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# Pr9693 - Specification for Mechanical Installations

## Pr9693 - Specification for Mechanical Installations

### Document Details

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## 1. Purpose

The purpose of this Specification is to set down minimum requirements for mechanical equipment to ensure quality of materials, equipment and workmanship.

## 2. Scope

This Specification shall apply to works to be constructed by contract, sub-contract or direct labour.

This Specification shall apply to works being constructed directly for Unitywater or other authority or for an owner who will hand over the ownership of the constructed works to a local government or who will retain ownership.

The Scope of Work shall include the design, supply, installation, testing and commissioning of all mechanical equipment as shown in the Contract documents.

## 3. References

### 3.1. General

All work carried out under this Specification shall comply in all aspects (i.e. in design, construction, testing and performance) with the latest relevant Australian (AS), British (BS) and IEC Standards and standards in the following sections.

Reference to specific clauses of the various codes is intended to highlight those points and shall not be taken to imply a lesser importance for all other applicable clauses.

All the works shall conform to the Rules and Regulations of the Statutory Authorities having jurisdiction over the Site.

If the requirements of this Specification do not comply with the minimum requirements of the statutory regulations and standards, the latter shall apply. If the requirements of this Specification are more exacting than the minimum requirements of the statutory regulations and standards, the former shall apply.

All Materials, fittings, accessories and equipment supplied by the Contractor shall be new and the best obtainable of their kind and shall comply in all respects with the requirements of the relevant Standards Australia specifications.

### 3.2. Applicable Legislation and Regulation

At least the following legislation and related regulation shall apply:

- a. [Work Health and Safety Act 2011 \(Qld\)](#)
- b. [Work Health and Safety Regulation 2011 \(Qld\)](#)
- c. [Water Supply \(Safety and Reliability\) Act 2008 \(Qld\)](#)
- d. [Environmental Protection Act 1994 \(Qld\)](#)
- e. [Queensland Building and Construction Commission Act 1991 \(Qld\)](#)

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### 3.3. Codes of Practice (ratified by Legislation)

The following Workplace Health and Safety Queensland Codes of Practice apply:

- [Managing Noise and Preventing Hearing Loss at Work Code of Practice 2021](#), WorkSafe QLD
- [Scaffolding Code of Practice 2021](#), WorkSafe QLD
- [SEQ Water Supply and Sewerage Design and Construction Code](#) (SEQ WS & SD & C Code).

### 3.4. Codes of Practice (not ratified by Legislation)

- WSA 101 - 2008 Industry Standard for Submersible Pumps for Sewage Pumping Stations.
- WSA 130 - 2011 Industry Standard for ISO End Suction Centrifugal Pumps.
- WSA 201 - 2017 Manual for Selection and Application of Protective Coatings.

International and Australian Standards

Standard	Title
Quality Systems	
AS 2990	Quality Systems for Engineering and Construction Projects
AS 3901	Quality Systems for Design/Development, Production, Installation and Servicing
AS 3902	Quality Systems for Production and Installation
AS 3903	Quality Systems for Final Inspection and Test
Drawings	
AS 1110	Technical Drawings
AS 1101	Graphical Symbols for General Engineering
AS 1102	Graphical Symbols for Electrotechnology
Materials and Workmanship	
AS 1055	Acoustics - Description and Measurement of Environmental Noise
AS 1111	ISO metric hexagon commercial bolts and screws
AS 1112	ISO metric hexagon nuts, including thin nuts, slotted nuts and castle nuts
AS 1170.4	Structural design actions
AS 1319	Safety signs for the occupational environment
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1359	Rotating electrical machines - General requirements
AS 1554	Structural steel welding
AS 1627	Metal finishing - Preparation and pre-treatment of surfaces - Method selection guide
AS 1646	Elastomeric seals for waterworks purposes
AS 1654	ISO System of Limits and Fits
AS 1657	Fixed platforms, walkways, stairways and ladders — Design, construction and installation
AS 2032	Installation of UPVC pipe systems

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Standard	Title
AS 2107	Acoustics – Recommended design sound levels and reverberation times for Building Interiors
AS 2312	Guide to the protection of iron and steel against exterior atmospheric corrosion
AS 2528	Bolts, studbolts and nuts for flanges and other high and low temperature applications
AS 2549	Cranes (including hoists and winches) - Glossary of terms
AS 2566	Plastics pipelaying design
AS 2638	Resilient Seated Gate Valve
AS 2842	Fluid power – O Rings and Housings, Inch Series, metric conversion
AS 2885	Pipelines - Gas and liquid petroleum - General requirements
AS 4037	Pressure equipment - Examination and testing
AS 4041	Pressure piping
AS 4087	Metallic flanges for waterworks purposes
AS 4024	Safeguarding of Machinery
AS 4991	Lifting devices
AS 4998	Bolted unrestrained mechanical couplings for waterworks purposes
AS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

## 4. Definitions/Abbreviations

Term	Meaning
ABS	Acrylonitrile Butadiene Styrene
AGMA	American Gear Manufacturers Association
ANSI	American National Standards Institute
API	American Petroleum Institute
AS	Australian Standard
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BS	British Standard
BSPT	British Standard Pipe Thread
CPVC	Chlorinated Polyvinyl Chloride
CSPP	Carbon Steel Polypropylene
Construction	Any work necessary for the installation, testing and commissioning of a pipeline, maintenance hole or house drain. The term includes such operations as taking care of existing assets, clearing, excavation, erosion control, bedding, laying, jointing, backfilling, restoration, forming, concrete placing, vibrating and stripping, pressure testing and quality testing.
DFT	Dry Film Thickness
DICL	Ductile Iron Cement Lined
DIN	Deutsches Institut für Normung

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Term	Meaning
DN	Nominal Diameter (Number) (mm)
DRG	Drawing
ECTFE	Ethylene chlorotrifluoroethylene
EPDM	Ethylene Propylene Diene Monomer
ERW	Electric Resistance Weld
GR	Grade
GRP	Glass Reinforced Plastic
Hazardous Area	As defined in AS60079, an area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of (electrical) apparatus.
HDPE	High Density Polyethylene
HMI	Human Machine Interface
ID	Inside Diameter
ISO	International Organisation for Standardisation
LCP	Local Control Panel
Materials	Any raw or manufactured materials or goods. This includes all machinery, equipment and components.
MPVC	Modified Polyvinyl Chloride
OD	Outside Diameter
P&ID	Process and Instrumentation Diagram
PE	Polyethylene
PLC	Programmable Logic Controller
PN	Nominal Pressure (Number) (bar)
PP	Polypropylene
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
PVDF	Polyvinylidene fluoride
Sch	Schedule
SI	International System of Units
SS	Stainless Steel
Superintendent	As defined in the General Conditions of Contract called up in the Contract document (such as AS 2124-1992 or AS 4000) – the Unitywater employee authorised to issue instructions to contractor(s).
TP	Type
UHMWPE	Ultra High Molecular Weight Polyethylene
UNO	Unless Noted Otherwise
UPVC	Unplasticised Polyvinyl Chloride
VSD	Variable Speed Drive
WSAA	Water Services Association of Australia

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### 5. General Requirements

#### 5.1. Language and Units of Measurement

- 5.1.1 All drawings and documentation shall be written in English.
- 5.1.2 The units used throughout the project shall be the SI metric system of measurement, in accordance with AS ISO 1000-1998. Where units of another convention are nominated, conversion to SI units shall be made in accordance with AS 1376.

#### 5.2. Design Criteria

##### 5.2.1 General

- 5.2.1.1 All equipment shall be of a sound and robust design, suitable for the specified capacity or the capacity necessary to achieve the performance requirements and provided with all minor and incidental items for proper functioning of the whole system.
- 5.2.1.2 Equipment and components shall be to the manufacturer's normal design for the service specified with readily available replacement parts.
- 5.2.1.3 The designer shall be responsible for assessing the specific operating and maintenance requirements and loadings for each individual piece of equipment or facility.
- 5.2.1.4 The scope of design shall include, but is not limited to, preparation of the following:
- Engineering Reports;
  - General Arrangement Drawings – to define each facility in general terms and to provide a basis for co-ordinating detail design engineering by other engineering disciplines;
  - Arrangement Drawings – to define and locate all equipment in relation to other equipment, piping and structures;
  - Assembly and Detail Design Drawings;
  - Standard Drawings;
  - Technical Specifications;
  - Standard Specifications;
  - Design Calculations;
  - Reliability Analysis.
- 5.2.1.5 At least the following shall be considered in the design of all equipment:
- Operational site topographical, environmental and seismic characteristics and conditions;
  - Design capacity for continuous operation with minimum downtime to meet prescribed service levels and availability;
  - Surge conditions and extreme excursions from the design operating point;
  - Robustness, and necessary de-rating, of equipment to meet off design conditions for extended periods;
  - Energy efficiency not only at the design point but across the anticipated operational range;
  - Starting of equipment under fully loaded conditions;
  - Failsafe modes of operation during power outages and safe re-starting modes;

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- Standardisation of assemblies and components selected to reduce spare parts inventory;
- Economy in capital and maintenance cost consistent with reliability and reasonable operating cost (minimising life cycle costs);
- Maximising shop fabrication of systems and components.

Full details of references, assumptions made and details of computer programs used for the design shall be submitted to the Superintendent for review.

### 5.2.2 Operating Conditions

- 5.2.2.1 The design of equipment and materials shall be governed by the need for long periods of service without frequent maintenance and attention being necessary. All equipment shall be capable of operating continuously for 24 hours per day, 365 days per year over the full operating range and equipment design life across the full range of climatic conditions specified below.
- 5.2.2.2 Plant shall consist of standard commercial equipment proven in actual service conditions on similar duties, suitable for service in sewage and sludge treatment processes and environments.
- 5.2.2.3 As the equipment is to be installed in a sewage treatment plant, air can be expected to contain some sulphur bearing compounds.
- 5.2.2.4 Particular attention shall be taken in the design to ensure ease of operation, inspection and maintenance, minimum corrosion and wear, safety of operation and cleanliness of the surrounding areas. Standard replacement parts shall be readily available in Australia.

### 5.2.3 Design Life

- 5.2.3.1 Unless stated otherwise elsewhere, all mechanical equipment shall have a minimum design life of 25 years. Within the design life of equipment, only routine maintenance shall be required, without the need for a major refit or replacement. Where the equipment is in highly abrasive fluid or highly abrasive solids service, replacement of wearing parts within the design life is considered acceptable.

### 5.2.4 Design Loads

- 5.2.4.1 Mechanical equipment shall be designed to accommodate the most adverse combination of loading(s) to which it may be reasonably subjected during its design life, without the risk of equipment damage or risk of injury to personnel. Design loads shall include, but may not necessarily be limited to the following:
- Dead loads;
  - Live loads;
  - Thermal loads;
  - Wind loads – including cyclone strength winds on equipment while full or empty;
  - Earthquake loads;
  - Pressure induced loads;
  - Loads applied by machine action (e.g. torque);
  - Acceleration or deceleration (inertia) loading (e.g. braking forces);
  - Impact loads;
  - Loading produced by expansion or contraction of materials of construction;

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- Loading produced by material spillage or abnormal operation (e.g. conveyor spillage onto included walkways, blocked chutes);
  - Loading produced during the course of plant maintenance (e.g. resting equipment on included platforms);
  - Loading occurring during transport and construction.
- 5.2.4.2 Equipment shall be designed in accordance with AS/NZS 1170.0, AS/NZS 1170.1, AS/NZS 1170.2 and AS 1170.4 - Structural design actions.
- 5.2.4.3 Where equipment is driven by a prime mover(s), e.g. an electric motor or other prime driver, it shall be designed to accommodate the maximum torque that the prime mover(s) can produce.
- 5.2.4.4 Where equipment is driven by a hydraulic or pneumatic prime mover(s), it shall be designed to accommodate the maximum torque or force the prime mover(s) can produce at the pressure relief valve setting, if the Superintendent approves the setting to be lockable. If the Superintendent does not approve the pressure relief valve setting to be lockable, the equipment shall be designed for the maximum torque or force the prime mover(s) can produce at the maximum system pressure. Note that a lockable device can be locked and a setting can only be changed after unlocking the device with a key or other agreed security feature.

### 5.2.5 Fatigue

- 5.2.5.1 Equipment shall be designed for a fatigue life at least equal to the plant design life when applying maximum operating loads unless otherwise specified or approved by the Superintendent.
- 5.2.5.2 Design loads for fatigue failure analysis shall be determined from those loads applied to, or produced by, a machine whilst operating at its maximum rated capacity assuming the machine's prime mover(s) is operating at its maximum continuous rating unless otherwise specified or approved by the Superintendent.

## 5.3. Quality and Standards

### 5.3.1 Applicable Standards

- 5.3.1.1 Unless otherwise specified, the equipment covered by this Specification shall be designed, manufactured, installed and tested in accordance with the following, listed in order of precedence:
- The Project Contract documents;
  - Requirements of the Statutory Authorities having jurisdiction over all or part of the manufacture, installation or operation of the plant;
  - The SEQ WS & S D & C Code;
  - All relevant Australian and governing Queensland standards where applicable;
  - Water Services Australia (WSAA) codes.
- 5.3.1.2 In the absence of relevant WSAA or Australian codes or standards, relevant industry, international (ISO), European or British standards shall be followed. International standards shall take precedence over European or British standards. The Contractor shall obtain approval from the Superintendent prior to using any non-Australian standards not nominated in the equipment specifications, schedules, datasheets or associated drawings.

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- 5.3.1.3 Where local or international standards do not exist, the manufacture and installation of equipment shall be in full compliance with the manufacturer's own recognised standards. Manufacturer's standards, where used, shall be submitted to the Superintendent by the Contractor for review and acceptance shall be obtained by the Contractor from the Superintendent prior to commencement of manufacture.
- 5.3.1.4 All equipment shall comply with relevant Federal and State Acts, Regulations and Codes including, but not necessarily limited to, the following:
- [Workplace Health and Safety Act 2011 \(Qld\)](#);
  - [Work Health and Safety Regulation 2011 \(Qld\)](#);
  - [WorkSafe Queensland Codes of Practice](#).
- 5.3.1.5 The version of any applicable standard or regulation shall be the revision in place at the date of invitation of contract packages.

### 5.3.2 Contractor Quality Systems

- 5.3.2.1 The Contractor shall have in place a dedicated quality system that conforms to ISO 9001.
- 5.3.2.2 Quality control procedures for management, inspection, review and evaluation of all materials, manufacture, workmanship and testing of all products shall be planned and implemented by appropriately skilled and qualified persons to ensure that requirements of the quality procedures are met and that high quality is maintained.

### 5.3.3 Manufacturer's Experience

- 5.3.3.1 The Contractor shall ensure that all equipment supplied/installed under this Specification is the product of a manufacturer who is fully experienced, reputable, qualified and regularly engaged for at least five years in the manufacture of the equipment to be supplied/installed.

## 6. Technical Mechanical Requirements

### 6.1. General

- 6.1.1 All equipment shall be configured to maximise operator safety, accessibility and maintainability.
- 6.1.2 Wherever possible the component parts of similar items of plant shall be interchangeable. Similar items of plant in an installation should be standardised where possible to minimise spare parts inventories.
- 6.1.3 Spares provisioned shall be manufactured from the same materials and to the same standards in all respects as the originals and readily available in Australia.
- 6.1.4 Equipment and materials provided shall to the latest appropriate technology and of a proven design as confirmed by reference lists and other such records provided by the Contractor and shall not in any way be experimental or at any stage of development without full knowledge and consent of the Superintendent.
- 6.1.5 The Contractor shall supply where possible equipment which is sourced within Australia and is supported locally. Spare parts not held by Unitywater shall be locally available such that availability of the equipment and its ability to function normally are not compromised.
- 6.1.6 All equipment, spare parts, consumables and packing materials shall be asbestos free.

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- 6.1.7 All equipment shall have industry standard connections and interfaces detailed elsewhere in this Specification necessary for the connection to other equipment not supplied by the Contractor.
- 6.1.8 The Contractor shall offer equipment and services which comply with the tender documents but, in addition, is also invited to offer alternative equipment and services which may present greater value to Unitywater, providing the Contractor details non-compliance with the specifications in every aspect.
- 6.1.9 Where the Contractor provides his own specifications for the assembly, packing, transport, offloading, storage, installation, testing and commissioning, such work shall comply with this Specification or the Contractor's specifications, whichever is the more stringent, unless the Contractor's warranty is compromised.
- 6.1.10 Where any material or equipment is hereby mentioned by a trade name or by any other specific reference, it shall be for the purposes of indicating suitable standards of quality and functionality for the purpose intended and for no other reason.
- 6.1.11 All access openings, access ways, ladders and walkways required for the safe access to and egress from equipment for operation, maintenance and inspection shall be provided.
- 6.1.12 All parts subject to wear shall be readily accessible.
- 6.1.13 Where more than one unit is provided, sufficient supports and/or isolation valves shall be provided to enable one unit to be maintained in-situ or removed for maintenance without disrupting operation of the system.
- 6.1.14 Equipment flanges shall conform to the drilling patterns of AS 4087. If other flange drillings are provided, the Contractor shall include appropriate mating flange(s) and confirm the amended overall dimensions for installation by others. For submersible pumps, DIN/EN flanges are acceptable.
- 6.1.15 Equipment shall be accessed by platforms, ladders, stairs, guardrails etc. where necessary for operations and maintenance in accordance with AS 1657 and statutory requirements.
- 6.1.16 The Contractor shall provide two sets of any special tools required for routine maintenance or repair.

### **6.2. Noise**

- 6.2.1 The Contractor shall manage construction noise in accordance with Unitywater's Noise Management Procedure (Pr8184) and requirements of any applicable statutory approvals for the project.
- 6.2.2 The Contractor shall implement controls for noise emission of completed works to achieve the maximum noise level permitted by conditions of any statutory approvals that apply to the operation of plant and equipment and are in accordance with Unitywater's Noise Management Procedure (WHS noise levels).
- 6.2.3 Equipment and systems which do not meet these requirements on site testing may be rejected.

### **6.3. Vibration**

- 6.3.1 Equipment, pipework and valves shall be designed and installed in a manner as to minimise the transmission of vibration and noise from rotating or reciprocating equipment to other building elements, structures or equipment.
- 6.3.2 The design and selection of any absorbing or vibration compensating devices shall suit the equipment and its installation in all operating conditions.

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6.3.3 The vibration level of any item of equipment or attached pipework shall not exceed Severity Classification 2.8 in accordance with AS 2625.1 when operating over its full range. Suppliers shall nominate maximum allowable vibration in the equipment data sheets, e.g. drive end and non-drive end, x and y directions.

### 6.4. Materials

#### 6.4.1 General

- 6.4.1.1 All pipes, fittings and other materials shall be of the best quality and fit for purpose. They shall conform to the requirements of the latest relevant Standards.
- 6.4.1.2 All materials and equipment supplied shall be new and shall be suitable for its intended duty and, where applicable, the nominated sewage treatment plant and its associated environment, with appropriate abrasive and corrosion resistance.
- 6.4.1.3 All materials in contact with drinking water shall comply with the requirements of AS/NZS 4020.
- 6.4.1.4 Materials and equipment shall include all machinery, equipment and components which form a part of the works to be provided by the Contractor/Superintendent.
- 6.4.1.5 All materials and equipment shall be:
- of a duty rating appropriate to the application;
  - suitable for the purpose;
  - proven in service;
  - suitable for installation in the spaces allocated with suitable access and clearances for normal and long-term maintenance requirements;
  - compatible with other materials and equipment to be used in the works;
  - complying with the Conditions of Contract;
  - supported by appropriate servicing facilities and locally available spare parts;
  - corrosion resistant;
  - wear resistant.
- 6.4.1.6 Where products of alternative manufacturers are proposed, their acceptability and approval must be obtained from the Superintendent.
- 6.4.1.7 The Contractor shall be responsible for ensuring that materials and equipment supplied meet the specified performance, construction, quality, space and structural loading requirements.
- 6.4.1.8 Material and equipment characteristics other than those specifically covered by the drawings and specifications, shall be at least equivalent to those of any mentioned trade name or, if no trade name is mentioned, typical of the respective material or equipment kind.
- 6.4.1.9 The Contractor shall be responsible for ensuring that full allowance is made for the proper connection and interfacing of the materials and equipment with other portions of the works.
- 6.4.1.10 Samples of material shall be taken in accordance with the appropriate Australian Standard where applicable.
- 6.4.1.11 Fibre Reinforced Plastic (FRP) products shall be manufactured from materials and by processes complying with international standards for the water industry.

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- 6.4.1.12 Orthophthalic polyester must not be used on any wastewater application or in aggressive environments or for applications where frequent handling is likely.
- 6.4.1.13 Where dissimilar metals come into contact, the surfaces shall be kept from direct metal to metal contact by use of PTFE gaskets, high strength phenol washers or other approved method of isolation.
- 6.4.1.14 The following materials are prohibited and shall not be included in any components of the equipment supplied:
- Asbestos and materials containing asbestos;
  - Polychlorinated biphenyls (PCBs) and materials containing PCBs;
  - Ceramic fibres;
  - Formaldehyde insulation;
  - Halon;
  - Lead based paints;
  - Chlorofluorohydrocarbons (CFCs);
  - Radioactive materials.

### 6.4.2 Shipping and Handling Protection

- 6.4.2.1 All equipment shall be suitably protected in accordance with the manufacturer's recommendations to prevent foreign substances from entering the working parts and to prevent damage during transport, storage at the manufacturer's and/or Contractor's premises, loading and unloading and storage at the installation site.
- 6.4.2.2 Materials and equipment shall be secured rigidly in water-proof crates suitable for open air storage. Crates shall be constructed so as to be easily handled by forklift and by slings. Lifting points and orientation shall be clearly marked.
- 6.4.2.3 Suitable blocking straps and skids shall be provided to protect the equipment from damage in transit.
- 6.4.2.4 All crates or packages shall have the gross weight painted thereon in a conspicuous location (as an aid to the receiver in providing proper handling facilities).
- 6.4.2.5 Prior to dispatch from the manufacturer's premises, rotating equipment shall be fitted with individual anti-brinelling clamps to prevent both axial and radial movement of shafts during transport. The Contractor shall advise when, before or after installation, such clamps can be removed.
- 6.4.2.6 Nozzles on all equipment items such as tank connections, suction and discharge nozzles and pipe ends shall be protected using timber or plastic covers and securing bolts or tape to prevent entry of foreign bodies into the relevant equipment. Where equipment is packed in robust closed shipping crates, nozzle covers are not required.
- 6.4.2.7 All gasket surfaces, flange faces, tube holes and tube ends shall be thoroughly cleaned and greased and protected with suitable wood, metal or other substantial covering to ensure their full protection.
- 6.4.2.8 All exposed threaded parts shall be greased and protected with metallic or similar substantial protectors.

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- 6.4.2.9 All female threaded openings shall be closed with tight fitting plastic closures unless otherwise specified. Where equipment is packed in robust closed shipping crates, closure plugs are not required.
- 6.4.2.10 Should special lifting frames or beams be required for installation purposes, these and their instructions for correct use shall be supplied by the Contractor.
- 6.4.2.11 Pipes, fittings, pipeline materials and equipment shall be stored, transported and handled with care. Adequate precautions shall be taken to maintain the circularity of the ends of all pipes to ensure watertight joints when assembled. Slings, hooks and lifting appliances shall be of the correct type as recommended by the manufacturer. Items shall be stacked safely, off the ground on timber or polystyrene blocks.
- 6.4.2.12 All gaskets shall be stored in a cool, dry place away from direct sunlight.
- 6.4.2.13 At the works and on site, all mechanical components and structural steelwork shall be stacked clear of the ground so that the collection of water in troughs, pockets and the like is reduced to a minimum. Parts which can be damaged by rain shall be stored under cover.
- 6.4.2.14 Any item of equipment that has been incorrectly exposed to the weather, flooding, heat, impact or similar abuse may be rejected by the Superintendent. The Contractor shall make good or replace any damaged materials or equipment.

