revision
2	Complete document (not published)	Merge general electrical design and industrial /plant electrical design standards into single document
2.1	Abbreviations	Update abbreviations list
	Part A:	
	4.2	Update standards reference lists
	7	Update to general electrical design scope. Removed software references
	Part B:	
	1.1	Update general layout requirements including level above flood plane
	1.5	Update emergency stop wording. No change in meaning
	1.7.2	Added structural earth for reinforced concrete
	1.7.3	Added notice to specific manufacturer requirements
	1.7.4	Reworded to minimum bond cable size
	1.7.5	Added lightening evaluation by assessment
	1.10	Description of light tower tilt considerations
	1.13	Section added for hazardous area considerations and reporting requirements
	2	Added I/O table for Watercare owned transformers
	3	Switchboard supplier requirements separated out to material supply standard. Design consideration remain.
	3.4	Expanded generator connection section
	3.5	Update table
	4	Deleted supplier information sections
	4.10.2	Update UPS fault table
	5	Added I/O table for actuators
	6	Minor wording changes. Mechanical mounting requirements removed
	7	Minor wording changes
	8	Motor rating to starter type changed
	10	Sections added for design input to harmonic mitigation etc. To be removed from supplier obligation
	11	Minor wording changes. Meaning remains same
	14.4	Minor updates to wiring table and other text amendments

Abbreviations

ac	Alternating current electricity.
ATS	Automatic transfer switch.
CP	Cathodic protection.
dc	Direct current electricity.
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.
IJ / IF	Insulating joint and insulating flanges.
IP	Ingress Protection rating, comprising of two numbered code
IR	Insulation Resistance.
MMOF	Multi-mode optical fibre.
MPO (MTP)	Standard fibre optic connectors.
PF	Power factor.
PVC	Polyvinylchloride.
STS	Static transfer switch.
SMOF	Single mode optical fibre.
TR	Transformer/rectifier. Refers to a direct current power supply that drains electric current from a Watercare pipeline in order to provide cathodic protection.
UPS	Uninterruptible power supply.

Part A – Preamble and general design requirements

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. Additional requirements may be specified based on the specific design.

2.1.4 Construction standards

Construction standards prescribe the methods and requirements for workmanship to be employed when constructing works in accordance with the design requirements, standard drawings and bespoke designs. To

achieve the best outcome the construction requirements focusses on proven methods and best practice to ensure quality is maintained to achieve the design life of infrastructure and that maintainability, health and safety and environmental requirements are met. Where construction standards are used or referred to in contracts they form part of the specification of the contract.

2.1.5 Project specific specification

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

2.1.6 Design build projects

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

3. Quality control and quality assurance

The final design report, inclusive of the calculations and design output shall be supported by a design compliance 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.

General engineering document submittals include:

- Preliminary design report
- Detailed design report
- Producer statements
- Equipment tag lists
- Specific design drawings
- Consents and legal transfers
- Calculations
- Functional description
- Material specification
- Equipment tag lists
- Compliance statements
- HAZOP/CHAZOP records
- O&M manual
- Standard operating procedures

4. Referenced standards

4.1 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.

4.2 Standards list

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

4.2.1 Watercare standards

DP - 10 Safety in Design guide

DP - 11 Watercare, 2017. Health and Safety in Facility Design

MS - Material supply standard

7363 - Watercare CAD manual

AI - Data and Asset Information standard series[1]

EC – General electrical construction standards

COP-03 Code of Practice for commissioning

DW17 – Electrical general drawing set

DW18 – Pump station electrical drawing set

DW19 – Electrical drawing set for automated line valves

DW20 - Bulk supply meter electrical and control drawing set

DW21 – Electrical drawings for treatment plants – Wastewater treatment plant motor starters

DW22 – Electrical drawings for treatment plants – Water treatment DCS sites motor control

4.2.2 National and international standards

4.2.2.1 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 60079 Electrical apparatus for explosive gas atmospheres

IEC 61300-3-35 NZ Electrical Codes of Practice

AS/NZS IEC 60947 Low-voltage switchgear and controlgear

NZS 5807 Code of Practice for Identification by Colour, Wording and other coding

4.2.2.2 Harmonics

NZECP 36 New Zealand electrical code of practice – Harmonic levels

AS/NZS 61000 Electromagnetic compatibility

4.2.2.3 Emergency stop

AS/NZS 4024 safety of machinery

AS/NZS 4024.1604 Design of controls, interlocks and guarding - Emergency stop – Principles for design

[1] At time of publication, the referenced standard is still under development and will take affect once published.

4.2.2.4 Switchboards, Distribution and Control centres

ANSI/IEEE C62.41.2 Surge Protection

AS/NZS 61439 Low Voltage Switchgear and Control Assemblies

4.2.2.5 Generator connections

AS/NZS 3010 electrical installations – Generating sets

4.2.2.6 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)

4.2.2.7 Motors

AS/NZS 1359 series of standards on rotating electrical machines

4.2.2.8 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

4.2.2.9 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

4.2.2.10 Cathodic protection

AS/NZS 4853 Electrical hazards on metallic pipelines

AS2239 Galvanic (sacrificial) anodes for cathodic protection

5. Health and safety

Refer to Watercare Health and Safety in Facilities, 2017 for output requirements on infrastructure connected to linear systems such as wet and dry chambers.

6. Asset capture

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

7. Electrical design scope

The electrical design of a facility or process shall include the works to complete the following, where applicable:

a) The power service main maximum demand. Watercare will apply for connections and arrange meter and lines agreements (in conjunction with the local power authority). The designer must identify maximum demand requirements.
b) The stand-by/auxiliary power systems (generators, UPSs, DC power supplies, batteries).
c) Electrical and control systems redundancy design. Design must consider minimum process requirements under single failure event. Failure event includes fire or loss of a single power service main.
d) The earthing of the electrical system, bonding and earthing of conductive pipes.
e) The design of the main switchboard, sub-boards and control panels.
f) The design of motor starter and motor control systems. The design shall be based on Watercare's standard drawings.
g) The selection and detailed installation design of the instrumentation.
h) The hardware design of the PLC or DCS Controller and/or RTU.
i) The control systems Level 1 Functional Description (FD) – the design of the FD shall be based on examples provided by Watercare.
j) The distribution board and local services - power and lighting layouts for the Building Services.
k) Cable route definition.
l) The cathodic protection system.
m) The lightning protection system.
n) Security Systems design and co-ordination with Watercare service provider.
o) Fire Systems design and co-ordination with Watercare service provider.

8. Design alternatives and standard design detail

In some instances the proposed design detail may not be able to meet the standard design criteria. Alternative designs may need to be investigated due to site peculiarity or innovative technologies.

