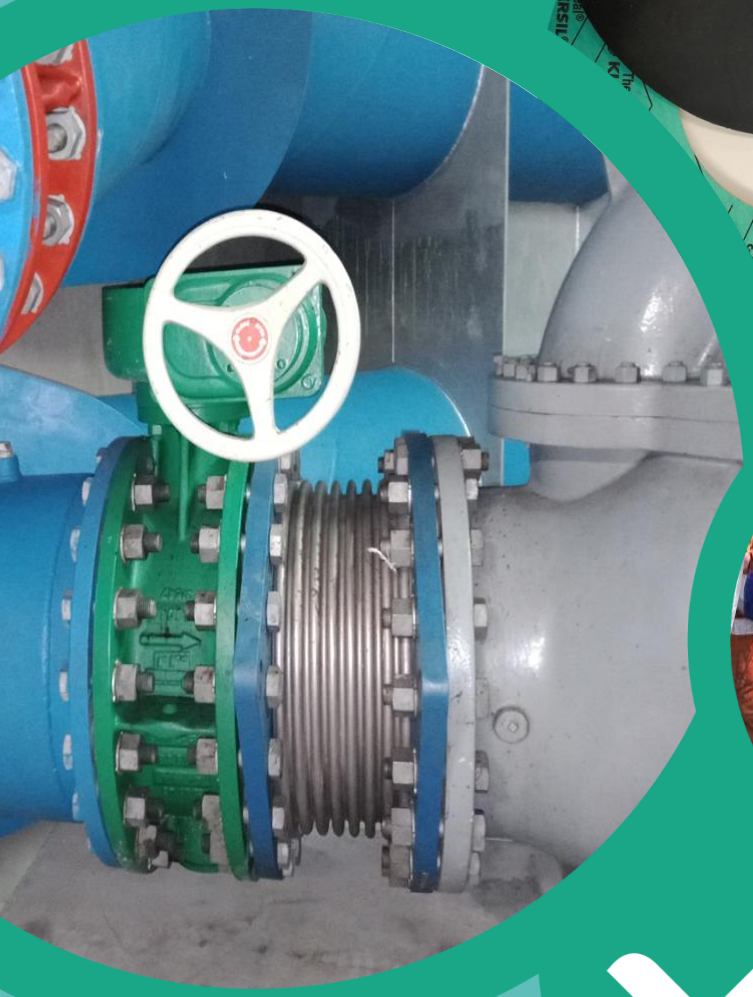

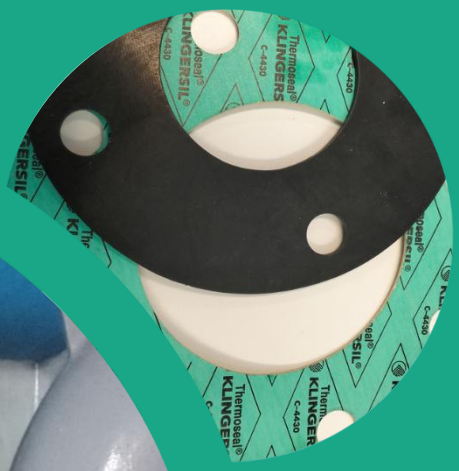

MECHANICAL AND ELECTRICAL

MECHANICAL CONSTRUCTION STANDARD

Document No. ESF-600-STD-701

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Watercare

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More information

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DOCUMENT CONTROL

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Version history

Version	Description of revision	Released by	Date
1	First release	J de Villiers	14/10/2016
1.1	Minor updates. Paragraphs numbered	J de Villiers	19/06/2019
1.2	Working draft - Minor update to weld tests and bolt torque tables	J de Villiers	25/03/2020
1.3	Draft status removed. No changes	J de Villiers	18/06/2020
2	Document format change, updates	W Strydom	07/06/2024
2.1	Updates to multiple sections including new sections added.	W Strydom	01/10/2025

This document takes effect on the date of release and supersedes all prior versions.

Summary of Changes

Version	Section	Description of revision
2.1	2.1.	Updated list of referenced standards for 'Installation of flanges components in pipelines.
	2.2	Note added on inspection of free-issue equipment
	2.2.6.3	Added new section on fastener lubrication
	2.3.1	Added comment on post weld heat treatment
	2.5.2	Minor wording update
	2.6.1.2	Added note on MPI testing.
	2.6.7.6	Added note on the use of olets
	2.6.8	Updated QA/QC template with testing requirements
	2.7.2.2	Updated requirement on NDT of fillet welds.
	2.7.4	Minor wording update
	2.7.6	Minor updates to QA/QC template for stainless steel welding
	2.8.1	Adde reference to Guidance Note: Steel bolted flanged joint assemblies (ESF-600-GDN-702).
	2.8.2	New section added on flanges
	2.8.3	Added new table for flange gasket types including application
	2.8.4	Additional requirements included. New bolt torque tables to replace previous tables.
	2.8.5.2	Minor wording update
	2.8.5.3	New section added on 'Alignment of flanged joint assemblies'
	2.8.5.4	New section added on 'Bolt tightening sequence'
	2.9.1	Added general requirement for actuators
	2.10	Added reference to Watercare standard drawings
	2.10.4.3	Updated placement of meters
	2.11.3	Minor wording update
	2.13	Minor wording update
	3.5.1	Destructive testing requirement updated

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Definitions

Assets	Infrastructure owned and/or operated by Watercare.
Competent person	A person who is qualified and experienced because of a specific knowledge, training and applicable experience that is familiar with all relevant legislation, including *The Health and Safety at Work Act (HSWA) 2015* and is 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.
DCVG	Direct current voltage gradient – a survey technique used for assessing corrosion protection effectiveness.
DN	Nominal diameter.
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 *Water Supply and Wastewater Network Bylaw 2015*.
GP	General purpose
Hazard	Potential source of harm.
ID	Internal diameter
Infrastructure	Facilities in an operational capacity that is managed by a controlling authority.
IRHD	International rubber hardness degree.
MAWP	Maximum allowable working pressure.
MPI	Magnetic particle inspection
NDT	Non-destructive test.
OD	Outside Diameter
PE	Polyethylene

Risk	Combination of the probability of the harm caused by a hazard and the impact or severity that may result.
SP	Structural purpose
Specific drawings	Drawings created to inform specific construction requirements from design basis that are not captured by the standards drawings.

1. Scope and general

1.1 Purpose and scope

This standard has been developed to provide the minimum standard of mechanical construction work acceptable to Watercare. Additional clauses must be added to contracts where specific site constraints exist. This general mechanical construction document must be supplemented with standards applicable to the specific operational area (see Section 2.1). The content of this standard may not be changed or amended. Equivalent or alternatives may only be used on written approval from Watercare. Construction work shall be completed by persons competent in their work possessing a minimum skill and competency level required from this standard.

1.2 Applicability

This standard applies to the installation of mechanical equipment during construction for infrastructure delivered or vested to Watercare. The standard is intended to supplement the design documentation issued for construction where applicable to the planned works. The level of workmanship and quality shall be demonstrated to meet this standard.

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.

1.3 Standards and documents overview

1.3.1 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 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:

1.3.1.1 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.

1.3.1.2 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. Below is a list of applicable standard mechanical drawings.

- Pipelines for water greater than 250mm diameter - drawing set (DW10 - ESF-500-DWG-103)
- Access structure drawings for water infrastructure (DW06 - ESF-500-DWG-104
- Access structure general drawings for public/non-public areas (DW07 - ESF-500-DWG-301)
- Cathodic protection mechanical and civil drawing set (DW23 - ESF-500-DWG-701)

1.3.1.3 Asset and material standards

Asset Information Standards describe the requirements for asset creation, asset numbering, asset capture, production of manuals and operational documentation.

Material standards describe the minimum performance and compliance requirements of materials, products and assemblies supplied for asset acceptance. Often selected materials will have limitations of use and requirements specific to the operating environment and infrastructure classification.

1.3.1.4 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, focus 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.

1.3.1.5 Project specific specifications (particular specifications)

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

1.3.1.6 Design-build projects

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

1.4 Quality control and quality assurance

1.4.1 Auditing during construction

A construction management plan shall identify the quality control points. This standard includes a number of quality control/assurance requirements that highlight key compliance checks to be carried out during construction – refer to Watercare's QA/QC Templates for General Mechanical Construction Standard (TMPL-09). These quality control templates shall be completed as part of the construction work together with any project specific record keeping requirements for Watercare. The templates provided are the minimum checks that need to be completed and in some instances are required to be completed more than once depending on the type of installation.

1.4.2 Dispensations affecting quality

Any departure from the standards for the works shall not compromise quality, safety and regulatory requirements. Any proposed departure shall be evaluated by completing an Application for Dispensation against the applicable standard and by demonstrating that the departure complies with the requirements and applicable certification by providing proof of quality documentation.

1.5 General engineering document submittal requirements

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

1.5.1 Quality control templates

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

Items noted as "required" on the QA/QC sheets (TMPL-09) must be provided or completed and items noted "As specified" is the quantity or requirements that are specified in the particular clauses of construction or referenced standard (whichever takes priority). Certification blocks that are greyed out with "N/A" defines that the item does not apply to the particular party for certification, or that there is no documentation required for the item.

The QA/QC templates shall be certified to confirm that all actions have been completed by everyone. Refer to Watercare's compliance policy for work certification to be delivered.

1.5.2 Documents for commissioning and livening of mechanical works

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

- Preliminary as-built drawings (redline mark-ups)
- Signed-off pre-commissioning test results.
- Process/piping and instrumentation diagrams (P&ID)

- Draft operations and maintenance (O&M) manual
- Residual risks register.
- Commissioning plan

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

- Post construction residual risk register.
- Operation and maintenance manual
- Design drawing sets (pdf), as-built drawings (AutoCAD, BIM) and survey data including point cloud scans.
- Asset certificates
- Material compliance certificates and warranty information
- Engineering producer statements
- Construction completion report
- Quality control certificates

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

Note: The above listed documents are required for general mechanical construction works. Where specific infrastructure is constructed and this standard is supplemented by the specific standard associated with a component, the additional requirements shall be provided in the project specific specification.

1.6 Materials

1.6.1 Material standards

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

All materials necessary for the work shall be supplied in accordance with Watercare's Material Supply Standard. Materials shall be new and suitable for their intended purpose and performance requirements.

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

1.6.2 Recycled and reused materials

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

1.7 Health and Safety

All work shall be conducted in accordance with the requirements of the Health and Safety at Work Act (HSWA) 2015. Watercare requires that all contractors undergo a Health and Safety induction programme provided by Watercare prior to any work progressing. Part of this process

involves completing the steps outlined in Watercare's Control of Work System. These steps include:

1. Scope the work and fill in the job safety analysis form (JSA)
2. Attach relevant work permits.
3. Include any supporting documents.
4. Return the work pack to your Watercare representative.

A complete list of requirements and instructions can be found on Watercare's website under Control of Work System.
The minimum health and safety requirements set out by Watercare must be adhered to and the documentation and procedures must be of an acceptable standard which:

- Describes the procedures to assure compliance with systems, good practice and legislation.
- Provides information to demonstrate that the Health and Safety Management System can manage specific hazards and meeting Watercare minimum requirements. Regulations, approved codes of practice and industry standards or guidelines should be referenced as the basis for hazard controls.
- Provides a Health and Safety Management Plan which addresses controls and unique high-risk activities or components of the work.
- Demonstrates the proposed risk controls are adequate and identify alternatives to further reduce risk. Where administrative controls are used, it must be demonstrated that these are sufficient, robust and how they will be properly managed.
- Provides the names of Health and Safety staff and their responsibilities.
- Verifies that all workers have received adequate training for managing the hazards and risks and undertaking the work safely.
- Conducts and record site specific inductions.

Below is a list of documents and forms generally required as part of the Control Work System:
Risk assessment documents and forms.

- Job safety analysis (JSA) – template
- Job safety analysis – user guide
- Access authority (AA) – template
- Access authority – user guide

Permit to work.

- Permit to work – process
- Permit to work – decision trees

Permits

- Working at height
- Safety device impairment
- Confined space
- Excavations
- Explosive atmosphere area
- Hazardous energy
- Hot work
- High risk activity

Forms

- Isolation certificate

Where work is on an existing Watercare facility or asset an Access Authority is required before work can start.

Refer to Watercare's Standard for Health and Safety and Environmental practice (HSE) for a more detailed breakdown of requirements.

Health and safety is the responsibility of every person.

1.8 Asset information

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

2. Mechanical construction

2.1 Referenced standards

2.1.1 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.

2.1.1.1 Watercare standards

- CG - General civil construction standard
- ESF-500-STD-601 - Material supply standard
- ESF-500-STD-502 – Standard for producing CAD and geospatial drawings
- AI - Data and Asset Information standard
- HSE – Standard Health and Safety and Environmental practices
- ESF-700-STD-801 - Code of Practice for commissioning
- ESF-600-STD-103 (COP-04) - Code of Practice for disinfection of water systems

2.1.1.2 National and international standards

Safety equipment and safety signs

- AS 1345 Identification of the contents of pipes, conduits and ducts
- AS/NZS 4024 (set) Safety of machinery
- NZS 4781 Code of practice for safety in welding and cutting.