### 6.4.3 Workmanship

- 6.4.3.1 All workmanship shall:
- be in accordance with the best modern trade practice, relevant Standards and Codes of Practice;
  - comply with the Project Contract documents;
  - be carried out by appropriately qualified and experienced tradesmen;
  - be carried out under the supervision of a competent foreman;
  - result in a high standard of construction and leave a thoroughly efficient, robust, tidy and fully operational and safe installation.
- 6.4.3.2 Machining shall be concentric, square to line and true. All sharp edges and burrs shall be removed.
- 6.4.3.3 Bolt holes shall be drilled and spot faced for bolt head and nut. Mating parts shall be match-marked and dowelled.
- 6.4.3.4 Defective work shall not be repaired by welding, filling, plugging or any other process unless written permission is granted by the Superintendent.
- 6.4.3.5 The Contractor shall ensure only qualified and competent personnel carry out welding work and, where necessary to meet Australian Standards, carry out non-destructive testing. Any periodic non-destructive testing, and its interval, deemed necessary during normal operation of the equipment shall be advised by the Contractor.

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### 6.4.4 Castings

6.4.4.1 Preferred grades for cast materials are outlined in the table below.

**Table 1 - Preferred Grades for Casting Material**

Material	Preferred Grade
Spheroidal Graphite Iron	AS 1831, grade 450-310-10
Austenitic Iron	AS 1833, grade S-Ni Cr 20 2 (spheroidal graphite)
Carbon Steel	AS 2074, grades C3 or C4
Stainless Steel	AS 2074, grade H6C

- 6.4.4.2 Castings shall be close and uniform in grain, homogeneous and free from blowholes, porosity, shrinkage, cracks and other injurious defects. Filling of holes with any substance shall not be permitted. Castings shall be properly cleaned, fettled and have all lumps and rough areas smoothed.
- 6.4.4.3 Defects in steel castings may be repaired by electric welding to the extent allowed by recognised good practice, provided that the approval of the Superintendent is first obtained.

### 6.4.5 Stainless Steel

- 6.4.5.1 Stainless steel plate and bar subjected to welding during the manufacture of any component shall be Grade 316L (X2CrNiMo1712 to ISO 9328). Stainless steel plate or bar not subjected to welding shall be grade 316 (X5CrNiMo1712 to ISO 9328).
- 6.4.5.2 Stainless steel castings shall be a stabilized grade in accordance with AS2074-2003 - Steel castings, grade H6C.
- 6.4.5.3 Stainless steel in shafts, spindles or similar shall be grade 420 (X20Cr13 to ISO 9328).
- 6.4.5.4 All stainless steel shall be passivated. Stainless steel fabrications in highly corrosive environments, un-vented sewage applications in the presence of hydrogen sulphide such as sewage pump station wet-wells shall be electropolished in accordance with System 22, Section 14.4 of this Specification.
- 6.4.5.5 Graphite greases, graphite packing and graphite compounds shall not be used in contact with stainless steel.
- 6.4.5.6 Stainless steel sheet and components shall be kept separate from carbon steels during fabrication, storage and assembly. Abrasive grinding and cutting wheels previously used on carbon steels shall not subsequently be used on stainless steels. Protective coverings and space separation of storage, fabrication and working areas shall be used to prevent contamination of stainless steels with particles of carbon steel.

### 6.4.6 Carbon Steel

- 6.4.6.1 Carbon steel shall be to AS 3679.1-1996 – Structural Steel – Hot-rolled bars and sections, grade 250.
- 6.4.6.2 All mechanical equipment of carbon steel construction shall be hot dip galvanized or shall be given protective coatings to the appropriate system as set out in Section 14 Corrosion Protection of this document. Such equipment shall include pipe and machinery supports, platforms, stairs, guardrails, baseplates, covers, and other items as specified. Galvanizing shall comply with AS/NZS 4680 and articles shall have a coating thickness not less than HDG 390.

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### 6.4.7 Frames and Mountings

- 6.4.7.1 Where the design of the baseplate is such that pockets of air would be trapped during grouting, air vent holes shall be provided to allow air to escape.
- 6.4.7.2 Where separate components/items of interconnected plant depend on correct alignment for satisfactory operation each item shall be positively located by machined spigots or by dowels or pins after alignment.
- 6.4.7.3 All supports, holding down details and fixings for plant and equipment shall be provided to ensure that all plant, equipment, mountings, supports and concrete plinths (where suitably designed and constructed) can withstand design loads in accordance with Section 5.2.4 of this document.
- 6.4.7.4 All plant items shall be delivered to site with the necessary support fixings and anchors.
- 6.4.7.5 Baseplates for motor driven plant shall rigidly hold both the driver and driven units. Sub-baseplates shall be welded to the main baseplate. Fixing systems provided with baseplates shall be designed for taking up adjustment necessary to compensate for coupling alignment and wear during normal service.
- 6.4.7.6 Baseplates shall have sufficient rigidity to support the equipment mounted on it during handling (where applicable) or use, without distortion or deflection that could permanently damage the equipment or baseplate. Eye bolts or holes shall be provided for lifting the complete assembly on the baseplate in addition to lifting facilities on the individual components. The entire assembly shall not be lifted on component lugs other than those on the baseplate itself.
- 6.4.7.7 Provision shall be made on all baseplates to enable them to be completely filled with grout after installation. Grout filling is not required for submersible pump baseplates.
- 6.4.7.8 All baseplates, pipe supports, and other items fixed to the concrete foundation shall have straight smooth sides.
- 6.4.7.9 No holes in steelwork shall be formed by flame cutting.
- 6.4.7.10 All bolt holes in steelwork shall be a distance of not less than 1.5 times the hole diameter from the nearest metal edge, unless otherwise specified.
- 6.4.7.11 Flexibly mounted equipment shall be provided with suitable snubbers with resilient surfaces to limit seismic movement.
- 6.4.7.12 With the exception of fabricated submerged equipment which needs to be periodically inspected for necessary integrity of welded components, frame members, if constructed from hollow sections, shall have ends closed off and be fully sealed against ingress of moisture. Galvanized hollow frame members shall have bleed holes fully sealed after being galvanized.
- 6.4.7.13 Mounting point holes shall be drilled for stainless steel bolts. These shall be used in conjunction with levelling nuts during equipment installation. Separation of the galvanized steel and stainless steel shall be required to prevent possible galvanic action.

### 6.4.8 Packers and Shims

- 6.4.8.1 All packers and shims used in the levelling of equipment shall be made from uncoated new material only, having flat surfaces free from corrosion, indents or burrs. Shims shall cover a minimum of 75% of the equipment foot face. Edges shall not protrude beyond the mating surfaces.
- 6.4.8.2 Shim material shall be "Plasti-Flex" or similar.

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6.4.8.3 Machined surfaces shall be coated with corrosion inhibiting grease (Lanotec Type A or similar).

### **6.4.9 Nuts, Screws, Washers, Bolts, Fixings and Fasteners**

- 6.4.9.1 All bolts, screws, studs, nuts and ISO metric hexagon lifting clamps shall be manufactured from grade 316 stainless steel, unless noted otherwise.
- 6.4.9.2 All bolts, screws, studs and nuts shall comply with all parts of AS 1111 and AS 1112, including thin nuts, slotted nuts and castle nuts.
- 6.4.9.3 All plain washers shall comply with AS 1237 normal diameter metric scales.
- 6.4.9.4 All dowels shall be manufactured from a suitable grade of stainless steel.
- 6.4.9.5 Nickel-based galling prevention compounds shall be applied to all stainless steel threads prior to assembly.
- 6.4.9.6 Flange bolting shall be in accordance with AS 2528. Stud bolts shall not be used unless required for tapped holes.
- 6.4.9.7 Blind rivets shall only be used where nuts, bolts and screws are not practicable, and shall comply with IFI-505:1999 "Metric Break Mandrel Blind Rivets".
- 6.4.9.8 Self-tapping screws shall comply with AS 3566.
- 6.4.9.9 The Contractor shall ensure that the supplier of the specific piece of equipment confirms the hold-down requirements and fixing points, and unless otherwise specified, the supplier also designs and supplies all anchor bolts, nuts and washers for the equipment supplied.
- 6.4.9.10 The minimum size of fixings and fasteners shall be M12 on all items other than proprietary items such as gearboxes and motors.
- 6.4.9.11 Each bolt and nut shall be assembled with one washer which shall be placed on the surface against which the stationary component is to be tightened. Tapered washers shall also be fitted, where necessary, to ensure full-face contact.
- 6.4.9.12 On fixings and fasteners that may be subject to vibration, an approved method of locking shall be incorporated. Anchor bolts for vibrating equipment installation shall follow approved standards. In the absence of an appropriate standard, the bolts should have a minimum length of 300 mm and shall be designed to be epoxy fixed into a hole drilled into the concrete by the Contractor. Epoxies exposed to potable water shall comply with AS 4020. Plant hold-down bolts shall have double nuts; machinery shall have nylon lock nuts, locking tab or spring washer.
- 6.4.9.13 Care shall be exercised when installing fixings and fasteners so as not to damage any thread or protective coating. Should any such damage occur, the fastener or fixing shall be replaced.
- 6.4.9.14 All bolts shall be of a length such that when assembled and fully tightened, the nut shall be totally engaged, but with no less than three threads and no more than five threads protruding.
- 6.4.9.15 Stainless steel fixings and fasteners shall be used for the fixing of demountable galvanized or aluminium parts. Fibre or nylon insulating washers shall be fitted beneath the bolt head and washer on such demountable items. Where it is not practicable to fit an insulating washer under the fastener head (e.g. countersunk screws securing an aluminium plate) the thread and head of the fastener shall be coated with an anti-corrosive compound such as Duralac-Anti Corrosive Joining Compound upon assembly.

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- 6.4.9.16 Equipment bolted to frames and structures shall have the bolt heads on top of the connecting components, so that the bolts will not drop out of the holes whenever a nut works loose.
- 6.4.9.17 Drilling of bolt holes shall be accurate and any slight misalignment in the matching of holes may be corrected by reaming. Where excessive misalignment occurs, the holes shall be filled by electric welding and re-drilled. Drifting to enlarge or draw unfair holes will not be permitted.
- 6.4.9.18 Where anchor bolts are required for fixtures to previously completed concrete work the Contractor shall submit details of the proposed chemical or mechanical masonry anchors or block-outs.

### 6.4.10 Tolerances

- 6.4.10.1 All identical parts of plant shall be manufactured to such tolerances as to ensure that they are fully interchangeable.

### 6.4.11 Limits and Fits

- 6.4.11.1 All limits and fits shall be selected in accordance with AS 1654.

### 6.4.12 Equipment Positioning and Placement

- 6.4.12.1 Each item of equipment shall be correctly positioned in both line and level in relation to relevant set out marks, bench marks, grid lines and dimensions.
- 6.4.12.2 Prior to commencing installation of equipment, all foundation elevations and bolt locations shall be verified. Bending of bolts to fit shall not be permitted. All interfaces between items of equipment shall be correct prior to start of installation.

### 6.4.13 Eyebolts and Lifting Lugs

- 6.4.13.1 All equipment shall be fitted with such permanent eyebolts, lifting lugs or jacking points as are required to install, remove, and maintain the equipment. These attachments shall be located such that equipment is balanced and stable during lifting placement. The lifting points shall be clearly marked.
- 6.4.13.2 Where equipment is fixed to a baseplate and both the equipment and baseplate are fitted with lifting lugs, only the lifting lugs fitted to the baseplate shall be used for lifting the baseplate and fixed equipment. The lifting lugs provided on the equipment shall not be used to lift the fixed equipment and baseplate together.

### 6.4.14 Lifting Equipment

- 6.4.14.1 All equipment shall be readily accessible for removal. Lifting gear, either fixed or portable, shall be provided as appropriate. All lifting points and appliances shall comply with the relevant Australian regulations and standards.
- 6.4.14.2 All items of lifting equipment supplied shall be clearly marked with the Safe Working Load in accordance with AS 2549 and AS 4991, with lettering that can be read easily from the nearest normal working platform or floor.
- 6.4.14.3 The Contractor shall provide an original Certificate of Test and Examination signed by the person doing the test and examination in accordance with AS 2549 and AS 4991.
- 6.4.14.4 All temporary lifting devices such as davits shall be load tested in their location of use and certified accordingly. Supports for such devices shall be designed such that overall deflection (including that of the support) remains within prescribed limits.

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- 6.4.14.5 All permanent lifting equipment and pressure systems must be registered with Unitywater. The Contractor shall inform the Superintendent of his intention to supply all such equipment and systems. The Contractor will be advised of the plant identification number for stamping, printing or otherwise fixing as directed by the Superintendent to the equipment after the completion of site testing.

### 6.4.15 Flexible Connections

- 6.4.15.1 Flexible connections shall be bolted directly to the flanged outlets of mechanical equipment as shown on the drawings.
- 6.4.15.2 Grade 316 stainless steel bolts and retainer plates or flanges shall be provided at each end of flexible connections. All flexible connections shall prevent any external loads from being transferred to the mechanical equipment. All flexible connections shall be rated for operating pressures including the pipeline design rating.

### 6.4.16 Keys and Keyways

- 6.4.16.1 All keys and keyways shall comply with BS 4235.

### 6.4.17 Lubrication and Lubrication Systems

- 6.4.17.1 All components shall be lubricated as required prior to testing and delivery.
- 6.4.17.2 Prior to placing machinery into service, all reservoirs, sumps and tanks shall be filled to their correct levels and all lubrication pipework shall be fully primed in accordance with the manufacturer's recommendations.
- 6.4.17.3 The lubricant shall be suitable for the particular duty and ambient temperature conditions. Two or more brands or types of lubricants shall not be mixed.
- 6.4.17.4 All items above coping level requiring lubrication shall be capable of lubrication from one location, if at all practical.
- 6.4.17.5 Unless specified otherwise, grease lines, brackets, and fittings shall be stainless steel. High pressure flexible lines shall be used in moving or vibrating applications. All grease lines shall be of adequate size and strength and permanently marked for identification.
- 6.4.17.6 The amount of oil used shall be adjusted in accordance with the manufacturer's instructions before and during start up, to ensure correct performance.
- 6.4.17.7 Brands, grades and types of lubricants shall not be mixed for the same machine application.
- 6.4.17.8 A list of recommended lubricants and their equivalents shall be provided by the Contractor. Lubrication points shall be labelled with "initial fill" lubricants.
- 6.4.17.9 All mechanical equipment shall be furnished with the correct lubricants to prevent corrosion during storage and installation and for starting and commissioning the plant. Gearboxes and transmissions shall be flushed with an approved flushing oil in accordance with the supplier's recommendations.
- 6.4.17.10 The flushing procedure shall include, where possible, manual rotation of equipment to ensure complete penetration. On completion of flushing the flushing oil shall be completely removed prior to filling with the running oil. Flushing oil, once used, shall not be re-used. Lubricants and frequency of application shall be as recommended by the relevant equipment manufacturer and provided to the Superintendent prior to commencement of commissioning.

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- 6.4.17.11 All lubrication and oil fill points shall be labelled to specify the type of lubricant used and the quantity required. A nameplate shall be provided at each remote lubrication point to indicate the item it serves. Plates shall be engraved stainless steel Grade 316, fastened with stainless steel screws. Lubrication nameplates are not required on submersible pumps.
- 6.4.17.12 Where lubrication is required at a frequency higher than one application per week an automatic lubrication system shall be provided. The automatic system, whether centralised or decentralised, shall be easily viewed for fill status and functionality by the operator.
- 6.4.17.13 All items of mechanical equipment shall be provided with a lubrication schedule showing recommended lubricants, acceptable alternative lubricants, lubrication points, lubrication volumes and lubrication frequency. The lubrication schedule for each item of equipment must be delivered to the Superintendent separately and prior to the delivery of the equipment.
- 6.4.17.14 Recirculating oil systems shall be provided with an easily and safely accessible reservoir. The reservoir shall be provided with a contents level indicator and a filler point complete with filter. Lubrication systems reliant upon pumped circulation of the lubricant and where failure of the system would result in catastrophic failure of the process plant or equipment shall incorporate instrumentation to provide an alarm signal in the event of a blockage, loss of lubricant or another malfunction.
- 6.4.17.15 Lubrication systems for plant used on potable water treatment installations shall be designed to ensure that failure will not affect the potable water supply.

### 6.4.18 Welding

- 6.4.18.1 All welding shall be performed in accordance with AS/NZS 1554.
- 6.4.18.2 Prior to carrying out any welding, both welding and welder qualification procedures for each type of weld to be used shall be provided to the manufacturer's Inspection and Test Plan as a hold point.
- 6.4.18.3 Site welding shall be minimised. All welding shall be of sound quality. In general, welding shall be continuous, smooth and straight and with no inclusions. All other equipment in the vicinity of welding work shall be adequately protected from spatter.
- 6.4.18.4 All welds shall provide a complete seal against the ingress of water to the interface of adjoining surfaces or into hollow section members where corrosion protection cannot be completely effective. Where intermittent welds are adequate for structural purposes, light seal welds shall be applied to form a complete seal.
- 6.4.18.5 Welds shall be ground smooth where necessary to allow appropriate coating over the internal surfaces. All weld spatter and slag shall be removed.
- 6.4.18.6 Stainless steel pipe welds shall be passivated as soon as practicable after welding. Welds shall be contiguous and fully penetrating so that crevices do not occur.
- 6.4.18.7 Cutting of pipe may be done either by mechanical means or by flame cutting, depending on the type of material to be cut. For carbon steel, flame (or arc) cutting and bevelling is acceptable only if the cut is reasonably smooth and true, and all oxides are removed from the flame cut surfaces by grinding back to bright and sound metal. For stainless steel, flame cutting is not permitted.
- 6.4.18.8 For stainless steel plasma cutting, if the pipe ends cannot be machined the pipe must be ground back to bright sound metal prior to welding.
- 6.4.18.9 All welding areas shall be adequately protected against inclement weather conditions such as rain, wind, dust and the like.

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- 6.4.18.10 All weld end preparations and adjacent areas 50 mm either side of the weld shall be thoroughly cleaned and degreased prior to welding.
- 6.4.18.11 Repairs to welded joints, defective or damaged pipe fittings or any other pressure part shall not be carried out without notifying the Superintendent.
- 6.4.18.12 If repairs or modifications are carried out after heat treatment has been completed, the areas affected by the repair or modification shall be heat treated again.
- 6.4.18.13 Joints shall be tested using non-destructive testing (NDT) techniques, unless it is necessary to use destructive testing to achieve adequate interpretation. When interpreting NDT findings of welds made in castings and ductile iron, consideration shall be given to allowable defects in the parent material. All NDT results shall be provided to the Superintendent.
- 6.4.18.14 Welded components shall be stress relieved prior to machining.

### **6.4.19 Guardrails, Fixed Platforms, Walkways, Ladders, Grating and Scaffolding**

- 6.4.19.1 Guardrails, stairways and ladders shall be designed, supplied and installed as required to comply with the requirements of this Specification, AS 1657 and those of Workplace Health and Safety Queensland and any other Statutory Authority having jurisdiction over the work.
- 6.4.19.2 The installer shall supply and install temporary scaffolding in accordance with the Workplace Health and Safety Queensland's Scaffolding Code of Practice 2021 and AS 4576 where required when installing the access system.
- 6.4.19.3 Permanent walkways, stairways and platform grating shall be of aluminium construction in accordance with the requirements of the Pr9903 - Specification for Building and Structural Works.
- 6.4.19.4 All dimensions shall be reconfirmed on site prior to fabrication.
- 6.4.19.5 Toe-boards shall be fitted to the side-offset and side mounted stanchions.
- 6.4.19.6 Cut-outs in the grating to suit valve spindles etc. and additional toe-boards shall be provided by the Contractor. Cut-outs in the grating shall be sized to suit and the exposed edges shall be fitted with welded trim bars across the longitudinal runners.
- 6.4.19.7 All guardrails, stairways and ladders shall be fabricated to measurements taken on site by the Contractor. Dimensions shall only be taken off or scaled from the drawings for pricing purposes.
- 6.4.19.8 Permanent guard railing, platforms and stiles shall be entirely fabricated off-site. Site welding or cutting shall not be permitted. Whenever possible, joints in the rails shall be inside the stanchion knuckles.
- 6.4.19.9 Where dissimilar metals come into contact with each other, their surfaces shall be protected, separated and isolated by gaskets, washers, or neoprene strip as applicable. All aluminium surfaces to be placed in contact with concrete shall be painted with two (2) coats of approved epoxy tar paint over the area of contact.
- 6.4.19.10 The number of openings for access shall be restricted to the minimum and closed off by self-closing gates and self-latching gates when not in use. The gates shall open towards the safe approach walkway and in the closed position shall resist the same loading as the guardrails. Barrier bars hinged and retained at one end may only be used with the written approval of the Superintendent. Chains across openings are not acceptable under any circumstances.
- 6.4.19.11 All cuts shall be square and accurate for minimum joint gap.
- 6.4.19.12 Weep holes shall be provided where necessary to drain all possible entrapped water.
- 6.4.19.13 Allowance for expansion shall be provided at a maximum spacing of 30 metres.

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### 6.4.20 Void Protection and Fall Arrest Systems for Pit Openings

- 6.4.20.1 All openings on pits such as pump station wet-wells, dry-wells, valve chambers, etc. that are normally covered by aluminium access covers shall be fitted with void protection systems.
- 6.4.20.2 The void protection system shall include the items outlined in the table below:

**Table 2 - Void Protection Requirements**

Void Protection Equipment	Requirements	Design Reference
Hinged aluminium safety grille	Safety grille is required on openings used for inspection or cleaning of the pit area, without personnel entry into the pit, e.g. pump station wet-wells, dry-wells, etc.	Refer SEQ-SPS-1304 series drawings for grille details
	Safety grille is not required on openings used primarily for entry into the pit, i.e. openings dedicated to pit access ladders, etc.	
Railsafe post inserts	Post inserts required for a temporary barricade around pit openings. Posts and handrails to be supplied by others.	Refer SEQ-SPS-1300 series drawings for positioning of Railsafe post inserts
Recessed davit base for a portable SALA davit	Flush-mounted davit base required to service the opening. A cap is required on certain models to plug the davit base. Davit to be supplied by others.	Refer SEQ-SPS-1300 series drawings for positioning of SALA davit bases
Fall arrest anchor point	Anchor point required for attaching safety lanyard when personnel are working around the pit opening.	Refer SEQ-SPS-1300 series drawings for positioning of anchor points

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6.4.20.3 The following height safety equipment shall be selected and installed where appropriate to provide fall arrest systems:

**Table 3 - Height Safety Equipment Requirements for Fall Arrest Systems**

Manufacturer	Vendor Part Number	Description
SALA	8518503 [HOLD]	Davit base, Floor-mounted galvanized steel
SALA	8518504 [HOLD]	Davit base, Wall-mounted galvanized steel
SALA	L-4035 [HOLD]	Davit base, Flush floor-mounted stainless steel with bevelled edge on top flange (suitable for retrofitting to concrete slab)
SALA	L-4034 [HOLD]	Davit base, Flush floor-mounted stainless steel with square edge on top flange
SALA	8510311 [HOLD]	Davit base, Flush floor-mounted cast-in-place zinc plated steel (suitable for casting in thin slab concrete)
SALA	8510109 [HOLD]	Davit base, Flush floor/core-mounted cast-in-place galvanized steel (suitable for casting in thick slab concrete)
SALA	8510553 [HOLD]	Sleeve cap, stainless steel for flush floor-mounted cast-in-place davit bases
SALA	2101000	Stainless steel anchor socket for detent pin
SALA	2101002	Stainless steel detent pin
SALA	8518001 supplied complete with Part No. 8516824 & 8510207 [HOLD]	Advanced upper offset mast
SALA	8518003 [HOLD]	Advanced lower mast extension, 1143 mm
SALA	3400956 supplied complete with mounting bracket Part No. 3401025	Emergency retrieval sealed self-retracting Lifeline, 15 m SS wire rope
Kennedy's Aluminium	2011-002	Railsafe Post Inserts
BTS	A30106-PD	PRO-3G Davit - 2.2m c/w Quick Release Double Sided Universal Male Interface Bracket
BTS	A30070-PD	PRO-3 Portable Base – "H" Frame Opening Size: 1.35m – 1.87m
BTS	A300115-PD	PRO-3 Portable Heavy Duty Base – "H" Frame Opening Size: 1.45m – 3.40m
BTS	A60002-PD	BTECH Man / Materials Rated Winch 18m wire rope

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### 6.4.21 Pressure Gauges and Pressure Gauge Connection Points

- 6.4.21.1 All pressure gauges shall comply with AS 1349. Pressure gauges shall be Bourdon tube gauges unless otherwise specified.
- 6.4.21.2 For wastewater and sludge applications, pressure gauges shall be independently mounted on a stub branch line not less than DN50 for pipe sizes of DN50 and above. For pipe sizes below DN50 the stub branch shall be the same size as the pipe. All gauges shall be protected by a stainless steel seal diaphragm. An isolating valve shall be installed in each stub branch line on the pump side of the diaphragm. A bleed valve shall be provided on a tee between the isolation valve and the gauge to enable zeroing of the gauge. All gauges shall have concentric dials of at least 100 mm graduated in kilopascals (kPa). Under maximum head conditions the gauge pointer shall not exceed 90% of Full-Scale Deflection (FSD). Ideally the guaranteed duty head shall be approximately 70% FSD.
- 6.4.21.3 Pump suction gauges shall be compound gauges to read both pressure and vacuum.
- 6.4.21.4 A test certificate for each gauge must be produced by the Contractor and a copy included in the relevant section of the Operating and Maintenance Manuals.
- 6.4.21.5 Pressure gauges shall be mounted in a position that is clearly visible from a walkway or access platform. Where practicable, pressure gauges on an item of plant shall be mounted at the same height.
- 6.4.21.6 Where gauge connections are requested without the gauge being fitted, the connection shall be provided with the isolation valve.