Alternative design proposals may be considered where:

- Watercare's standardised design is not suitable
- Watercare's Health and Safety in design minimum standards are achieved
- The design features do not involve extraordinary operational, maintenance or renewal obligations
- The alternative design are able to demonstrate that the required performance outcomes are met

Acceptance of an alternative design in concept does not conclude approval of any design criteria, construction technique or material selection. Specific approval must be sought during the design process.

9. Design deliverables

Design work shall be completed by a Chartered Professional Engineer or a suitably qualified engineer who have their work reviewed by a Chartered Professional Engineer in accordance with the Watercare compliance statement policy. Any design produced may be subjected to review by a Chartered Professional Engineer.

The designer must consider the design under the full operational requirements and apply good engineering practice that reflects:

- Compliance with New Zealand legislation, the most recent national standards, regulations and local conditions

- Watercare standards as included and referenced in this standard
- Historical information that may impact on the design
- Community and customer expectations
- Other information or specific conditions as provided by Watercare

The design shall incorporate the current approved Watercare standardised template designs.

The following comprehensive documents shall be provided to Watercare for evaluation of the design:

a) Basis of design report highlighting design definition, constraints, key assumptions, etc.
b) Risk analysis
c) Preliminary design report describing options and selection of design, see section 9.1
d) Design report, see section 9.1
e) Material schedules, see section 9.2
f) Project execution plan, see section 9.3
g) Site specific specification for construction
h) Nominated minimum levels of construction supervision
i) Drawings showing location and detailed sections
j) Functional descriptions (FD)
k) O&M manual draft
l) Standard operating procedure (SoP) draft
m) New assets register in accordance with Watercare's data and asset information standards
n) Design compliance statement – See Watercare compliance statement policy

9.1 Design report contents

The level of detail should reflect the complexity and scale of the project. The following sections shall be mandatory:

- Project description
- Planning considerations and level of service performance
- Analysis of alternatives
- Design criteria
- Resilience analysis
- Assumptions and non-compliance
- Engineering calculations
- Material selection
- Value engineering that includes, constructability analysis, simplification, innovation and life-cycle costing
- Legal considerations
- Operations and maintenance considerations

9.2 Material schedules - material selection at design

Material selection shall be completed by the designer on the following principle:

Feasible materials shall be shortlisted based on their limitations of use to ensure reliability, future maintenance and the cost of repair is kept to a minimum. The consideration to technical advantages shall only be taken on the shortlisted materials. Function and maintainability takes precedence.

The selected material shall be fit for purpose and proposed to Watercare for approval before commencing with detailed design.

As part of the design output, the designer shall complete the procurement schedules for the products and identify any design specific requirements over the minimum requirements stated by Watercare's Material Supply standard.

9.3 Project execution plan

The project execution plan identifies how the project must be executed based on:

- Assumptions made for execution of the construction that may have formed part of the design considerations
- Satisfying the requirements and conditions of any building consent, discharge consent or resource consents.
- Watercare's connection requirements and operational constraints that will impact the installation.

Significant deviation from the project execution plan requires that the design be re-submitted for approval by Watercare and any consequent design rework. Significant changes include:

- Change in operational process/philosophy
- Change in material
- Change in control/automation method and behaviour
- Changes in size, diameter or capacity
- Significant re-alignment or change in location

Part B – Electrical design

1. General electrical design requirements

1.1 Equipment installation locations

Equipment design and specification must be suitable for the environmental conditions that equipment will be installed and operated in.

General requirements when determining the location for electrical equipment:

a) Equipment shall be readily accessible
b) Avoid areas that require Traffic Management Plans, is classed as a hazardous area or a confined space. If electrical equipment must be installed into a hazardous area then design must fulfil requirements of AS/NZS 60079.
c) The installation shall allow easy access for maintenance and removal as required by the equipment supplier
d) 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
e) Equipment shall be on a level of minimum 500mm above the 1 in 100 year flood level with easy truck access for maintenance.
f) High voltage and low voltage equipment shall be segregated into separately accessible areas.

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

a) The centre of wall mounted cabinets to be approximately 1.2m above ground or standing access levels
b) Separated from plant infrastructure (e.g. moving equipment, pipe lines and cable support). In addition design shall not allow equipment to be fixed to safety handrails.
c) Transmitters or local controllers shall be located in an accessible location as close as possible to the primary process connection
d) Equipment shall not cause any obstruction to walkways, trip hazard, headroom or loss of access to other plant items
e) Indicators, switches and displays shall be plainly visible and accessible when standing in front of the equipment
f) Field mounted equipment not requiring vents to be fitted into enclosure for equipment cooling shall be housed in 316 stainless steel boxes with a minimum IP65 rating. Cable and process entries shall be at the bottom of the box. Any penetrations shall be glanded such that the enclosure IP rating is maintained.
g) Field mounted equipment requiring vents to be fitted into enclosure for equipment cooling shall be housed in 316 stainless steel boxes with a minimum IP54 rating. Cable and process entries shall be at the bottom of the box. Any penetrations shall be glanded such that the enclosure IP rating is maintained.

1.2 Energy minimisation

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

a) Power factor correction at the switchboard to ensure system power factor is not less than 0.96 lagging, but no more than unity 1.0 during normal operation
b) Load balancing across phases
c) Automatic control of lighting using timers and/or sensors as appropriate for the operating area
d) Use of LED lighting
e) Correct sizing of electrical devices
f) Material selection of high efficiency
g) Load distribution over operational time to reduce peaks
h) Reduce harmonics over the full operating range of equipment to comply with NZECP 36
i) 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.*

1.3 Reliability of operation

a) Component criticality shall be identified and provided with adequate redundancy. Criticality shall be assigned in consultation with Watercare.

b) Equipment shall be manually operable using push buttons in the event of failure of the automatic operation.
c) Equipment related to a particular process shall be grouped together and located in the same switchboard where possible.
d) Design must consider minimum process requirements under critical failure events. Failure events includes fire or loss of a single power service main:
   - Dual supplies and/or back up power supplies design considerations must ensure minimum process requirements are met during loss of a single power service main.
   - Equipment separation and/or other fire risk mitigation design considerations must ensure minimum process requirements are met if a fire occurs due to equipment failure.
e) Minimum process requirements are related to site criticality and criticality shall be assigned in consultation with Watercare.

1.4 Harmonics and voltage distortion in the power supply system

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.