- BS EN 12899-2 Fixed, vertical road traffic signs. Trans-illuminated traffic bollards
- BS EN ISO 3266 Forged steel eyebolts grade 4 for general lifting purposes
- AS 4991 Lifting devices

General mechanical works

- NZS 6801 Acoustics – Measurement of environmental sound
- NZS 6802 Acoustics – Environmental noise
- ISO 5349 Mechanical vibration
- ISO 4016 Fasteners hexagon head bolts, product grade C
- ISO 4034 Hexagon nuts, product grade C
- NZS 3404 Steel structures standard
- AS 2177 Non-destructive testing – Radiography of butt joints in metal
- AS 2207 Non-destructive testing – Ultrasonic testing of fusion welded joints in carbon and low alloy steel
- ISO 17643 Non-destructive testing of welds – Eddy current testing of welds by complex-plane analysis

Miscellaneous and non-structural steelwork

- AS/NZS 4792 Hot-dipped galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or specialised process.
- AS/NZS 1214 Hot-dip galvanized coatings on threaded fasteners
- ISO 2063 Thermal spraying. Zinc, aluminium, and their alloys.
- Steel Structures Painting Council (SSPC) Painting manual (Volume 1 & 2)
- BS EN 10088 (Part 1) Stainless steels - List of Stainless Steels

  (Part 4) Stainless steels - Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes.

  (Part 5) Stainless steels - Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes.
- ISO 2560 Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels.

Structural steelwork

- AS/NZS 1554 (Part 1) Structural steel welding
- AS/NZS 2312 (Part 2) Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanising
- NZS 3404 Steel structures standard

Access structures

- AS 1657 Fixed platforms, walkways, stairways and ladders. Design, construction and installation.
- NZS 3404 Steel structures standard
- AS/NZS 4792 Hot-dipped galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or specialised process.
- AS 3678 Structural steel – hot-rolled plates, floor plates and slabs
- AS 3679 (Part 1) Structural steel – Hot-rolled bars and sections
    - (Part 2) Structural steel – Welded I sections.
- AS 1163 Cold-formed structural steel hollow sections
- AS 1101 (Part 3) Graphical symbols for general engineering – Welding and non-destructive examination
- AS/NZS 1252 High strength steel bolts with associated washers for structural engineering
- ISO 4016 Fasteners hexagon head bolts, product grade C
- ISO 4034 Hexagon nuts, product grade C

Steel pipe welding

- AS/NZS 3992 Pressure equipment – Welding and brazing qualification
- AS 1579 Arc-welded steel pipes and fittings for water and wastewater
- AS4458 Pressure equipment - Manufacture
- ASME B31.3 Process piping – ASME Code for pressure piping
- ASME Boiler & Pressure Vessel Code - V
- NZS 4442 Welded steel pipes and fittings for water, sewage and medium pressure gas
- API 1104 Welding of pipelines and related facilities

- ASTM A380 Standard practice for cleaning, descaling, and passivation of stainless steel parts, equipment and systems

Installation of flanged components in pipelines

- ASME PCC-1: Pressure boundary flange joint assembly
- AS/NZS 4087 Metallic flanges for waterworks purposes
- BS EN 1092-1 Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated. Part 1: Steel flanges
- BS EN 1092-2 Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated. Part 2 Cast iron flanges
- BS EN 1591 (Part 1) Flanges and their joints. Design rules for gasketed circular flange connections - Calculation.
- ISO 16047 Fasteners – Torque/clamp force testing
- PIPA POP007: Flanged Joints for Polyethylene (PE) Pipe

Actuators for valves

- AS 2671 (ISO 4413) Hydraulic fluid power – General requirements for systems
- AS 2788 (ISO 4414) Pneumatic fluid power – General requirements for systems

Installation of pumping units and motors

- BS EN 9906 Rotodynamic pumps. Hydraulic performance acceptance tests Grade 1 and 2
- BS ISO 10816-7 Mechanical vibration – Evaluation of machine vibration by measurement on non-rotating parts
- BS ISO 21940-11 Mechanical vibration. Rotor balancing. Procedures and tolerances for rotors with rigid behaviour
- NZS 5821 (Part 2) Laser safety – Plain language code of practice for the safe use of lasers in surveying, levelling and alignment

Drives and couplings

- BS 3790 Specification for belt drives, endless wedge belts, endless V-belts, banded wedge belts, banded V-belts and their corresponding pulleys
- ISO 10823 Guidelines for the selection of roller chain drives

2.2 General works for mechanical equipment

The equipment manufacturer or supplier specific installation instruction shall take precedence over any requirements set out in this section.

2.2.1 Mechanical equipment delivery

a) Equipment shall be delivered with the manufacturer's label intact and with certificates of compliance, data sheets, factory testing and casting certificates (if applicable).
b) On delivery to site the contractor shall ensure that the materials and equipment are correct, complete and undamaged from transit or customs inspection and clearance requirements.
c) Equipment free issued by Watercare shall be inspected by both Watercare's representative and the contractor prior to handover. Once free-issued materials are handed over to the contractor, it will be the contractor's responsibility to store and install the equipment without any damage.
d) All equipment shall be stored off the ground safely stacked in a dry, waterproof location away from vibration. The contractor shall be liable for any damage caused as a result of poor storage, handling or assembly.
e) Dust caps shall be provided for valves and pumps to prevent potential contaminants from settling inside the equipment.
f) Where rotating equipment is stored and not immediately installed, the manufacturers storage instructions shall be followed to prevent seizing of parts, permanent indentation and corrosion of the bearings surface and seal faces.
g) Special lifting frames or beams that may be required for installation purposes shall be supplied by the contractor.
h) Before installation, all parts shall be cleaned and all rust, dirt, grit and foreign matter shall be removed.
i) Grease or other protective coatings supplied for protection of the equipment in shipment or storage, except primer coating, shall be removed by using suitable solvents or cleaners which will not damage the finish of the equipment.
j) The Contractor shall flush all applicable equipment in accordance with the manufacturer's recommendations. The flushing procedure shall include, where possible, the manual rotation of equipment to ensure complete penetration.
k) On completion of flushing, the flushing oil shall be completely removed prior to filling with the running oil.
l) Flushing oil, once used, shall not be re-used and shall be disposed of appropriately.

2.2.2 Workmanship

a) All workmanship shall be carried out by appropriately qualified and experienced tradesmen under the constant supervision of a competent foreman.
b) The contractor shall arrange for the installation of all major equipment items **to be completely checked by a fully qualified and trained representative of the manufacturer**, or its agent.
c) Materials and equipment shall be installed in accordance with the manufacturer's written instructions.
d) The contractor shall provide all labour and materials required to carry out work on materials and equipment which the manufacturer or his agent, may consider necessary to achieve a satisfactory installation.

e) The **contractor shall supply evidence** that installation checks have been made and shall provide a description of any corrective measures taken to rectify any faults or to satisfy the requirements of the manufacturer or its agent.

2.2.3 Installation and mounting

This section applies where the mounting and installation of mechanical equipment has not been specified by design.

a) Equipment shall be installed so that sufficient access and clearance is provided to allow for the safe and efficient carrying out of routine inspections and maintenance activities.
b) All equipment shall be readily accessible for removal and be fitted with appropriate and clearly identifiable lifting points. The lifting lugs or jacking points shall be permanent.
c) Each item of mechanical equipment shall be set in position, true to line and level in the positions shown on the drawings.
d) The equipment shall be supplied with certified drawings, tolerances for alignment and level and any other installation instructions as specified. The contractor responsible for installing the equipment shall adhere to these tolerances and instructions.
e) Where equipment is to be mounted on concrete plinths or concrete slabs the finished concrete level shall have not less than 20mm or more than 40mm of grout under the equipment base plate.
f) The void between the plinth and baseplate shall be grouted with a non-shrink product. The grout edges shall be chamfered to allow water run-off.
g) Where pumps are frame-mounted, the base of the frame shall extend beyond the top section to accommodate positioning and anchoring of the frame.

2.2.4 Location and alignment

a) All mechanical equipment must be set, levelled, aligned and inspected with precision tools. All alignment shall be with the use of laser alignment equipment.
b) For rotating equipment both the driver and the driven shafts shall be rotated simultaneously to 0°, 90°, 180° and 270° at which readings shall be taken. See Section 2.11.3.
c) Where separate items of interconnected mechanical plant depend upon correct alignment for satisfactory operation, then every item shall be positively located in its correct position using dowels, locating pins, fitted bolts or other approved means to make sure that correct re-alignment can be easily achieved for maintenance.

2.2.5 Mechanical machinery noise

This section applies where machinery noise has not been specified by design.

a) The overall sound pressure level (L_{10}) for all equipment shall be measured at a distance not greater than three metres radius from any equipment or sound enclosure. The sound assessment shall be completed by a specialist contractor and measured in accordance with NZS 6801 and assessed in accordance with NZS 6802.
b) The maximum acceptance level is 75dB(A) within the measurement radius, or lower as otherwise required under the Auckland Unitary Plan requirements at the boundary of neighboring properties. Where this is not the case it shall be referred to the designer.

2.2.6 Bolting and fasteners

2.2.6.1 General

a) Bolts shall be long enough so that the threaded portion of each bolt extends through the nut at least one thread and not more than 5 threads. For self-locking nuts, the bolt thread shall be at least flush with the top of the locking element in the nut.
b) Tensioned bolts for structural applications shall be bolted to the requirements in NZS3404.
c) Bolt torque sequencing and testing shall be completed to the testing requirements in Section 3.4 of this standard.
d) The particular requirements for flange bolting are given in Section 2.8.
e) Torque equipment shall have an accuracy of ±2%.

Note: The minimum thread protrusion ensures that all the nut threads are engaged. Where threads protrude in excess of 5 threads it is considered material waste and a health and safety risk especially in accessible areas. Excessive protrusion may also impair clearances for maintenance or other components.

Thread protrusion also provides a good indication to verify that studs have been properly driven home.

f) A washer shall be provided under the rotated part (bolt or nut, or both).
g) Where the angle between the axis of the bolt and the joint surface is more than 3º off normal a bevelled or tapered washer shall be used against the tapered surface. The non-rotating part shall be placed against the tapered washer.
h) Where the non-rotating part may cause damage to any protective coating a washer shall be used. **More than one washer on either or both sides of bolt assemblies is not allowed**.
i) All joint surfaces shall be free of dirt, loose scale, loose rust burrs and other foreign material or surface defects. For friction-type joints the surface shall be free of any unspecified finish.

2.2.6.2 Corrosion protection

a) Mild steel and high tensile steel bolts and nuts shall be hot dipped galvanised.
b) Stainless steel bolt and nut threads shall be treated with a nickel anti-seize free of copper, lead, sulphides, chlorides and carbons (graphite).
c) High strength acceptable nylon or phenolic insulating washers shall be fitted under metal washers and bolt heads and a bolt stem insulating sleeve when dissimilar metals are directly joined.
d) Where insulating sleeves are used the bolt holes shall be oversized to accommodate the sleeve. Using smaller bolts is not allowed, except where hot-bolting has been approved. Refer Section 2.8.5.
e) Bolts shall **not** be painted when installed for flanged (pipe) assemblies to prevent threads from clogging up during future maintenance.

2.2.6.3 *Fastener lubrication*

a) During assembly of flanged joints, all fasteners, mating threads and bearing surfaces shall be lubricated (in addition to factory applied lubricants) as noted below. Contamination of flange and gasket faces with fastener lubricant shall be avoided.
b) Flange fastener and bearing surface lubricants selected for use in drinking and non-drinking water applications shall comply with AS/NZS 4020, a scaling factor of 0.05 should be used for assessment of products.
c) Fasteners will typically be supplied with an oily residue, this is not considered sufficient lubrication for assembly and additional lubrication shall be applied to fasteners and contiguous bearing surfaces.
d) Nickel based lubricants shall not be permissible as they emit carcinogenic fumes when burnt (e.g. oxycutting bolts).
e) A high-quality solid type lubricant such as molybdenum disulphide (Molykote 1000 or Loctite 771) shall be used for bolts.
f) Fasteners for isolation joints shall be lubricated with a non-conductive lubricant such as NCH ThreadEze Ultra, Lanotec, or Loctite heavy duty anti seize.

Note: NCH Thread-Eze Ultra has AS/NZS 4020 approval and is suitable for use in drinking and non-drinking water applications

2.2.6.4 *Fasteners general application by type*

Table 2.1: *General fastener type application*

Application	Supply standard	Fastener class
General timber construction. Not permitted for steel work except purlins and girts	ISO 4016 &4034	Class 4.6 or as otherwise specified
Structural steel (Not to be used with grey iron (cast iron))	AS/NZS 1252	Class 8.8/TB
	Washers – AS1252 or AS2465	Class 8.8
General Stainless steel	ISO 4016 &4034	A4-50
Flanges	Refer to Section 2.8 of this standard	

2.3 Miscellaneous and non-structural steelwork

2.3.1 General

a) Materials shall have clean surfaces and be free from rust, mill scale, and other foreign substances before being worked on.
b) Materials before and after fabrication shall be straight unless required to be curved and shall be free from twists.
c) All steelwork shall be stored and handled so that items are not subjected to excessive stresses, damage, sun-exposure or corrosion and so that surface coatings are not damaged.

d) Post welding heat treatment or stress relief annealing of steel shall be carried out where required to reduce residual stress introduced during welding. This is to improve the overall mechanical properties of the steel prior to any final machining required.

2.3.2 Fabrication

a) Shearing, sawing or flame cutting are acceptable. If shearing or flame cutting is used sufficient metal shall be allowed beyond the neat line to permit machining or grinding to final dimensions.
b) All holes shall be drilled.
c) Unless otherwise dimensioned finished holes shall be maximum 2 mm larger than the bolt passing through them.
d) All bearing surfaces shall be squarely faced to ensure total contact.
e) All hollow sections shall be sealed to prevent moisture access to the inside of members.
f) Where vent holes are required for galvanising these holes shall be sealed with lead plugs.
g) Welding shall be class GP (general purpose) unless otherwise specified.

2.3.3 Corrosion protection

a) Steel fittings and shall comply with the necessary edge preparation requirements and be shop assembled in as large sized units as is practicable before the protective coating is applied as specified.