### 6.4.22 Plant and Equipment Identification

- 6.4.22.1 Labelling and identification of equipment, services (pipework, ductwork, etc.) and the like shall be in accordance with AS 1319 and AS 1345.
- 6.4.22.2 All equipment shall be provided with permanently fixed nameplates and tag plates of engraved stainless steel Grade 316. Fixings shall be of similar material as the label or nameplate. Adhesive nameplates or labels shall not be used unless otherwise approved. All labelling shall be plainly visible at the angle from which the equipment is likely to be viewed.
- 6.4.22.3 Nameplates on mechanical equipment shall show all information necessary for the proper identification, servicing, maintenance and operation of equipment and shall include the following information where applicable:
- Manufacturer's name, model number, size and serial number;
  - Date and country of manufacture;
  - Critical operating (capacity) data and adjustments such as pump capacity (m<sup>3</sup>/h or L/s)
  - Head (m H<sub>2</sub>O or kPa);
  - Design and hydrostatic test pressure (kPa(g));
  - Impeller or rotor type and size;
  - Rotating equipment speed (rpm);
  - Lubrication—type, quantity, frequency, and fill levels;
  - Direction of rotation and/or flow;
  - Warning notices;
  - Temperature limits;
  - Weight (dry or wet but this must be specified);
  - Machine bearing identity drive end and non-drive end.

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- 6.4.22.4 A separate equipment tag plate shall be affixed to the equipment including the following information:
- Tag number in accordance with Unitywater's Asset Numbering System, in letters not less than 3 mm thickness and 25 mm high;
  - Name of equipment.
- 6.4.22.5 Machines shall have a direction of rotation arrow cast into casing or indicated on a stainless steel plate mounted on the bearing housing or machine pedestal close to the drive end.
- 6.4.22.6 All motors shall also be fitted with engraved stainless steel nameplates fastened to the motor body.
- 6.4.22.7 Valves shall be provided with identification tags. Tags shall be engraved stainless steel plate and securely fastened to the valve.
- 6.4.22.8 Every instrument shall have a tag stating the tag number securely attached to the body. Tags shall be engraved stainless steel plate. Note that Dymo style tags are not acceptable.
- 6.4.22.9 Tag format shall be as provided in the equipment schedules and drawings.
- 6.4.22.10 All labels shall be in English.
- 6.4.22.11 Sample labels shall be provided for acceptance by the Superintendent.
- 6.4.22.12 Identification lettering and banding for pipes and services shall be applied in accordance with AS 1345:
- For buried and concealed runs (including in floors and walls) – at the points where the service disappears/reappears;
  - For concealed runs in ceiling spaces – at least once;
  - For exposed runs – at least once.
- 6.4.22.13 The identification on the band shall consist of indelible stencilled lettering 25 mm high.
- 6.4.22.14 The direction of flow in pipes and ducts shall be appropriately indicated by an arrow of length 3 x diameters of pipe and its insulation.
- 6.4.22.15 Where these services are required to be painted, the identification band colour shall extend throughout the length of the service.
- 6.4.22.16 Colours, letters, arrows and labels shall be plainly visible at the angle from which the works are most likely to be viewed.

### 6.4.23 *Balancing and Critical Speed*

- 6.4.23.1 Rotating elements shall be statically and dynamically balanced. Vibration levels shall not exceed values stated above and shall be evaluated in accordance with AS 2625.4. Lateral critical speeds shall not occur within the range between  $\pm 20\%$  of the rotational speed. Fixed speed machinery which needs to pass through its first critical speed to reach its normal running speed shall do so without damage to the machine and other rotating elements. The speeds of machines which are designed to be driven at variable or partial speed shall be comfortably in range of "normal running speed" so as not to cause damage or adversely affect machine design life. Torsional critical speeds shall not occur within the range between  $\pm 10\%$  of the rotational speed.

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### 6.4.24 Bearings

- 6.4.24.1 All bearings shall be heavy duty, grease lubricated unless noted otherwise, and selected to accommodate all mechanical loads imposed by the operation of the equipment including starting and motor stall, up to its maximum operating conditions.
- 6.4.24.2 All bearings shall be to ISO standard SI unit dimensions where practicable.
- 6.4.24.3 All bearings shall be sealed to prevent contamination and fitted in machined housings and located by dowels to assist maintenance.
- 6.4.24.4 Ball and roller bearings shall be steel caged. All ball or roller bearings shall be rated in accordance with AS 2729 with factors a1, a2 and a3 equal to one (1) to give a L<sub>10</sub> life of 100,000 hours unless otherwise specified.
- 6.4.24.5 Bearings on rotating machinery shall be supported during transportation to ensure work hardening does not take place. Signage to this effect must be prominently displayed.
- 6.4.24.6 Plain bearings shall have steel shafts running in bronze bushes and shall have a loading, based on projected area, of not more than 300 kPa. Materials other than steel and bronze may be accepted where full details are submitted to and accepted by the Superintendent.
- 6.4.24.7 Drive shafts shall be mounted in heavy duty bearing assemblies. The bearings may be oil or grease lubricated. Oil-bath lubricated bearings shall be fitted with a pressure venting device, oil fill and drain tappings and an oil-level sight glass. Where grease lubrication is provided, grease relief provisions shall be supplied to prevent over greasing. Routine greasing points shall be located at an accessible location, without the need for removal of guards or covers.

### 6.4.25 Seals – General Requirements

- 6.4.25.1 Seals shall be designed for a life of 100,000 hours except for applications where this cannot be achieved by current seal technology. In this exception long life seals shall be used and the seal installation shall be designed to permit quick replacement without major equipment dismantling. The service life shall be extendable for an additional 100,000 hours with retrofitting.
- 6.4.25.2 Seals shall be an approved design effective for their purpose and requiring a minimum of maintenance.
- 6.4.25.3 Material for seals shall be natural rubber, synthetic polyisoprene or a mixture of natural rubber and nitrile rubber. The rubber hardness shall be as required by the seal design for the pressure specified and, if required, shall be reinforced with Kevlar fabric.
- 6.4.25.4 Subject to the approval of the Superintendent, other elastomers with durability and mechanical properties at least equivalent to the materials specified may be substituted.

### 6.4.26 Seals - O-Rings

- 6.4.26.1 O-rings for flanges shall comply with AS 4087.
- 6.4.26.2 O-rings which seal components shall comply with the relevant sections of AS 1646 and AS 2842.

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### 6.4.27 Mechanical Seals

- 6.4.27.1 Mechanical seals shall have a design life of 5 years when working 24 hours per day, 365 days per year.
- 6.4.27.2 Where mechanical seals are fitted the pump shaft deflection, at the location of the seal, shall be 50 µm (0.05 mm) or less.
- 6.4.27.3 For pumping applications the seals may be single face seals or double face seals, depending on the service conditions and the fluid being pumped. Seal faces shall be lapped flat to within two (2) helium light bands and the depth of interface roughness shall not exceed 0.3 µm.
- 6.4.27.4 Mechanical seals shall preferably be designed to operate without the need for external cooling/flush water. If seal cooling/flush water is required, the Contractor shall indicate the flow rate and pressure necessary.
- 6.4.27.5 Pump and seal design shall be such that interface temperatures under operating conditions remain safely below the vaporisation temperature.

### 6.4.28 Couplings

- 6.4.28.1 Couplings shall be selected to enable separation of the driver and driven components without the need to disturb the “other” component. Split-type couplings shall be supplied as a matched pair and shall be marked accordingly. Couplings shall be manufactured from forgings and shall be secured to their shafts by key and keyway. Spacer-type couplings shall be used where this would facilitate maintenance of either the driver or driven machine in-situ.
- 6.4.28.2 Couplings shall be designed to take up axial shaft movement from either driver or the machine, or both, without either the driver or the machine being affected.
- 6.4.28.3 Flexible shaft couplings shall be provided, where necessary, between motor shafts and the driven shafts. Flexible couplings shall be of cone ring type or flexible element type rated to suit the torque output of the motor or gearbox under all conditions of loading.
- 6.4.28.4 All nuts, bolts and studs on the couplings shall be of stainless steel Grade 316.
- 6.4.28.5 All exposed couplings shall be furnished with a coupling guard.

### 6.4.29 Alignments

- 6.4.29.1 The installed alignments, fits, pre-tensions, float, and settings on all items of equipment shall be in accordance with the item manufacturer’s written instructions which may include precision tools (for example, steel straight edge, dial indicator and graduated machinist levels).
- 6.4.29.2 Specifically, all direct driven equipment shall be aligned by the use of a dial test indicator or laser alignment. Both the driver and the driven shafts shall be rotated simultaneously to each of the four positions at 0°, 90°, 180° and 270° at which readings shall be taken.
- 6.4.29.3 The maximum allowable out-of-alignment tolerance shall be 50 µm (0.05 mm) unless specified otherwise in individual equipment installation instructions. An alignment record sheet shall be supplied with the installation instructions showing the factory set alignment and shall be completed for each coupling aligned. This alignment procedure shall also conform to the equipment manufacturer’s instructions. All alignments are to be inspected and approved by the Contractor. Inspections by the Contractor shall be coordinated and documented by the Superintendent.

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- 6.4.29.4 Where separate items of interconnected plant, such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation, then each and every item shall be positively located in its correct operational position by means of dowels, locating pins, fitted bolts or other approved means to ensure that correct re-alignment can be easily achieved when re-assembling the items after removal for overhauls.

### 6.4.30 Belt Drives

- 6.4.30.1 Belt drives shall be designed such that not more than 20% of the speed reduction is achieved by pulley ratios. All belt drives shall include a means of adjusting the tension of the belt(s) so that belts maintain motion in a single plane and are not subject to lateral movement.

### 6.4.31 Gearboxes and Casings

- 6.4.31.1 Gearboxes shall be designed to operate continuously at maximum duty with a minimum service factor in accordance with AGMA standards based on maximum operating torque and the specified ambient operating condition. In addition, each gearbox shall be designed to withstand starting torques of up to 250% of the full load running torque of the driving motor.
- 6.4.31.2 The Contractor shall supply the recommended grade of gear box oil.
- 6.4.31.3 Gearboxes and casings shall be designed to suit the machine seating arrangement and the service specified.
- 6.4.31.4 Gear housings shall be in two-piece constructions with a top cover for ease of inspection and maintenance where practicable.
- 6.4.31.5 The direction of rotation of input and output shaft shall be permanently marked on the housing.
- 6.4.31.6 Removable inspection covers, complete with gaskets, shall be provided to permit inspection of the gears without disassembly of the gear reducer/increaser where practicable. Lifting lugs shall be provided to facilitate safe lifting for gearboxes heavier than 20 kg.
- 6.4.31.7 Unless otherwise specified gears shall be splash lubricated from a sump and the bearings shall be either splash lubricated or grease lubricated. Where grease lubricated bearings are fitted, seals shall be installed to retain the grease in the housing. Grease nipples and grease relief devices shall be fitted to housings containing grease-lubricated bearings. Greasing tubes and nipples shall be connected to the bearing housing and terminated in a location accessible for application of a grease gun if the bearing housing is otherwise inaccessible.
- 6.4.31.8 The gearbox itself shall be provided with sight glasses or indicators to observe lubrication oil levels.
- 6.4.31.9 All oil fill points and drain lines shall be of sufficient size to permit efficient functioning without spillage and shall be located on the gear unit in a position which is easily accessible from the floor. A drain tray/lubricant container shall be supplied to fit beneath the drain valve. The drain tray/container shall have sufficient capacity to receive the total volume of waste gearbox oil and be designed to be easily and safely transported without spillage.

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### 6.5. Safeguarding of Machinery

#### 6.5.1 General Requirements

- 6.5.1.1 Moving machinery shall be provided with safeguarding in accordance with Australian Standards. The design of the guarding shall be appropriate for the category of machine being guarded.
- 6.5.1.2 The machinery safeguarding system shall be designed, manufactured, installed and validated in accordance with the requirements of relevant Australian Standards. Documentation pursuant to the requirements of AS 4024.1501 shall be submitted with the guarded machinery that demonstrates how the safeguarding design was determined and validated.

#### 6.5.2 Hazard Analysis and Risk Assessment

- 6.5.2.1 During the detailed design, the Contractor shall undertake a hazard analysis and risk assessment in consultation with the Superintendent. This hazard analysis and risk identification shall determine the approach to the safeguarding system and the category for the safety-related parts of the machinery control system.
- 6.5.2.2 The safeguarding system shall be designed to satisfy the requirements of the hazard analysis and risk assessment.
- 6.5.2.3 The Superintendent shall ratify the category to be attributed to the safety-related parts of the control system prior to the commencement of the guard design. If the category attributed by the Superintendent to the safety-related parts of the control system differs from that attributed by the Contractor, the higher category shall take precedence. The Superintendent will declare the outcome in this case.

#### 6.5.3 Guidelines for Safeguarding

- 6.5.3.1 The safeguarding system shall be designed in accordance with the requirements of relevant Australian Standards with respect to the nature of the machinery and the category attributed to the safety-related parts of the control system.
- 6.5.3.2 Fixed (non-interlocking) guards shall be provided:
- 6.5.3.3 To prevent personnel from contact with the hazardous parts of the machine;
- 6.5.3.4 Where the parts of the machine to be guarded do not require access by the machinery operators in order to operate the machine or attend to frequent lubrication, adjustment or other regular duties required to maintain the machine in operation.
- 6.5.3.5 Interlocking guards shall be provided:
- 6.5.3.6 Where operators need to access hazardous parts of the machine frequently in order to operate the machine or perform regular tasks required to maintain the machine in operation;
- 6.5.3.7 If operators cannot be protected from risk by fixed guards, keeping hazardous parts out of reach etc.
- 6.5.3.8 Indications shall be provided of the status of all interlocking guards and alarms when interlocking guards are open.
- 6.5.3.9 Where interlocking guards are provided the machine control system shall include control mode selections for auto, manual and maintenance mode operation as required.
- 6.5.3.10 Emergency stop devices shall be provided on all machines in accordance with the relevant Unitywater electrical specification (Electrical Installations at Treatment Plants and Electrical Installations at Network Sites).

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- 6.5.3.11 Manual suspension of the stop-function of the movable guards may be necessary where an INCHING mode operation of the machine is required for maintenance while personnel are within the hazardous area. Such suspension of the stop function shall be fully workshopped and approved by the Superintendent prior to construction.
- 6.5.3.12 The machine safeguarding system shall include provisions for the isolation and dissipation of all energy sources: electrical energy, fluid pressure, gravity, etc. associated with the machine.
- 6.5.3.13 Where the machine includes components that move under gravity the machine safeguarding system shall include provision to fix the moving parts in a safe position.
- 6.5.3.14 Where the machine is part of a process and connected to upstream and downstream equipment and/or materials supplies the safe guarding system shall include:
- Interlocking of upstream processes and equipment to prevent the supply to the machine of materials or energy when the safety related parts of its control system have been activated;
  - Stop function when the safety related parts of downstream processes and/or equipment are activated.

### 6.5.4 Guards

- 6.5.4.1 The size of the guards shall be sufficient to cover the area of protection required to the extent that an operator can view the covered area but cannot contact the hazardous parts of the machine through the guard nor reach or climb around the guard to do so.
- 6.5.4.2 The anthropomorphic data (human body measurements) for the design of the guards shall be taken from AS 4024.1704.
- 6.5.4.3 Guards shall be constructed of rigid, impact resistant, corrosion resistant material and securely fixed either to the machine frame, surrounding fixed surface or floor by fixings of adequate strength, spacing and number to ensure that guards remain secure under any foreseeable loading. Fixing shall be by means of mechanical fasteners or clamps, welded or bonded joints or other means suited to the application. Self-tapping screws shall not be used to secure guards.
- 6.5.4.4 Pursuant to clause 6.3.4 of AS 4024.1601, each guard assembly shall be designed such that process material cannot easily become lodged in it and for easy cleaning.
- 6.5.4.5 Guards shall be suitable to facilitate manual installation and removal, and shall be hinged where practical. Any single guard panel (dimension or mass) shall not be more than 2.0 metres in length or 16 kilograms in weight. Movable hinged guards or removable sections of fixed guards shall be designed to be of a suitable size and weight to permit ease of handling/operation. If possible, operating forces shall be reduced by the use of springs, counterbalances or gas struts. Movable guards shall be interlocked.
- 6.5.4.6 Plugged tachometer holes shall be provided in guards at pulley shaft centres.
- 6.5.4.7 Guards shall not foul any moving components of the equipment.
- 6.5.4.8 Guards attached to equipment handling hazardous substances (e.g. chemical dosing systems) shall be transparent to allow personnel to detect leaks before they are removed/opened.
- 6.5.4.9 Appropriate workplace health and safety warning signs complying with AS 1319 shall be fastened to all equipment.

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### 6.5.5 Fixed Guards

- 6.5.5.1 Fixed guards shall be provided in accordance with the requirements of AS 4024.1601 for a Fixed Guard (Non-Interlocking).
- 6.5.5.2 Fixed guards shall be bolted and require the use of tools for removal.

### 6.5.6 Interlocking Guards

- 6.5.6.1 Where interlocking guards are required the design criteria for these guards shall be as follows:
- Designed in accordance with the requirements of AS 4024.1601 for an interlocked fixed or movable guard as required;
  - At least one fastener on each guard shall be a locking device as defined by clause 4.6.2 and 6.4.10 of AS 4024.1601;
  - The locking device shall be an electrically interlocked safety latch, Amstop4 type or equivalent approved, arranged with the bolt on the guard and the interlocking keeper fixed to the machine frame and interlocked to the machine control system using a dual output safety relay selected from the SICK Electronics or Schmersal range or equal approved.
- 6.5.6.2 Pursuant to clause 6.1.2 of AS 4024.1601:
- An interlocking guard, when unlocked, shall allow as free and unobstructed access as is technically possible to the machine assembly for cleaning and maintenance or other task required;
  - The guard assembly when fixed in place shall allow safe and ergonomic access for operating the machine;
  - Lubrication points covered by closed guards shall be brought outside the guard by tubing and presented in a logical and labelled arrangement on a lubrication manifold.
- 6.5.6.3 Pursuant to clause 6.1.4 of AS 4024.1601, the stop function activated when any guard is unlocked shall stop all material and energy feed into the machine including all its immediate upstream process and energy sources.
- 6.5.6.4 Pursuant to clause 8.4 of AS 4024.1601, each guard shall be painted Safety Yellow (AS 2700 colour Y14) and a sign shall be affixed to the outside reading "HAZARD – MOVING MACHINERY. Lock guard in place for normal production operation."

### 6.5.7 Documentation

- 6.5.7.1 Pursuant to the requirements of AS 4024.1501 section 5.3, the Contractor shall submit to the Superintendent for acceptance, documentation describing the process which was undertaken to determine the selection, design and validation of the safeguarding system provided including:
- Hazard analysis and risk assessment;
  - Determination of the risk reduction provisions;
  - Specification for any safety related parts of the machine control system;
  - Safeguarding design drawings, specifications, descriptions that fully detail the safeguarding system provided;
  - The safeguard validation process undertaken.

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### 6.6. Installation

#### 6.6.1 General

- 6.6.1.1 Equipment shall be designed and installed so as to provide ample access and clearance to allow for the safe and efficient carrying out of routine inspections and maintenance activities.
- 6.6.1.2 Valves, actuators, pumps, drives, manual controls and other equipment requiring access shall be accessible from ground level or from permanently installed access platforms where operation and maintenance can be readily carried out without the use of any ladders, scaffolding etc.
- 6.6.1.3 Valves and manual controls shall be located so that no part of a valve or control in any way constitutes a hazard to personnel. There shall be no encroachment on recognised walkways or areas set aside for maintenance.
- 6.6.1.4 All equipment shall be readily accessible for removal and be fitted with appropriate and readily identified lifting points.
- 6.6.1.5 All equipment shall be capable of being isolated for maintenance or removal without interrupting process flows.
- 6.6.1.6 Inertia blocks shall be provided and fitted where required and shall be mounted on appropriately supported spring mountings. Inertia blocks shall be designed and mounted to suit the static and dynamic loadings transferred from the equipment to its mountings and its operational characteristics in its most extreme of operating conditions.
- 6.6.1.7 Equipment mounted direct to concrete slabs or plinths shall have not less than 20 mm nor more than 35 mm of grout. Baseplates shall be shimmed or held firmly in position by double nuts before grouting. Installed equipment which has been grouted shall not be run or operated within the recommended curing period for the grout.
- 6.6.1.8 Plinths for the mounting of equipment, formed of concrete, shall extend no less than 75 mm beyond the edge of the extremity of the equipment. Surfaces shall be shaped and shall be graded to drain when appropriate. Bases shall have bevelled or rounded edges and corners.
- 6.6.1.9 Installation of equipment shall not commence within 14 days after the pouring of concrete foundations.
- 6.6.1.10 Equipment shall be installed to prevent the accumulation of spilled material, dust, water and other liquids.
- 6.6.1.11 Where equipment or machinery is required to be assembled outdoors, it shall not be carried out in wet or dusty conditions unless the work area is suitably protected.
- 6.6.1.12 Non-structural fastenings including flanges, guards and mounting points for mechanical equipment shall have the fasteners coated with a suitable anti-seize compound at final assembly.
- 6.6.1.13 Where equipment is buried and threaded fixings are exposed to the surrounding media, those fixings shall be 'Denso' tape wrapped for their protection.
- 6.6.1.14 Where necessary equipment which has been installed and run for commissioning, torque of holding down bolts shall be checked and bolts re-tightened where necessary. The Contractor shall advise the torque required and, where necessary, order of bolt tightening and interval for periodic checking of bolt tightness during normal service.

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### 6.6.2 Installation Activities

- 6.6.2.1 Before installation, all parts shall be thoroughly cleaned and all rust, dirt, grit and foreign matter shall be removed. Grease or other protective coatings supplied for protection of the equipment in shipment and/or storage, except prime coating, shall be removed by using suitable solvents or cleaners which will not damage the finish of the equipment.
- 6.6.2.2 The Contractor/installer shall thoroughly flush all applicable equipment (e.g. reduction gearboxes) with approved flushing oil, in accordance with the manufacturer's recommendations.
- 6.6.2.3 The flushing procedure shall include, where possible, the manual rotation of equipment to ensure complete penetration. On completion of flushing, the flushing oil shall be completely removed prior to filling with the running oil. Flushing oil, once used, shall not be re-used.
- 6.6.2.4 The Contractor/installer shall provide labour and materials required to clean, treat, shim, grout, adjust, alter, support or do any other work on materials and equipment which the manufacturer, or its agent, may consider necessary to achieve a satisfactory installation.
- 6.6.2.5 The Contractor shall obtain from the manufacturer the equipment certified drawings, tolerances for both alignment and level and such general and specific installation instructions as may be pertinent for successful installation of all materials and equipment.
- 6.6.2.6 The Contractor/installer shall adhere to such tolerances and instructions which shall be deemed to form part of this Specification.
- 6.6.2.7 Each item of mechanical equipment shall be set in position, true to both line and level in the positions shown on the drawings.