1.5 Emergency stop

a) Machinery and Equipment Emergency stops shall be included in the design as required to fulfil requirements of AS/NZS 3000 and AS/NZS 4024.1604. Emergency Stop design is included in Watercare standard design templates. Emergency Stop design shall include:
   - Control system monitoring of activation.
   - A latching push button suitably located in the vicinity of motors.
   - For transmission plant submersible pump applications, the Emergency Stop button shall generally be located on the cell door of the motor controller but must be assessed as part of the Safety in Design process.
   - For process plant submersible pump applications where the submersible pump has an accessible field control station/motor termination panel adjacent to the pump – the Emergency Stop shall generally be fitted to the front door of this panel but must be assessed as part of the Safety in Design process.
   - When the button is released the motor shall not restart and automatic control shall not be available, but only permit restarting.
   - The emergency stop system shall interrupt the voltage supply to the motor through a contactor or circuit breaker.
b) Manual reset shall not be available until the emergency stop is physically disengaged by an intentional human action.

1.6 Isolation and interlock

a) Isolation and protection of incoming supplies, outgoing feeders and motors shall be by means of ACB/MCCB/Fuse switch disconnectors as defined in AS/NZS IEC 60947. Assignment of motor disconnect mechanism shall be assigned in consultation with Watercare as site preference varies between MCCB and Fuse disconnect.
b) Switches shall be of AC23 category as per IEC 947-3 and have “ON” and “OFF” position indication and locking facility.
c) 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

- Critical equipment interlocks not identified above that are provided for both safety and also to ensure unsafe failure is equipment is not possible.

d) Start, stop and emergency stop local buttons shall not be used for equipment isolations. Isolation mechanism must physically break the power to the drive.

1.7 Earthing

a) The earthing system shall be designed in accordance with NZ Electricity Regulations, New Zealand Standard AS/NZS 3000 and any special requirements of the electrical supply company.

1.7.1 Electrodes, main earth and main earth bar

a) A main earth bar shall be provided in the MCC rooms and/or Transformer pits at a convenient location. All connections to the main earth bars shall be accessible and shall be removable for testing purposes.
b) For outdoor installations the main earth bar shall be located within the switchboard.
c) Earth system sizing must ensure equipment protection operates as intended and earth loop impedance values do not inhibit protection from operating. .Each Main Earth bar and Main Earth conductor shall be oversized by 20% to allow for future connections.
d) The designer must identify sufficient number of electrodes required to ensure any risks associated with HV touch and step potential are eliminated.
e) Where more than one earth electrode is required, the main earth shall form a ring circuit.

1.7.2 Structural earth

a) The building housing the main switchboard and any structural steel associated with the building shall be earthed with minimum two 35mm^2 copper earth conductors configured to achieve low earthing impedance.
b) Concrete slabs with reinforcement shall be earthed with a minimum of one 70mm^2 Wricon.

1.7.3 Instrument earth

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

Note: some manufacturers will require a dedicated instrument bar for their equipment e.g. Emerson DeltaV DCS.

1.7.4 Bonding

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

1.7.5 Lightning protection system

a) Where required by risk assessment, a lightning protection system shall be provided in accordance with AS/NZS 1768.
b) Aerial mounting masts shall be earthed through a separate earth electrode mounted as close as practical to the mast.
c) The earth conductor between the earth electrode and the mast shall be the most direct route without sharp bends.

1.8 Outdoor electrical equipment

a) Equipment design and specification must be suitable for the environmental conditions that equipment will be installed and operated in.
b) Breather plugs and/or anti-condensation heaters must be considered in the design to ensure no condensation or moisture is present within the equipment.
c) Heat dissipation from equipment and equipment sunlight exposure must be considered in the design to ensure that equipment never exceeds acceptable temperatures and per supplier's recommendations.

1.9 Seismic actions

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

1.10 Lighting

a) All luminaires shall conform to AS/NZS 1680 set (as applicable) and AS/NZS 1158 set (as applicable).
b) Luminaires subject to atmospheric corrosion shall be specified as resistant to such adverse environmental conditions. Exterior fittings shall be specified vandal-resistant.
c) Fittings installed in the plant areas shall have an IP56 rating.
d) All lighting equipment shall be suitable for the applicable ambient temperature it is operating in.
e) All light towers shall be tilting type to allow for easy maintenance and lamp replacement. The towers shall be positioned so that when they are tilted down for maintenance, the light fittings are located on flat ground and do not clash with other equipment.
f) All light fittings for new lighting towers shall be LED type.
g) Exit signs within buildings are to be continuously powered on (maintained).

1.11 Protection and finishes

a) Protection against corrosion, deterioration, absorption of moisture and the like shall be provided for all materials and equipment.
b) Any protection required in addition to the manufacturer's standard finish shall be provided. This includes the conformal coating of all electronic printed circuit boards (PCB) and components to IEC 61721 class 3C3. Class 3C2 may be applied in some cases with the agreement of Watercare.
c) Precautions shall be taken to prevent electrolysis from occurring due to the use and connection of dissimilar metals. Dissimilar metals shall be protected from electrolysis by means of bituminised felt, neoprene gasket, Teflon tape, insulating union or equivalent means suited for the duty.
d) Steel requiring galvanising shall be hot dipped galvanised. Painting of galvanised fittings requires Watercare approval.
e) Drilling, cutting, etc. of galvanised steel shall be touched up with corrosion resistant coating.

1.12 Service conditions

a) The table below shows service conditions that electrical equipment must operate in over the life of the piece of equipment. The design brief for a specific project must confirm details as shown in the table when works are being undertaken directly for Watercare.

***Note** – The design brief must confirm site 3 phase voltage. Some sites use 400VAC whilst others use 415VAC. The designer is to confirm.*

Item	Detail	Notes
Service Conditions	Indoors or outdoors, with adequate ventilation	
Supply Voltage (V)	11kV 3 phase, 415V 3 phase, 4 wire 400V 3 phase, 4 wire	
Supply Frequency (Hz)	50 Hz	Equipment installed should be rated to support 50 Hz $\pm$ 5%.
Ambient Temperature	-5 - 40 °C	
Relative Humidity	Up to 90%	Damp conditions
H_2S	Present at waste water sites.	

Item	Detail	Notes
Atmospheric Conditions	Coast/Marine	

1.13 Hazardous areas

The designs shall, as far as practicable avoid electrical equipment to be installed within hazardous areas.

The following items apply when undertaking a design for electrical equipment in a hazardous area. The design, classification, installation and maintenance of electrical equipment in hazardous areas shall be conducted to AS/NZS 60079.