Note: Cold galvanising is not permitted. Refer to the Material Supply Standard for acceptable corrosion protection products, or as otherwise specified

b) Welded field joints shall be ground to remove rough surfaces and shall receive a protective coating suitable for the application.
c) All ferrous metalwork except plate covers and frames shall be hot dip galvanised after fabrication unless otherwise specified.
d) Plate covers and frames shall be zinc metal sprayed in compliance with ISO 2063.

2.3.4 Galvanising

a) All galvanised metal work except standard steel pipe and fittings shall be protected by dipping the articles in a molten bath of zinc.
b) The zinc coating shall be adherent, smooth, continuous and free from imperfections. Beads or heavy deposits of zinc that will interfere with the intended use of material are not permitted.
c) The coating shall be sufficiently bonded so as not to be removable by any reasonable process of handling and construction.
d) A test sample per galvanising batch shall be completed. The weight of zinc coating per square metre of actual surface shall be not less than the weights shown in Table 2.2.

Table 2.2: *Minimum zinc weights*

<table>
<tr><th>Product</th><th colspan="2">Minimum zinc weight</th></tr>
<tr><td>Products fabricated from rolled, pressed or forged steel, 3 mm or thicker, grey iron, malleable iron and steel castings</td><td colspan="2">Minimum 600gm per square metre.</td></tr>
<tr><td>Steel shapes less than 3 mm thick</td><td colspan="2">Average 500gm per square metre with none less than 450gm per square metre.</td></tr>
<tr><td>Bolt threads</td><td colspan="2">To AS/NZS 1214. No additional tolerance for threads is made for galvanising.</td></tr>
<tr><td rowspan="10">Nuts threads</td><td colspan="2">To AS/NZS 1214. Allowances for oversized tapping of threads is given below:</td></tr>
<tr><td>Size</td><td>Microns</td></tr>
<tr><td>Up to M 22</td><td>400</td></tr>
<tr><td>M 24</td><td>450</td></tr>
<tr><td>M 27</td><td>500</td></tr>
<tr><td>M 30</td><td>550</td></tr>
<tr><td>M 33</td><td>600</td></tr>
<tr><td>M 36</td><td>600</td></tr>
<tr><td>M 36 to M 48</td><td>800</td></tr>
<tr><td>M 48 to M 64</td><td>1000</td></tr>
</table>

2.3.5 Stainless steel

a) All material including bolts, nuts and washers shall be 316 grade stainless steel unless otherwise shown in the drawings and shall comply with BS EN 10088.
b) Stainless steel of proven quality must be used. Certification of compliance with the standards is required with the material testing data. Refer to Section 2.7 for stainless steel welding.

2.3.5.1 Tank connection nozzle piping

Unless specified and demonstrated by the manufacturer, no loading shall be allowed on tank nozzles connecting to other equipment or pipework.

Tank nozzles shall have a minimum length of 150mm from tank wall to the nozzle flange face.

2.3.6 QA/QC template – Miscellaneous and non-structural steelwork

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Preparation	Work surfaces and joints clean, no rust, scale or other foreign matter	N/A	Required	As specified
2	Corrosion protection	Hot dip galvanised to standard. Paint pre-preparation and coatings to standard	Required	Required	N/A
3	Specified steel grade confirmed	Steel testing completed to the design specified steel grade in accordance with the recognised standard	Required	Required	N/A
4	Bolting	To applicable specified requirements. Tests completed to Section 3.4	Required	Required	Required
		Sign-off			

2.4 Structural steelwork

2.4.1 General

This section excludes pipeline welding (refer Section 2.6) or steel structures subject to high level fatigue loading. Paint coating types shall be to the paint manufacturer's specification for the specific application.

Note – Watercare has currently standardised on Altex for paint coatings. The full manufacturer specifications for the product range and application for Watercare's infrastructure is available under the Watercare Materials Supply Standard.

2.4.2 Storage and handling

a) During handling padded slings shall be used to handle all coated steelwork.
b) All steel at the site shall be stored and handled so that members are not subjected to excessive stresses, damage, or corrosion.

2.4.3 Fabrication and assembly

a) Material shall be clean and free from rust, and other foreign substances before being worked in the shop. In fabrication all members shall be in one full length without joints unless specifically noted on the drawings.
b) All material before and after fabrication shall be straight unless required to be curved and shall be free from twists.

2.4.3.1 Cutting and edge preparation

a) Plates shall be cut to size and shape and edge preparations formed by machining, laser, water jet or machine flame cutting.
b) Plates less than 25 mm thick may also be cut by cold shearing. If cold shearing is used that the sheared edge shall be cut back by machining or chipping for a distance of one quarter of the plate thickness but not less than 3 mm.
c) Hand gas cutting may be substituted for machine gas cutting if machine gas cutting is impracticable.
d) No steel shall be cut while its temperature is below 5°C for mild steel and 10°C for medium tensile steel.
e) The cut edges shall be uniform, smooth and free from defects. Where edges have been sheared, the edges will be free from drags and tears. All edges shall be examined for defects immediately after cutting and at all consequent preparation stages for welding.
f) The building up of edges with weld metal is not permitted.

2.4.3.2 Bearing surfaces

a) All abutting bearing surfaces shall be faced to ensure that full contact of metal surfaces is achieved.
b) The ends of all web stiffeners shall be ground or sawn to fit tightly between the flanges of the sections to which they are to be welded.

2.4.3.3 Holes

a) All holes shall be drilled. Alternatively, plasma cutting can also be accepted where this is carried out during manufacturing in a controlled environment.
b) Holes through more than one thickness of material shall where possible be drilled after the members are assembled and tightly clamped or bolted together.
c) All matching holes for rivets or bolts shall register with each other so that a gauge 2 mm smaller than the holes will pass freely through the assembled members at right angles to the members.
d) Finished holes shall be maximum 2 mm larger than the bolt or rivet diameter passing through them unless shown otherwise on the specific drawings.

2.4.3.4 Hollow sections

a) Hollow sections to be galvanised shall be vented in a manner approved by the designer.
b) All hollow sections shall be fully sealed against moisture entering the inside of the members, except those to be hot dip galvanised.

2.4.3.5 Forming

a) Hot and cold forming shall be by machine in the first instance. Where hammer forming is required, it shall be with heat.
b) Where parts are hot formed, testing is required to ensure the material's properties remain fit for the intended purpose.
c) Parts that must be formed to an internal radius of less than ten times the material thickness shall be appropriately heat treated to retain the intended service properties.

d) Curved plates shall be formed to the correct contour up to the extreme edge of the plate. Where rolling of plates is required, plates and rolls shall be free from hard lumps or patches of scale before making each pass through the rolls.

2.4.3.6 Assembly

a) The component parts shall be assembled such that they are not twisted or damaged. The parts shall be prepared so that the specified cambers are provided.
b) The cutting of slots, notches or holes will only be permitted where shown on approved drawings.
c) Plate handling clamps used at any stage of the work shall be used without causing damage the plate surface.
d) Welded attachments to aid assembly or for handling may be used but shall be kept to a minimum. Their material, location and method of attachment shall only be as approved by the designer. Attachments that are not permanent fittings shall be removed except where specific approval is given for them to remain.
e) All assembly attachments and tack welds not incorporated in the joint shall be removed. Removal shall not damage the parent material and be followed by grinding smooth.

Note: Removal by hammering is specifically excluded.

f) All bolts, nuts or washers exposed to weather or used to fasten galvanised or zinc sprayed members shall be hot dip galvanised.

2.4.4 Welding of structural steel

2.4.4.1 Qualification

a) The qualification of the welding procedure shall be to AS/NZS 1554.1, Clause 4.2 (c) and Clause 4.3 unless otherwise specified.
b) All welding shall be supported by a weld quality management plan.
c) All welds shall be visually inspected by a qualified AS/NZS 2214 welding inspector with applicable welding and fabrication experience.
d) A welding procedure qualified by one fabricator shall only be valid for use by a second fabricator if the welding procedure identifies both the original and second fabricator.
e) Welders shall have current certification and evidence provided of welds completed to the standard of similar construction. Recognised qualifications shall comply with any of the following standards:
    - AS 1796
    - AS/NZS 3992
    - AS/NZS ISO 9606.1
    - ASME IX

2.4.4.2 General

a) Structural welding shall be completed to the requirements set out in AS/NZS 1554.1 unless otherwise specified.
b) Fusion faces and surrounding surfaces within 50mm of the welding edge shall be thoroughly cleaned of rust, scale, oil, moisture or other contaminants.

c) The first run in the root of a weld shall be completed in one operation. If this is not possible, or if the welding operation is interrupted and the laid weld becomes cold the joint shall be preheated.
d) The ends of butt and fillet welds shall have run-on and run-off plates. Run-on and run-off plates shall be of the same thickness and material as the plates being joined and with the same preparation. The plates shall be long enough to ensure that the start and stop of each run of weld can be made on the attached plates and not less than 25 mm from the end of the work.
e) Attachment of run-on and run-off plates may be made by tack at the roots of the preparation only. When the plates are removed the ends of the main weld shall be dressed back to the edge of the member. Notches shall not be introduced in the edge of the member at this point.
f) Tack welds may be incorporated in the welded joint provided the shape is suitable for inclusion and they are free from cracks and other faults. Defective tack welds shall be cut out.
g) For welded connections, where two steel members are in close proximity, a seal weld shall be made to prevent the ingress of moisture. The seal weld shall be made regardless of whether the weld is detailed on the drawings, or the members are expected to have exposure to the weather.
h) Weld testing shall be selected as appropriate for the type of weld (see Section 3.5.) at frequency as specified by the design. Where not specified, all welds shall be 20% MPI tested.

2.4.4.3 Field welds

a) Field welding shall be completed to the same requirements as shop welding.
b) The Contractor shall supply and install adequate screens and covers for the protection of welders and work when welding is being done outdoors – particularly during inclement weather. This protection shall ensure that no water, breeze or other deleterious matter finds its way into the joint during welding and that the work is adequately protected from cold draughts of air.

2.4.4.4 Repair to welds

a) Where a defective section of weldment has been removed, the welding inspector shall inspect the section to ensure the defect has been fully removed.
b) The repair weld may commence following approval by the welding inspector.
c) The section under repair shall be preheated to a temperature of 95 - 120^{o}C for a distance of 75 - 100mm beyond each end of the ground out portion.
d) Throughout the repair the temperature shall be held at 95-120^{o}C and shall be maintained after the completion of the repair for a period of 15 minutes.

2.4.5 Specific galvanising requirements

All bending of structural steel shall adhere to the requirements set out in AS/NZS 5131 before galvanising.

2.4.6 Installation

a) During structure assembly, steelwork shall be made safe against any loading that may occur.

b) After assembly the application of all dead loads on all members shall be level and straight, unless otherwise specified.
c) Bedding under base plates shall be dry-pack mortar or accepted grout. Unless specified otherwise a nominal gap of 20mm shall be provided.
d) The space under the steel shall be thoroughly cleaned and be free from moisture immediately before grouting. Grout shall completely fill the space and shall either be placed under pressure or by ramming against fixed supports.
e) The installation shall be tested in accordance with the requirements in Section 3 of this standard.

2.4.7 QA/QC template – Structural steelwork

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Specified steel grade confirmed	Steel testing completed to the design specified steel grade in accordance with the recognised standard	Required	Required	N/A
2	Weld quality management plan	Templates in AS/NZS 1554	Required	Required	N/A
3	Qualification of welding procedure, completed	AS/NZS 1554.1 appendix C	Required	Required	N/A
4	Welding Inspector qualification	AS/NZS 2214 certified	Required	Required	Required
5	Welder qualification	AS 1796, or AS/NZS 2980, or AS/NZS 3992, or ISO 9606-1, or ASME IX	Required	Required	As specified
6	Weld test samples tested	NZS 3404, alternative NDT by recognised certifying body as required	Required	Required	N/A
7	Welding inspector sign-off	AS/NZS 1554.1 Appendix C Welding record sign-off.	Required	Required	N/A
8	Galvanising inspected for defects (where specified).	As per Section 2.3.4	Required	Required	As specified
9	Base plate bedding as required	Specified by design engineer	N/A	Required	Required
10	Bolting inspected	Correct bolting size and grade.	N/A	Required	Required
		Sign-off			

2.5 Access structures and platforms

2.5.1 General

a) This section shall be read with Section 2.2, 2.3 and 2.4 of this standard.
b) Access structures and platforms shall be manufactured to comply with the requirements specified in AS 1657.
c) In the absence of a project specification the material application shall be suitable for outdoor installation with continuous relative humidity of 90% from 5°C to 35°C and appropriate for marine coastal environment.

2.5.2 Fabrication

a) Shop drawings of all structural components shall be produced and reviewed by the design engineer. The drawings shall include layout and fabrication details.
b) All members shall be one length without a splice unless otherwise noted on the specific drawings.
c) Bolting for the various structures shall be as specified on the drawings. A copy of all assembly records shall be provided.
d) Fabrication parts shall have the minimum requirement as stated in Table 2.3 unless otherwise specified by the specific drawings.

Table 2.3: *Fabrication part minimum requirements*

Fabrication part	Minimum requirement – Unless otherwise specified
Steel plate	Grade 300 (AS 3678)
Bars and sections	Grade 300 (AS 3679)
Hollow sections	Grade 250 (AS 1163)
Welding	Class SP (AS/NZS 1554.1)

Note: Aluminium access structures and platforms may be considered depending on the environment and manufacturers compliance with AS 1657.

e) Surfaces shall be smooth with no projections.
f) Elevated access at plants and pump station facilities shall be by stairways or inclined tread unless otherwise specified, vertical ladders shall not be used for these applications without Watercare's prior approval.
g) Handrails shall be provided around elevated walkways, access platforms and open structures as specified in AS 1657.