### 6.6.3 Spacing between Equipment

- 6.6.3.1 In the selection and placement of equipment, access and egress requirements shall be maintained in accordance with WH&S Regulations.
- 6.6.3.2 Plinths for equipment shall be positioned with consideration to operating and maintenance access.
- 6.6.3.3 Manufacturer's recommendations for minimum maintenance access shall be followed.
- 6.6.3.4 Clearance requirements for access and maintenance shall be as required by relevant codes and standards but shall not, in any case, be less than the following:
  - Main access 1.8 m
  - Operating aisle 1.2 m
  - Maintenance 0.6 m
  - Overhead clearance from ground level 2.1 m
- 6.6.3.5 No supports, pipework, cables, ducting or any other plant and equipment shall be installed which will obstruct the minimum required clearances.

### 6.6.4 Installation in Hazardous Areas

- 6.6.4.1 Particular care needs to be taken with equipment installed in hazardous areas. Where an area is classified as hazardous, the installation shall be appropriate for that area and comply with AS/NZS 60079 and HB 13. This includes the equipment selection and installation.
- 6.6.4.2 Equipment shall be certified for use in the particular hazardous area in which it is to be installed. Suitable documentation shall be provided with each equipment item for inclusion on the site hazardous area equipment register.

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- 6.6.4.3 The installation and maintenance of equipment located in hazardous areas shall only be carried out by personnel who fulfil the hazardous area competencies as outlined in AS/NZS 4761.1.

### 6.7. Inspection, Testing and Commissioning

#### 6.7.1 Factory Inspection Tests

- 6.7.1.1 The Superintendent reserves the right to witness factory tests as applicable.
- 6.7.1.2 The Contractor shall obtain from the supplier Inspection and Test Plans for approval 28 days prior to commencement of factory testing.
- 6.7.1.3 The Contractor shall notify the Superintendent of the test date 14 days prior to the test.
- 6.7.1.4 All major items of equipment shall be subject to factory testing prior to delivery to ensure compliance with the specified performance criteria. A factory certification of compliance shall accompany each item and a copy shall be included in the Operations and Maintenance Manuals.
- 6.7.1.5 Test certificates, Operations and Maintenance Manuals, installation manuals and all other documents specified in the Inspection and Test Plan, as approved by the Superintendent, shall be provided to the Superintendent separately from the equipment before the equipment is delivered.

#### 6.7.2 Installation and Pre-Commissioning Checks

- 6.7.2.1 The Superintendent reserves the right to inspect equipment during the installation period.
- 6.7.2.2 After the plant and equipment has been installed, the following checks shall be performed as a minimum and recorded to confirm and certify satisfactory installation and construction completeness:
- Checking that installation conforms to the design and specifications using available data (design drawings, manufacturer's drawings and manuals, piping and instrument drawings, schematic diagrams and connection diagrams);
  - Confirming the suitability of mechanical equipment operation by:
    - Checking alignment of all couplings, belts, gears, valves;
    - Checking freedom of correct shaft rotation;
    - Checking tightness of seals and inspecting packing of glands;
    - Checking tightness of all fixings and that mounting and bracketing is tidy and secure;
    - Checking that lubrication of equipment is complete and correct lubricant is supplied in correct quantities;
    - Checking that all moving parts and hot surfaces are properly protected;
  - Checking that all safety guarding and insulation is in place and secured as designed;
  - Checking access required to carry out operations and maintenance tasks;
  - Conducting a Hazard and Operability (HAZOP) review with Unitywater's operations and asset maintenance personnel;
  - Checking cleanliness of equipment and systems, including piping, tanks and machinery;
  - Point to point checking of all wiring and cabling to verify continuity and connection to correct terminals and correct identification/labelling;
  - Insulation resistance tests on power cabling;
  - Checking calibration, setting and adjustment of all instrumentation;

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- Obtaining installation acceptance certification from all equipment suppliers;
  - Conducting any other checks specified or recommended by the equipment manufacturer and supplier.
  - Checking that electrical installation is complete and all instrumentation is configured correctly.
- 6.7.2.3 The above shall include all checks and tests which can be performed without energising the plant or equipment.
- 6.7.2.4 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/supplier or their agent.
- 6.7.2.5 The Contractor/installer shall supply documentary evidence that the above installation check has been made and shall provide a description of any corrective measures taken to rectify faults or to satisfy the installation requirements of the manufacturer/supplier or their agent.
- 6.7.3 Hydrostatic Pressure Testing**
- 6.7.3.1 All water pressure pipelines shall be hydrostatically pressure tested in accordance with SEQ Water Supply & Sewerage Design & Construction Code, WSA 03 Water Supply Code Part 3: Construction, Clause 19.4 HYDROSTATIC PRESSURE TESTING.
- 6.7.3.2 The Contractor shall note that SEQ WS&S D&C Code V1.0-2013 specifies the system test pressure shall be minimum 1200 kPa.
- 6.7.3.3 All sewer rising main pressure pipelines shall be hydrostatically pressure tested in accordance with SEQ Water & Sewerage Design & Construction Code, WSA 04 Sewage Pumping Station Code Part 3: Construction, Clause 36.5 HYDROSTATIC PRESSURE TESTING OF RISING MAINS.
- 6.7.3.4 Contractor shall note that SEQ WS&S D&C Code V1. 1 -201 4 specifies the system test pressure as minimum 900 kPa.
- 6.7.3.5 All above ground pressure piping systems shall be hydrostatically pressure tested in accordance with AS 4041 and AS 4037. The system test pressure shall be 1.25 times the design pressure or 1200 kPa for class PN16 piping systems whichever is greater.
- 6.7.3.6 The Contractor shall provide all instruments, testing equipment, labour and fittings necessary for the test. Test equipment required to carry out the hydrostatic test shall include, but not be limited to, the hand pump, isolation valves, pressure gauge(s), pressure relief valve, pipework and fittings for connection of the test equipment.
- 6.7.3.7 In relation to water requirements for pressure testing:
- The Contractor shall make his own arrangements to procure at his own expense the water necessary for carrying out these tests;
  - If water should be available from the Principal's mains and the Contractor desires to use it, he shall give the Principal seven days' notice;
  - The Principal will make a charge for water supplied to the Contractor, such charge to be the subject of agreement between the Contractor and the Principal.

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6.7.3.8 In applying the test procedure(s), the Contractor shall address the following procedural aspects:

- Hydraulic testing shall not be carried out unless all permanent and temporary thrust blocks are adequately cured;
- All temporary pipes, connections and blanking devices shall be designed and installed to withstand the appropriate test pressure;
- Temporary spades and blanks installed for testing purposes shall be suitable to withstand the test pressure without distortion; presence of spades shall be clearly visible during testing;
- Spring supports shall be restrained or removed and unrestrained expansion bellows removed or adequately tied during hydrostatic testing;
- Pressure testing against closed valves shall not be undertaken unless the valves are fully restrained and it is possible to check for leakage past the valve seat;
- No component undergoing pressure testing shall be subjected to any form of shock loading;
- Contractor to ensure that the sump pumps at the bottom of valve chambers/flow meter pits have been checked and are fully operational prior to the commencement of the hydrostatic test;
- Pipelines shall be drained for removal of testing equipment and preparation for final connections if necessary. Test water shall be discharged in accordance with Water Services Australia (WSAA) Guideline: Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019;
- Testing equipment shall be disconnected and any equipment removed for testing purposes shall be reinstated.

6.7.3.9 A visual inspection of the pipework shall be made during and after testing to identify any distortion of pipe spools. Distorted sections shall be replaced and the pipe supports replaced before retesting of the pipework.

6.7.3.10 Pipe failures detected during pressure testing shall be remediated and the pressure test repeated until test results demonstrate the mains complies with the above standards to the satisfaction of the Superintendent.

### **6.7.4 Flushing, Disinfection and Quality Testing of Mains**

6.7.4.1 Before any pipelines are taken over by the Principal, the Contractor shall clear them by removing dirt and other matter by flushing and/or scouring and/or swabbing and/or ice pigging.

6.7.4.2 The Contractor shall dispose of flushing water from the pipe system in accordance with Unitywater's Pr9137 - Internal Reservoir Inspection and Cleaning Work Instruction and Water Services Australia (WSAA) Guideline: Dechlorination of Drinking Water to Discharged Waterways, National Guidance for the Urban Water Industry 2019.

6.7.4.3 For potable water mains, the Contractor shall utilise Unitywater's Pr9032 - Procedure for Determination of Acceptance of New Mains as the basis for the process of determining acceptability of new mains in terms of public health risks and compliance with Unitywater's approved Drinking Water Quality Management Plan.

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### 7. Pipework

#### 7.1. Design Life of Pipework

7.1.1 All pipework supplied shall be suitable for the specified operating conditions and shall be designed and constructed for a minimum design life as follows:

- SPS internal pipework 70 yrs
- STP internal pipework 50 yrs
- STP pipework 50 yrs
- SCDP pipework 50 yrs
- Sewer pipework 70 yrs, subject to pipe material (as per Job Specification)
- WCDP pipework 70 yrs
- Water pipework 70 yrs
- WRP internal pipework 50 yrs
- Recycled water pipework 80 yrs

7.1.2 Within the design life of the pipework, only routine maintenance shall be required, without the need for a major refit or replacement.

#### 7.2. Pipework Design

7.2.1 The pipework installation shall be designed and arranged to provide for ease of erection and future dismantling. All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner.

7.2.2 Pipes may only be supported from existing structural steel works where approval has been obtained from the Superintendent. Pipes shall not be supported from roof members or other structures not specifically designed for pipe loadings.

7.2.3 Pipes crossing roads shall be designed and constructed for this purpose and to withstand the traffic loading applicable to the road.

7.2.4 Sufficient dismantling joints, flange adaptors or flexible couplings shall be provided to enable removal for replacement, cleaning and maintenance. Removable pipe take-down fittings (Gibault, Straub or similar) and clean-outs shall be provided on sludge lines to facilitate cleaning and maintenance.

7.2.5 Pipes laid horizontally shall have a gradual fall towards drain or scour points as appropriate.

7.2.6 Overhead piping shall be run clear of all walkways with a minimum clearance of 2.1 m.

7.2.7 Pipework which has potential to suffer from blockages (raw sewage, grit, screenings and sludge etc.) shall be fitted with adequate facilities for cleaning. These may include blank flanges, flanged bends, tee pieces and pigging stations.

7.2.8 Pipelines conveying sludge shall not be smaller than DN100.

7.2.9 For pipes run at ground level, the minimum clearance between piping and ground level is to be 300 mm measured to the underside of the pipe, unless specified otherwise, providing the following dimensions (measured between extremities) are also observed:

- Pipe - Pipe : 100 mm;
- Flange - Pipe : 50 mm;
- Flange - Flange : 50 mm.

7.2.10 Clearance between crossing pipes shall be a minimum of 300 mm.

7.2.11 For pipes with unions, sufficient clearance shall be provided to allow tools to be used to undo the union.

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- 7.2.12 Where valves, flow meters, strainers and other devices mounted in the pipework are large enough to put undue strain on the pipework, these shall be supported independently of the pipes to which they connect. Particular care shall be taken to ensure that pipework thrusts are not transmitted to pumps, tank nozzles, machinery or associated apparatus.
- 7.2.13 The high points of all pipe routes shall have provision for venting any trapped air. The low points shall have provision for drainage if appropriate.
- 7.2.14 Design details shall be such as to minimise head loss in the pipework. To this end, long radius bends shall be used wherever possible, particularly on sludge lines. Long radius bends shall be used on all pipes carrying solids unless approved otherwise by the Superintendent.
- 7.2.15 Pipe runs shall be laid out to minimise crossovers and shall be co-ordinated with other services. All pipes, valves and fittings shall be so arranged that they are conveniently accessible and readily replaceable.
- 7.2.16 Plant and pipework shall be supported independently unless written agreement is provided by the plant manufacturer confirming acceptability of imposed loads.
- 7.2.17 High standards of cleanliness must be maintained during the erection of piping systems to ensure that no foreign matter is introduced that could adversely affect the use or performance of the plant.

### 7.3. Pipe Loads

- 7.3.1 The design pressure for each line is the maximum non-shock internal pressure. The design temperature for each line is the maximum internal service temperature.
- 7.3.2 Unless otherwise stated, thermal expansion pipeline stress calculations shall be based on 0°C ambient low temperature and the design flow temperature of the pipeline or 50°C whichever is greater.
- 7.3.3 Where pipework is exposed or subject to temperature variations, the installation shall include expansion loops or other approved devices to take account of thermal expansion.
- 7.3.4 Anchors shall be provided at all necessary points to properly direct the movement of the line to the expansion loop or joint.

### 7.4. Pipe Supports

- 7.4.1 Piping shall be properly supported on racks or by anchor brackets, saddles or supports. Pipe support assemblies shall only be used for supporting pipelines.
- 7.4.2 Suitable pipe supports shall be designed, supplied, assembled, constructed and installed for all of the pipework.
- 7.4.3 The pipework shall be rigidly and safely supported at intervals not exceeding the manufacturer's recommendation or where not provided by the manufacturer, as stated in AS 4041. Supports shall be designed and arranged so that no restrictions in access are created.
- 7.4.4 Pipework shall be adequately supported to prevent undue sagging, vibration, and strain on connected equipment.
- 7.4.5 Plastic pipes shall be supported to minimise deflection to less than 3 mm between supports.
- 7.4.6 Pipe supports shall be designed to allow for pipe movement due to thermal expansion and contraction and vibration from mechanical equipment.
- 7.4.7 Pipework shall be suitably anchored to minimise pipe stresses caused by pipe pressure, thrust and weight of valves, instruments and equipment.

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- 7.4.8 Pipework shall be designed with independent supports and restraints to accommodate loads and thrust so as not to transfer stresses onto machinery or plant items. Pumps, valves, meters, strainers and other such in-line equipment shall be supported independently of the pipework.
- 7.4.9 Pipe supports shall be designed such that no static or dynamic load is transferred to equipment.
- 7.4.10 Pipe spools and pipe supports shall be designed with respect to the maintenance of mechanical equipment, instrumentation and valves. Where pipework is required to be removed for maintenance it shall be suitably flanged and include lifting lugs at appropriate locations to assist in removal.
- 7.4.11 At each change of direction of the pipeline, hangers, supports or a pipe rack shall be provided in each direction.
- 7.4.12 Where not specifically designed, hangers, saddles, racks and clamps shall be standard purpose manufactured 'Unistrut' components or equal.
- 7.4.13 Where pipework is supported from a concrete structure 'Unistrut' or equal channel sections adequately anchored into the concrete shall be provided and particular attention shall be given to the safe load capacity of such inserts.
- 7.4.14 Hangers shall not be used where pipe vibrations are expected.
- 7.4.15 All springs shall be preloaded and provided with travel stops for hydrostatic line testing. Stops shall be removed after testing, and springs adjusted to the correct load.
- 7.4.16 Additional supports shall be provided adjacent to connections to pumps, tanks, etc. and on either side of valves, measuring instruments and the like. Expansion joints and/or bends thrust blocks and anchors shall be provided where appropriate.
- 7.4.17 In assessing the design loads of pipe supports, all pipelines shall be assumed to be full of water. Further, the design loading of supports shall assume that every alternate support takes no load. The location and type of support to be installed shall make the appropriate allowance for thermal expansion of pipework including plastic pipelines.
- 7.4.18 Some cases of thin wall pipe or high specific gravity fluid may require individual calculations to determine pipe support requirements.
- 7.4.19 All fabricated pipe supports shall be manufactured from suitable grade structural steel unless noted otherwise.
- 7.4.20 All carbon steel pipe supports shall be hot dipped galvanized after fabrication and painted where specified.
- 7.4.21 All pipe supports that come into contact with any plant process fluid shall be fabricated from stainless steel Grade 316 unless noted otherwise.

### 7.5. Pipe Sleeves

- 7.5.1 Unless shown as being cast in, pipes passing through walls, floors or ceilings shall be sleeved. The sleeve type shall be selected by the Contractor to suit the application and shall be subject to the approval of the Superintendent. Sleeves used as water stops shall ensure that no leakage can pass through the wall and shall take account of the effect of pressure surges on plastic pipes at the wall face.

### 7.6. Tank Connection Piping

- 7.6.1 The minimum length of tank nozzles shall be 150 mm from the inside wall of the tank to the nozzle flange face.

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### 7.7. Flushing Connections

- 7.7.1 Flushing connections shall be used on all sludge lines. Connections shall be a minimum of DN50.
- 7.7.2 Flushing connections shall be located either side of valves, at the bottom of vertical risers and at suitable intervals on long horizontal runs.

### 7.8. Drains and Vents

- 7.8.1 All sludge lines shall be designed to drain by gravity in the event of pump failure. Lines shall be sloped to 1 in 50 (where possible) down to the discharge point or back to the pump.
- 7.8.2 Drains shall be provided to facilitate shutdown and general maintenance.
- 7.8.3 Adequate high point vents and low point drains shall be included to suit the spooling arrangement.
- 7.8.4 Valved drains shall be provided at the bottom of riser piping and other pipework low points (where shown in the drawings) to drain liquids completely from the piping.
- 7.8.5 Other drain points shall be provided for equipment including drains for drip trays, automatic air vents and equipment with drain points.
- 7.8.6 Pipework which is double contained shall be provided with catch pots at the end of the double containment where appropriate.
- 7.8.7 In addition to pump volute drains, drain point connections shall be installed on the suction piping of all pumps in between the first suction isolation valve and the pump. Unless specified otherwise, a 100 mm long DN25 nozzle shall be provided with a DN25 ball valve installed in accordance with the provisions of this section.
- 7.8.8 Drain size shall generally be a minimum DN25. For pipework smaller than DN25, the drain size shall be the same as the main pipe size.
- 7.8.9 Any piping within buildings which runs at low level shall be located in concrete trenches where reasonably practicable. The trenches shall be provided with suitable grating and drainage to the satisfaction of the Superintendent.

### 7.9. Mechanical Jointing

#### 7.9.1 Grooved Pipe Couplings

- 7.9.1.1 Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods on carbon or stainless steel pipework. The grooved components, including gaskets shall be supplied from an ISO 9001 certified manufacturer and shall be fully compatible with AS 4041.
- 7.9.1.2 Pipe end grooves may be rolled or cut as appropriate to the pipe material, wall thickness, pressure rating, size and method of jointing. Grooves shall be in accordance with the manufacturer's guidelines. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
- 7.9.1.3 Couplings shall generally be of ductile iron construction. Where design conditions require the use of an alternative to ductile iron piping materials for both interior and exterior piping surfaces, stainless steel Grade 316 couplings shall be used as determined by the Superintendent.
- 7.9.1.4 Fittings shall be selected and assembled fully in accordance with the manufacturer's recommendations.

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### 7.9.2 Victaulic Pressfit Pipe Couplings

- 7.9.2.1 Victaulic Pressfit pipe couplings, fittings, valves and other components may be used as an option to welding, threading or flanged methods of jointing on stainless steel pipework up to DN50 diameter.
- 7.9.2.2 Pipework shall be certified for use with Pressfit products. Pipes shall be finished annealed with polished OD. Pipes shall be square cut to  $\pm 0.75$  mm, properly de-burred and cleaned to ensure a leak tight O-ring seal.
- 7.9.2.3 Coupling and fitting housings shall be Pressfit products formed of approved 316L stainless steel.
- 7.9.2.4 Pipework shall be assembled fully in accordance with Victaulic recommendations.

### 7.9.3 Flanges

- 7.9.3.1 Flanges shall comply with AS 4087 as specified in the pipe class specifications. All flanges shall be assembled square and true prior to bolting to a matching flange.
- 7.9.3.2 Flanges shall be to a class in excess of the maximum pressure they will attain in service including any surge pressures.
- 7.9.3.3 Flange bolt holes shall be spaced equally on the pitch circle circumference and, for integral flanges, the bolt holes shall be spaced equally off the centreline of the component of which it forms part and shall be parallel to the axis of the flange, in accordance with AS 4087. Flange bolt holes shall be located to straddle centrelines to allow correct and neat orientation of valves, instruments and equipment.
- 7.9.3.4 Flanged connections shall be tightened sequentially diagonally opposite in a clockwise or anticlockwise order so that even gasket seating results. Each bolt shall be initially tightened in sequence to approximately 50% tightness, then the sequence repeated to give 75%, 90% and then 100% tightness.
- 7.9.3.5 The surface of the flange gasket face shall be free from rust, weld spatter, scars, paint, dents, arc strikes, corrosion pitting and other imperfections.
- 7.9.3.6 Bolting torque for valves and lined piping shall be in accordance with the manufacturer's recommendations.
- 7.9.3.7 Bolts shall be to the nearest standard length with a minimum of three threads projecting.
- 7.9.3.8 Nickel based anti-seize compounds shall be used for stainless steel bolts, stud bolts and nuts to prevent binding.
- 7.9.3.9 Flanges shall be installed square with the run of pipe and aligned parallel to each other.
- 7.9.3.10 Misalignment shall not be corrected by bolting.
- 7.9.3.11 Flange jointing sets shall include all bolts, nuts, washers and flange gaskets or insertions necessary for jointing together the flanges of the specific diameter and pressure rating.
- 7.9.3.12 Flanged joints shall be made with bolts or studs with nuts where the flange is tapped.
- 7.9.3.13 For equipment and valves fitted with flanges other than the above, the mating piping flanges shall be compatible and match that of the equipment and valve flanges.

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### 7.9.4 Fixed Couplings and Dismantling Joints

- 7.9.4.1 Flexible pipe couplings, flange adaptors, proprietary dismantling joints or flanged fittings shall be incorporated into the pipework as appropriate to:
- facilitate removal of plant items for maintenance without the need to dismantle or disturb adjacent pipework/manifolds; and
  - allow for final closure of pipework joints without superimposing stresses onto plant items; and
  - provide flexibility on pipelines which may be influenced by ground movement. Couplings shall be suitable for buried installation as appropriate.
- 7.9.4.2 Rubber jointing rings for use in spigot and socket pipes shall be as supplied by the pipe supplier for the particular pipe. Rubber jointing rings shall be stored in a cool shaded environment and shall not be hung over pegs or similar supports. Previously used rings shall not be reused.
- 7.9.4.3 Unrestrained mechanical couplings shall comply with AS/NZS 4998.
- 7.9.4.4 Band type couplings shall be of stainless steel Grade 316 construction, with stainless steel Grade 316 fasteners and EPDM sealing sleeves complying with AS 1646.
- 7.9.4.5 Gibault, Victaulic, similar slip over couplings and non-tension resisting type pipe couplings shall be cast iron or fabricated steel with stainless steel bolt sets as supplied or recommended by the pipe manufacturer for use with the particular pipe.
- 7.9.4.6 On pressure pipes, the dismantling joints shall be suitable for the transfer of longitudinal thrust.

### 7.9.5 Expansion Joints

- 7.9.5.1 Flexible connections shall be provided at all equipment where vibration, thermal expansion or loading may be a problem.
- 7.9.5.2 Flexible connectors shall be installed adjacent to all pumps, where shown on the drawings, and vibrating or vibration sensitive plant or equipment. Where necessary, flexible connectors shall incorporate tension-resisting tie bolts. Connectors shall be Tift or Radcoflex Type FSF, single sphere or equal unless specified or required otherwise.
- 7.9.5.3 Flanged, flexible expansion joints shall be provided where shown on the drawings. Expansion and contraction shall be compensated for either by flexible rubber or metal expansion bellows with materials of selection compatible with the relevant pipework and equipment, material to be conveyed and the environmental conditions.
- 7.9.5.4 Flexible rubber joints shall incorporate nylon reinforced synthetic rubber suitable for use with waste water. Metal bellows shall be supplied with flanges suited to the body of the joint and tied or hinged where required.
- 7.9.5.5 Expansion joints shall be designed to allow for vibration and thermal expansion and contraction.
- 7.9.5.6 Any internal lining/sleeving shall be suitably designed to prevent vibration. Internal lining/sleeving shall not be used in a coupling where a liquid is being conveyed and the design allows the conveyed material to contact the compensating element.
- 7.9.5.7 Expansion joints shall not be used to correct pipe misalignment.
- 7.9.5.8 Pipework adjacent to the coupling shall be adequately supported and restrained for the intended service and shall not rely on the coupling to provide such support/restraint other than that required to compensate for intended axial movement.