1.13.1 Documentation requirements

a) The designer shall populate the layout and content of the hazardous area dossier including but not limited to:
   - Classification drawing and report
   - Loop drawings
   - Datasheets
   - Hazardous area equipment certificates
   - Signed entity calculations for barrier to field instrument (for intrinsically safe circuits)
   - Equipment register

b) The equipment register shall include but not be limited to:
   - Field instruments
   - Valves
   - Motors
   - Junction boxes
   - Glands
   - Plugs
   - Adaptors

c) The equipment register shall detail the following for each item of equipment:
   - Tag number
   - P&ID drawing reference
   - Location
   - Instrument type
   - Manufacturer
   - Model
   - Serial number
   - Loop drawing
   - Classification drawing
   - Protection technique
   - Equipment certification number

1.13.2 Equipment requirements

a) IECEx certified equipment is preferred, equipment certified to CSA, FM and UL are not permitted

b) Any modification of field equipment (such as adding new equipment, terminals or drilling new cable entries) may invalidate the hazardous area certification and is generally not permitted. Where such modifications are necessary, they shall be conducted by the OEM or supplier who shall provide revised hazardous area certification where necessary

c) Hazardous area equipment certified with suffix ‘U’ are generally for an enclosure only with no internal content and shall not be used.

d) Hazardous area equipment certified with suffix 'X' shall be designed and installed in accordance with the special conditions of the hazardous area certificate.
e) Where simple apparatus are used it shall be installed with a suitable intrinsically safe barrier
f) All equipment installed shall bear, and be installed, to show an indelible nameplate detailing hazardous area protection technique, gas group rating, temperature class, temperature rating, IP rating and certificate number
g) All intrinsically safe circuits shall utilise light blue cables, trunking and terminals up to the input at the intrinsically safe barrier
h) Intrinsically safe field junction boxes shall be marked with light blue background traffolyte tag with white text stating "Intrinsically Safe Circuits" and may only be IP65 rated and not necessarily hazardous area certified.

2. Transformers (≥1kV)

2.1 General

a) Transformers shall be located in a transformer yard or inside a suitably vented masonry room with suitably sized containment provided for oil filled transformers.
b) The transformer shall be mounted on a concrete pad or plinth in accordance with the specific drawings.
c) A minimum clearance of 1000mm shall be provided around the transformer enclosures.
d) Transformer rooms shall have concrete floors with cable trenches. In-filled floors are not accepted.
e) High Voltage transformers shall monitor:
   - Low oil level
   - High Pressure
   - High Temperature
f) 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.
g) Transformers shall be a three winding, three phase core-type transformer and shall be capable of delivering rated kVA through the complete tapping range.
h) Where the transformer is dedicated to a single switchboard, the switchboard mains cables shall be sized for the full transformer load unless otherwise specified.

The following I/O shall be integrated into the RTU/PLC/DCS from dedicated, Watercare owned transformers:

I/O description	RTU/PLC/DCS I/O type
High oil temperature alarm (digital input)	Digital input
High high oil temperature trip (digital input)	Digital input
High pressure trip (digital input)	Digital input
Low oil level alarm (digital input)	Digital input
Low low oil level trip (digital input)	Digital input
Shunt trip	Digital output

2.2 Design considerations for procurement

a) The following shall be considered when preparing specifications for the procurement of transformers:
   - Type of transformer required
   - Vector group
   - 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.
- Frequency
- Cooling method
- 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.

3. Switchboards, Distribution and Control centres

3.1 Switchboard layout and general requirements

a) Refer to Watercare's material supply standard for switchboard construction requirements.
b) The use of vendor turnkey pump control systems with integrated switchboards / pump controls may be provided for low risk applications (e.g. small water pump stations) but is conditional to specific approval by Watercare.
c) Switchboards shall be of dead front construction, consisting of vertical sections bolted together to form a rigid, free standing, compartmentalized assembly.
d) The use of double sided switchboards must be approved by Watercare during design.
e) The design and arrangements of components shall permit easy operation and maintenance with minimum disruption to services and ensure the safety of operating personnel.
f) The design shall permit future addition of vertical sections and interchanging of units.
g) The door/cover of each cell shall be mechanically interlocked with the main isolator for that cell. It shall be possible to open the door/cover only when the isolator is in the off position.
h) It will be permissible to obtain access to live parts through a door or cover whilst the equipment is live by defeating the mechanical interlock or using special tools. Such an interlock shall be automatically restored on refastening the door or cover.
i) 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.
j) The switchboard shall be designed to meet the requirements of NZS 1170.5. In addition, 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.
k) The layout of all switchboard cubicles and doors shall be accepted by the Watercare before manufacture of the switchboard commences.
l) Refer to Watercare material supply standard for supplier build requirements.

3.2 Switchboard electrical requirements

a) The main busbars shall be fully rated over their whole length for the current and short circuit rating indicated in the single line diagram. The droppers shall be rated for the full short circuit rating shown in the same drawing.
b) Main switchboards with an incoming isolator greater than 80A shall have a power meter installed with an RS485 Modbus or Ethernet IP adaptor module.
c) 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. The diverter shall provide auxiliary digital outputs connected to the site PLC/DCS to indicate the status of the unit. The surge diverter unit shall be maintainable by way of replaceable cartridges.
d) An RTU, DCS or PLC control cabinet may be provided as part of the switchboard and shall be constructed and finished to the same standard. Inclusion of the cabinet shall not prevent future extension to either end of the switchboard.
e) Isolation and protection of incoming supplies and outgoing feeders shall be by means of ACB/MCCB switch-disconnectors.

3.3 Outdoor switchboards

a) Outdoor switchboards shall be housed in a pillar box arrangement constructed of powder coated marine grade aluminium or 316 stainless steel.
b) IP ratings for this equipment are as follows:
   - Switchboards not requiring vents to be fitted into enclosure for equipment cooling shall have a minimum IP65 rating.
   - Switchboards requiring vents to be fitted into enclosure for equipment cooling shall have a minimum IP54 rating.
c) Equipment design and specification must be suitable for the environmental conditions that equipment will be installed and operated in.
d) Breather plugs and/or anti-condensation heaters must be considered in the design to ensure no condensation or moisture is present within the equipment. Heat dissipation from equipment and equipment sunlight exposure must be considered in the design to ensure that equipment never exceeds acceptable temperatures and per supplier's recommendations.
e) Any penetration into an outdoor enclosure shall maintain the enclosure IP rating.

3.4 Generator connections

a) A temporary generator connection shall be provided where the installation is deemed to require backup power in the event of a sustained loss of mains electricity supply. The criticality of the installation shall be determined in consultation with Watercare.
b) The generator connection for a switchboard shall be via an externally mounted connection enclosure. A mechanical interlock shall be provided between the main incomer and changeover switch.
c) Refer to the Watercare General Electrical Construction standard for fitting details.

3.4.1 Cable mechanical protection

Mechanical protection shall be installed from the wall penetration to the generator connection point. The mechanical protection shall allow for easy installation and removal of temporary generator cables.