2.5.3 Surface treatment

a) Steel material, nuts bolts and washers shall be hot dipped galvanised, or alternatively a suitable grade of aluminium shall be specified.
b) All drilling, cutting or machining of items must be completed prior to galvanising. Cold galvanising is not permitted.
c) Members or fittings of different material types shall not be in contact with each other.

2.5.4 Installation

a) Drilling and fixing to existing or other structures shall be as per the specific drawings or manufacturers shop drawings.
b) Padded slings shall be used to lift work pieces into place.
c) Hole-coring through concrete structures is not permitted. Where grout is used under footings or fixings, the minimum compressive strength shall be 40 MPa at 28 days.
d) The finished work shall be certified for correctness.

2.5.5 QA/QC template – Access structures and platforms

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Delivery	Material inspected for defects. Certification and data sheets received and confirmed as compliant	Required	Required	Selected
2	Fabrication	Shop drawings received	Required	Required	N/A
3		Test certificates received. Compliance with AS 1657 or equivalent	Required	Required	Required
4	Corrosion protection	Hot dipped galvanised certification	Required	Required	N/A
5	Installation	Installed as per specific design drawings. – compliance statement (CS3 and CS4, or PS3 if required by building code)	Required	Required	Required
		Sign-off			

2.6 Steel pipe welding

2.6.1 Welding qualification

a) Welding pre-qualification shall be as required by AS/NZS 3992.
b) All welding shall be supported by a weld quality management plan which also includes an inspection and testing plan.
c) All butt and fillet welds shall be entirely (100%) visually inspected by a welding inspector qualified to AS1796 Certificate 10, ASME XI, or AS/NZS 2214 with applicable welding and fabrication experience noted in these standards. The appropriate visual inspection method shall be followed e.g. ASME BPVC: V – Article 9. 20% of the welds shall be independently inspected (i.e. the inspector shall not represent the manufacturer or appointed contractor), however all welds shall be inspected by a qualified welding inspector.
d) A welding procedure qualified by one fabricator shall only be valid for use by a subsequent fabricator if the welding procedure identifies both the original and subsequent fabricator.

e) Welders shall have current certification and evidence provided of welds completed to the standard of similar construction. Recognised qualifications shall comply with any of the following standards:
   - AS/NZS1796
   - ASME IX
   - AS/NZS ISO 9606.1
   - AS/NZS 2980

2.6.1.1 Welding pre-qualification

Prior to any pipeline welding (including prefabrication work) the contractor shall:

i. Submit the names and qualifications of all welders, including tested experience within the last 6 months.
ii. Submit a portfolio of weld procedures covering the sizes and types of welds to be used on the project procedures to be approved by certified independent agency.
iii. Pre-qualify and welding work required for wet welding or water-backed welding.

2.6.1.2 Test plan

a) All butt and fillet welds shall be entirely visually inspected.
b) Unless otherwise specified by the design:
- All welds for fabricated bends shall be 100% radio-graphically tested. Other welds can be tested using ultrasonic testing.
- Where fillet weld testing frequency has not been specified, a minimum of 20% shall be MPI tested.

c) A minimum of one destructive test shall be completed. Refer to Section 3.5 for testing requirements.
d) Additional ultrasonic testing or Eddy current testing shall be as specified in the contract.

Note: Where pipes are welded both internally and externally, MPI testing shall be carried out internally and externally, as this method of assessment generally only surface / subsurface discontinuities up to a depth of about 5mm.

2.6.2 Welding preparation

a) The weld preparation shall be clean, dry and be free from any foreign material that will affect the welding process and quality.
b) All pipe materials 15mm either side of the weld preparation shall be clean and rust free prior to any welding.
c) The weld root gap of any pipe-to-pipe section, including any repair section, shall meet the tolerances stated in the approved welding procedure being used.
d) Surfaces to be welded shall be prepared by an approved cutting process and dressing method. Cut material shall be burr free.
e) Weld faces shall be free of any condition that may affect the quality of the deposited weld metal.
f) Prior to commencing any welding, defects shall be ground out to produce a cavity with a width to depth ratio of not less than 4 to 1, and to the following maximum depths:
   - For manual welding – metal manual arc (MMAW) and gas tungsten arc (GTAW): 2 mm
   - For automatic welding – gas metal arc (GMAW) and flux-cored arc (FCAW): 1 mm

g) Imperfections exceeding the above limits shall be weld repaired in accordance with the original welding procedure or as otherwise specified.
h) Pipes shall be held in the correct alignment and positioned using an appropriate alignment device until welding is complete without passing any stresses onto the pipe.

2.6.3 Welding sequences

a) A weld map shall be used to identify the welding sequences during fabrication.
b) **A qualified welding supervisor shall oversee the welding process** to ensure that the planned sequences are followed.
c) Welding sequences shall include:
- Inspection of the weld preparation and pipe prior to the start of welding.
- Welding procedure to be applied.
- Sequence of pipes and components to be welded.
- Number and location of welders at each stage of assembly.
- Repair procedure sequences as applicable.

2.6.4 Welding interruption

a) Welding shall be a continuous operation. Welding shall continue until at least the root run and the hot pass are complete.
b) If welding must be interrupted the weld area shall be covered with a heat blanket to slow cooling. Before continuing on welds cooled to ambient temperature, the weld shall be visually inspected for cracks.
c) Where cracks are suspected the weld shall be inspected by magnetic particle inspection (MPI) or dye penetrant examination by the welding supervisor to determine acceptability.
d) Before continuing, any weld shall be pre-heated as required by the weld procedure.

2.6.5 Workmanship

a) Tack welds must be to the same quality and workmanship as the final weld and strong enough to withstand the fabrication welding stresses. Tack welds shall be minimum four times the thickness of the material and not less than 40mm long.
b) Tack welds that are not removed must be fully melted and incorporated into the completed weld, however all cracked tack welds shall be completely removed before final welding commences. Tack welds that form part of the completed welds shall be ground at the start and finish.
c) Where excessive gaps occur, buttering of the pipe with weld metal may be permitted to restore the specified weld preparation. Buttering shall not be used as a general fabrication technique. No more than 10 mm of the buttering weld metal shall be deposited to achieve the required root gap to patch the material gap. All deposited buttered weld metal shall be dressed smooth to meet the shape required before completing the welding. Buttered weld metal shall not protrude into the pipeline bore.
d) For double sided full penetration butt welds the second side shall be cleaned to sound metal before welding the second side runs. If carbon arc air gouging is used, all carbon and other residue shall be completely removed by appropriate mechanical methods.
e) All welds shall blend smoothly with the pipe material and have a consistent profile. Backing bars can be used with prior approval from the welding supervisor.
f) The width of individual submerged arc weld beads shall be less than seven times the consumable wire diameter.

g) Peening (hammering or other weld property alteration) of the weld is not permitted.

2.6.6 General welding of pipe

i. All welding shall be carried out with the pipework in a clean and dry condition.
ii. Where the work consists of pipework leak repair or a cut-in, every effort shall be made to obtain watertight isolation. If a dry weld condition cannot be achieved, then pre-qualification and a specific weld plan shall be developed. (refer Section 2.6.1.1)
iii. Appropriate protection shall be provided during welding operations to ensure a satisfactory welding environment and protect the weld area from inclement weather.
iv. At least 300mm or 30^{o} of the pipe diameter should be used to stagger any longitudinal welded joints between sections of pipe.
v. All circumferential lap welds in pipelines of 700 mm ID or greater diameter shall be fully welded internally and externally to the requirements specified in the welding procedure. The annular space between the spigot and socket joint or weld band joint shall be tested for proper seal.
vi. Refer to the civil construction standard for lining repair on diameters < 700mm ID where there is no internal welding.
vii. Any pipe section may be formed to the required shape by any process that will not impair the quality or function of the pipe.
viii. The out of roundness of the pipe shall not exceed 10% of the pipe diameter or 10mm maximum.
ix. Welds joining temporary attachments to the pipeline must be to the same quality as the final weld. Temporary attachments must be removed carefully, the area visually inspected for surface flaws and restored.

2.6.7 Pipe bends, special spools and flange welding

a) The weld preparation for pipeline branches and connections shall be in accordance with the welding procedure.
b) The root face preparation shall be of consistent shape and size with a root gap of not greater than 3mm.
c) The following tolerances apply to butt welds and branch connection welds:
    i. The root face shall be that specified in the welding procedure.
    ii. The bevel angle shall be prepared within 0^{o} to +5^{o} of the tolerance specified in the welding procedure.
    iii. For single sided welding, the tolerance on the root gap shall be –1.5mm to +3mm of the tolerance specified in the welding procedure.
    iv. The gap between mating surfaces of fillet welds shall not exceed 2mm.
    v. Butt weld cap reinforcement shall not exceed 3mm height with a slope not exceeding a ratio of 4:1.
    vi. The weld penetration into the bore of the pipeline shall be even and shall not exceed 3mm.
    vii. Fillet welds shall be of equal leg lengths ±2mm unless otherwise specified in the welding procedure.
    viii. The weld toes of butt and fillet welds shall blend smoothly with the parent material.

2.6.7.1 Flanges

Flange alignment shall be such that:

i. The spindles on butterfly valves are horizontal.
ii. The spindles on gate, scour, and air valves are vertical.
iii. Flange to flange bolt holes straddle the vertical and horizontal centrelines.

2.6.7.2 Spool sections and tapers

Where spool sections or tapers are required for a valve assembly, diameter or material change:

i. The material used for the spool sections and tapers shall comply with AS 1579
ii. The shell thickness and yield strength shall not be less than that of the adjoining pipe.
iii. The internal lining shall be in accordance with material supply standards.

2.6.7.3 Pipe access manholes

Manholes shall be welded as specified in the standard drawing 2001979.075 or as supplied by the pipe manufacturer.

2.6.7.4 Bypass and scour pipework

a) The scarfed bypass pipe sections shall be joined at a tangent to the spool sections at the required locations, unless specified otherwise.
b) The internal lining for the bypass pipe section shall be as specified. The internal lining shall be applied after all welding operations. Where the bypass pipework joins into the spool section, any mortar lining (steel main pipe is typically mortar lined) shall overlap the painted lining by 50mm.

2.6.7.5 Air valves

a) Air valves shall be fitted to a flanged vertical steel riser welded to the top of the spool section in accordance with the standard drawing 2001979.145.
b) The vertical steel riser may not be placed on or over any welded pipeline joint.

2.6.7.6 Olets

Olets shall be installed vertically on the top of the pipe unless agreed otherwise by Watercare where side tapping connection is required.
Olets shall not be positioned on or over any welded pipeline joint.

2.6.7.7 Welding bands

a) Welding bands shall be manufactured and installed in accordance with the standard drawing 2001979.019.
b) Packers must not be used when using welding bands. Gaps are to be filled using the buttering procedure, as described in Section 2.6.5.

2.6.8 QA/QC template – Mild steel pipe welding (Includes cement lined steel)

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	General	Welding prequalification check to AS/NZS 3992	Required	Required	N/A
2		Welder qualification provided	Required	Required	Required
3		Weld-maps produced including test plan	Required	Required	N/A
4		Weld conditions clean and dry (site and shop)	N/A	Required	Required
5	Pipework	Weld surfaces prepared	N/A	Required	Selected
6		Correct dimensions	N/A	Required	Selected
7		Correct location and orientation in assembly	N/A	Required	Required
8		Flange alignment correct – typical flange bolt holes straddle centre line	N/A	Required	Required
9		Lifting lugs on pipework	N/A	Required	Required
10		Lifting lugs on pipework removed where required after installation			
11		Temporary pipe supports	N/A	Required	Required
12		Welding 100% visually inspected	N/A	Required	N/A
13	Pipe access manhole	Backing plate of correct size welded in place	N/A	Required	Selected
14		Lid correct size and thickness	N/A	Required	Selected
15		Lid evenly fitted (weld down type, bolt down type see Section 2.8)	N/A	Required	Selected
16	Air valve stubs	Position confirmed - not spanning any weld seams.	N/A	Required	Required
17		Backing plate of correct size welded in place	N/A	Required	Selected
18		Flange alignment – bolt holes straddling pipe centre line	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
19	Weld bands	Correct size and thickness for pipe being welded	N/A	Required	Selected
20		No packers used to fill gaps	N/A	Required	Selected
21		Test hole closed on completion of nitrogen test	N/A	Required	Selected
23	Weld joint test	Non-destructive test (NDT) completed. Certification provided (see clause 2.6.1.2) • MPI testing: 20% of fillet welds • Radiographic for all fabricated bends, and ultrasonic testing for other welds Destructive testing (see clause 3.5.1) Eddy current testing (where specified in the contract)	Required	Required	N/A
24		Nitrogen test passed on pipework ≥ 700mm. Test records provided	Required	Required	Selected
25	Lining and external coating	Repaired to standard (Refer civil construction standard). DCVG test on steel pipe.	Required	Required	N/A
		Sign-off			

2.7 Stainless steel pipe welding

2.7.1 General

Corrosion of stainless steel may occur when the thin protective film (passive oxide layer) is damaged, disturbed or depleted in chromium, which occurs after exposure to high temperatures during welding. This results in the creation of various thicknesses of oxide film produced on the stainless steel weld and heat affected zone, called heat tints.

A heat-tinted weld can be reinstated if the heat tint and the underlying chromium-depleted layer are completely removed. The corrosion resistance of the stainless steel in the weld and heat affected zone will then be fully restored.

2.7.2 Welding qualification

2.7.2.1 Welding pre-qualification

a) A Work Method Statement (WMS) including a Welding Procedure Specification (WPS) shall be prepared and submitted, detailing the methods to be employed to undertake the cleaning and flushing of the stainless steel piping. Work shall not commence until the WMS is approved.
b) Prior to any pipeline welding (including prefabrication work) the contractor shall:
   iv. Submit the names and qualifications of all welders, including tested experience within the last 6 months.
   v. Submit a portfolio of weld procedures covering the sizes and types of welds to be used on the project procedures to be approved by certified independent agency.
   vi. Pre-qualify and welding work required for wet welding or water-backed welding.