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7.9.5.9 Extreme care shall be taken during handling and erection of expansion joints. Shipping rods shall remain in place until erection is complete but must be removed immediately after the expansion joint is installed. Proper care shall be taken to prevent ingress of moisture or dirt into the expansion joint during erection.

### **7.9.6 Tapping Bands**

7.9.6.1 Tapping bands shall consist of two semi-circular rings manufactured from gunmetal. The two rings shall be bolted at the horizontal diameter using gunmetal studs and nuts.

7.9.6.2 The upper ring shall incorporate an elastomeric seal designed to prevent leakage between the pipe and band at the system design pressure.

7.9.6.3 The two rings shall be designed so as to provide full circle pipe support and to prevent over-tightening.

### **7.9.7 Screwed Joints**

7.9.7.1 Screwed pipe connections shall be in accordance with AS 1722, Part 1 (BSPT compatible). Screwed connection threads shall be sealed with degreased PTFE tape or a thread sealing compound.

### **7.9.8 Fasteners**

7.9.8.1 Flange bolts shall be fitted with nuts and two flat washers.

7.9.8.2 Where bolts are used in a location not in the horizontal plane, the bolt should be at the top of the joint and nut below.

7.9.8.3 Stud and bolt lengths shall be such that three threads shall protrude from the nut when fitted.

### **7.9.9 Gaskets**

7.9.9.1 Unless specified or required otherwise because of pressure or other criteria, flange gaskets shall be full-face thickness to suit the test pressure and flange dimension but not be less than 3 mm thick for EPDM gaskets and 1.5 mm for compressed fibre gaskets.

7.9.9.2 The gasket material shall be suitable for contact with the fluid being conveyed, the operating conditions and the environment. Unless otherwise specified, gasket materials for all flanged pipework shall be EPDM or compressed fibre, with the exception of gaskets on sodium hypochlorite pipework which shall be PTFE.

7.9.9.3 All gaskets shall be supplied and installed in accordance with AS 1646.

7.9.9.4 Insertion rubber gaskets are not acceptable.

### **7.9.10 Instrument Fittings**

7.9.10.1 Unless otherwise specified, G $\frac{1}{2}$  (BSPT compatible) branch connections shall be used. The connectors shall be selected and fitted in accordance with the manufacturer's recommendations.

7.9.10.2 Each connection shall be fitted with a G $\frac{1}{2}$  (BSPT compatible) plug, installed with PTFE tape and tensioned to provide a seal at the pipe hydrostatic test pressure.

7.9.10.3 All instrumentation piping shall be manufactured from Grade 316L stainless steel seamless tube and fittings of a thickness suitable for threading.

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### 7.10. GPR Pipes and Fittings

#### 7.10.1 Standards

- 7.10.1.1 GRP piping shall be designed, constructed and installed in accordance with AS 2885.1 and ISO 14692 Parts 1 to 4. It is recognised that AS 2885.1 primarily relates to steel pipelines but provides guidelines for the use of pipe manufactured from GRP. Consequently, certain provisions of AS 2885.1 are not applicable to GRP piping (specifically those relating to materials, fracture control, stress, strain and corrosion) and the relevant provisions of ISO 14692 shall be used in their place.

#### 7.10.2 Raw Materials

- 7.10.2.1 Thermoset resins shall be as specified below:
- Inner Surface and Corrosion Barrier:
    - vinyl ester (VE) Derakane 411-350 or equivalent with minimum elongation of 4.5% and a heat distortion temperature (HDT) not less than 20°C higher than the pipe design temperature;
  - Structural Resin:
    - isophthalic polyester (IP) resin, high grade resin with a minimum elongation of 2% and a HDT not less than 20°C higher than the pipe design temperature;
  - Outer Surface and External Corrosion Layer Resin:
    - IP resin containing an ultraviolet ray absorber /inhibitor;
    - No colour code pigment shall be used for pipework installed indoors unless specified;
  - Post Curing Resins:
    - The Contractor, in conjunction with the resin supplier/manufacturer, shall determine whether post-curing is necessary and ensure that the resin cure is adequate for service duties and life expectancy requirements;
    - Post-curing shall be performed in accordance with the resin manufacturer's requirements and published data.
- 7.10.2.2 Glass fibre reinforcements shall be as specified below:
- Surfacing Veil 'Tissue':
    - Glass veil shall be a minimum 25 g/m<sup>2</sup> non-woven commercial grade type C glass with binder compatible to lay up resins;
  - Chopped Strand Mat (CSM):
    - CSM shall be 450 g/m<sup>2</sup> and 600 g/m<sup>2</sup> commercial grade type E (electrical borosilicate) glass in non-continuous strands with coupling agent to provide compatible bond to resins;
  - Woven Rovings (WR):
    - a. WR shall be 600 g/m<sup>2</sup> and 800 g/m<sup>2</sup> commercial grade type E (electrical borosilicate) glass with coupling agent to provide compatible bond to resins and warp and weft to be equal;
  - Continuous Rovings (CR):
    - CR shall be commercial grade type E (electrical borosilicate) glass with coupling agent to provide compatible bond to resins;

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- Glass to Tape:
  - Glass tape shall be plain weave glass fibre fabric with selvage edge 195-325 g/m<sup>2</sup> in 50, 75 and 100 mm wide;
- Glass Cloth:
  - Cloth shall be plain woven glass fibre cloth 195-325 g/m<sup>2</sup> in 1520 mm width roll;
- ECR Reinforcement:
  - When required, corrosion resistant CSM and WR shall be specified by type and mass according to the application.

7.10.2.3 Reference shall be made to the raw material supplier's Safety Data Sheets and guides for safe handling of unsaturated polyester resin and curing systems.

### **7.10.3 Pressure Design Basis**

- 7.10.3.1 Piping shall be designed and manufactured in accordance with the service conditions as provided in the pipe schedule.
- 7.10.3.2 In any case, the GRP piping shall not have a pressure rating less than PN6.
- 7.10.3.3 The Contractor shall provide design calculations for all sizes and classes of pipe, fittings, flanges and joints together with unit masses.

### **7.10.4 Pipe Stiffness**

- 7.10.4.1 The minimum allowable pipe stiffness shall be 10,000 N/m<sup>2</sup> for all underground pipes except where otherwise stated by the Superintendent.
- 7.10.4.2 The stiffness class shall be verified by the Contractor in accordance with the design to ensure suitability with burial conditions, axial loads, traffic loads and negative pressures.

### **7.10.5 Pipe Construction**

- 7.10.5.1 The pipe shall be manufactured by machine-made filament winding process using thermosetting resin to impregnate strands of continuous glass filament rovings which are wound onto a straight mandrel at a prescribed helix angle and under controlled tension over a thermosetting chemical barrier.

### **7.10.6 Flanges**

- 7.10.6.1 Flanges shall be of the full-face type with tapered necks in preparation for butt/over wrap joints. Flanges shall be drilled in accordance with AS 4087.
- 7.10.6.2 Flanges shall be flat faced GRP contact moulded from CSM and WR impregnated with thermosetting resin with a design strain of 0.0020.
- 7.10.6.3 Minimum glass content of flanges shall be 30%.
- 7.10.6.4 In the event that flanges with O-ring seals are called for, the seal groove shall be machined and suitably resin sealed, ensuring that the O-ring contact surfaces are smooth, uniform and free from resin runs.
- 7.10.6.5 The outer surface shall comprise a clear waxed reinforced resin rich finishing coat of thermosetting resin containing an ultraviolet ray absorber/inhibitor.
- 7.10.6.6 All bolt holes shall be drilled after full cure of the laminate has been achieved. The backs of flanges are to be smooth, flat and suitable for backing ring acceptance and/or correct washer seating. Special attention shall be paid to the hub area in order to facilitate torque wrench and socket access when tightening up the bolts.
- 7.10.6.7 Flat split galvanized steel backing flanges shall be fitted behind flange faces on flange sizes above DN500 when used for pressure duties above 600 kPa. It is the Contractor's responsibility to determine the optimum internal diameter of the backing ring so that it does not make contact with the hub neck/flange transition radius.

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### 7.10.7 Fittings

- 7.10.7.1 Fittings shall be one-piece contact moulded reinforced with CSM and RW, impregnated with thermosetting resin.
- 7.10.7.2 All fittings shall be manufactured, and suitability prepared for butt and over wrap jointing to pipe.
- 7.10.7.3 Standard bends shall be manufactured having radii of 1.5 x the pipe diameter as standard.
- 7.10.7.4 Tapers shall be manufactured with standard reductions.

### 7.10.8 Jointing System and Procedures

- 7.10.8.1 Butt and over wrap joints are the preferred method of jointing, however, the Contractor shall prove competence through quality systems and qualification testing of these joints. Design calculations shall also be provided for the overlay widths and thickness requirements of these joints.

### 7.10.9 Corrosion Barriers

- 7.10.9.1 Unless specified, all pipe and fittings shall be constructed with a 2 mm internal and 0.2 mm external corrosion barrier.

### 7.10.10 Tolerances

- 7.10.10.1 Tolerances shall be in accordance with ISO 14692-2 and ISO 14692-4.

## 7.11. Polyethylene Pipes and Fittings

- 7.11.1 Polyethylene pipe shall be designed, fabricated and installed in accordance with WSAA document WSA 01-2004 "Polyethylene Pipeline Code".
- 7.11.2 Polyethylene pipe shall not be subjected to bending to a radius tighter than 25 times the pipe outside diameter.
- 7.11.3 Hot bending shall not be permitted.
- 7.11.4 All fusion bonding processes shall be strictly in accordance with the pipe manufacturer's recommendations and procedures.
- 7.11.5 The Contractor shall take special care with all polyethylene pipes and fittings which are prone to surface damage if incorrectly handled or stored as well as being subject to degradation when exposed to sunlight. All handling and storage shall be strictly in accordance with the manufacturer's recommendations and procedures. No metal chains or slings shall be used.
- 7.11.6 All pipe laying shall be in accordance with both the manufacturer's recommendations and installation procedures and AS 2566.
- 7.11.7 Polyethylene has a relatively high coefficient of linear expansion (approximately 0.18 mm/m/°C). When laying/installing pipe, sufficient allowance must be made for expansion and contraction.

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### 7.12. Potable Water Fittings

- 7.12.1 Potable water systems shall be designed, installed and commissioned in accordance with AS/NZS 3500.1. All fittings and other components in potable water systems shall be guaranteed to be manufactured from material approved for use with potable water as per AS 4020.
- 7.12.2 The surface of pipes, valves and fittings which come into contact with potable water shall be protected by materials that:
- shall not constitute a toxic hazard;
  - shall not support microbial growth; and
  - shall not give rise to unpleasant taste or odour, cloudiness or discolouration of the water.
- 7.12.3 Bituminous paints and coatings shall be made from petroleum or asphaltic bitumen and NOT coal tar bitumen. Surfaces to be protected shall be correctly prepared and given two coats of protective finish. The Contractor shall specify the finish to be applied for future repairs.

### 7.13. Flexible Piping

- 7.13.1 Hose for process pipework shall be textile reinforced rubber, Dunlop D214 or equal.
- 7.13.2 Hose for wash down purposes shall be GEM type or equal. Reels for hose storage shall be fabricated from stainless steel and be supplied with 20 metres of 25 mm diameter hose (PVC), except where shown otherwise. Flow shall be controlled at the downstream end by use of a proprietary nozzle allowing adjustment from jet through spray to stop.

### 7.14. Fabrication and Installation

#### 7.14.1 Workshop Requirements

- 7.14.1.1 Site fabrication of pipe spools will not be permitted.
- 7.14.1.2 The surface preparation and painting of pipe spools shall be conducted in a separate area from the pipe fabrication.
- 7.14.1.3 A separate area shall be provided for non-destructive testing. This area shall be located at a safe distance from the piping spool fabrication. The area shall comply with all statutory and safety requirements.

#### 7.14.2 Preparation and Welding of (Stainless) Steel Pipework

- 7.14.2.1 All welding and associated procedures shall be in accordance with AS 4041.
- 7.14.2.2 Cutting of pipe may be done either by mechanical means or by flame cutting, depending on the type of material to be cut.
- 7.14.2.3 For carbon steel, flame (or arc) cutting and bevelling is acceptable only if the cut is reasonably smooth, true and all oxides are removed from the flame cut surfaces by grinding. After flame cutting the bevel end, preparation shall be ground back to bright and sound metal.
- 7.14.2.4 For stainless steel, plasma cutting and grinding back to bright sound metal is required if the pipe ends cannot be machined. Flame cutting is not allowed.
- 7.14.2.5 All welding areas shall be adequately protected against inclement weather conditions.
- 7.14.2.6 All weld end preparations and adjacent areas 50 mm either side of the weld preparations shall be thoroughly cleaned and degreased prior to welding.

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- 7.14.2.7 Any supplier-applied coating shall be removed for a margin of 50 mm from each shop weld joint.
- 7.14.2.8 All uncoated surfaces of the spool shall be surface prepared and painted immediately after all non-destructive testing of the welds has been completed.
- 7.14.2.9 Use of permanent internal backing rings is prohibited. Consumable inserts shall not be used.
- 7.14.2.10 Prepared weld ends (bevels) shall be examined for defectiveness or damages and repaired. Use of hot or cold hammering as a means of repair is prohibited.

### 7.14.3 Misalignment Tolerance

- 7.14.3.1 All piping fit-ups shall be subject to the bore misalignment tolerances indicated in the table below:

**Table 4 - Pipe Misalignment Tolerance**

Nominal Pipe Size (DN)	Misalignment Tolerance (mm)
≤150	1.0
200 – 300	2.0
≥350	2.5

- 7.14.3.2 Misalignments shall be minimised wherever possible, at least by rotating the pipe/fitting for best fit and/or by grinding the bore as required.

### 7.14.4 Slip-on Flanges

- 7.14.4.1 Slip-on flanges shall be positioned so that the end of the pipe is recessed from the face of the flange a distance equal to the lesser of the pipe wall thickness or 9 mm.
- 7.14.4.2 Seal welding for slip-on flanges shall be carefully applied in order to avoid refacing the flange. Internal and external welds shall be as identified in AS 4041.
- 7.14.4.3 Pipes for insertion in slip-on flanges shall be cut square within 0.5 mm.

### 7.14.5 Socket Welding

- 7.14.5.1 Pipe insertion in a socket weld joint shall be cut square within 0.5 mm. A minimum gap of 1.6 mm shall be maintained between the end of the pipe and the bottom of the socket.

### 7.14.6 Threaded Connections

- 7.14.6.1 Unless otherwise specified, all threads shall be in accordance with AS 1722.1 (taper threads) (BSPT compatible).
- 7.14.6.2 Reaming shall deburr inside ends of threaded pipes.
- 7.14.6.3 All threaded connections shall be gauged checked or chased after galvanizing.
- 7.14.6.4 Threaded connections shall not be seal welded except where specified.
- 7.14.6.5 Threaded joints in a piping system shall be made up using PTFE pipe tape or thread seal compound installed on the male except for stainless steel piping where nickel-based thread tape shall be used.

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### 7.14.7 Branch Connections

- 7.14.7.1 Fabricated branch connections shall be in accordance with AS 4041.
- 7.14.7.2 All cuts shall be carefully bevelled and accurately matched to form a suitable preparation for welding and to permit full penetration of welds between the branch and the run pipe at all points.
- 7.14.7.3 All reinforcement pads for pressure openings or each segment of build-up type reinforcement pads for pressure openings shall be provided with ¼ inch (6 mm) BSP threaded hole for testing and venting. The vent hole shall be sealed after completion of the pressure test with grease or silicon sealant to prevent ingress of moisture.
- 7.14.7.4 Branch connections, vent nozzles, trunnions and other attachments including reinforcing pads shall not be welded over or near longitudinal or circumferential welds. The minimum distance between the weld in the pipe and the weld at the fitting shall be 50 mm measured between the heat affected zones. For reinforcing pads, the minimum distance measured between the heat-affected zones of the weld in the pipe and fillet weld of the pad shall be 25 mm.

### 7.14.8 Cold Bending

- 7.14.8.1 Pipes of DN40 and smaller shall be bent only where cold bending is indicated on the project drawings. In all other cases, butt weld, socket weld or screwed elbows shall be used depending on piping class.
- 7.14.8.2 Cold bending shall be carried out using pipe bending machines; otherwise presses and dies shall be employed to prevent flattening.
- 7.14.8.3 Unless noted otherwise, the centreline radius of bends shall be five nominal pipe diameters. Butt welds in the arcs of bends or for the addition of pulling legs shall not be permitted.
- 7.14.8.4 All bends shall be smooth, free from cracks and surface defects, without buckles and they shall be within tolerance limits identified in AS 4041.
- 7.14.8.5 Cold or hot bending of stainless steel pipe is prohibited.

### 7.14.9 Mitre Bends

- 7.14.9.1 Segmented bends shall be manufactured by butt welding together segments of pipe, shaped to produce the required bend. Wherever possible, the segments shall be taken from the same length of pipe. However, the segments shall be limited to applications detailed on piping drawings.
- 7.14.9.2 The change of centreline at butt welds in segmented bends shall not exceed 30 degrees.

### 7.14.10 Preheat and Treatment

- 7.14.10.1 Preheat and inter-pass treatment temperature control and heat treatment shall be in accordance with AS 4041.

### 7.14.11 Post-Welding Treatment – Stainless Steel

- 7.14.11.1 All welds shall be cleaned, pickled and passivated on completion of welding to ASTM A380.

### 7.14.12 Stainless Steel

- 7.14.12.1 Stainless steel fabrication shall be carried out in an area where contamination from carbon steel grindings and other carbon steel items is completely prevented.
- 7.14.12.2 Direct contact between carbon steel and stainless steel is not permitted. The Contractor shall confirm that the supplier uses procedures which prevent such contact and the resultant contamination of the stainless steel.

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7.14.12.3 Tools and grinding discs containing carbon steel shall not be used on stainless steel. Tools used for fabrication of stainless steel shall be clearly identified and labelled, used only for fabrication of stainless steel piping and piping components. They shall be stored separately to avoid accidental switching with tools previously used on carbon steel fabrication work.

### **7.14.13 Painting of Piping**

- 7.14.13.1 Piping shall be painted in accordance with Section 14.3 of this Specification.
- 7.14.13.2 Flange gasket faces shall be protected against damage and paint deposits during blasting, cleaning, surface preparation and painting.
- 7.14.13.3 The following pipework shall not be painted:
- Stainless Steel (unless noted otherwise);
  - Insulated carbon steel piping (prime coated only prior to installation of insulation);
  - GRP;
  - ABS.

### **7.14.14 Pipeline Identification**

- 7.14.14.1 All piping regardless of piping class or coating requirements shall be identified with colour coding, flow direction and fluid ID markers in accordance with AS 1345 and AS 2700S.
- 7.14.14.2 Colour coding shall either be by bands or by full colour code according to the Australian Standards.
- 7.14.14.3 Identification markings shall be placed in accordance with AS 1345. All piping shall have pipe fluid identification marker labels.
- 7.14.14.4 Hazardous fluid identification shall be provided as required. It shall comprise a 75 mm wide band with diagonal black and yellow strips of equal width for all services greater than DN40 and a 25 mm wide band for services DN40 or less.
- 7.14.14.5 Height of numbers shall be half the pipe diameter for pipes below DN200 and 75 mm high for pipes DN200 and higher.
- 7.14.14.6 Flow direction arrows shall be the same colour as the identification numbers.
- 7.14.14.7 On pipe runs the identification on different pipelines shall be within 500 mm of each other.
- 7.14.14.8 Service identifications shall comply with AS 1345.

### **7.14.15 Material and Pipe Spool Identification**

- 7.14.15.1 All pipes and fabricated fittings shall be tagged or marked using an approved system and procedure.
- 7.14.15.2 Piping spools shall be marked/stamped after fabrication and prior to corrosion protection.
- 7.14.15.3 In addition, metal tags stamped with the pipeline number shall be securely tied to each spool.
- 7.14.15.4 Material identification shall be maintained throughout the fabrication, installation, up to and including final inspection. In particular, an approved system shall be used to clearly identify the material of all pipes and fittings of ABS, UPVC and CPVC construction due to their visual similarity.

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### **7.14.16 Factory Inspection and Testing**

- 7.14.16.1 All fabrication shall be inspected in accordance with AS 4041.
- 7.14.16.2 Inspection shall include 100% visual examination and any other additional examination necessary to ensure compliance with this Specification.
- 7.14.16.3 Inspection and testing shall be carried out before any painting or coating is applied.
- 7.14.16.4 Non-destructive testing of welds shall be carried out after final heat treatment is completed.
- 7.14.16.5 The extent of non-destructive inspection of fabricated piping shall be in accordance with AS 4041 unless stated otherwise.

### **7.15. Storage and Handling**

#### **7.15.1 General**

- 7.15.1.1 All piping components shall be stored in a clean area away from the fabrication and construction activities and handled such that no damage or mixing of materials occurs.
- 7.15.1.2 Materials shall be stored on pallets and not on the ground. End caps shall be kept on all components during storage. Threaded ends shall be protected by end caps.
- 7.15.1.3 Hooks shall not be used for lifting. Pipes shall not be rolled off or dropped onto the ground or dragged over the ground.
- 7.15.1.4 Flange facings shall be protected from damage. Covers shall be securely fastened to flange facings during handling, transportation and storage at site.

#### **7.15.2 Stainless Steel Materials**

- 7.15.2.1 Stainless steel materials must be stored on non-metallic pallets.
- 7.15.2.2 End caps shall be kept on piping components until immediately prior to installation.
- 7.15.2.3 All flanges and flanged connections shall be sealed with blinds to prevent ingress of water, moisture and foreign matter. Threaded ends shall be capped with a plastic cap and sealed.
- 7.15.2.4 Stainless steel piping and components shall be stored in separate areas away from storage areas for carbon steel and other materials to avoid direct contact causing galvanic corrosion.
- 7.15.2.5 Steel wire slings shall not be used for handling and transporting stainless steel materials. Canvas or nylon slings shall be used.
- 7.15.2.6 The surfaces of components shall be cleaned with acetone and then rinsed with demineralised water to remove deposits of foreign materials.

#### **7.15.3 Lined Steel Pipes**

- 7.15.3.1 Pipes and piping components shall be handled in such a way that the lining and other materials are not damaged.
- 7.15.3.2 For cement lined pipe, airtight end covers shall be fitted at all times to ensure a moist atmosphere inside the pipe and for retaining any broken pieces of the lining.
- 7.15.3.3 Lined pipe shall not come into contact with sharp edges and shall always be supported uniformly along its length.
- 7.15.3.4 The lined pipe shall be stored under cover to protect it from exposure to high temperatures.

#### **7.15.4 Repair of Coatings and Linings**

- 7.15.4.1 The Contractor shall ensure that damage caused to the coatings or linings of pipework before acceptance of delivery at site shall be repaired by the supplier using the appropriate repair procedures in accordance with manufacturer guidelines.