3.4.2 Generator connection point

3.4.2.1 Detachable Connection (Appliance Inlet)

a) Where the temporary standby generator is connected to the installation via a detachable connection, the detachable connection shall consist of:
   - A fixed 5-pin appliance inlet for three phase sites.
   - A fixed 3-pin appliance inlet for single phase sites.

b) An appliance inlet connected to a flexible lead is not acceptable. The appliance inlet shall be fixed to a switchboard enclosure or be wall mounted.
c) Copper busbars shall be provided within the switchboard. The appliance inlet shall connect to the busbars. The busbars shall be shrouded with protective barriers.
d) The intent of the busbars is to provide for emergency connection of a generator that has not been provided with a suitable cord connector, or the phase sequence is incorrect.

3.4.2.2 Connection via Busbars

The temporary standby generator shall be connected to the installation via suitably rated fixed copper busbars. The generator cables shall be lugged and bolted to the busbars.

3.4.2.3 Location

The generator connection point shall be installed inside the installation.

3.4.2.4 Outdoor generator connection point

a) Outdoor connection points should not be installed for new installations but may exist in existing installations.
b) Installations with no fixed buildings may have an outdoor connection point.

3.4.2.5 Identification

Signage installed at the generator connection point shall include:

- The required generator capacity for correct operation of the installation;
- The mains phase sequence; and
- The required procedure for generator connection and disconnection.

3.4.2.6 Phase sequence identification

a) A phase sequence indicator shall be permanently installed at the generator connection point.
b) The phase sequence indicator shall have a connection to both mains and generator supplies via a rotary changeover switch.

3.4.3 Supply transfer system requirements

3.4.3.1 Manual transfer switch

a) A Manual Transfer Switch (MTS) shall be connected on the line side of the installation's main switch. The MTS shall have an intermediate off position and shall be lockable in this position.
b) In new installations the MTS shall be installed within a dedicated cell of the installation's main switchboard.
c) The MTS shall consist of interlocked load break switches. The load break switches shall be rated for:
    - The greater of the maximum load current of the installation or the supply source protection unit; and
    - The maximum fault current of the mains or generator supply.

3.4.3.2 Transfer switch poles

a) For installations connected via a detachable connection, the MTS shall switch the neutral pole of the generator connection. The MTS shall be:
    - A 3-pole/4-pole arrangement for three phase sites.
    - A 1-pole/2-pole arrangement for single phase site.
b) For installations connected via busbars the MTS shall not switch the neutral pole of the generator connection. The MTS shall be a 3-pole/3-pole arrangement.

3.4.3.3 Power factor correction interlock

Capacitor/inductor based Power Factor Correction (PFC) systems shall be disconnected automatically when the installation is connected to the generator supply.

3.4.3.4 Essential services switchboards

Where an installation has a separate essential services switchboard supplied from the line side of the main switchboard's main switch, an additional MTS shall be provided to connect the generator to the essential services.

3.4.4 Monitoring requirements

3.4.4.1 Remote voltage monitoring

a) The installation's electricity supply state shall be monitored remotely. The supply state shall be determined by the status of phase failure relays energised from the following locations:
   - Line side of the mains incomer;
   - Line side of the generator incomer; and
   - Load side of the switchboard main switch.

b) The table below can be used to determine the electricity supply status of the installation.

State	Mains line side	Generator line side	Switchboard load side
Mains available with load connected.	On	Off	On
Mains available with load disconnected.	On	Off	Off
Mains not available. Generator supply available with load connected.	Off	On	On
Mains not available. Generator supply available with load disconnected.	Off	On	Off
Mains not available. Generator supply not available. Main switch status unknown. Indicates either generator not connected, or generator faulted.	Off	Off	Off

*either mains or generator supply is required for switchboard load side PFR to be energised.

c) The phase failure relays shall have a minimum of one changeover relay contact (SPDT). The phase failure relay shall de-energise after a set time delay in the event of:
   - Loss of any phase;
   - Voltage above the adjustable tolerance limit; or
   - Voltage below the adjustable tolerance limit.

d) The phase failure relays shall be connected to discrete inputs within the site control system.

3.4.4.2 Local voltage monitoring

a) Phase indication lamps shall be energised from the following locations:
   - Line side of the mains incomer. Labelled 'Mains Supply Available';
   - Line side of the generator incomer. Labelled 'Generator Supply Available'; and
   - Load side of the switchboard main switch. Labelled 'Switchboard Bus Live'.

b) The phase indication lamps shall be of the high intensity type with an IP rating to match the enclosure.
c) The phase indication lamps shall be installed on the door of the main switchboard cell enclosing the main switch.

3.5 Switchboard specific requirements

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

Item	Detail	Notes
Service Conditions	Indoors / outdoors, with adequate ventilation	
Cable Entry (Incoming Supply Cables)	Bottom or top entry	
Cable Entry (Outgoing Cables)	Bottom or top entry	
Operating Access	Dead Front Construction	
Bus Bar and Bus Dropper Access	Via removable covers at back and top of switchboard	If entry into bus section can only be via the front – this must be approved by the Watercare
Shipping Break	Required if switchboard >3m or access limitations prevail	
Supply Voltage (V)	11kV 3 phase, 415V 3 phase, 4 wire 400V 3 phase, 4 wire	
Supply Frequency (Hz)	50 Hz	Equipment installed should be rated to support 50 Hz ± 5%.
Fault Level (kA)	10 kA Minimum.	Rated short-time withstand current (Icw). Designer to update if calculated fault level exceeds 10 kA.
Fault Duration (sec)	1 second	
Diversity	1	
Neutral	Solidly Earthed (MEN system)	
Ambient Temperature	-5 - 40 °C	
Relative Humidity	Up to 90%	Damp conditions
H_2S	Present at waste water sites.	
Atmospheric Conditions	Coast/Marine	
Incoming ACB/MCCB (i.e. incoming supplies to	Fixed Cell. ACBs to be withdrawable via ACB chassis.	

Item	Detail	Notes
MCC)		
Outgoing ACB/MCCB (i.e. feeders to other MCC's)	Fixed Cell. ACBs to be withdrawable via ACB chassis.	
Co-ordination	Type 2	
Spare cells	20%	Spare cells shall be sized to the most common cell size in switchboard
Segregation	4a (Classification in AS/NZS 61439.1 – No ELV or LV terminals in wire way except for Neutral and Earth Bars)	Switchboards constructed to AS/NZS 61439 Form 2 and 3 may be provided but must be approved by the Watercare
Degree of Protection	IP42 for indoor IP54/IP65 for outdoor	Live parts, ingress of foreign bodies (dust) & liquids (water spray)

4. Uninterruptable power supplies (UPS)

4.1 UPS function

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

4.2 UPS configurations

a) To assist the designer, three standard UPS configurations have been developed:
   - Type 1 – Single UPS unit;
   - Type 2 – Dual parallel redundant; and
   - Type 3 – Dual independent with/without static transfer switches.
b) 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.
c) 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. Therefore, for existing installations, a Type 2 configuration may be considered.
d) Determination of the UPS load criticality requires Watercare approval.