2.7.2.2 Test plan

a) The contractor is responsible for submitting an inspection and test plan (ITP) for review and approval before the start of any work. The welding inspector or engineers witness needs to approve the ITP before any work starts.
b) Material testing certificates shall be independently certified to confirm that material properties meet ASTM A312, and the nominated grade specified.
c) All butt and fillet welds shall be entirely (100%) visually inspected by a welding supervisor qualified to AS1796 Certificate 10, ASME XI, or AS/NZS 2214 with applicable welding and fabrication experience noted in these standards. The appropriate visual inspection method shall be followed e.g. ASME BPVC: V – Article 9.
d) Unless otherwise specified by the design:
   - All butt welds shall be 100% radio-graphically tested.
   - Where weld testing frequency has not been specified, a minimum 10% of shop fabricated welds shall be radio-graphically tested.
   - 20% of fillet welds shall be dye penetrant tested.
   - All field welds shall be 100% radio-graphically tested.
   - Where the pipe bore cannot be visually inspected, CCTV inspection shall be undertaken to confirm the integrity of the pipe wall and evaluation of heat tint.
   - Hydrostatic leak testing shall be completed for the in-line pipe system (on-site).
e) A minimum of one destructive test shall be completed. Refer to Section 3 for testing requirements.

Note: Ultrasonic testing shall **not** be considered for the evaluation of stainless steel welds as the formation of the austenitic materials grain structure both attenuates and distorts the ultrasonic testing beam.

2.7.3 Weld preparation

a) Stainless steel fittings shall be fabricated, where possible, of a grade to match adjacent pipework.
b) To avoid contamination, the use of handheld tools for cleaning and weld preparation of stainless steel welds should be exclusively used with stainless steel and not used if

they have come into contact with **any** carbon steel, e.g., grinding discs, flapper/cutting discs, files, wire brushes etc.

c) The ends of the sheets or pipe to be joined shall be prepared by shearing, machining, plasma arc, sawing or grinding, and all burrs removed.
d) All pipework shall be cleaned and flushed to remove all welding residue and heat tint to an acceptable colour.
e) All stainless steel weld surfaces shall be cleaned both internally or externally of scale, oxides, discolouration, grease and oil, dirt, flux, weld spatter, and other contaminates before pickling procedures are employed.
f) Solvent cleaning shall be used to remove grease, oil and foreign matter. Chlorinated solvents shall not be used.
g) Accepted cleaning specification:
    - ASTM A380 Standard practice for cleaning and descaling stainless steel parts, equipment, and systems.
    - ASTM A380 table A2.1 describes the universally accepted methods for acid cleaning of stainless steel.

2.7.4 Welding

a) Tools used to prepare welded joints such as ground clamps, wire brushes, steel wool, chisels, and files shall be **made from stainless steel**. Ground / earth clamps made of copper or brass are acceptable.
b) All metal that is to be fused during welding shall be free of cutting lubricants, grease and paint.
c) Heat shall not be used in the alignment of joints. Joint alignments shall be made with mechanical devices and shall be free of depressions and bumps.
d) Tack welds shall have all slag and oxides removed before making the finished weld.
e) To address heat tints, oxygen levels must be controlled within the specified limits (25-50 parts per million) by introducing an inert “backing” gas such as *Argon* or *Nitrogen*. The gas shall be forced through the pipe (or hollow structure) to remove residual oxygen around the internal welding area, mitigating the effects of heat tint. Oxygen levels shall be no greater than 0.04% before welding commences.
f) All welding shall be carried out using approved welding techniques. Welds shall be performed using low hydrogen filler material and shall be fully passivated in accordance with ASTM A380 following completion of all welding and fabrication works.
g) All heat tint, tape, markings and all other surface contamination shall be removed.

Notes:
The use of TGX filler wire is **NOT** permitted as an alternative to gas purging.
Permanently sealed sections where no oxygen can enter after fabrication shall consider back purging.

2.7.4.1 Weldolets

Weldolets shall **NOT** be installed vertically on the top of stainless steel pipe, a tee- or reduced tee connection shall be appropriately welded.

2.7.5 Post-weld treatment

a) Stainless steel weld heat tints showing discolorations such as straw, dark straw, dark blues, purples and black colours, are unacceptable for corrosive service and the heat tint shall be removed by an approved cleaning technique or welding procedure:
   i. AWS D18.2-2009 shows examples of heat tints resulting from welding stainless steel in varying oxygen levels. Heat tints darker than no. 2 (25 ppm of oxygen) are deemed to be unacceptable and the weld shall be pickled and passivated.
   ii. ASTM A380 Standard practice for cleaning, descaling, and passivation of stainless steel parts, equipment and systems.
   iii. All welds exhibiting weld tint colour other than specified shall be pickled. The most appropriate means of treatment for each pipe spool shall be selected from those below or other approved Acid pickling methods — Determination of method:
      - Pickling paste application, where the welds are easily accessible.
      - Immersion pickling, where the pipe spool is immersed in the pickling acid for a predetermined time. This method may involve agitation. Butt weld ended valves shall not be immersion pickled.
      - Flow-through acid pickling, where pipe spools are connected together, and pickling acid is circulated through them in a pumped recirculation loop. This requires the pipework to be fed from a dedicated pump and discharged to dedicated vessels for the pickling acid. This will only apply where non-compliant welds have been identified inside the bore of the pipe.
      - Alternate methods such as electropolishing or electro-cleaning may be submitted for approval.

Note: Where heat tint is present, superficial discolouration can be removed on the outside of the pipe using *Scotch-Brite* or an appropriate stainless wire brush, however **chemical pickling is still required** to fully reinstate the corrosion resistance properties of the material. An appropriate ***pickling and passivation procedure*** should be documented and followed by the contractor to treat heat tints.

2.7.6 QA/QC template – Stainless steel pipe welding

Refer to next page.

No.	Activity	Inspection or Test Required	Reference Document	Acceptance Criteria	Records	Contractor			Welding Inspector/Engineer's Witness		
1	**Pre-Fabrication**					Scope	Sign	Date	Scope	Sign	Date
1.1	**Design / Manufacturing drawing**	Review and approval	Issue for Construction drawings	Design specifications (Example: ASME B31.3)	Design Drawings followed by Shop Drawings	Hold Point			Review		
1.2	**Inspection and Testing Plan Review**	Review and approval	N/A	(Example: ASME B31.3)	Approval of ITP	Hold Point			Review / Approve		
1.3	**Welding Procedure Specification (WPS)**	Review and approval	Approved Welding Procedure Specification	(example: ASME IX)	WPS	Hold Point			Review		
1.4	**Welder Qualification Record (WQR)**	Review and approval	Approved Welder Certification	(Example: ASME IX)	Welder Qualification Certificate	Hold Point / Review			Review		
2	**Fabrication and Welding**					Scope	Sign	Date	Scope	Sign	Date
2.1	**Material Inspection**	Inspect all material upon delivery	Quality Control Document			Inspect			N/A		
2.2	**Material Certificates** (independently certified ILAC accredited)	Review and approval	As per ASTM Code	Material test certificates to comply with ASTM A312)	Material Test Certificates	Review			Review		
2.3	**Check fit-up, joint clearance, internal alignment and dimensions prior to welding**	Visual and dimension checks	Drawings and WPS	(Example: ASME B31.3) Drawings and WPS	Weld Map / Visual and Dimensions control report	Inspect			Witness		

2.4	**Monitoring of welds**	Quality Control Procedure and recording of oxygen levels when back purging.		WPS	Weld Map	Inspect			Review		
3	**Testing and Evaluation**					**Scope**	**Sign**	**Date**	**Scope**	**Sign**	**Date**
3.1	**Cleaning, pickling and passivation**	After welding slag, heat tint and residual surface contaminants to be treated / removed	ASTM A380	Chromium depleted layers removed and clean welds	Pickling and passivation procedure	Inspect			Review and inspect		
3.2	**Visual weld checks**	Visual inspection of all (100%) welds post cleaning Where pipe bore cannot be visually inspected, CCTV inspection should be undertaken to confirm integrity of pipe wall and presence of heat tint.	ASME B31.3 (Visual inspection to ASME V article 9)	(Example: ASME B31.3)	Inspection record and CCTV footage	Hold Point			Review		
3.3	**Non-destructive testing (NDT) Radiographic Inspection**	**10% of shop fabricated welds** shall be radio-graphically tested. **All field welds shall be radiographically tested**	ASME B31.3: Section 341.4	(Example: ASME B31.3: Section 341.4)	Testing Report	Hold Point			Review		

3.4	**Hydrostatic leak testing**	In-line pipe system		(Example: ASME B31.3: Section 345.4 - No leak or pressure drop)	Testing Report	Hold Point			Review		
4	**Handover**					**Scope**	**Sign**	**Date**	**Scope**	**Sign**	**Date**
4.1	**Repairs**	Review defects remediation	Snag list and remediation methodology	Repair report		Hold Point			Review and witness repairs		
4.2	**As-built drawings**		Red-line drawing mark-ups	Within specification tolerances	As-built drawings	Hold Point			Review		
4.3	**Final Inspection / Practical Completion**				Submission of all QA documentation approved	Hold Point			Review		
5	**Sign-off and Final Approval**					**Comments**					
		Company Name	**Full Name**	**Signature**	**Date**						
	Contractor Representative										
	Welding Inspector										
	Client Representative										

2.8 Installation of flanged components in pipelines

2.8.1 General

a) Refer to Watercare Guidance Note: Steel bolted flanged joint assemblies (ESF-600-GDN-702).
b) Refer to the Watercare's Material Supply standard for acceptable flanges.

***Note** - Special proprietary couplings and connections shall be installed as per the manufacturer's instructions and are not covered by this standard*

c) Once a bolt, washer, nut or gasket has been used, it shall not be re-used.
d) After installation, flanged components shall be wrapped in an accepted corrosion protection system (unless installed in an above-ground application). Refer to Watercare's General Civil Construction Standard for the application technique and material supply standards for acceptable products.

2.8.2 Flanges

Flanges shall be manufactured to the requirements contained in the relevant standards (AS/NZS 4087 or EN 1092 as applicable).

2.8.2.1 Tolerances

Flange face profile including flatness shall comply with the relevant standard (AS/NZS 4087 or EN 1092 as applicable). Manufacturers shall demonstrate that their casting / machining process achieves the required accuracy and parallelism (≤ 1°), in which case spot facing should not be required, although a final determination is at Watercare's discretion. The necessary quality assurance testing shall be submitted to Watercare for confirmation. This can be done through an appropriate and calibrated measurement or scanning device. It is recommended that type / batch testing shall suffice to demonstrate the accuracy of the casting method used for each fitting type.

Note: Where steel flanges are cut from a plate and machined, this would not require any spot facing (this excludes cast / machined weld neck flanges).

Also refer to Guidance Note: Spot facing of flanges (ESF-500-GDN-703) for more detailed information.

2.8.3 Flange gaskets

a) Gaskets shall be stored flat in a relaxed state. No other material may be placed on top of stored gaskets, and they shall be protected from sunlight and chemicals.
b) Only accepted gaskets shall be used. Refer to Watercare's Material Supply standard. Gaskets should be matched with the bolting type (tensile load for clamping force) and flange size. Contrary to the standard, flat face flanges match with full face gaskets and raised face flanges match with ring gaskets.
c) Compressed fibre gaskets with a high elastomer content (e.g. Klinger C6327 or equivalent) may be used for blank flanges or access covers to assist gasket compression and sealing of the joint.

Table 2.4: *Flange gasket types*

Application	Gasket material	Bolt grade
Water networks (up to and including DN 250)	EPDM "Blue" Rubber, full face	Grade 4.6 or A4-50
Water Transmission (DN 300 and larger)	Compressed Fibre (CNAF), full face	Grade 8.8
Wastewater pressure networks (up to and including DN 300)	Nitrile Insertion Rubber, full face	Grade 4.6 or A4-50
Wastewater pressure transmission (larger than DN 300)	Compressed Fibre (CNAF), full face	Grade 8.8

Note: Nitrile insertion rubber gaskets may be considered for wastewater transmission pipelines up to DN600, in circumstances where a compressed fibre gasket is unforgiving. For these applications Grade 4.6 or A4-50 bolts should be used with the appropriate torque value to prevent damaging the gasket.

Note – Watercare has standardised the use of raised face flanges. If a full-face flange is specified for a specific function, the gasket type shall be ring type but otherwise be in accordance with the above table.

Compressed fibre gaskets require a higher tension to affect a proper seal that cannot be achieved with Grade 4.6 bolts or Class 50 stainless bolts. Should there be any deviation specified from the above table the bolt/gasket/flange arrangement must be reconsidered in combination with the pipe nominal pressure.

a) Gaskets shall be inspected for any defects such as bulges, protruding reinforcing or any other markings.
b) The inner diameter of the gasket shall be larger than the inner diameter of the connecting flanges and be the correct size for the flange and bolt holes.
c) Gaskets that do not meet these requirements will be rejected and replaced.

2.8.4 Bolt torque requirements

a) Torque equipment shall have a minimum accuracy tolerance of ±2% and have a valid calibration certificate less than 6 months old. Calibration shall be to ISO 6789. Impact driving methods to fasten bolts are not allowed.
b) Bolts are to be tightened in a star pattern.
c) Where polyethylene (PE) flanged joints are installed, the bolts shall be re-torqued after 12-24 hours of the initial installation to account for short term relaxation of the PE stub flange, prior to hydrostatic testing (also refer to the Plastics Pipe Association industry guideline POP007: Flanged Joints for Polyethylene (PE) Pipe.