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### 7.16. Pipe Class Specifications

#### 7.16.1 Ductile Iron Cement Lined (DICL) pipes

7.16.1.1 The following descriptors apply to the DICL pipe class:

- **Pipe Sizes:** DN 100 to 750
- **Design Pressure:** 1600 kPa
- **Design Temperature:** 50°C (limited by EPDM gaskets)

7.16.1.2 The following specification and standards apply to the DICL pipe class:

**Table 5 - Specifications for DICL Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	100 to 750	AS 2280 Pipe to WSA PS-200	Ductile iron pipe, PN 35 spigot and socket ends for rubber ring joints and flange class for flanged joints. Unless specified otherwise, external coating shall be bituminous paint 50 µm thick or approved equivalent for underground pipes and in accordance with Section 14 <i>Corrosion Protection</i> of this Specification for above ground pipes. Pipes shall be of 5.5 m effective lengths unless otherwise specified.
Fittings	100 to 750	AS 2280 Fittings to WSA PS-201	Ductile cast iron with thermal bonded polymeric coating.
Joints: Rubber Ring Joints	100 to 750	AS 1646	EPDM Rubber ring to be located in a specially designed groove within the socket.
Joints A: Flanges	100 to 750	AS 2280	To conform to AS 4087 PN16, Ductile Cast Iron, raised face flange. Preferred option: Integrally cast with pipe or fittings. Non-preferred alternative: Screw-on flange only to be used with Flange Class pipe; thread sealed with epoxy.
Joints B: Gibault joints	100 to 750	AS 2280	Long barrel type or short barrel to suit pipe joint geometry. Bolts shall be metric, 316 stainless steel.
Dismantling joints	100 to 750	Ductile iron	Thrust or non-thrust type to be nominated by the Engineer. Coating shall be thermal bonded polymeric. Bolts shall be metric, 316 stainless steel.
Gaskets	100 to 500	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD.
Gaskets	600 to 750	Compressed fibre WSA-109	Full face gasket - 1.5 mm thick
Flange Bolts	100 to 500	ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)

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Item	Size DN (mm)	Material/ Standard	Description
Nuts	100 to 500	ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs	100 to 500	DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Flange Bolts	600 to 750	ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 70
Nuts	600 to 750	ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 70
Studs	600 to 750	DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 70
External protection for buried piping	100 to 750	Polyethylene sleeve	Loose polyethylene sleeve shall be fitted and strapped over the piping in accordance with AS 3680 and the installation instructions from the sleeving and pipe supplier. Sleeving colour shall be blue for potable and raw water supply, cream for sewerage and lilac for reclaimed effluent.
Lining	100 to 600	AS 3972	Cement Mortar Lining: <ul style="list-style-type: none"> <li>• Thickness = 5 mm</li> <li>• Tolerance <math>\pm 1.5</math> mm</li> </ul>
	750	AS 3972	Cement Mortar Lining: <ul style="list-style-type: none"> <li>• Thickness = 6 mm</li> <li>• Tolerance <math>\pm 1.5</math> mm</li> </ul>

- 7.16.1.3 Bolt-on type puddle flanges shall be designed to resist the thrust from a dead-end pipe with the full test pressure applied. As a minimum, the pipe shall be grooved to receive the flange and an epoxy applied between the flange and the pipe.
- 7.16.1.4 Bellmouths shall be of a shape that will promote low head loss flow entry into a pipeline. Tapers are not acceptable. The diameter of the bellmouth lip shall be not less than 1.5 times the pipe diameter. The length of the bellmouth shall be not less than the pipe diameter.
- 7.16.1.5 The following preferred diameters and branch types apply to the DCIL pipe class:

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**Table 6 - Preferred Diameters and Branch Types for D1CL Pipes**

Line pipe size (DN mm)	Branch pipe size (DN mm)										
	100	150	200	225	250	300	375	450	500	600	750
100	ET										
150	RT AV/H	ET									
200	RT AV/H	RT	ET								
225	RT AV/H	RT	RT	ET							
250	RT AV/H	RT	RT	RT	ET						
300	RT AV/H	RT	RT	RT	RT	ET					
375	RT+R AV/H	RT+R	RT	RT	RT	RT	ET				
450	RT+R AV/H	RT+R	RT+R	RT+R	RT	RT	RT	ET			
500	RT+R AV/H	RT+R	RT+R	RT+R	RT	RT	RT	RT	ET		
600	RT+R AV/H	RT+R	RT+R	RT+R	RT+R	RT	RT	RT	RT	ET	
750	RT+R AV/H	RT+R	RT+R	RT+R	RT+R	RT	RT	RT	RT	RT	ET

**Legend**

- ET Equal tee
- RT Reducing tee
- RT+R Reducing tee plus reducing taper
- AV/H Air valve/hydrant tee for flanged branch

### 7.16.2 Carbon Steel Pipes

7.16.2.1 The following descriptors apply to the Carbon Steel pipe class:

- **Pipe Sizes:** DN 20 to 250
- **Design Pressure:** 1600 kPa
- **Design Temperature:** 50°C (limited by EPDM gaskets)

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7.16.2.2 The following specifications and standards apply to the Carbon Steel pipe class:

**Table 7 – Specifications for Carbon Steel Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	20 to 40	API 5L Gr B or ASTM A53 Gr B	ERW pipe, schedule 80, plain ends
	50 to 250	API 5L Gr B or ASTM A53 Gr B	ERW pipe, schedule 40, plain ends
Fittings	20 to 250	ANSI B 16.9	Wrought fittings, butt welding
Flanges	20 to 250	AS/NZS 3678 250	AS 4087 PN 16, steel, plate flange, raised face, slip-on
Gaskets	20 to 250	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Bolts		ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Joints	20 to 250	AS 4041	Butt welds or flanges

7.16.2.3 The following preferred diameters and branch types apply to the Carbon Steel pipe class:

**Table 8 - Preferred Diameter and Branch Types for Carbon Steel Pipes**

Line pipe size (DN mm)	Branch pipe size (DN mm)										
	15	20	25	40	50	65	80	100	150	200	250
15	ET										
20	RT	ET									
25	RT	RT	ET								
40	SO	SO	SO	ET							
50	SO	SO	SO	RT	ET						
65	SO	SO	SO	SO	RT	ET					
80	SO	SO	SO	SO	RT	RT	ET				
100	SO	SO	SO	SO	SO	SO	RT	ET			
150	SO	SO	SO	SO	SO	SO	W	RT	ET		
200	SO	SO	SO	SO	SO	SO	W	W	RT	ET	
250	SO	SO	SO	SO	SO	SO	W	W	W	RT	ET

**Legend**

ET Equal tee  
RT Reducing tee  
W Weldolet  
SO Sockolet or Half Coupling

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### 7.16.3 Stainless Steel (GR 316L) and ERW Pipe (Butt Welded) Pipes

7.16.3.1 The following descriptors apply to the Stainless Steel and butt welded ERW pipe class:

- **Pipe Sizes:** DN 15 to 500
- **Design Pressure:** 1400 kPa
- **Design Temperature:** 50°C (limited by EPDM gaskets)

7.16.3.2 The following specifications and standards apply to the Stainless Steel and butt welded ERW pipe class:

**Table 9 - Specifications for Stainless Steel Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	15 to 50	ASTM A312-TP316L ANSI B36.19M	Stainless steel seamless pipe Sch 40S
	80 to 500	ASTM A312-TP316L ANSI B36.19M	Stainless steel ERW pipe Sch 10S plain ends
Screwed fittings	15 to 50	ASTM A182-F316L	Forged austenitic stainless steel Grade 316L fittings, screwed to AS 1722.1 (BSPT compatible)
Butt-welding fittings	15 to 500	ASTM A403-WP316L	Wrought austenitic stainless steel butt weld fittings
Flanges	15 to 500	ASTM A240-316L	AS 4087 PN 16, stainless steel Grade 316L, plate flange, raised face, slip-on
Gaskets	15 to 500	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Welded joints	15 to 500	AS 4041	Butt welds
Screwed joints	15 to 50	AS 1722.1 (BSPT compatible)	BSPT: RT series
Welding, pickling, passivation	15 to 500	AS 4041 ASTM A 380	Refer to clause 6.4.18

7.16.3.3 As an alternative to threaded pipe, DN 15 to DN 50 pipe may be plain ended to suit butt-weld fittings where specified.

### 7.16.4 Spiral Welded Stainless Steel (GR 316L) Pipes

7.16.4.1 The following descriptors apply to the spiral welded Stainless Steel pipe class:

- **Pipe Sizes:** DN 150 to 1200
- **Design Pressure:** 700 kPa
- **Design Temperature:** 50°C (limited by EPDM gaskets)

7.16.4.2 The following specifications and standards apply to the spiral welded stainless steel pipe class:

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**Table 10 - Specification for Stainless Steel Pipes (spiral welded)**

Item	Size DN (mm)	Material/ Standard		Description
Pipe	150 to 1200	ASTM A554 TP316L		Stainless steel spiral welded pipe (inert gas shielded spiral TIG butt weld), fully pickled and passivated, plain ends
	<b>DN (mm)</b>	<b>OD (mm)</b>		<b>Min. Wall Thickness (mm)</b>
	150	168		2.5
	200	219		2.5
	250	273		2.5
	300	324		3
	400	406		3
	450	457		3
	500	508		3
	600	610		4
	700	711		4
	750	762		4
	800	813		4
	900	914		5
	1000	1016		5
	1200	1219		5
Fittings	150 to 1200	ASTM A403-WP316L		Wrought austenitic stainless steel butt weld fittings
	400 to 1200	ASTM A554 TP316L AWWA Manual M11		Fabricated from pipe of same or larger wall thickness as line pipe
Flanges	150 to 1200	ASTM A240 316L neck ring ASTM A240 316L back-up flange		Neck ring with stainless steel back-up flange to AS 4087 PN16 Neck ring wall thickness not less than pipe wall thickness
Gaskets	150 to 1200	Solid EPDM WSA-109		Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Bolts		ISO 4014 AS 1111		Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112		Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528		Metric, 316 stainless steel, DIN A4 Class 50 (min)
Joints	150 to 1200	AS/NZS 1554-6		Butt welds or flanges as specified
Welding, pickling, passivation	150 to 1200	AS/NZS 1554-6		Unless specified otherwise, all weld filler material shall be 316L. All welds shall be TIG or MIG. Passivation and pickling shall be carried out on all welded areas as per clause 6.4.18.

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7.16.4.3 All spiral wound stainless steel tube used shall be manufactured in accordance with the requirements set out in AS 4041 for class 3 piping with Straub, Vanstone or equal couplings.

### 7.16.5 Copper Tube

7.16.5.1 The following descriptors apply to the Copper Tube pipe class:

- **Pipe Sizes:** DN 15 to 50
- **Design Pressure:** 1400 kPa
- **Design Temperature:** 50°C (limited by EPDM gaskets)

7.16.5.2 The following specifications and standards apply to the Copper Tube pipe class:

**Table 11 - Specifications for Copper Tube**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	15 to 20	AS 1432 Type A	Bendable grade copper tube, plain ends, straight lengths
	25 to 50	AS 1432	Hard drawn copper tube, plain ends, straight lengths
Fittings	15 to 50	AS 1572	Copper alloy dezincification resistant (DR) fittings for soldered, threaded and compression type joints
Flanges	15 to 50	AS 1572	Copper plate flange brazed inside and outside or integral flange, flat face, AS 4087 PN16
Gaskets	15 to 50	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Flange bolts		ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Joints	15 to 50		Soldered, capillary, brazed, compression or threaded fittings to approved standards. Refer to notes below.

7.16.5.3 Compression fittings shall be “Alltite”, “Starkie” or equivalent. “Crox” unions shall not be acceptable.

7.16.5.4 Brazed joints shall be socket and spigot type, using an oxyacetylene flame with “Silbeloy 15” (containing 15% silver) and shall be neatly made to avoid dead legs or other features which may lead to corrosion or build-up of debris.

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### 7.16.6 Polyethylene (PE) Pipes

7.16.6.1 The following descriptors apply to the Polyethylene pipe class:

- **Pipe Sizes:** DN 20 to 630
- **Design Pressures, PN16:**
  - 1600 kPa @ <20°C
  - 1400 kPa @ <30°C
  - 1200 kPa @ <40°C
  - 1000 kPa @ <50°C
- **Design Temperature:** 50°C (limited by EPDM gaskets)
- **Pipe Sizes:** DN 710 to 1000
- **Design Pressures, PN10:**
  - 1000 kPa @ <20°C
  - 860 kPa @ <30°C
  - 730 kPa @ <40°C
  - 630 kPa @ <50°C
- **Design Temperature:** 50°C (limited by EPDM gaskets)

7.16.6.2 The following specifications and standards apply to the Polyethylene pipe class:

**Table 12 - Specifications for PE Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	20 to 1000	AS/NZS 4130, AS/NZS 4131	Series 1 PE 100 PN 10 (SDR 17) and PN 16 (SDR 11) pressure pipe, plain ends
Fittings	20 to 1000	AS/NZS 4129, AS/NZS 4131	PE 100 PN 10 (SDR 17) and PN 16 (SDR 11) electrofusion or butt welding type
Flanges	20 to 1000	AS/NZS 4131, AS/NZS 3678	PE 100 PN 10 (SDR 17) and PN 16 (SDR 11) electrofusion or butt welding type stub flange with carbon steel hot-dip galvanized backing flange to AS 4087 PN 16
Gaskets	20 to 1000	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Flange Bolts		ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)

- 7.16.6.3 AS 2129 Table D (or E for  $\leq$  DN 100) flanges may be accepted if AS 4087 PN 16 type are not available.
- 7.16.6.4 Where polyethylene pipework of colours other than black is exposed to sunlight, the pipework shall be wrapped using an approved wrapping material or painted using a minimum of two coats of a white water-based paint.
- 7.16.6.5 The wrapping or paint shall extend 300 mm below the exposed section of pipe into the supporting material, e.g. soil, concrete.
- 7.16.6.6 Compression fittings shall not be used without prior written approval from the Superintendent.
- 7.16.6.7 Polyethylene pipe shall not be subjected to bending to a radius tighter than 25 times the pipe outside diameter. Hot bending shall not be permitted.

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- 7.16.6.8 All fusion bonding processes shall be strictly in accordance with the pipe manufacturer's recommendations and procedures.
- 7.16.6.9 The Contractor shall take special care with all polyethylene pipes and fittings which are prone to surface damage if incorrectly handled or stored as well as being subject to degradation when exposed to sunlight. All handling and storage shall be strictly in accordance with the manufacturer's recommendations and procedures. No metal chains or slings shall be used.
- 7.16.6.10 All pipe laying shall be in accordance with both the manufacturer's recommendations and installation procedures and AS 2566.
- 7.16.6.11 Polyethylene has a relatively high coefficient of linear expansion (approximately 0.18 mm/m/°C). When laying/installing pipe, sufficient allowance must be made for expansion and contraction.

### 7.16.7 Acrylonitrile Butadiene Styrene (ABS) Pipes

- 7.16.7.1 The following descriptors apply to the ABS pipe class:
- 7.16.7.2 **Pipe Sizes:** DN 15 to 750
- 7.16.7.3 **Design Pressures, PN15:** 1500 kPa @ -20 to ≤ 20°C  
850 kPa @ >20 to ≤ 40°C  
630 kPa @ >40 to ≤ 50°C  
**Design Temperature** 50°C (limited by EPDM gaskets)
- 7.16.7.4 **Design Pressures, PN12:** 1200 kPa @ -20 to ≤ 20°C  
680 kPa @ >20 to ≤ 40°C  
500 kPa @ >40 to ≤ 50°C  
**Design Temperature** 50°C (limited by EPDM gaskets)
- 7.16.7.5 The following specification and standards apply to the ABS pipe class:

**Table 13 - Specifications for ABS Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	15 to 750	ABS to AS 3518	PN 12 and PN 15 pipe, plain ends
Fittings	15 to 750	ABS to AS 3518	Moulded with female socket ends for ABS solvent cement joints. PN not less than pipe pressure class
Flanges	15 to 50	AS/NZS 3678 or AS 1548 backing flange	Full face flange with socket solvent cement joint to pipe and with carbon steel hot dip galvanized backing flange to AS 4087 PN 16
	80 to 750	AS/NZS 3678 or AS 1548 backing ring	Stub flange with socket solvent cement joint to pipe and with carbon steel hot dip galvanized backing ring conforming to AS 4087 PN 16
Gaskets	15 to 750	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Flange Bolts		ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min).
Joints	15 to 750		Solvent cement joints

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- 7.16.7.6 All flanged ABS piping shall be fitted with backing rings as specified above. In services and areas where pH is less than 6 or greater than 12, galvanized carbon steel backing flanges are not suitable. In such conditions flanges and fasteners shall be of all stainless steel Grade 316 construction.
- 7.16.7.7 If exposed to direct heat from sun, use pressure rating stated above for 40°C.
- 7.16.7.8 All ABS pipework systems shall be installed in accordance with AS/NZS 369.

### 7.16.8 Unplasticised Polyvinyl Chloride (uPVC)

7.16.8.1 The following descriptors apply to the uPVC pipe class:

- **Pipe Sizes:** DN 15 to DN 300
- **Design Pressures, PN 18:**
  - 1800 kPa @ <20°C
  - 1620 kPa @ <30°C
  - 1260 kPa @ <40°C
  - 900 kPa @ <50°C
- **Design Pressures, PN 12:**
  - 1200 kPa @ <20°C
  - 1080 kPa @ <30°C
  - 840 kPa @ <40°C
  - 600 kPa @ <50°C

7.16.8.2 The following specifications and standards apply to the uPVC pipe class:

**Table 14 - Specifications for UPVC**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	15	UPVC AS/NZS 1477	PN15 or PN18 pressure pipe plain ends, not less than PN of piping system. Dimensions to AS/NZS 1477 Series 1 for solvent cement joints
	20 to 300	UPVC AS/NZS 1477	PN12 or PN18 pressure pipe plain ends, not less than PN of piping system Dimensions to AS/NZS 1477 Series 1 for solvent cement joints or Series 2 for rubber ring joints, compatible with ductile iron pipes ≥ DN 100
Fittings	15 to 300	UPVC AS/NZS 1477	PN12, PN15 or PN18 UPVC socket type fittings, not less than PN of piping system. Dimensions to AS/NZS 1477 Series 1 for solvent cement joints
Flanges	15 to 40	UPVC AS/NZS 1477	PN18 full face UPVC flange to AS 4087 PN 16
Gaskets	15 to 300	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Flange bolts		ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Joints	15 to 300		Solvent cemented joints unless stated otherwise. Refer to notes below.

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- 7.16.8.3 All uPVC systems shall be installed strictly in accordance with the requirements of AS/NZS 2032 and AS/NZS 2566.
- 7.16.8.4 AS 2129 Table D (or E for  $\leq$  DN 100) flanges may be accepted if AS 4087 PN 16 type are not available.
- 7.16.8.5 Where pipe will be exposed to direct sunlight, pipe shall be painted with acrylic paint of light colour. Oil – based paint must not be used.
- 7.16.8.6 Cleaning fluids or solvents that might damage uPVC must not be used.
- 7.16.8.7 Pipe and/or fittings containing lead-based stabilisers and/or plasticisers are not allowable and shall not be used.
- 7.16.8.8 Pipes shall be cut square and flat using a fine-toothed saw. Burrs shall be removed from both inside and outside edges of the pipe and a 15° chamfer cut on the external surface.
- 7.16.8.9 Joints shall be made in accordance with the pipe manufacturer’s recommended method using pressure grade solvent cement and the associated cleaner/primer as supplied by the pipe manufacturer.
- 7.16.8.10 Immediately after application of the cement the socket shall be pushed over the spigot, rotating one quarter to one half turn at the same time until the spigot “bottoms” in the socket.
- 7.16.8.11 Joints shall not be disturbed for a minimum period of five minutes after making the joint.
- 7.16.8.12 Excess cement shall be removed from both internal and external surfaces.

### 7.16.9 Oriented Polyvinyl Chloride (oPVC)

- 7.16.9.1 The following descriptors apply to the oPVC pipe class:
  - **Pipe Sizes:** DN 100 to DN 375
  - **Design Pressures, PN 16:**
    - 1600 kPa @  $<20^{\circ}\text{C}$
    - 1390 kPa @  $<30^{\circ}\text{C}$
    - 1120 kPa @  $<40^{\circ}\text{C}$
    - 1020 kPa @  $<45^{\circ}\text{C}$
- 7.16.9.2 The following specifications and standards apply to the oPVC pipe class:

**Table 15 - Specifications for oPVC Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	100 to 375	oPVC, PN16 AS/NZS 4441 ISO 16422	Dimensions to AS/NZS 4441 Series 2 for rubber ring joints, compatible with ductile iron pipes
Joints	100 to 375		Rubber ring joints only

- 7.16.9.3 Where pipe will be exposed to direct sunlight, pipe shall be painted with acrylic paint of light colour. Oil – based paint must not be used.
- 7.16.9.4 Cleaning fluids or solvents that might damage the oPVC must not be used.
- 7.16.9.5 Pipe and/or fittings containing lead-based stabilisers and/or plasticisers are not allowable and shall not be used.
- 7.16.9.6 Pipes shall be cut square and flat using a fine toothed saw. Burrs shall be removed from both inside and outside edges of the pipe and a 15 degree chamfer cut on the external surface.
- 7.16.9.7 Joints shall be made in accordance with the pipe manufacturer’s recommended method using pressure grade solvent cement and the associated cleaner/primer as supplied by the pipe manufacturer.

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- 7.16.9.8 Immediately after application of the cement the socket shall be pushed over the spigot, rotating one quarter to one half turn at the same time, until the spigot “bottoms” in the socket.
- 7.16.9.9 Joints shall not be disturbed for a minimum period of five minutes after making the joint.
- 7.16.9.10 Excess cement shall be removed from both internal and external surfaces.

### 7.16.10 Modified Polyvinyl Chloride (mPVC)

7.16.10.1 The following descriptors apply to the mPVC pipe class:

- **Pipe Sizes:** DN 100 to DN 375
- **Design Pressures, PN 16:** 1600 kPa @ <20°C  
1390 kPa @ <30°C  
1120 kPa @ <40°C  
925 kPa @ <50°C

7.16.10.2 The following specifications and standards apply to the mPVC pipe class:

**Table 16 - Specifications for MPVC Pipes**

Item	Size DN (mm)	Material/ Standard	Description
Pipe	100 to 375	mPVC, PN16 AS/NZS 4765	Dimensions to AS/NZS 4765 Series 2 for rubber ring joints, compatible with ductile iron pipes
Joints	100 to 375		Rubber ring joints only

- 7.16.10.3 Where pipe will be exposed to direct sunlight, pipe shall be painted with acrylic paint of light colour. Oil – based paint must not be used.
- 7.16.10.4 Cleaning fluids or solvents that might damage the mPVC must not be used.
- 7.16.10.5 Pipe and/or fittings containing lead-based stabilisers and/or plasticisers are not allowable and shall not be used.
- 7.16.10.6 Pipes shall be cut square and flat using a fine-toothed saw. Burrs shall be removed from both inside and outside edges of the pipe and a 15 degree chamfer cut on the external surface.
- 7.16.10.7 Joints shall be made in accordance with the pipe manufacturer’s recommended method using pressure grade solvent cement and the associated cleaner/primer as supplied by the pipe manufacturer.
- 7.16.10.8 Immediately after application of the cement the socket shall be pushed over the spigot, rotating one quarter to one half turn at the same time until the spigot “bottoms” in the socket.
- 7.16.10.9 Joints shall not be disturbed for a minimum period of five minutes after making the joint.
- 7.16.10.10 Excess cement shall be removed from both internal and external surfaces.

### 7.16.11 Glass Reinforced Plastic (GRP)

7.16.11.1 The following descriptors apply to the GRP pipe class:

- **Pipe Sizes:** DN 300 to 1200
- **Design Pressure:** To suit service conditions. Not less than PN6
- **Design Temperature:** 35°C  
Apply de-rating factors:  
0.9 for 45°C design temperature  
0.8 for 55°C design temperature

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7.16.11.2 The following specifications and standards apply to the GRP pipe class:

**Table 17 - Specification for GRP Pipes**

Item	Size DN (mm)	Material/ Standard	Item
Pipe	300 to 1200	AS 2885.1, ISO 14692-2	GRP piping, pressure rating to suit service conditions as defined in Pipe Schedule (minimum PN6) Stiffness 10 000N/m <sup>2</sup> for buried pipes
Flanges	300 to 1200	ISO 14692-2, AS/NZS 3678	Full face GRP flanges with AS 4087 PN16 drillings
Gaskets	300 to 1200	Solid EPDM WSA-109	Full face gasket - 3.0 mm thick Type WA, WC or WG to suit fluid Hardness - 70 IRHD
Flange bolts	300 to 1200	ISO 4014 AS 1111	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Nuts		ISO 4032 AS 1112	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Studs		DIN 976-1 AS 2528	Metric, 316 stainless steel, DIN A4 Class 50 (min)
Fittings		ISO 14692-2	GRP fittings, pressure rating to suit service conditions (minimum PN6)
Joints	300 to 1200	ISO 14692-2	Butt joints and over wrap joints preferred

## 8. Valves and Actuators

### 8.1. Valves

#### 8.1.1 General Requirements

- 8.1.1.1 Valves shall be double-flanged unless unavailable or otherwise specified.
- 8.1.1.2 Unless otherwise stated, flanged valves shall be to AS 4087.
- 8.1.1.3 All isolating valves shall be capable of opening against full unbalanced head and closing against full flow. They shall open and close smoothly without vibration or cavitation and without damage. Isolating valves shall be permit disassembly of downstream piping with the valve closed against the rated pressure.
- 8.1.1.4 Valves shall be closed by an anti-clockwise rotation of the closing mechanism. The face of each mechanism shall show clearly the labels OPEN and CLOSE to indicate the direction of turn to open and close the valve.
- 8.1.1.5 Exceptions to the valve closing directions nominated in clause 8.1.1.4 above are outlined in the table below.