4.2.1 Type 1 – Single UPS unit

a) 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.
b) The maintenance bypass cabinet shall incorporate a maintenance bypass switch plus isolators for UPS rectifier supply, bypass supply and UPS output.
c) 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.
d) Where alternative supplies to a site are available, an automatic supply changeover switch shall be incorporated on the input supply to the UPS.

4.2.2 Type 2 – Dual parallel redundant

a) 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.
b) 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.
c) The maintenance bypass switch shall have three positions:
   - Position 1 – 'Normal'. The load is supplied from the UPS units
   - 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
   - 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
d) 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.
e) 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.
f) 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.
g) Each UPS unit in a dual parallel redundant configuration shall be capable of supplying the full UPS load independently.
h) The parallel UPS units shall incorporate a communications link that controls synchronism and load sharing between the UPS units.

4.2.3 Type 3 – Dual Independent with or without static transfer switches

a) 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.
b) The output of each UPS unit shall supply its own UPS output distribution board comprising miniature circuit breakers.
c) 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.
d) 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.
e) 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.
f) 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.
g) 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.

4.2.4 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.

Condition	Requirement
Corrosive Gas Presence	Low levels of hydrogen sulphide, chlorine, fluoride and other gases may be present at some sites
Ambient Air Temperature	0 - 40 °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

4.2.5 Minimum UPS technical requirements

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

***Note** – The design brief must confirm site 3 phase voltage. Some sites use 400VAC whilst others use 415VAC. The designer is to confirm.*

4.2.5.1 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).

4.2.5.2 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

Parameter	Requirement
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.

4.2.5.3 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)

4.2.5.4 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.

4.2.5.5 Conformal coating

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

4.3 Modes of operation

a) 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.
b) 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.

4.4 Battery selection

a) 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.
b) 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.
c) The maximum anticipated load is defined as the current UPS load with 25% additional capacity for future UPS load increases.
d) 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.

4.5 Battery testing

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

4.6 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.

4.7 UPS locational requirements

a) UPS systems shall be located within a dedicated, swipe card accessible room that is a dry, dust and chemical free environment.
b) Electrical switchrooms are classified as dedicated rooms for electrical equipment and also fulfils other requirements.
c) Equipment separation and/or other fire risk mitigation design considerations must ensure minimum process requirements are met if a fire occurs due to equipment failure.
d) 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.
e) 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.
f) Equipment separation and/or other fire risk mitigation design considerations must ensure minimum process requirements are met if a fire occurs due to equipment failure.

4.8 UPS electrical protection

a) Selection and co-ordination between the UPS and protection devices shall be considered as UPS systems offer limited fault capacity to its output circuits.
b) Fault discrimination is required to avoid one device overloading the UPS and isolating all UPS loads.

4.8.1 UPS load distribution board schedules

a) 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.
b) 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.

4.9 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.

4.9.1 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:

a) 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

b) 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.

c) 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.

d) 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.

4.10 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.

4.10.1 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

Parameter	Units
Output Frequency	Hertz
Ambient Temperature	Degrees C
Battery Time Remaining	Minutes

4.10.2 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
Auxiliary mains out of tolerance	The voltage or frequency limits accepted by the bypass have been exceeded
Battery alarm	Battery circuit failure or faulty operation
Battery charger general alarm	Battery charger fault
Battery circuit open	The battery switch is open
Battery discharged	The energy available in the battery has been used up
Blocking inverter for overload	Inverter shutdown due to overload
Bypass general alarm	Bypass fault
Fan failure	Fans faulty or blocked
Improper condition of use	Improper condition of use verified (load, mains and temperature)
Input mains out of tolerance	The voltage or frequency limits accepted by the rectifier have been exceeded
Inverter general alarm	Inverter fault
Maintenance bypass active	Q6 in position 2
Max battery temperature	Control of the temperature of the battery cabinet
Module 1-6 general alarm	Module failure
Option board general alarm	Fault related to the optional PC8s in the slots
Output overload	Power required in output over the limits
Over temperature	Temperature excessive or ventilation problems
Periodic service check-up	Warning for periodic check by support service
Phase rotation fault	Wrong phase cycle direction
Rectifier general alarm	Rectifier fault
Stop for overload	The duration of the overload has inhibited the bypass

The UPS general fault relay shall be activated by any of these conditions. This table must be incorporated into the UPS drawing.

4.10.3 UPS Battery test initiation

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

5. Electrical actuators

a) 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.
b) Actuators shall be installed in locations and environments that are easily accessible for maintenance and replacement. Single phase, three phase and 24Vdc electric actuators are acceptable.
c) The minimum required I/O for electrical actuators are:

I/O description	RTU/PLC/DCS I/O type
Valve opened	Digital input
Valve closed	Digital input
Open valve*	Digital output
Close valve*	Digital output
Position in**	Analog input
Position out**	Analog output

*Non-modulating valve only

**Modulating valve only

5.1 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.

6. Instruments and Controls

a) PLC or DCS's digital signal voltage levels, and the power supply to instruments vary from site to site. The designer must confirm the site specific configuration with Watercare.
b) Instrument displays shall be mounted at a convenient height/position for viewing.
c) Instrument pipe stands or racks shall be used to mount remote mounted instruments and transmitters. Handrails and vibrating equipment shall not be used for mounting instruments.
d) The location of all equipment shall be such that convenient safe access for service, testing and calibration is provided without the need for temporary staging or ladders.
e) The environmental conditions shall be reviewed when selecting instrumentation, panels and their supports to apply the required corrosion protection. This includes conformal coating of all electronic printed circuit boards (PCB).
f) All outdoor electrical equipment that is fitted with operator interface screens or controls for operator adjustment shall be protected from direct sunlight in all directions.
g) Two wire proximity switches shall be used for limit feedback functions. The body shall be plastic wherever possible. Three-wire type devices may be used where greater range is required and on approval by Watercare.