Note – The expected bolt torque values used in this standard are based on well lubricated, un-insulated bolts. The ASME PCC-1 "Nut factor calculation" has been applied, using a nut factor value of 0.16 for lubricated bolts. **The tables shown are for specific flange, gasket and lubrication arrangements for PN16 application. Alternative combinations must be recalculated.**
Lightly oiled bolts require a much higher torque to achieve the tensile load and small changes in torque can lead to large changes in tensile load. The combination of high torsional stress combined with direct stress, can lead to a combined stress over the bolt yield strength, leading to failure. A lower frictional resistance at the specified torque may cause excessive tensile load that will cause the yield strength to be exceeded and brittle failure of the bolt to occur.

The use of non-specified lubrication requires torque values to be reassessed. The revised torque value shall be to yield strength of the material between the following ranges:

- Mild steel Grade 4.6: 55% to 65% of the yield strength
- High tensile steel Grade 8.8: 60% to 65% of the yield strength
- Stainless steel Grade 316 Class 50 and Class 80: 60% to 70% of the yield strength

Note: The use of threaded rod in lieu of bolts is not preferred and is therefore considered a departure from Watercare Standards. They should not be considered an equivalent substitute for bolts and shall generally not be allowed for flanged mechanical assemblies. Also refer to Guidance Note: Threaded rods vs bolts for flanged assemblies (ESF-500-GDN-704) for more detailed information.

The following torque tables apply to flanges of ductile iron (DI) connecting to DI, or DI-to-steel or steel-to-steel. Ductile iron flanges shall be examined for buckling – if any signs of buckling occur, STOP. The values indicated in the tables below are indicative and should be confirmed with the manufacturer's recommendation based on the flange configuration.

Note: Note that a clearance of 2mm must be provided on bolt-hole diameter to prevent damage to coating surfaces in the bolt holes.

Table 2.5: *Recommended torque values using* ***EPDM or Nitrile Insertion Rubber Gaskets*** *for* ***AS/NZS 4087*** *Flanges with* ***Grade 4.6 or A4-50 Bolts*** *(network water and wastewater up to DN 600[(a)])*

Pipe DN	No. Bolts	Bolt Size (mm)	Target Torque "T" (Nm)	Gasket Thickness (mm)	Water Networks	Wastewater Pressure
100	4	16	48	2	EPDM	Nitrile Rubber
150	8	16	48	2	EPDM	Nitrile Rubber
200	8	16	48	2	EPDM	Nitrile Rubber
250	8	20	94	2	EPDM	Nitrile Rubber
300	12	20	94	2	N/A	Nitrile Rubber
350	12	24	163	3	N/A	Nitrile Rubber[(a)]
400	12	24	163	3	N/A	Nitrile Rubber[(a)]
450	12	24	163	3	N/A	Nitrile Rubber[(a)]
500	16	24	163	3	N/A	Nitrile Rubber[(a)]
600	16	27	238	3	N/A	Nitrile Rubber[(a)]
700	20	27	238	3	N/A	N/A
800	20	33	440	3	N/A	N/A
900	24	33	440	3	N/A	N/A
1000	24	33	440	3	N/A	N/A

(a) **Note**: Nitrile rubber gaskets should only be used where it's demonstrated that compressed non-asbestos fibre (CNAF) gaskets are not suitable. Where nitrile rubber gaskets are required, bolts shall be grade 4.6 or A4-50, using the associated torque values.

Table 2.6: *Recommended torque values using* ***EPDM or Nitrile Insertion Rubber Gaskets*** *for* ***EN 1092-1(2)*** *Flanges with* ***Grade 4.6 or A4-50 Bolts*** *(network water and wastewater up to DN 600[(b)])*

Pipe DN	No. Bolts	Bolt Size (mm)	Target Torque "T" (Nm)	Gasket Thickness (mm)	Water Networks	Wastewater Pressure
100	8	16	39	2	EPDM	Nitrile Rubber
150	8	20	75	2	EPDM	Nitrile Rubber
200	12	20	75	2	EPDM	Nitrile Rubber
250	12	24	130	2	EPDM	Nitrile Rubber
300	12	24	130	2	N/A	Nitrile Rubber
350	16	24	130	3	N/A	Nitrile Rubber[(a)]
400	16	27	190	3	N/A	Nitrile Rubber[(a)]
450	20	27	190	3	N/A	Nitrile Rubber[(a)]
500	20	30	259	3	N/A	Nitrile Rubber[(a)]
600	20	33	352	3	N/A	Nitrile Rubber[(a)]
700	24	33	352	3	N/A	N/A
800	24	36	452	3	N/A	N/A
900	28	36	452	3	N/A	N/A
1000	28	39	585	3	N/A	N/A
1200	32	45	903	3	N/A	N/A
1400	36	45	903	3	N/A	N/A
1600	40	52	1404	3	N/A	N/A
1800	44	52	1404	3	N/A	N/A

[(a)] **Note**: Nitrile rubber gaskets should only be used for transmission wastewater where it's demonstrated that compressed non-asbestos fibre (CNAF) gaskets are not suitable. Where Nitrile rubber gaskets are required, bolts shall be grade 4.6 or A4-50, using the associated torque values.

Table 2.7: *Recommended torque values using* ***Compressed non-asbestos fibre (CNAF) Gaskets*** *for* ***EN 1092-1(2)*** *Flanges with* ***Grade 8.8 Bolts*** *(Transmission assets only)*

Pipe DN	No. Bolts	Bolt Size (mm)	Bolt Grade	Target Torque "T" (Nm)	Gasket Thickness (mm)	Gasket Type	Application	
100	8	16	8.8	129	2	CNAF	Water Transmission	N/A
150	8	20	8.8	251	2	CNAF	Water Transmission	N/A
200	12	20	8.8	251	2	CNAF	Water Transmission	N/A
250	12	24	8.8	434	2	CNAF	Water Transmission	N/A
300	12	24	8.8	434	2	CNAF	Water Transmission	N/A
350	16	24	8.8	434	3	CNAF	Water Transmission	Wastewater
400	16	27	8.8	635	3	CNAF	Water Transmission	Wastewater
450	20	27	8.8	635	3	CNAF	Water Transmission	Wastewater

Pipe DN	No. Bolts	Bolt Size (mm)	Bolt Grade	Target Torque "T" (Nm)	Gasket Thickness (mm)	Gasket Type	Application	
500	20	30	8.8	862	3	CNAF	Water Transmission	Wastewater
600	20	33	8.8	1173	3	CNAF	Water Transmission	Wastewater
700	24	33	8.8	1173	3	CNAF	Water Transmission	Wastewater
800	24	36	8.8	1506	3	CNAF	Water Transmission	Wastewater
900	28	36	8.8	1506	3	CNAF	Water Transmission	Wastewater
1000	28	39	8.8	1949	3	CNAF	Water Transmission	Wastewater
1200	32	45	8.8	3009	3	CNAF	Water Transmission	Wastewater
1400	36	45	8.8	3009	3	CNAF	Water Transmission	Wastewater
1600	40	52	8.8	4680	3	CNAF	Water Transmission	Wastewater
1800	44	52	8.8	4680	3	CNAF	Water Transmission	Wastewater

Table 2.8: *Recommended torque values using* ***Compressed Fibre Gaskets*** *for* ***AS/NZS 4087*** *Flanges with Grade 8.8 Bolts (Transmission wastewater)*

Pipe DN	No. Bolts	Bolt Size (mm)	Bolt Grade	Target Torque "T" (Nm)	Gasket Thickness (mm)	Gasket Type	Application
100	4	16	8.8	-	2	-	N/A
150	8	16	8.8	-	2	-	N/A
200	8	16	8.8	-	2	-	N/A
250	8	20	8.8	-	2	-	N/A
300	12	20	8.8	-	2	-	N/A
350	12	24	8.8	564	3	CNAF	Wastewater
400	12	24	8.8	564	3	CNAF	Wastewater
450	12	24	8.8	564	3	CNAF	Wastewater
500	16	24	8.8	564	3	CNAF	Wastewater
600	16	27	8.8	825	3	CNAF	Wastewater
700	20	27	8.8	825	3	CNAF	Wastewater
800	20	33	8.8	1407	3	CNAF	Wastewater
900	24	33	8.8	1407	3	CNAF	Wastewater
1000	24	33	8.8	1407	3	CNAF	Wastewater

2.8.4.2 Bolt torques for PE flanges

This section shall be read in conjunction with PIPA POP007: Flanged Joints for Polyethylene (PE) Pipe.

The recommended bolt torque values are based on the following conditions:

a) AS/NZS 4087 flanges
b) All bolt threads and nuts are well lubricated with a molybdenum disulphide or equivalent product.
c) EPDM gaskets conforming with Watercare's Material Supply Standard shall be used.
d) Nut factor (K) for hot dipped galvanised bolts (grade 4.6) is 0.15.
e) Nut factor (K) for stainless steel bolts (grade A4) is 0.2.

Table 2.9: *PE stub flange adaptor to non-PE flanges (PN16)*

PE Pipe DN	PN16	
	Bolt Grade 4.6	Bolt Grade: A4-50
110	36	47
160	32	42
200	50	66
225	45	60
250	86	115
315	74	98
400	198	264
500	159	213
630	241	321
710	262	349

Table 2.10: *PE stub flange adaptor to PE stub flange adaptor – P10 and PN16*

PE Pipe DN	PN10		PN16	
	Bolt Grade 4.6	Bolt Grade: A4-50	Bolt Grade 4.6	Bolt Grade: A4-50
110	33	44	38	51
160	27	36	33	43
200	44	59	50	67
225	33	44	46	61
250	68	91	87	116
315	56	75	74	99
355	91	121	121	161
400	110	147	149	199
450	176	235	226	301
500	115	153	161	215
630	169	225	242	323
710	183	245	264	352

2.8.4.3 Bolt torques for magnetic flowmeters

Note – The torque values in Table 2.11 are for the current approved Endress and Hauser Promag W400 meters at PN16 rated. Alternative parameters must be sought outside these conditions from the meter manufacturer.

***Table 2.11**: Magnetic flow meters (PN16)*

Flange size DN	AS/NZS 4087	EN 1092
	Bolt torque (Nm)	Bolt torque (Nm)
50	32	-
80	49	40
100	76	43
150	52	74
200	77	70
250	147	98
300	103	134
350	203	154
375	137	-
400	226	193
450	301	198
500	271	275
600	393	415
700	330	278
800	631	369
900	627	353
1000	595	502
1200	703	701
1400	-	762
1600	-	1100
1800	-	1003
2000	-	1324

2.8.4.4 Bolt torques for seal-on-body butterfly valves/lugged valves

Note – Table 2.12 shows maximum values for both AS/NZS4087 and EN1092 flanges PN16 to PN25. These valves are installed without a gasket; the seal is made against the body liner which wraps around onto the valve face.

***Table 2.12**: Bolt torque for butterfly/ lugged valves*

Bolt Size x pitch (mm)	Bolt torque (Nm)
M10	23
M12	40
M16	90
M20	180
M24	310
M27	450

Note: Where manufacturers torque values differ from those listed above, the manufacturers values shall be used for installation.

2.8.5 Installation sequence

Where practical, assemblies shall be shop completed. Following manufacturing the pipework shall be inspected for defects, completeness, dimensional correctness and proper alignment before bolting. Once on site, the bolt torques shall be confirmed before installation.

2.8.5.1 Pre-assembly inspection

a) Flange faces shall be free of paint unless otherwise specified (some applications may require the factory paint to remain, such as for wastewater), grease, oil or any other foreign material.
b) No damage to the gasket face in particular splits, creases, bulging and be clean from any marking other than the manufacturers.
c) Bolts are correct length and grade for the application.
d) Washers are correct diameter and thickness.
e) Bolt threads are cleaned and well lubricated with an accepted lubricant, refer Section 2.2.6.2.
f) The nut must be able to be screwed by hand onto the bolt for the full thread length and but must not be loose on the bolt thread.

2.8.5.2 Joint assembly

a) Flanged joints shall be assembled and aligned correctly, and supported without weight, external loads or strain transferred to the joint including the flanges.
b) Any connecting valves shall be partially open prior to starting the bolting procedure.
c) All bolts shall be inserted, and hand tightened before starting the bolt torque procedure.

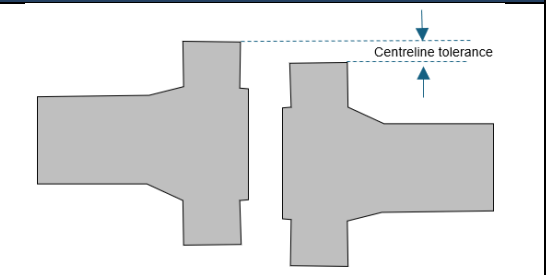
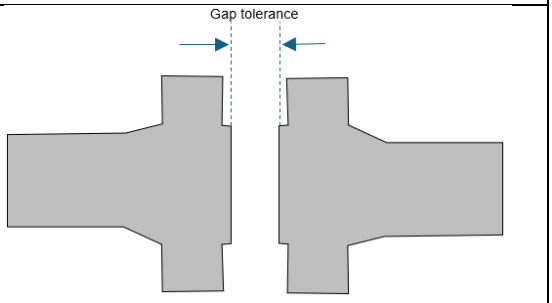
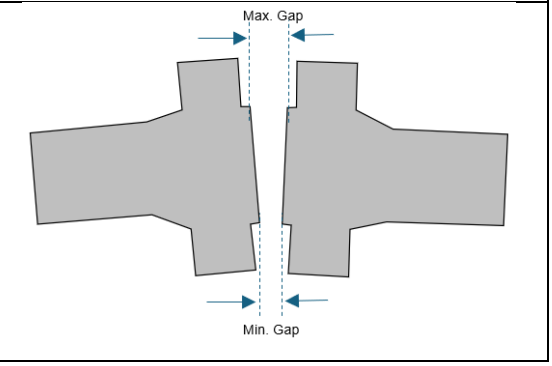
d) The assembly shall only be lifted using the lifting lugs (to be supplied on pipe spools and assembly componentry). The assembly must not be lifted by any single component.
e) Only soft slings and timber supports shall be used against painted or machined surfaces. The weight of the assembly shall be supported adjacent to the flanges and not beneath the spool sections.
f) On assemblies DN 1000mm and greater the spool or taper sections shall be kept round at the ends by means of cross bracing tack welded into position. Roundness shall be within the limits of ±4mm on the nominal diameter.
g) All bolts shall be re-checked for torque at delivery to site.