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**Table 18 - Valve Closing Direction Exceptions**

Valve Type	Closing Direction
All valves smaller than DN80	clockwise closing
Knife gate valves	clockwise closing
Ball valves with lever operator	clockwise closing
Butterfly valves with lever operator	clockwise closing
Valves in sewage treatment plants, mounted above ground or in open pits accessible via standard walkways. Definition of below ground is: Buried valves, valves mounted in enclosed pits where confined space entry is required or operation via a valve extension spindle is required.	clockwise closing

- 8.1.1.6 Unless specified otherwise, the maximum allowable manual torque applied to the spindle shall be 125 Nm under the maximum operating pressure. If greater than maximum allowable manual torque, a gearbox shall be provided to reduce torque to no greater than 125 Nm.
- 8.1.1.7 Valve spindles shall be of the non-rising type, except for knife gate valves. If required, the end of a valve operating spindle shall be designed to accommodate a standard steel extension spindle in accordance with AS 2638.
- 8.1.1.8 Valves shall be placed, when possible, so that they can be operated and serviced from grade or an access platform.
- 8.1.1.9 All screws, nuts and bolts used to fasten equipment shall be threaded in accordance with the relevant Standard.
- 8.1.1.10 Butterfly valves shall be installed with the spindle in the horizontal plane and have the lower part of the disc move in the same direction as the flow when the valve is opened.
- 8.1.1.11 Butterfly valves shall be heavy pattern double flanged valves of the seal-on-body type. The sealing surfaces of the valves shall bed on the metal face of the pipework flanges, not on the cement lining.
- 8.1.1.12 If the valve sealing surface does not bed on the metal face, the Contractor shall provide minimum 6 mm thick stainless steel Grade 316 insertion rings and additional rubber insertion joint rings.
- 8.1.1.13 Swing check valves shall preferably be located in horizontal pipe runs. However, where conditions warrant, they may be installed in vertical upflow lines.
- 8.1.1.14 Air valves shall be mounted above a manual isolation valve of the same diameter as the air valve in a manner that will allow removal of the air valve without removing the isolation valve or requiring the pipeline to be taken out of service.
- 8.1.1.15 Level control valves shall be located in sight of their level indicators. Locally mounted indicators or controllers shall be located in sight of the control valve they control.
- 8.1.1.16 Control valves shall be suitable for cavitation free operation over the complete range of valve operating conditions. When possible, control valves shall be installed with the stem in the vertical position.
- 8.1.1.17 Pressure safety valves shall be installed in an upright position and in a position accessible from a platform or grade. Pressure safety valves discharging hazardous liquids or gases shall be piped to a point of safety to personnel.
- 8.1.1.18 The strength and pressure rating of all parts shall be sufficient to provide an appropriate safety factor under all working conditions.
- 8.1.1.19 Valves shall be drip tight in the closed position.
- 8.1.1.20 Valve internal surfaces shall be free of sharp protrusions.

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- 8.1.1.21 All parts requiring grease lubrication shall be fitted with hydraulic grease nipples.
- 8.1.1.22 The same manufacturer shall be used when two or more equipment items of the same type and sized are required.

### 8.1.2 Material Requirements

- 8.1.2.1 Castings shall be made in accordance with best foundry practice and shall be free from all defects.
- 8.1.2.2 All nuts, bolts, washers and studs for flange connection shall be stainless steel Grade 316 to suit the mating flanges and suitable for maximum working pressure.
- 8.1.2.3 All shafts, spindles and appropriate supports shall be manufactured from stainless steel Grade 316. External components not specifically detailed shall be from stainless steel Grade 316 or other approved corrosion resistant material.

### 8.1.3 Valve Identification

- 8.1.3.1 The following lettering shall be cast on the body of the valve:
- Manufacturer's brand
  - Valve size and type
- 8.1.3.2 The cast lettering shall be in legible block type letters and, where practical, not less than 25 mm high and projecting not less than 3 mm.

### 8.1.4 Water Services Australia Specifications

- 8.1.4.1 Valves shall comply with this Specification, Unitywater's Infrastructure Products and Materials Lists and WSAA Product Specifications (in that order) where such specifications exist. Reference is made to the following WSAA Product Specifications:

**Table 19 - WSAA Valve Product Specifications**

WSAA Valve Product Specification	Title	Coating Standard	DFT [ $\mu$ m] Polymeric coating - External surfaces	DFT [ $\mu$ m] Polymeric coating – Internal surfaces	DFT [ $\mu$ m] High-build two-pack epoxy coating (no primer)	DFT [ $\mu$ m] High-build two-pack epoxy coating (with primer)
WSA PS – 260	Gate Valves, Resilient Seated	AS 4158	300	350	Not accepted	Not accepted
WSA PS – 261	Gate Valves, Metal Seated	AS 4158	300	350	Not accepted	Not accepted
WSA PS – 262	Extension Spindles for Gate Valves	AS 4158 AS 3750	350	N/A	Not accepted	Not accepted
		Alternative: Hot-dip galvanized in accordance with AS 4680				
WSA PS – 263	Butterfly Valves	AS 4158 AS 3750	300	350	500	550
WSA PS – 264	Non-Return (Reflux) Valves	AS 4158	300	350	Not accepted	Not accepted
WSA PS – 265	Air Valves for Water Supply	AS 4158 AS 3750	300	350	500	550
WSA PS – 266	Knife Gate Valves for Water and Sewerage	N/A	Uncoated	Uncoated	Uncoated	Uncoated

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WSAA Valve Product Specification	Title	Coating Standard	DFT [ $\mu\text{m}$ ] Polymeric coating - External surfaces	DFT [ $\mu\text{m}$ ] Polymeric coating – Internal surfaces	DFT [ $\mu\text{m}$ ] High-build two-pack epoxy coating (no primer)	DFT [ $\mu\text{m}$ ] High-build two-pack epoxy coating (with primer)
WSA PS – 268	Automatic Control Valves for Water	AS 4158 AS 3750	300	350	500	550
WSA PS – 269	Extension Spindles for Valves, General	AS 4158 AS 3750	350	N/A	Not accepted	Not accepted
		Alternative: Hot-dip galvanized in accordance with AS 4680				
WSA PS – 274	Ball Valves for Water & Sewerage	N/A	Uncoated	Uncoated	Uncoated	Uncoated
WSA PS – 275	Air Valves for Sewerage	AS 4158 AS 3750	300	350	500	550

- 8.1.4.2 The WSAA Product Specifications make reference to various options for each valve. These options will be specified in the valve schedule.
- 8.1.4.3 Valve types that are not covered by the WSAA Product Specifications shall comply with this Specification, Unitywater’s Infrastructure Products and Materials List and the valve schedule.
- 8.1.4.4 Knife Gate Valves for water and sewerage as detailed in WSA PS – 266 shall be used for general applications such as valve pits and open-to-atmosphere installations on STPs or in the water and sewage network.
- 8.1.4.5 Bonneted Knife Gate Valves shall be used for a highly corrosive environments, un-vented sewage applications in the presence of H<sub>2</sub>S, such as sewage pump station wet-wells.

## 8.2. Eccentric Plug Valves

### 8.2.1 General Requirements

- 8.2.1.1 Plug valves shall be non-lubricated eccentric type.
- 8.2.1.2 Plug valves shall have a nickel seat welded to the valve body and an elastomeric plug which shall provide tight shut off against maximum working pressure from either direction.
- 8.2.1.3 Materials shall be as specified in the project requirements detailed below. Alternative materials having strength, temperature and corrosion resistance characteristics equal or superior to those specified may be offered.
- 8.2.1.4 Valve designs shall be such as not to allow grit build up within the valve or alternatively be provided with a collection point which is cleared when the valve is actuated. Grit protectors shall be used around bearings to prevent bearing damage.

### 8.2.2 Valve Body

- 8.2.2.1 Valves of size DN50 and larger shall be fully flanged.
- 8.2.2.2 Flanges shall be truly machine faced for their full width and the faces shall be square to the axis of the valve. The back faces shall be either machined or spot faced at bolt holes.

### 8.2.3 Valve Plug and Seat

- 8.2.3.1 The axis of rotation of the plug shall be offset from the plane of the sealing surfaces.

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- 8.2.3.2 The plug shall be manufactured from materials specified in the schedule and shall be properly cleaned and finished. The valve seat shall be fully welded to the body and shall provide a uniform seal around the perimeter of the valve.

### 8.2.4 Valve Operating Assembly

- 8.2.4.1 Valve bearings shall be of the sleeve type and shall be self-lubricated. Bearings shall be designed for a minimum  $L_{10}$  operating life of 100,000 hours and shall be readily replaceable.
- 8.2.4.2 The design of the trunnion shaft and bearings shall be such that they will safely sustain maximum differential pressure rating across the closed valve.
- 8.2.4.3 The shaft and any keys or dowels etc. for transmitting the torque between the shaft and disc shall be capable of withstanding the maximum torque required to operate the valve. The valve shaft shall be securely attached to the plug by suitable mechanical means.
- 8.2.4.4 Fixings shall be of stainless steel Grade 316 or materials of equal or superior strength and corrosion resistance. The valve packing shall be asbestos-free.
- 8.2.4.5 Manually operated valves up to and including size DN150 shall incorporate a positive latching operation lever with ten (10) positions. Manually operated plug valves over size DN150 shall incorporate gear boxes.

## 8.3. Diaphragm Valves

### 8.3.1 General Requirements

- 8.3.1.1 Diaphragm valves shall have straight pattern bodies with no lining. The diaphragm assembly shall be replaceable inline. Valves shall have non-rising hand-wheel spindle operation and a position indicator protruding from the bonnet assembly.
- 8.3.1.2 Valves shall be easily automated by the replacement of the manual bonnet assembly with a pneumatic actuator bonnet assembly.

### 8.3.2 Valve Body

- 8.3.2.1 Valves of size DN50 and larger shall be fully flanged.
- 8.3.2.2 Flanges shall be truly machine faced for their full width and the faces shall be square to the axis of the valve. The back faces shall be either machined or spot faced at bolt holes. Each body shall be manufactured from the materials specified in the schedule and shall be properly cleaned and finished.

### 8.3.3 Valve Diaphragm

- 8.3.3.1 The diaphragm shall be manufactured from materials specified in Table 20 below.
- 8.3.3.2 The diaphragm shall provide a uniform seal around the throat of the valve.

### 8.3.4 Valve Operating Assembly

- 8.3.4.1 Valve bearings shall be self-lubricated. Bearings shall be designed for a minimum  $L_{10}$  operating life of 100,000 hours and shall be readily replaceable.
- 8.3.4.2 The design of the spindle and bearings shall be such that they will safely sustain maximum differential pressure rating across the closed valve. The spindle and any keys or dowels etc. for transmitting the torque between the shaft and hand wheel shall be capable of withstanding the maximum torque required to operate the valve.

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- 8.3.4.3 The operating assembly shall be provided with adequate drainage of any diaphragm leakage of water to indicate a diaphragm failure. The valve spindle shall be securely attached to the bonnet by suitable mechanical means.
- 8.3.4.4 Fixings shall be of stainless steel Grade 316 or materials of equal or superior strength and corrosion resistance. The valve packing shall be asbestos-free.
- 8.3.4.5 The following material requirements apply to valve operating assemblies:

**Table 20 - Valve Operating Assembly Material Requirements**

Valve Operating Assembly Component	Material
Body and bonnet materials	Cast Iron ASTM A-126 CL
Liner material	Cast Iron ASTM A-126 CL
Diaphragm material	Butyl Rubber
Compressor material	Cast Iron ASTM A-126 CL
Spindle material	Carbon Steel
Spindle nut material	Brass
Body bolt material	316 Stainless Steel
Flanged joint bolting selection (fasteners)	Metric, 316 stainless steel, DIN A4
Coatings	System 6, Section 14.4 of this Specification or approved equivalent
Flange gaskets, O-rings and lubricants	EPDM, Nitrile and Dow Corning O-ring Lubricant #55 or approved equivalent

### 8.3.5 Pressure Safety Valves

- 8.3.5.1 Pressure safety valves (PSV) shall be angle pattern relief valves with the spring assemblies physically separated from the process medium.
- 8.3.5.2 PSVs shall include a lever actuator for manual opening of the valves. The valves shall be capable of passing the maximum required flow at 10% over the valve set pressure.
- 8.3.5.3 The following material requirements apply to pressure safety valves:

**Table 21 - Pressure Safety Valve Material Requirements**

Pressure Valve Component	Material
Body materials	Cast Bronze AS 1565-C83600
Cover material	Cast Bronze AS 1565-C83600
Spindle material	DR Brass AS 1567-486
Disc material	Cast Bronze AS 1565-C83600
Seat material	Cast Bronze AS 1565-C83600
Spindle gland packing or O-ring	PTFE or Nitrile
Spring material	Spring steel
Flanged joint bolting selection (fasteners)	Metric, 316 stainless steel, DIN A4
Flange gaskets, O-rings and lubricants	EPDM, Nitrile and Dow Corning O-ring Lubricant #55 or approved equivalent
Bactericidal lubricant	BK Standard Pipe Jointing Lubricant or approved equivalent

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8.3.5.4 Pressure safety valves on chemical feed systems shall be of diaphragm type. The setting of pressure relief shall be field adjustable. Diaphragm material shall be PTFE/EPDM or an alternative material as required to suit the fluid application.

### 8.3.6 Reduced Pressure Zone Valves

8.3.6.1 Reduced pressure zone (RPZ) valves shall be straight through, double check valve style units suitable for high hazard rating areas.

8.3.6.2 RPZ valves shall be supplied with a strainer and 2 No. lockable isolation valves assembled into the 1 No. unit. RPZ valves shall be suitable for horizontal installation.

8.3.6.3 RPZ valves shall conform to AS 2845.1 and AS 2845.3.

8.3.6.4 The following material requirements apply to reduced pressure zone valves:

**Table 22 - RPZ Valve Material Requirements**

RPZ Valve Component	Material
Body materials	DN 20 to DN 50: Bronze or 316 stainless steel DN 65 to DN 150: Ductile Iron, TBP coated
Disc/Piston material	316 stainless steel
Spring material	316 stainless steel
Seat material	EPDM
Flanged joint bolting selection (fasteners)	Metric, 316 stainless steel, DIN A4
Flange gaskets, O-rings and lubricants	EPDM, Nitrile and Dow Corning O-ring Lubricant #55 or approved equivalent

### 8.3.7 Solenoid Valves

8.3.7.1 Solenoid valves shall be of a modular style, comprising a valve assembly and a push-over coil. The valve diaphragm shall be attached to the armature as a single assembly.

8.3.7.2 The diaphragm/armature assembly and the armature guide tube shall be mounted on the valve body. The coil shall push over and attach to the armature guide tube and therefore be isolated from the process fluid.

8.3.7.3 The valves shall be capable of operating from zero pressure.

8.3.7.4 Pilot operated solenoid valves will not be acceptable.

8.3.7.5 Solenoid valves shall be suitable for a 24 V DC power supply.

8.3.7.6 Solenoid valves shall be soft opening and closing type to mitigate against the effects of water hammer.

8.3.7.7 Solenoid valves shall be provided with manual over-ride facility (lock in position type).

8.3.7.8 Solenoid valves shall have an IP56 protection rating as a minimum. Higher degrees of protection shall be provided where appropriate.

8.3.7.9 Unless noted otherwise, solenoids shall be configured to fail in the closed position.

8.3.7.10 The following material requirements apply to solenoid valves:

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**Table 23 - Solenoid Valve Material Requirements**

Solenoid Valve Component	Material
Body materials	General applications: Brass Corrosive environments: 316 Stainless Steel
Diaphragm material	EPDM
Coatings	N/A
Additional testing	N/A
O-rings and lubricants	Nitrile and Dow Corning O-ring Lubricant #55 or approved equivalent

### 8.3.8 Valve Testing

- 8.3.8.1 The Contractor shall carry out the following tests (sections 8.3.9 to 8.3.12) on all valves at their own cost in the works of the valve manufacturer before the valves are shipped.
- 8.3.8.2 The Contractor shall advise the Superintendent of the date of the tests so that a representative of the Superintendent may elect to attend the tests. Tests shall be in accordance with the relevant Australian Standard for the particular valve type.
- 8.3.8.3 The tests shall simulate a valve in a terminal position held rigidly at one end. In this condition the valve shall be blanked off in such a manner that the axial hydraulic force is not externally restrained. This simulates a valve in a fully differential pressure situation held rigidly at one end only.

### 8.3.9 Valve Testing – Body Tests

- 8.3.9.1 The valve shall be blanked off at both ends and a body test pressure of 1.5 times the valve rated pressure shall be applied for 15 minutes with the disc in the partially open position.
- 8.3.9.2 No leakage shall be visible through the valve body, end joints or shaft seals. Nor shall any part of the valve be permanently/plastically deformed.

### 8.3.10 Valve Testing – Gates Tests

- 8.3.10.1 The valve shall be flanged off at the upstream flange only and a test pressure of 1.5 times the valve rated pressure shall be applied for 5 minutes with the valve in the closed position.
- 8.3.10.2 There shall be no visual evidence of structural damage to or leakage through the disc or valve seat.

### 8.3.11 Valve Testing – Operational Test

- 8.3.11.1 The operational test shall prove that the rim force required on the valve operating mechanism does not exceed 120 N.
- 8.3.11.2 The valve shall be operating from fully closed to fully open positions and reverse under no-flow conditions in order to demonstrate the valve assembly operates normally.

### 8.3.12 Valve Testing – Seat Testing

- 8.3.12.1 The valve shall be flanged off at the downstream flange only and a test pressure of 1.5 times the valve rated pressure shall be applied for 5 minutes with the valve in the closed position.
- 8.3.12.2 No leakage of the valve seat shall be observed.

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8.3.12.3 If the previous tests are not part of the manufacturer's standard, then an optional price and/or extra time may be required to be stated. The manufacturer's standard testing is to be stated regardless.

### **8.4. Actuators**

#### **8.4.1 General requirements**

- 8.4.1.1 The Contractor shall be responsible for ensuring that the actuators will provide the valve operating torques required to meet the operating conditions specified.
- 8.4.1.2 The Contractor shall co-ordinate the valve and actuator manufacturers to ensure that the actuators are compatible with the valves in every aspect.
- 8.4.1.3 Actuated valves shall be designed to not cause surging in the pipeline.
- 8.4.1.4 The rating of each actuator shall be adequate to produce torque/thrust required to actuate the valve under all conditions and shall be able to produce and withstand 1.5 times the maximum torque/thrust required under normal operating conditions.
- 8.4.1.5 Valves shall only be accepted as satisfactory after hydrostatic testing of complete valve and actuator assemblies are complete, approved and appropriate certification issued.
- 8.4.1.6 All actuators shall be electric unless noted otherwise.
- 8.4.1.7 All components of the actuators shall have lifetime lubrication.
- 8.4.1.8 All actuators and accessories shall have an IP56 protection rating as a minimum. Higher degrees of protection shall be provided where appropriate.

#### **8.4.2 Electric Actuators for Valves**

- 8.4.2.1 Electric actuators for isolating applications shall be 415 V AC Rotork IQ or, where appropriate, IQT or approved equivalent. Modulating applications shall use the Rotork IQM range of actuators, or approved equivalent. Electric actuators shall have the functionality of both local (manual) and remote-control capability with local control being integral to the actuator where applicable. Actuator control boards shall have the functionality to be supplied by an external 24 V supply.
- 8.4.2.2 Unless noted otherwise, in the event of a power failure the actuator shall be able to retain the last operating state or set point.
- 8.4.2.3 As a minimum, the following control and monitoring signals shall be available from the actuator control board:
  - Valve Available;
  - Valve in remote/local control;
  - Valve Fault;
  - Valve Fully Opened;
  - Valve Fully Closed;
  - Valve % open (for modulating valve actuators);
  - Remote Open;
  - Remote Close.
- 8.4.2.4 The operating speed of the actuator/gearbox assembly shall be such as to give a gate opening and closing speed of 200-300 mm per minute.
- 8.4.2.5 The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure normal operation with the supply voltage 10% below nominal.
- 8.4.2.6 Each actuator supplied shall be provided with its own programming tool.

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- 8.4.2.7 Cable glands shall be from stainless steel Grade 316. There shall be no external carbon steel components. Any external component not specifically mentioned shall be from stainless steel Grade 316 or other approved alternative corrosion resistant material.

### 8.4.3 Manual Gearboxes for Valves

- 8.4.3.1 Manual gearboxes shall be of the totally enclosed, weatherproof, grease lubricated type. The gearbox shall be operated by means of a hand wheel or taper square valve key. The direction shall be permanently indicated on the hand wheels. The gearbox shall be self-locking in any position and the maximum rim pull force shall not exceed 120 N necessary for operation of each valve under maximum differential head conditions.
- 8.4.3.2 Manual gearboxes mounted on resilient seated gate valves installed in pits or direct buried shall be spur-gear type and comply with AS/NZS 2638.2 Section 6. Input shaft and output sleeve shall operate in the same direction. Directional arrows for open/close operation to be stamped on drive spindles. Gearboxes shall comply with ingress protection rating IP68 to a maximum depth of 15 m.
- 8.4.3.3 Manual gearboxes mounted on valves installed in pits or direct buried shall be spur-gear type with dual input spindles. One spindle shall engage directly on the valve spindle, while the second spindle shall engage on the reduction drive input. Refer SEQ-WAT-1308-2 drawing for typical valve and gearbox layout.
- 8.4.3.4 Manual gearboxes shall be coated with a polymeric coating to System 13, Section 14.4 of this Specification or high build two-pack epoxy with 350 µm DFT (minimum).
- 8.4.3.5 The following material requirements apply to manual gearboxes:

**Table 24 - Gear Box Material Requirements**

Gear Box Component	Material
Gearcase	Cast Iron to ASTM A48 35B/40B, or SG Iron to ASTM A536 65-45-12
Gears	Steel to ASTM 1010 or 4340
Input Shaft	Steel to ASTM 1010 or 4340
Input Shaft bearings	Ball bearings
Output thrust bearings	Needle Roller Bearings or Roller Thrust Bearings
Fasteners	Metric, 316 stainless steel, DIN A4
Seal and O-rings	EPDM or Nitrile Rubber

## 9. Penstocks and Stopboards

### 9.1. Performance Requirements

- 9.1.1 Penstocks and stopboards shall be designed for continuous operation against the on-seating and off-seating heads indicated in the penstock/stopboard schedule. Leakage rates shall be limited to 0.15 L/min per metre of wetted perimeter seal length (on penstocks and stopboards) against all potential operating conditions. Leakage rates shall be tested on site after installation.

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### 9.2. Technical Requirements - Penstocks

#### 9.2.1 General requirements for Penstocks

- 9.2.1.1 Penstocks shall be designed for the conditions shown on the drawings with on or off-seating capability as specified in the schedule and fixing as appropriate. Off-seating wedges shall be provided where required.
- 9.2.1.2 Wall mounted installations shall have non-shrink grout between the penstock and the wall. Embedded installations shall have non-shrink grout around the frame flush with the concrete face. All designs shall take into account operating locations such as handrails and flooring.
- 9.2.1.3 All penstock and stopboard arrangements shall be to the satisfaction and approval of the Superintendent.