7. Feeder - Air circuit breakers

a) LV Air Circuit Breakers (ACB) circuit shall be withdrawable from a fixed ACB chassis with matching current transformers and solid state protection unit.
b) The solid state protection unit shall have over current short circuit and earth fault characteristics adjustable on time and current basis.
c) The circuit breaker shall have the following accessories:
   - Motor operated, spring charged operating mechanism (close-open cycle before recharge)

- Handle for hand charging the spring
- Close - open push button
- Spring "charged" - "discharged" mechanical indicators
- Key locks for "connected", "disconnected" and "test" position
- Door interlock
- Functional position indicator : "connected", "disconnected" and "test" position
- Breaker "open" and "closed" local indication
- Breaker “open”, “closed” and “fault” PLC/DCS indication.
- Padlocking facilities in "disconnected" or "test" position
- Fault trip indicator/breaker reset push button
- Operation counter
- Under voltage release / shunt trip / closing coil
- Open/closed and 2x fault/trip auxiliary contacts
- Safety shutters on busbar and cable side with pad locking facility.
- Earth fault relay with a current transformer mounted on the neutral (either separate or integral to the ACB is acceptable)

d) The short circuit breaking capacity of the circuit breaker shall be equal to or more than the busbar fault level.

e) Current transformers shall comply with applicable standards and shall be supplied to suit the protection and metering being provided. Unless otherwise shown the metering current transformers shall be of accuracy class 1 and 7.5 VA burden.

f) All current transformers shall have the same secondary current rating of 1 amp.

8. Motor starters

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

b) Motor control shall be via direct on-line (DOL), soft starters or variable speed drives (VSD).

c) For transmission sites - motors 7.5kW and larger shall be provided with assisted start arrangements (soft starters or VSDs) and not DOL.

d) For treatment plant sites - motors 15kW and larger shall be provided with assisted start arrangements (soft starters or VSDs) and not DOL.

e) Instrument gauges shall comply with applicable standards for indicating instruments, and shall be moving iron with accuracy class 1.5.The instrument gauges shall be flush mounted. All instrument gauges shall be equipped with non-glare glass, white dial and black pointer.

f) Fault indicating lamps are required as shown on the typical motor starter diagrams. These shall be the high intensity LED type.

g) Labeling and identification of equipment shall be in accordance with NZS 5807 Code of Practice for Identification by Colour, Wording and other coding.

h) Star-delta starters are not accepted.

i) 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.

j) Power factor correction shall be provided for motors larger than 5kW. Power factor correction may be by static or switched capacitors, active unit applied to switchboard main bus or part of a site wide automatic correction system.

k) All control relays shall be flat pin plug in type. All contacts shall be rated at least for 5A inductive at 0.4 pf. An indication to show relay operation is required. Bases have terminals accessible for testing when the relay is installed. The coil hold-in current shall not exceed 500mA at 24V ac/dc or 300mA at 110V ac.

l) Motor starter configuration varies from site to site.

Note: The design brief will indicate which motor starter set is applicable.

m) Switches shall be of AC23 category as per IEC 947-3 and have “ON” and “OFF” position indication and locking facility.

9. Motors

9.1 General

Refer to the Watercare General Electrical Construction standard for fitting details and the material supply standard for motor selection requirements.

9.2 Local control

a) Local manual control should not rely on the health/functionality of the station controller. The motor shall run if the manual-off-auto switch is in the manual position and the start button depressed.
b) Field start/stop station may be incorporated if considered necessary best practice.

9.3 Auto control

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

Digital Inputs	**Digital Outputs**
Running	Start/Stop
Healthy (no faults)	Auto available/not available
Auto selected	-
Emergency-stop operated	-
Analogue Inputs	**Analogue Outputs**
Motor current (or speed for VSDs)	Speed reference (for VSDs only)

10. Variable Speed Drives

10.1 General

a) Variable speed drives (VSDs) will be used to control the speed and torque of three phase, squirrel cage, induction motors operating on 415 V, 50 Hz power supply by the simultaneous adjustment of the output voltage and frequency of the electrical power supplied to the motor.
b) The VSDs shall continue to operate satisfactorily when the input voltage drops to 90% or rises to 110% of the rated voltage.
c) The power supply will be derived from a circuit breaker within the supply MCC.
d) Conformal coating shall be applied to the VSD componentry in high H_2S environments.

***Note** – Design brief to confirm site 3 phase LV voltage. Some sites use 400VAC whilst others use 415VAC. Designer to confirm.*

10.2 Speed control method

a) The following speed control methods may be used depending upon the application:
   - V/Hz Control
   - Open-Loop (sensor less) Vector Control
   - Direct Torque Control
b) The control system shall maintain smooth control of the motor speed from 0.5 to 50 Hz. Frequency stability shall be better than 0.05% of maximum frequency.
c) Automatic slip compensation shall be incorporated to maintain motor speed within ± 1% of set speed irrespective of load.
d) The control system shall ensure that stable operation is achieved even if the motor is operating on no load.

10.3 Power Rating

a) The VSD kW rating shall exceed the rated output of the connected motor by a minimum of 15% and shall have an overload capacity of 150% of the rated motor kW for 30 seconds in keeping with motor specification.
b) VSDs shall provide a minimum of 150% of full load torque at start-up. The VSDs shall provide an automatic voltage boost by measurement of motor current to prevent stalling of the motor at start-up or during any portion of the run-up. Any de-rating of the drive due to temperature or alterations to switching frequency shall not detract from the power requirements.

10.4 EMC/RFI

a) The VSDs shall comply fully with the requirements of the Radio communications Interference Notice 1993, including amendments 1 - 4. Any filters or other means necessary to achieve compliance shall be included.
b) The VSD shall include integrated radio frequency suppression according to the requirements of AS/NZS CISPR 11:2002 or equivalent.

10.5 Cabling

a) The cable shall minimise capacitance of the power conductors and have an electrically balanced construction including split earths and a copper screen.
b) The supplier shall declare the required cable types, sizes and formats necessary to comply with the requirements for current carrying capacity, system earthing, installation conditions, maximum lengths, EDM mitigation and other functional requirements set out by the design specification.

10.6 Harmonic Mitigation

a) Where the point of common coupling (PoCC) is on a Watercare network NZECP 36 shall determine the harmonic requirements. Where the PoCC is on an electricity distributor's network then the harmonic requirements shall be set by the electricity distributor.
b) Full consideration of the potentially detrimental effect of VSD generated harmonics on the power supply system and other connected loads is required. Any proposed additional equipment shall be supplied with the calculated reduction in harmonic levels.

10.7 Motors

a) Where PWM VVVF VSDs are to be used, the motors shall be appropriately rated against damage to the motor bearings caused by Electro Discharge Machining (EDM) and other related phenomenon i.e. insulated bearings, frame grounding, etc.
b) The motor insulation shall not be stressed by high switching speeds or the voltage reflection effect.
c) dV/dt filters shall be provided for standard (not inverter rated) duty motors or where the insulation integrity of the motor is old or unknown.