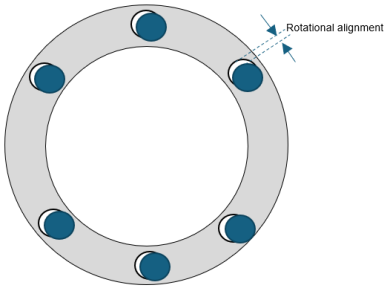
Note: Carbon (mild) steel lifting chains shall not be used for stainless steel pipe assemblies.

2.8.5.3 Alignment of flanged joint assemblies

When fitting up flanged joint assemblies, accurate alignment is necessary to ensure uniform loading of the gasket and prevent unintended stress and strain transferring to the flanged elements. It is also imperative that these assemblies and connecting pipework is designed and constructed so that gasket faces are unconstrained upon assembly and within the tolerances outlined. Four key alignment considerations are shown in Table 2.13.

***Table 2.13**: Flange joint alignment aspects and tolerance.*

Alignment aspect	Tolerance	Illustration
Centreline tolerance	1.5mm	
Gap between flanges	2 x the gasket thickness	
Parallelism	Max. gap – Min. gap ≤ 0.8mm	

Alignment aspect	Tolerance	Illustration
Alignment of bolt holes (rotational alignment)	3mm	

2.8.5.4 Bolt tightening sequence

Step 1: Hand tighten the assembly to between 15 Nm and 30 Nm (but not exceeding 20% of the target torque "T" value). This ensure that the flanges are fitted up snug and uniformly against the gasket.

Step 2: Tighten to 20% - 30% of the target torque "T", while monitoring the flange gap around the circumference of the assembly. Ensure that that the gap is kept continuously uniform. Adjust appropriately if required.

Step 3: Tighten to 50% - 70% of the target torque "T", while monitoring the flange gap around the circumference of the assembly. Ensure that that the gap is kept continuously uniform. Adjust appropriately if required.

Step 4: Tighten to 100% of the target torque "T", while monitoring the flange gap around the circumference of the assembly. Ensure that that the gap is kept continuously uniform. Adjust appropriately if required.

Step 5: Continue tightening the bolts, but in a circular clockwise pattern until no further rotation occurs at 100% target torque.

Step 6: Wait 4-hours following the final torquing (Step 5) and repeat Step 5 to account for any short-term creep relaxation or embedment losses. This may also be required following pressure testing where the test pressure is higher than the operating pressure.

2.8.5.5 Bypass pipework

a) The bypass pipework shall be installed once the main assembly is completed.
b) All bypass pipework shall be correctly designed, sized, and assembled and no load shall be transferred to flanged components and/or assemblies.

2.8.6 Flange retrofitting and hot bolting

a) On all flange retrofitting the bolts, washers and nuts shall be replaced with new fasteners. A bolt that has relaxed under preload shall not be re-torqued under service. The bolt shall be replaced.
b) Gasket replacement shall follow the requirements for new installations as per Section 2.8. The flange face shall be cleaned of all foreign matter to the original surface before the new gasket is inserted.

c) Flange retrofitting (hot bolting) may be used to replace corroded bolts or to make an electrically isolated joint of an in-service joint.
d) Creating an electrically isolated joint shall only be allowed if the existing gasket meets the required insulating properties. Refer to Watercare's Cathodic Protection Standard (ESF-500-STD-704) and Electrical Construction Standard (ESF-600-STD-703).
e) Hot bolting is done by replacing the flange bolts, one at a time, in a star pattern. Bolts shall be preloaded to the final torque setting required and clamping load for the gasket and flange type. Once the bolt replacement is complete; carry out a final clockwise pass confirming the final torque value.

Important

Hot bolting shall only be allowed where a pipe cannot be taken out of service and **only where the operating pressure is less than 60% of the maximum allowable working pressure**. The flange must have a minimum of 8 bolts and be fully supported on both sides of the joint, i.e. no stress is introduced. The pipe content shall be confirmed as non-toxic and not harmful to health or the environment. Consideration shall be given to the location of work and safe evacuation passage. The existing installation shall be inspected by a suitably qualified engineer to verify the integrity of the fasteners, flange and pipe condition before the operation may commence. The operation shall be completed under strict controlled conditions.

2.8.7 Electrically isolated joints

a) Electrical isolation shall use insulating kits into flanges adjacent to valves or fittings to be isolated.
b) The insulating kit will normally be installed in the joint at the unprotected joint, or at the joint adjacent to the pipe with the lower protection - so that the valve or fitting is on the cathodically protected pipe side of the isolated flange.
c) The isolated joint shall have a resistance greater than 1 mega-ohms.
d) New electrically isolated joints shall be constructed with the bolt sizes as specified in Section 2.8.3. Bolt holes shall be factory drilled to suit.
e) Electrically isolated joints retrofitted to existing flanges shall depend on the suitability of the existing gasket for the isolation and clamping load required. Refer to Section 2.8.5. for hot bolting requirements.
f) Insulation kits fitted into an existing flange require a smaller bolt size to be used. Table 2.14 gives the alternative bolt sizes and tensile loads needed to provide a seal.

Note – The expected bolt torque values used in this standard are based on well lubricated, un-insulated bolts. A coefficient of friction 0.12 on threads and 0.15 on washer contact has been used in the torque tables.

The use of non-specified lubrication requires torque values to be reassessed. Any revised torque value representing yield strength of less than 50% or more than 80% shall not be considered.

Table 2.14: *Torque values for insulated joint replacement bolts*

Flange Size (EN1092 & AS/NZS 4087 flange with C4430 gasket)	Bolt Size x pitch (mm)*	Tensile load (kN)	Bolt torque (Nm)**
	Grade 8.8 galvanised - based on obtaining proper seal with Klinger C4430 compressed fibre gasket. The insulation kit shall be selected to withstand the clamping load		
80 to 125mm	M14 x 2 (instead of M16)	51	121
200mm	M18 x 2.5 (instead of M20)	86	255
250 to 350mm	M22 x 2.5 (instead of M24)	135	476
400 to 450mm	M24 x 3 (instead of M27)	158	618
500mm	M27 x 3 (instead of M30)	205	897
600 to 700mm	M30 x 3.5 (instead of M33)	251	1224
800 to 900mm	M33 x 3.5 (instead of M36)	310	1645
1000mm	M36 x 4 (instead of M39)	317	1971
1200 to 1400mm	M39 x 4 (instead of M45)	437	3141
1600 to 1800mm	M45 x 4.5 (instead of M52)	543	4504
2000mm	M52 x 5 (instead of M56)	674	5591

**The bolt sizes are indicative of one size smaller to accommodate the insulation kit; however this is dependent on the insulator sleeve wall thickness*

Ductile iron flanges shall be examined for buckling – if any signs of buckling occur,* ***STOP

2.8.8 QA/QC template - Flanges

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Flanges	Correct size, pattern and class	N/A	Required	Required
2		Gasket face undamaged	N/A	Required	Selected
3		Alignment correct	N/A	Required	Required
4	Fasteners	All bolts present	N/A	Required	Required
5		Correct size, length (within protrusion range) and grade	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
6		All washers/nuts present – corresponding grade to bolts	N/A	Required	Required
7		Isolation sleeves and washers (where required)	N/A	Required	Required
8		Bolt thread lubrication – well lubricated as per Section 2.2.6.2	N/A	Required	Selected
9		Correct bolt torque rating selected for flange type and gasket type	N/A	Required	Required
10		Star pattern followed for assembly – number sequence marked on back of flange	N/A	Required	Selected
11	Gaskets	Correct selection for flange size and type	N/A	Required	Selected
12		Correctly stored	N/A	Required	Selected
13		Inspected for defects	N/A	Required	Selected
14	Insulated joints	Flange holes factory drilled to accept standard bolt size with insulation kit.	N/A	Required	Required
15		Location confirmed	N/A	Required	Required
16		Insulation test value > 1 mega-ohm	Required	Required	N/A
17	Components/equipment being assembled	Correct size with corresponding flange patterns and class rating	N/A	Required	Required
18		Correct position in assembly	N/A	Required	Required
19		Correct orientation	N/A	Required	Required
20		Valve opened before bolting	N/A	Required	Selected
21	Handling and delivery	Correctly loaded and supported – no load transferred onto joints during assembly, handling and installation	N/A	Required	Required
22		Final torque values confirmed before installation	N/A	Required	Selected
23	Hot bolting / Retrofit	Pre-inspection by qualified engineer.	N/A	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
24		Specific methodology developed (hot bolting) – Pressure < 60% MAWP Min 8 bolt flange	Required	Required	N/A
25		Correct bolt selection and torque range for retrofit	N/A	Required	Required
		Sign-off			

2.9 Actuators

2.9.1 General requirements

a) Materials shall be handled and stored in accordance with the requirements of the product supplier. All ports shall be factory plugged. Actuators that have been shelved for longer than six months shall be stroked before mounting.

b) Before installation the specific requirements for the installation shall be cross checked for each application against the following parameters:
- Spindle type (rising or non-rising)
- Angle of rotation (quarter turn, multi turn)
- Direction of rotation (clockwise or anti clockwise)
- Gearbox requirements
- Full range travel time
- Voltages, motor and control
- Remote operation method and mode of control
- Communication protocol
- Duty cycle (i.e. modulating valve installation)

c) Inspect the mounting surfaces to ensure a proper fit and that the seating area is debris free. Mount the actuator to avoid damage or misalignment of the mechanical interface and align mounting bolt holes.

d) Set limit switches and test actuation in accordance with the supplier requirements.

e) Actuator operation is specified for the particular operating environment.

Note: It is preferred that actuators are mounted on valves in the workshop / factory and that limit switches and other ancillaries are set. The valve shall then be tested to confirm sealing. Once these parts are mounted they shall not be removed from the valve prior to installation (unless warranted).

2.9.1.1 *Electric actuators*

Refer to Section 2.5 of the Electrical Design Standard for electrical operation.

2.9.1.2 *Pneumatic and hydraulic actuators*

a) Installation and the connecting power fluid system shall be in accordance with the AS2788 for pneumatic actuator installation and AS2671 for hydraulic actuator installation.
b) Test the actuator in accordance with the product supplier's requirements.

2.9.2 QA/QC template - Actuators

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	General	Actuator stroked before installation	N/A	Required	Selected
2	Setup	Actuator specifications comply with specific operational requirements and working environment	N/A	Required	Required
3		Inspect mounting surfaces, fit and alignment	N/A	Required	Required
4		Valve travel limits correct	N/A	Required	Required
5		Limit switch calibrated	Required	Required	N/A
		Sign-off			

2.10 Magnetic flowmeter installation

This section shall be read with Section 2.8 and specifically bolt torques as set out in Section 2.8.3.2 of this standard.

Also refer to Watercare's standard drawings 2013182.001 – 2013182.004 for application details.

2.10.1 Meter flange connections, general requirements

a) Pipework flanges may have a raised face or full-face configuration as required by the meter manufacturer.
b) Flange alignment shall be such that the meter cable connection box is located on top of the assembly.
c) Gasket material shall be nitrile insertion rubber or natural insertion rubber material, 3mm thick with cotton reinforcement, and have hardness between 60 and 75 IRHD units.

d) The gaskets shall be full faced having the same outside diameter as the flanges and precision located bolt holes. The internal bore diameter of the gaskets shall be the same as the internal bore diameter of the meter.
e) Gaskets are to be installed on either side of each earthing ring.
f) Two washers shall be used per bolt, one beneath the bolt head and one beneath the nut.
g) Two insulating washers per bolt shall be used, between the steel washer and the flange.
h) The flange bolts shall be insulated from the flanges and earthing rings.

2.10.2 Electrical isolation and pipeline bonding

a) Meter flanges shall be electrically isolated, according to Section 2.8.6.
b) Unless otherwise specified by the meter supplier, a pipeline bonding cable shall be installed crossing to the pipe flanges. This is to provide electrical continuity to the pipeline.

2.10.3 Assembling of meters to pipework

a) The assembly of the meter and connecting pipework shall be completed without load transfer between the flanges and the meter.
b) Ensure the correct orientation of earthing ring connecting tabs to the meter cable connecting box.
c) Minimum clear pipe lengths shall be maintained in accordance with manufacturer recommendations.
d) Check the alignment of the pipework, gaskets and earthing ring to the bore of the meter.
e) The gasket and/or earthing ring shall not protrude into the flow path of the meter.
f) The allowable tolerance for misalignment is given in Table 2.15.

Table 2.15: *Tolerance for misalignment or diametric difference*

Meter nominal bore (mm)	Maximum misalignment (mm)
< 50	1.5
50 – 300	2.0
> 300	4.0

g) With the connecting pipework in place, all bolts shall be installed from the pipe flange towards the meter. Tighten the nuts to the torque requirement defined in Section 2.8.3.2.
h) Impact wrenches shall not be used.
i) Check for any deformation to the meter lining during and after bolt tightening.

2.10.4 Installation

Handle the assembly to prevent damage to linings and coatings and deformation of the gaskets or breakage of any kind.

2.10.4.1 Handling of assembly

a) After the assembly is complete and before the meter has been fully installed, the meter assembly shall be supported next to the pipework flanges in a way that does not bend the assembly or apply uneven loading on the rubber gaskets or the rubber facing on the meter flanges.
b) Soft slings and timber supports shall be used against painted or machined surfaces. A stiff lifting beam and uniform length slings may be required.
c) The assembly must not be lifted by slinging under the meter only, or by using the meter lifting lugs.

2.10.4.2 Confirmation of insulation

a) The insulation and earthing rings shall be checked and approved after completion of the joint assembly and before any protective coatings are applied.
b) A continuity or resistance test shall be carried out from each nut on an unprotected part of the flange on the opposite flange of the joint. A resistance value above 100,000 ohms is considered satisfactory for meter flange joints.
c) Testing of insulated joints must not be carried out with a megger.

2.10.4.3 Protection meters

Meters shall generally be placed inside chambers to allow for routine inspection, monitoring and maintenance.

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2.10.5 QA/QC template – Magnetic flowmeters

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Meter	Correct size	N/A	Required	Required
2		Correct location in assembly	N/A	Required	Required
3		Correct orientation for flow	N/A	Required	Required
4		Internal lining undamaged	N/A	Required	Required
5		Gasket face undamaged	N/A	Required	Required
6		Earthing rings	N/A	Required	Required
7		Gaskets (two per flange joint)	N/A	Required	Required
8	Sensor unit	Cable potted	N/A	Required	Required
9		Glands correctly installed	N/A	Required	Required
10		Unused cable entries blanked	N/A	Required	Required
11		Matching serial numbers	N/A	Required	Required
12	Electrical Isolation	Bonding cables (minimum 6mm copper)	N/A	Required	Required
13		Insulation kit fitted	N/A	Required	Required
14	Bolting	Compliant with Section 2.8.3.2	Required	Required	Required
15		Lining not deformed	N/A	Required	Required
		Sign-off			

2.11 Installation of pumping units and motors

2.11.1 General

a) Pump performance testing and certification requirements are set out in Table 2.16 below. This shall be confirmed and accepted prior to any installation.

***Table 2.16**: Pumps performance testing requirements*

Pump motor size	Test certificate grade (in accordance with ISO 9906)	Certificate testing required	Witnessed (in-person or as agreed with Watercare)
<30 kW	2B	Type-testing / Manufacturers model testing	No
≥ 30 kW < 100 kW	2B	Testing of each pump ordered	No
≥ 100 kW	1B	Testing of each pump ordered	Yes

b) Pump and motor installations shall be completed by a suitably qualified and experienced person (SQEP) in mechanical engineering trade.
c) The installation shall be in accordance with the manufacturer's requirements and procedures.
d) Machines shall be handled using the lifting points as provided by the manufacturer.
e) The pump shall be installed before the motor. Where gearboxes are installed, the gearbox shall be aligned to the pump and the motor to the gearbox.

2.11.2 Setting out

a) Prior to lifting the pump into place, the concrete plinth and baseplate shall be inspected for trueness and the setting out details confirmed as shown on the design drawings.
b) All mounting surfaces shall be cleaned, dressed and cleared from burrs.

2.11.3 Levelling and alignment

a) Baseplates and machinery shall be properly levelled, aligned, set and adjusted on packers and shims.
b) Packers shall be proprietary product of sufficient size for an effective load bearing area. Shims shall be of the same size as the packer. Shim material shall be pre-cut plastic or stainless steel. Aluminium stock is not acceptable.
c) No more than three shims shall be used under mounts. If the total thickness required is more than 6 mm, a single machined plate shall be used.
d) Soft and parallel soft foot shall be corrected with shims. Angular soft foot may be corrected with a bevelled shim and washer to a maximum of 3°. For greater deviation the machined base shall be removed, and shop milled to the correct fit.
e) Grouting of 20mm to 40mm is allowed between the plinth and the pump base plate. Stainless steel wedges shall be used to set the base true and level.
f) The void between the plinth and baseplate shall be grouted with a non-shrink product. The grout edges shall be chamfered to allow water run-off.
g) Alignment with connecting pipework shall be true and level. Additional adjusting nuts may be installed under the baseplate.

h) No stress shall be passed between the pump or motor base, anchors and adjusting nuts. Connecting pipework shall be self-supported, without loads transferred through misalignment or weight supported on the pump connections.
i) Rotate the pump manually to ensure free movement.
j) Slotted holes shall be fitted with square washers at least 5mm thick. Round washers are not allowed on slotted holes.
k) Hold down bolts shall be suitable to withstand the dynamic loads.
l) Once the pump has been setup the motor shall be aligned to the pump to manufacturer's tolerance. Where no tolerance is stated the minimum acceptable tolerance for offset and angularity shall be:
    - 0.03mm for flexible couplings
    - No tolerance for rigid couplings
m) The shaft alignment shall be completed with a calibrated laser system.
n) An alignment record sheet shall be completed for each coupling aligned. All alignments are to be inspected by the relevant equipment supplier's representative. Inspections by the equipment supplier shall be coordinated and documented by the contractor.

2.11.4 QA/QC template – Installation of pumping units and motors

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Pump testing	ISO 9906 testing certificate meeting tolerances of grade specified.	Testing certificate	Required	Required
1	Preparation	Base and plinth clean	N/A	Required	Required
2		Baseplate dressed	N/A	Required	Required
2	Setting out	Plinth true, sized and located per design	N/A	Required	Required
3	Alignment	Proprietary shimming material sized to loading surface	N/A	Required	Required
4		Connecting pipework self-supporting and correctly aligned	N/A	Required	Required
5		Footing true (check for angular or parallel soft foot)	N/A	Required	Required
6		Grout depth 20-40mm	N/A	Required	Required
7		Anchor size correct size and grade. Correct washer type and size	N/A	Required	Required
8		Alignment – tolerance to manufacturer spec; or: • Max 0.03mm for flex coupled shafts • No tolerance for rigid coupling Alignment record provided	Required	Required	Required
		Sign-off			

2.12 Installation of gearboxes

2.12.1 General

a) The gearbox shall be matched with the output torque and sizing requirements.
b) Before installation the gearbox specification and the oil level shall be confirmed.

Note - In some gearboxes a different mounting position may require the oil level to be adjusted.

c) Gearboxes must be installed in the specified working position, ensuring the breather vent, drain screws and oil check / refill plug are clear and accessible.

d) Unless otherwise specified by the manufacturer, all mounting bolts shall be grade 8.8 or higher. Welding is not allowed on gearboxes or mounting shafts.
e) The manufacturer's installation procedure shall be followed. Confirm the rotational direction of input and output before installation. The direction shall be permanently marked on the casing.
f) Clean all connecting shafts with a suitable solvent. Take care not to let the solvent get into contact with oil seals.
g) Mounting and dismantling of the gearbox shall be facilitated with a manufacturer approved lubricant. Proper mounting tools shall be used to connect the gearbox to the shaft. Hammering is not accepted.

2.12.1.1 Gearboxes for valves and actuators

The gearbox shall provide a minimum torque capability of 30% above the valve manufacturer's specified torque for the particular application before installation. For critical applications, valve bodies shall also be checked for induced stresses under maximum actuator torque loads.

2.12.1.2 Gearboxes for pump and motor coupling

The gearbox shall provide a minimum torque capability of 250% of the driving motor full load above the valve manufacturer's specified torque for the particular application before installation.

2.12.2 Alignment

Refer to Section 2.11.3 for alignment.

2.12.3 QA/QC template – Installation of gearboxes

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Gearbox type and model	Correct model, matching application and torque requirements	N/A	Required	Required
2	Installation position	Correct orientation. Oil level confirmed for orientation	N/A	Required	Required
3		Input and output direction confirmed	N/A	Required	Required
4	Preparation	Mounting surfaces cleaned and lubricated with acceptable product	N/A	Required	Selected
5	Installation	Alignment procedures followed as per Section 2.11	Required	Required	N/A
6		Manufacturer bolting and torque requirements followed	Required	Required	Required

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
7		Safety covers installed such as to allow air circulation as specified by the manufacturer	N/A	Required	Required
		Sign-off			

2.13 Drives and couplings

2.13.1 Couplings

a) The torque rating of couplings shall be suitable for the installation.
b) All power transmission elements shall be balanced. Balancing shall be done before the keyway is cut. After assembly the complete assembly shall be balanced with the key in place.
c) Sprocket or gear wheels and pulleys shall be mounted with the hub facing the shaft end. The driving axis shall be mounted close the shaft bearing to prevent high overhung loads.

Note: Slowly rotation equipment may not require balancing

2.13.2 V-belts, Wedge belts and toothed belt drives

a) Belt tension shall be set to the manufacturer's specification for the speed and load required by the design.
b) Where not specified, the maximum belt deflection at mid-point between the pulleys shall be 0.01 of the total pulley centre to centre distance.
c) Belts shall be commercially available complying with BS3790.
d) After a running period of 48 hours the tension shall be re-checked and tightened if necessary.

2.13.3 High speed chain drives

Chains shall be roller type selected in accordance with ISO10823. Sprockets shall be steel with hardened teeth to 360 Brinell.

2.13.4 Alignment

a) Read this section in conjunction with Section 2.11.3.
b) Pulley and sprocket alignment shall be checked both horizontal, vertical and for axial offset.
c) Alignment shall be completed with a calibrated laser alignment system.
d) The maximum misalignment tolerance shall be 0.4° or an offset of 0.7mm.

2.13.5 QA/QC template – Drives and couplings

Quality / Control		Measurement	Certification		
			Document supplied	Site supervisor witness	Engineer witness
1	Coupling	Torque rating suitable	N/A	Required	Required
2		Coupling balanced – record	Required	Required	N/A
3		Mounting arrangement with hub facing shaft end	N/A	Required	Required
4		Belt/Chain selection compliant – record	Required	Required	N/A
5	Alignment	Laser alignment. Alignment record provided	Required	Required	N/A
6	Belt tension	To manufacturer specification - record	Required	Required	N/A
7	Safety covers	Fitted and inspected by qualified H&S inspector	Required	Required	Required
		Sign-off			

3. Testing

3.1 Structural steel work

Testing shall be to NZS 3404 Part 1, Section 17. The test report is to be supplied as per this standard.

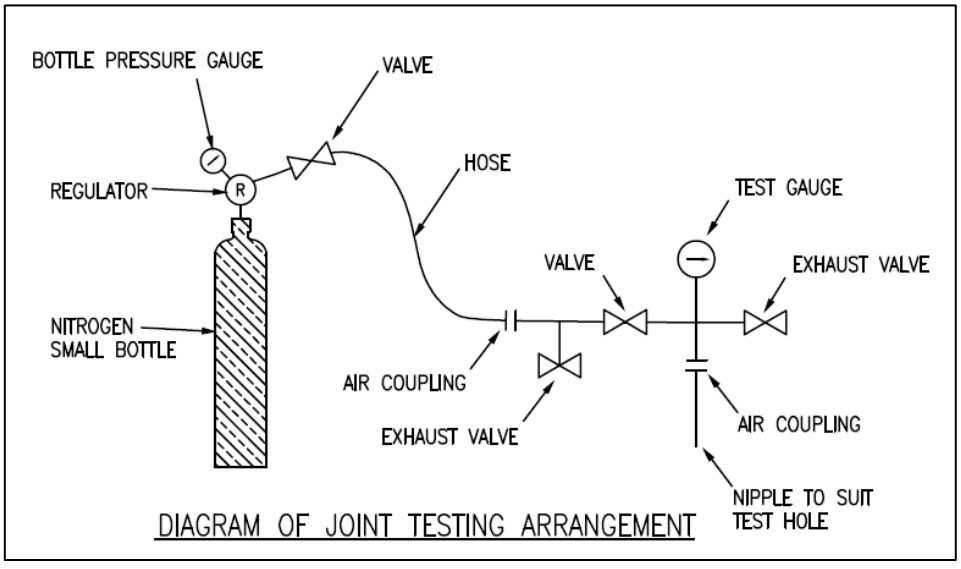
3.2 Access structures and platforms

Testing of platform load integrity shall be to NZS 3404 Part 1, Section 17. The test report is to be supplied as per the referenced standard.

Testing of guardrails and posts shall be to AS 1657 appendix B and C.

3.3 Steel pipe welding: band, socket and spigot joints – Pipe ≥ DN 700mm

The test shall be carried out after completing internal and external welds. Connect nitrogen /air supply and apply test pressure of 1,800 kPa to the annular space through a pre-drilled and tapped connection point in the joint. Once the test pressure is reached the supply is isolated and left for 5 minutes. The test is considered to pass if there is zero pressure drop. Any faults shall be rectified by cutting out and re-run of the weld section. The joint shall then be re-tested. On completion of the test the tapping shall be welded shut.



3.4 Installation of fasteners – verification of torque for flanges, structural and other bolting uses

The torque testing shall be completed to ISO 16047. The test report shall be in the format required by this standard.

3.5 Welding tests

3.5.1 Destructive testing

Destructive testing of field welds on steel pipelines is generally not required and shall only be carried out where explicitly called out in project specifications.

Where specified, destructive testing shall be carried out in accordance with AS/NZS3992 Section 7 for every pipe where severe thermal restraint and joints which may produce lamellar tearing is expected. The number of test samples shall be based on the steel thickness range as per Table 6.1 (of AS/NZS3992).

3.5.2 Non-destructive testing (NDT)

The NDT shall be selected to the weld method. Testing shall be carried out by a NATA/IANZ accredited laboratory.

- AS 2177 Non-destructive testing – Radiography of butt joints in metal
- AS 2207 Non-destructive testing – Ultrasonic testing of fusion welded joints in carbon and low allow steel.
- ISO 17643 Non-destructive testing of welds – Eddy current testing of weld by complex plane analysis

Test reports are to be supplied as per the referenced standard.