11. Electrical cables and cables support systems

11.1 Electrical cables

a) Where abbreviations of cable types are given they shall have the following meanings:
   - Cu- Copper conductor.
   - Al - Aluminium conductor. Explicit permission from Watercare required.
   - PVC/PVC - Polyvinyl chloride insulated and sheathed.
   - XLPE/PVC - Cross-linked polyethylene insulated, PVC sheathed XLPE/VSD - Cross-linked polyethylene insulated, PVC sheathed, 3C + 3E for VSD applications
   - SWA - Steel wire armoured
   - FLEX - Multistranded copper cables
b) Refer to the Watercare electrical construction standard for cable types, sizes, minimum spacing and cable support fitting details. Cable corridors shall be designed and not left up to the installer to resolve.

11.2 Cable support systems

a) To enable easy pulling of cables, draw pits shall be provided at the beginning, end and nominal intervals throughout underground duct runs
b) Cable support systems shall be run level, in one plane whenever possible, straight and parallel with building lines to produce a tidy installation.
c) Design for supports and fixings shall comply with NZS 4219. The design of supports, frames, hangers and the like shall comply with the NZ Building Code, Section B1, VM1, clause 12.0.
d) Cable support systems shall not be fixed to handrail systems or process pipework. Support mechanisms for electrical equipment must remain independent from these.
e) The cable support system design must ensure cable support system is left post installation with 20% spare capacity.
f) The type of cable support chosen shall accommodate the type of cables to be carried (size and weight).

12. Fibre optic

12.1 Carrier duct

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

12.2 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.

13. Cathodic protection

13.1 Impressed current anode ground-beds

a) The design for large systems shall avoid positioning anodes within 50m of metal structures of any kind including reinforced concrete.
b) 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.
c) Exceptions may only be made if the metal structures are explicitly part of the CP design or with written permission from Watercare.

13.2 Sacrificial anode ground-beds

a) The design for small systems shall avoid positioning anodes within 3m of metal structures of any kind including reinforced concrete.
b) 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.
c) Exceptions may only be made if the metal structures are explicitly part of the CP design or with written permission from Watercare.

13.3 Electrical hazard analysis

a) 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.
b) High voltage means 1000V or higher, and includes electrified railway networks.

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

13.4 Test points

13.4.1 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

13.4.2 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

13.4.3 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.

13.4.4 Test point cabling

a) 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.
b) 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.

13.4.5 Interference test points

a) 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.
b) 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.

13.5 Cabling and connections

a) 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

b) 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.

c) The minimum standard of insulation for impressed anode cable tails and feeder cable(s) is Olex XLPE or equivalent.

14. Cable identification

14.1 Cable numbering

a) A cable number is made up of the destination equipment number (excluding the Facility Code when there is only one facility on site) of the device that is connected followed by a cable type designation and a sequential number.

b) When the equipment number is used the dashes (-) are removed from it and a single dash is added before the cable type designation.

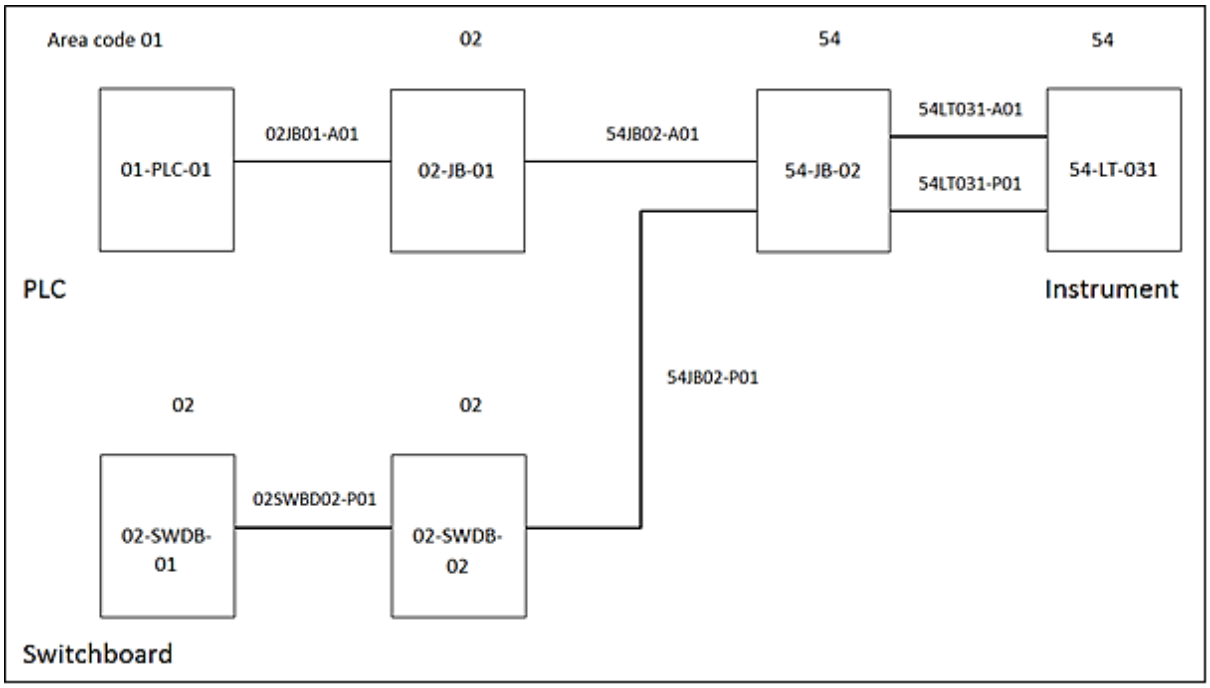
14.2 Cable type designation

The cable type shall be defined as follows:

Type Code	Description
P	Shall indicate a power cable carrying LV 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.

14.3 Cable numbering example



14.4 Wire numbering

a) 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

b) The wire function is shown in the table below:

Order of importance	Letter	Wire function
N/A	H	ac supply
	J	dc supply
	N	Neutral (or 0Vdc)
	E	Earthing connection
	C	Current Transformer
	T	Thermistor
	Y	Telephone Circuit
1	R	Interlock
2	L	Alarm/Indication
3	S	Instrument loop
4	K	Closing & Tripping control circuit
5	U	Spare
6	X	Miscellaneous circuits not covered above

c) Where a wire performs more than one function, the letter for the most important function shall be used. The order of importance is defined in the table above. For example, if a wire is part of an interlock circuit and also used to provide indication it shall be labelled 'R'.

d) Where numbering ELV wires the prefix "W" is used before the wire function identifier e.g. WL113, WK12, WN01, WJ01.

e) Extra low voltage is less than 50Vac or 120Vdc.