#### 9.2.2 Frames

- 9.2.2.1 The frames shall be made of stainless steel Grade 316, designed to withstand all loads resulting from the nominated maximum head acting on the gate and from the operator. Frames fabricated from 'Unistrut' channel section are not acceptable. Side guides shall be provided over at least 1.7 times gate height. All components shall be designed for maximum deflection of  $L/720$  for worst case loads.
- 9.2.2.2 Frames for embedment mounting shall be of cross section so that the block outs required in the structure are kept to a minimum to reduce interference with the concrete reinforcement steel. Frames for side wall and floor mounting shall be of a minimum cross section to reduce disruption of flow.

#### 9.2.3 Gates

- 9.2.3.1 The gates shall be made of stainless steel Grade 316 and suitably stiffened. The stem connection shall be of clevis type coupling for rising stem applications, or a lift nut supported in a welded nut pocket for non-rising stem applications.
- 9.2.3.2 The coupling or nut pocket shall be capable of withstanding, without permanent deformation, at least five times the rated output of the operator.

#### 9.2.4 Seals and Guides

- 9.2.4.1 Side and top seals and guides shall be low friction, low wear, resilient backed material such as UHMW polyethylene with neoprene backing. They shall be under compression and shall be readily replaceable. The bottom seal shall be flush with the floor of the channel and shall be of resilient material such as neoprene, not less than 20 mm thick or 20 mm wide. All seals shall be fastened, not glued, in place.
- 9.2.4.2 Off-seating penstocks may have music note type neoprene seals where leakage is critical, and a flush bottom invert is not required. In this case the seal shall be continuous around the opening and the gate shall be forced against the seal by a wedging action on closure. Sealing arrangements which do not require wedges shall also be acceptable.
- 9.2.4.3 Seals shall be bi-directional unless noted otherwise.
- 9.2.4.4 One full set of replacement seals and fasteners shall be provided.
- 9.2.4.5 Seals shall have a design life of ten years under normal operating conditions.

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### 9.2.5 Spindles/Stems

- 9.2.5.1 The stem shall be not less than 28 mm diameter but, in any case, shall not have a slenderness ratio ( $L/r$ ) greater than 200. A limit nut shall be supplied on rising stems and set such that excessive force applied by the operator at closure cannot buckle the stem. The stem shall be rising where possible. The stem thread shall be ACME or stub ACME. The stem shall be capable of withstanding, without permanent deformation, twice the rated output of the operator.
- 9.2.5.2 Nuts and screws for modulating service penstocks shall have high tolerance ACME threads. The stress on the threads shall be less than 6 MPa. The drive nut shall be sized to achieve the required thread stress.

### 9.2.6 Handwheels and Operating Mechanisms

- 9.2.6.1 Manual actuators shall be designed such that the maximum rim pull force of 180 N applied to the handwheel will actuate the penstock. Finish shall be two pack epoxy or fusion bonded epoxy. Stainless steel Grade 316 or clear polycarbonate stem covers shall be provided. Handwheels or crank handles shall be between 1000 mm and 1200 mm above the operating floor level and shall be cast iron or stainless steel Grade 316. Handwheels shall be mounted horizontally where practicable.
- 9.2.6.2 The penstock shall be closed by a clockwise rotation of the closing mechanism.
- 9.2.6.3 The minimum bolt size including seal pressure adjustment shall be M12 except for any seal fasteners. Anchor bolts shall be included complete with 2 No. nuts and 1 No. washer per anchor.
- 9.2.6.4 Calculations of deflections, operating torques and stem capacity shall be provided by the Contractor if requested by the Superintendent.

### 9.2.7 Other Accessories

- 9.2.7.1 Extension stems or spindles (if required) shall be provided with guides, couplings and thrust tubes. Guides shall be suitably spaced for stability. Where stems or spindles are required in more than one piece, couplings to join stems shall be threaded and pin/screw lockable.
- 9.2.7.2 Gearboxes where fitted shall comply with requirements of Section 8.4.

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### 9.2.8 Materials

9.2.8.1 Materials of construction shall be as indicated in the table below.

**Table 25 - Penstock Construction Materials - General Requirements**

Penstock Component	Material
Frame	Stainless steel Grade 316
Gate	Stainless steel Grade 316
Bolts and fasteners	Metric, 316 stainless steel, DIN A4-70
Seals	Polyurethane or neoprene
Guides	Low friction plastic, e.g. UHMW polyethylene
Lift nut	Bronze to BS 1400 Gr. LG2 or AS 1565 Gr. C83600 or non-metallic
Limit nut	Bronze to BS 1400 LG2 or AS 1565 C83600
Stem	Stainless steel Grade 316
Stem cover	Stainless steel Grade 316 or clear polycarbonate
Handwheel	Cast iron or Stainless steel Grade 316
Guide	Stainless steel Grade 316 and UHMW polyethylene
Coupling	Stainless steel Grade 316
Thrust tube	Stainless steel Grade 316

9.2.8.2 All welding shall be pickled, passivated in accordance with System 21, Section 14.4 of this Specification to remove all evidence of weld scorching.

### 9.2.9 Penstocks for Sewage Pump Station Inlet Isolation

9.2.9.1 Penstocks in un-vented sewage applications in the presence of hydrogen sulphide such as sewage pump station inlet isolation service shall comply with the following special requirements and materials of construction:

**Table 26 - Penstocks for sewage pump station inlet isolation service**

Penstock Component	Requirements
Frame	Flange mounted frame to suit AS 4087 PN16 flange drilling pattern, or: Wall mounted
Opening direction	Upward
Action	Off-seating
Stem	Rising stem mounted within non-rising torque tube
Method of operation	316 Stainless steel Taper square valve key
Torque tube	316 Stainless steel torque tube enclosing stem
Stem nut mounting	Stem nut mounted on thrust tube above top water level (Overflow level for sewage pump stations). Stem nut to be enclosed in a 316 Stainless steel housing with O-ring sealing for the rotating parts.
Stem guides	UHMWPE stem guide bushes mounted in thrust tube at spacing to manufacturers recommendations to prevent buckling

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Penstock Component	Requirements
Thrust tube	316 Stainless steel thrust tube supported on brackets at spacing to manufacturers recommendations to prevent buckling.
Top seal, side seal, invert seal	UHMWPE. Elastomeric seals are not acceptable.
Lift nut material	Aluminium Bronze to BS 1490 Gr. AB2 or AS 1565 Gr. C95810
Surface treatment	Stainless steel components shall be electropolished to System 22, Section 14.4 of this Specification
Lubrication and special coating	Torque tube shall be packed with grease on assembly to ensure lubrication of stem. Exposed surfaces of bronze stem nut shall be coated on assembly with wax-based, general purpose, corrosion preventive compound, Tectyl 506 or equal approved.
Pressure head at invert	10 m (minimum)

### 9.3. Stopboards

- 9.3.1 Stopboards shall be manufactured from marine grade aluminium of grade 6005A, 6061 T6, grade 6351 T5 or T6 or grade 5083 H321, H116 or H112.
- 9.3.2 Guide frames shall be fabricated from stainless steel Grade 316L to AS 1449.
- 9.3.3 The stopboards shall be suitably designed to withstand all loads resulting from the nominated maximum head acting on it. Deflections shall not exceed 1/500 for the frame and 1/360 for the board of any span nor shall maximum stresses exceed half the yield stress of the material whichever is the worst case.
- 9.3.4 On completion of fabrication, all stainless steel shall be pickled and passivated to ASTM A380 and cleaned to remove all evidence of weld scorching.
- 9.3.5 The stopboards shall be suitably braced to prevent distortion when fitting and/or removing.
- 9.3.6 The stopboards shall be required to seal against the guide frames with full hydraulic head on either side of the stopboard as defined in the Mechanical Equipment Schedule.
- 9.3.7 The guide frames shall be fixed by means of stainless steel Grade 316 threaded bar, set into the walls by stainless steel Grade 316 chemical anchors. Frames for wall and floor mounting shall be of a minimum cross section to reduce disruption to the flow. Frames for embedment mounting shall be of a cross section so as the block outs required in the structure are kept to a minimum to reduce interference with the concrete reinforcement steel.
- 9.3.8 Frames shall be fitted with sealing faces around the aperture. The side sealing faces shall provide minimal friction with the surface of the gate. The invert sealing shall be of resilient flush bottom seal arrangement and shall be securely attached to the frame along the invert. Side and invert seals shall be easily replaceable. One full set of replacement seals shall be provided.
- 9.3.9 Stopboards shall be manually removable and shall be provided with a lifting device for gate removal and deployment if the resultant lift force exceeds 36 kg.

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### 9.4. Portable Actuators

- 9.4.1 Portable actuators shall be used for penstocks actuation in open channel or slide gates where indicated on the schedule. They shall consist of a lightweight marine grade aluminium chassis with UHMWPE handle. The gear motor shall have a lightweight aluminium single phase motor coupled with an aluminium gearbox with a stainless steel Grade 316 torque plate and locating pins.
- 9.4.2 Portable actuators shall have adjustable torque limiter, mounted forward and reverse switch and power lead with 3 pin plug.
- 9.4.3 The operating speed of the actuator shall give a gate opening and closing speed of 200 – 300 mm per minute.
- 9.4.4 The available torque operating margin shall be at least 25% greater than the required seating or unseating torque (whichever is the greater) of the gate. The safety margin of motor power available for seating and unseating the gate shall be sufficient to ensure normal operation with the supply voltage 10% below nominal without nuisance tripping of the actuator.

### 9.5. Supervision of Installation

- 9.5.1 An experienced and qualified supervisor shall be provided to oversee the installation of the penstocks and stopboards to ensure that the specified or claimed leakage rates are obtained and not compromised as a result of sub-standard installation.

### 9.6. Fastenings

- 9.6.1 Internal and external fastenings of all components shall be from stainless steel Grade 316, DIN A4-70. Holding down bolts and bracket attachment bolts shall be manufactured from stainless steel Grade 316.

### 9.7. Painting

- 9.7.1 The equipment will be sited in an outdoor corrosive environment and will be subject to warm damp conditions. Painting of components shall be in accordance with System 3, Section 14.4 of this Specification. Manufacturer's standard painting systems shall be considered suitable where they are equal to or better than the provisions of this Specification.

## 10. Pumps

### 10.1. Performance Requirements

#### 10.1.1 Duty Requirements

- 10.1.1.1 The Contractor shall select a pump to meet the full range of duty conditions stated in the pump data sheet. Pumps shall be capable of delivering the specified performance across the full range of site climatic conditions. The advantages of lower impeller speeds shall always be considered.
- 10.1.1.2 The pump shall have a stable head-quantity characteristic curve (i.e. negative gradient from zero flow to end of curve) and the motor shall be non-overloading for all system conditions.
- 10.1.1.3 The guaranteed duty flow rate shall be in the range from 70 to 120% of best efficiency flow for the selected impeller. However, the run-out conditions shall be considered such that the run-out flow for any pump shall not exceed 120% of the best efficiency flow rate for the selected impeller diameter.

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- 10.1.1.4 The pump shall be selected to maximise operating efficiencies without modification, polishing or coating of the impeller and without cavitation or damaging vibration over the entire range of flow conditions.
- 10.1.1.5 For a variable speed driven pumps, the drive speed shall be capable of being increased by at least 3% above the supply frequency without overloading the drive system.
- 10.1.1.6 The Net Positive Suction Head Required (NPSHr) of the pump shall be based on actual 3% head drop method test results. The pump shall have a NPSHr at least 1.5 m less than Net Positive Suction Head available (NPSHa) or, the NPSHa shall be at least 135% greater than the NPSHr, whichever is the greater, at any point between zero flow and the maximum operating range flow attainable against the characteristic curve.

### 10.1.2 Efficiency and Power Consumption

- 10.1.2.1 The pump shall be selected to maximise operating efficiencies without modification, polishing or coating of the impeller.
- 10.1.2.2 Power consumption of the pump shall not exceed the motor rated power output at any point on its curve.

## 10.2. Technical Requirements

### 10.2.1 General

- 10.2.1.1 The layout of the pumps shall provide adequate clearance and safe access for operation and maintenance.
- 10.2.1.2 The pumps shall be provided with clearly identified, permanent lifting points to give a safe and balanced lift.
- 10.2.1.3 The equipment shall be the manufacturer's standard design with the additional requirements called for by this Specification. Preference will be given to equipment for which local spare parts are available.
- 10.2.1.4 For dry-mount pump sets, pumps and the associated equipment shall be suitable for installation in an open, unprotected outdoor environment and shall be suitable for unattended operation and have minimal maintenance requirements.

### 10.2.2 Materials of Constructions

- 10.2.2.1 Where not specified, materials shall be selected with proper reference to the specified operating environment, pumped medium, guaranteed/expected service life and availability.
- 10.2.2.2 Phenolic insulating sets or dielectric unions shall be used for cathodic protection when dissimilar metals are joined.

### 10.2.3 Baseplates

- 10.2.3.1 A common baseplate shall accommodate pump and drive unit with the necessary adjusting devices to allow accurate alignment of the pump/motor coupling. The pump/drive unit baseplate shall be designed with sufficient rigidity to maintain alignment in accordance with the requirements of the coupling manufacturer without requiring additional rigidity to be supplied from the foundations. The mounting pads for the pump and drive shall be milled/machined flat and level. Shims shall comply with Section 6.4.8 of this document. The motor and gearbox shall be positively located so that they can be readily removed and replaced into position without requiring extensive coupling alignment checks.
- 10.2.3.2 Motor feet shall be provided with jacking bolts to assist with alignment of the coupling.
- 10.2.3.3 The baseplate shall be manufactured from carbon steel and hot dip galvanized in accordance with System 23, Section 14.4 of this Specification. The baseplate shall be stress relieved after welding prior to galvanizing.

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### 10.2.4 Couplings

10.2.4.1 Couplings shall be either Falk Steelflex Grid or Falk Wrapflex Elastomer type as recommended by the coupling supplier or nearest commercial equivalent.

### 10.2.5 Reverse Rotation

10.2.5.1 All pump motor and coupling components shall withstand without damage temporary reverse flow through the pump due to inadvertent reverse operation of the pump, such as may occur during commissioning, etc.

10.2.5.2 Submersible pumps may be controlled via an automated pump unblocking control system that initiates a short reverse rotation / forward rotation cycle. Submersible pumps shall be capable of withstanding this reverse / forward flow operation without damage.

### 10.2.6 Casing

10.2.6.1 The casing shall be designed to resist abrasion and mechanical shock imposed by solids in the pumped flow.

10.2.6.2 The casing casting shall be dressed to a good commercial standard to expose any surface imperfections.

10.2.6.3 Components in the pump casing that may be subject to wear shall be easily removable for refurbishment or replacement.

10.2.6.4 All mating surfaces shall be accurately machined and provided with deep registers, dowels and spigots to ensure alignment.

10.2.6.5 If specified on the data sheet, connections shall be provided on the pump flanges or casing for connection of pressure gauges and venting, drain and seal flushing pipework.

10.2.6.6 Instrument tappings shall be DN 20 half couplings screwed BSP female tapered to AS 1722.1 (BSPT compatible).

10.2.6.7 Instrument tappings shall be welded to the pipe and fitted with a screwed reducing nipple and DN 15 ball valve of stainless steel construction. Venting connections shall be positioned on the highest practicable point on the casing. All unused, tapped holes shall be fitted with solid, corrosion resistant metal plugs.

### 10.2.7 Shaft

10.2.7.1 The shaft shall:

- Be machined from solid one-piece bar stock of stainless steel Grade 316 or stainless steel of equivalent PREN-value;
- Have a ground finish over its entire length; and
- Be equipped with replaceable shaft sleeves in areas subjected to wear from gland packing or other contact type sealing arrangements. Shaft sleeves are not required for pumps fitted with mechanical seals.

10.2.7.2 The shaft shall be designed such that the first lateral critical speed is not less than 150% higher than the maximum operating speed of the pump.

10.2.7.3 The first lateral critical speed shall be calculated for the maximum diameter impeller able to be fitted to the pump, without any support from wearing ring(s) or neck ring(s).

10.2.7.4 The maximum lateral deflection of the shaft shall be determined to establish permissible internal clearances, taking into account all lateral hydraulic reactions on the impeller and any external loads.

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### 10.2.8 Impeller

- 10.2.8.1 The pump impeller shall be a one-piece casting specifically designed/profiled for the duty and conditions detailed in the data sheet.
- 10.2.8.2 The impeller shall be fixed to the shaft such that shaft rotation in either direction shall not cause it to loosen.
- 10.2.8.3 The impeller shall be dynamically balanced prior to assembly in accordance with ISO 1940-1.
- 10.2.8.4 Impeller tip speeds shall not exceed the values indicated in the table below:

**Table 27 – Maximum Impeller Tip Speeds**

Fluid type	Max allowable tip speed m/s
Water/wastewater	40
Medium Slurries	35
Heavy Slurries	30
Elastomer Impellers	26

### 10.2.9 Wear Rings

- 10.2.9.1 Replaceable wear rings shall be provided on clean water pumps between the impeller and casing at the front and back of the impeller.
- 10.2.9.2 Replaceable wear rings are not preferred as the impeller sealing mechanism for sewage pumps, sludge pumps or pumps handling highly abrasive fluids.
- 10.2.9.3 Renewable wear rings shall be supplied on the suction side of fully shrouded impellers and there shall be renewable wear rings fitted to the matching parts of the bowls.
- 10.2.9.4 Renewable wear rings shall be supplied on the back side of all impellers that have balancing holes and there shall be renewable wear rings fitted to the matching parts of the bowls.
- 10.2.9.5 Renewable wear rings shall be of one piece and shall be securely locked in position to prevent rotation.

### 10.2.10 Bearings

- 10.2.10.1 Bearings shall be of metric dimensions and be manufactured by a well-established and easily sourced manufacturer.
- 10.2.10.2 Bearing mountings shall be designed to allow for variations in shaft temperature.
- 10.2.10.3 The shaft bearings shall be ball or roller bearings designed for an L<sub>10</sub> Rating Fatigue Life of a minimum of 50,000 hours at the maximum operating speed.
- 10.2.10.4 Bearings shall be lubricated by oil bath or grease lubrication.
- 10.2.10.5 Oil bath lubricated bearings shall have fill and drain plugs, a breather and a method of checking the oil level.
- 10.2.10.6 Each grease lubrication point shall be fitted with a self-contained automatic lubricator, sized to provide the required degree of lubrication for at least six months. Automatic lubricators are not required on pumps unless noted otherwise.
- 10.2.10.7 Extension tubes shall be fitted to lubrication points to allow convenient positioning of, and access to, automatic lubricators for maintenance and replacement purposes.
- 10.2.10.8 Extension tubes shall be primed prior to fitting automatic lubricators.
- 10.2.10.9 The bearing housing shall be totally enclosed to prevent contamination.
- 10.2.10.10 The bearing housing shall be sealed at the shaft openings by lip seals.
- 10.2.10.11 Sealed-for-life bearings may be provided.

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### 10.2.11 Seals

- 10.2.11.1 The pump component materials selected shall be compatible with the process fluid in which they operate as detailed on the respective pump datasheets to minimise corrosion and wear.
- 10.2.11.2 Pumps shall be fitted with single balanced cartridge type mechanical seal arrangement or other approved arrangement such that no external flushing and cooling of the seal arrangement is required.
- 10.2.11.3 Details of all types of mechanical seal offered by the pump manufacturer shall be submitted for approval.
- 10.2.11.4 All seals shall be individually replaceable.
- 10.2.11.5 Spring and other metal components shall be manufactured from stainless steel Grade 316 or stainless steel of equivalent PREN-value.
- 10.2.11.6 Seal failure detection shall be provided on all submersible equipment. The Contractor shall advise the Superintendent of the make and model number of a pump seal failure detection relay compatible with the equipment. The relay will be supplied by the motor starter cubicle supplier.

### 10.2.12 Connections

- 10.2.12.1 Dry-mount pump suction and discharge flanges shall comply with AS 4087.
- 10.2.12.2 Submersible pump suction and discharge flanges shall comply with EN 1092 PN10.
- 10.2.12.3 Flange pressure ratings shall be not less than the pressure rating of the pump casing.
- 10.2.12.4 Flexible connections shall be provided at all equipment where vibration, expansion or loading may be detrimental to the equipment as determined by the Superintendent.
- 10.2.12.5 Flanges shall be arranged so that bolt holes symmetrically straddle the north/south, east/west and horizontal/vertical centre lines.

### 10.2.13 Nameplate

- 10.2.13.1 A name plate manufactured from stainless steel Grade 316 shall be affixed to the body of the pump unit by means of stainless steel grade screws, stamped or engraved with the following information:
- Manufacturer's name;
  - Model/type description;
  - Serial number;
  - Impeller reference number;
  - Design flow rate;
  - Design head;
  - Rated speed;
  - Maximum speed;
  - Total weight;
  - Date of manufacture.
- 10.2.13.2 Unitywater's equipment tag number shall be separately stamped on the pump baseplate. A second identical nameplate shall be supplied loose for installation by Unitywater at a suitable location for equipment identification purposes.

### 10.2.14 Fastenings

- 10.2.14.1 All bolts, anchors and fasteners, internal and external to the pump, shall be manufactured from stainless steel Grade 316. Holding down bolts shall be stainless steel Grade 316.

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### 10.2.15 Vibration

- 10.2.15.1 Acceptable vibration levels shall be as specified in AS 1359. Requirements for monitoring equipment shall be as noted in the datasheets.

### 10.2.16 Personal Protection

- 10.2.16.1 Rotating shafts shall be fitted with guards designed in accordance with Section 6.5 of this Specification.

### 10.2.17 Painting - General

- 10.2.17.1 Painting of components shall be in accordance with relevant systems of Section 14 of this Specification. Manufacturer's standard painting systems may be considered suitable where they are equal to or better than the provisions of this specification.
- 10.2.17.2 Surfaces to be coated which will become inaccessible after assembly or installation shall be cleaned and coated before becoming inaccessible.

### 10.2.18 Painting - Dry Mount Pumps

- 10.2.18.1 Internal coating of dry-mount pumps:  
Internal wetted surfaces of cast iron pumps shall be coated in accordance with System 12, Section 14.4 of this Specification. Internal components of the pump include: Inside surface of the volute and back plate.
- 10.2.18.2 Only cast iron or ductile iron internal components require coating. Wear resistant, bronze, brass or high alloy components shall remain uncoated.
- 10.2.18.3 External coating of dry-mount pumps:  
External surfaces of cast iron pumps shall be coated in accordance with System 6, Section 14.4 of this Specification. Top coat colour shall be in accordance with Table 29 colour code of this Specification.

### 10.2.19 Painting - Submersible Sewage Pumps

- 10.2.19.1 Submersible pumps with a motor rated power of 3 kW or less shall be painted to the Manufacturer's standard painting system. For pumps with a motor rated power of more than 3 kW, the following painting system shall apply:
- 10.2.19.2 Internal coating of submersible sewage or sludge pumps:  
Internal wetted surfaces of cast iron pumps shall be coated in accordance with System 11, Section 14.4 of this Specification. Internal components of the pump include: Impeller, wear plate, back plate and inside surface of the volute.
- 10.2.19.3 Only cast iron, ductile iron, bronze or brass internal components require coating, wear resistant, or high alloy components shall remain uncoated.
- 10.2.19.4 External coating of submersible sewage pumps:  
External surfaces of cast iron pumps shall be coated in accordance with System 6, Section 14.4 of this Specification, or a high build two-pack epoxy system to 300 µm DFT (minimum). Top coat colour shall be in accordance with Table 29 colour code of this Specification, or to Manufacturer's standard colour.
- 10.2.19.5 Pump pedestal and locking plate coating:  
Pump pedestals and locking plates shall be coated internally and externally in accordance with System 6, Section 14.4 of this Specification, or a high build two-pack epoxy system to 300 µm DFT (minimum). Top coat colour shall be in accordance with Table 29 colour code of this Specification, or to Manufacturer's standard colour.
- 10.2.19.6 Pump guide rail bracket coating:  
Cast iron and ductile iron pump guide rail brackets shall be coated in accordance with System 11, Section 14.4 of this Specification.

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### 10.2.20 *Electrical and Protection Requirements*

- 10.2.20.1 Electric motors shall be provided in accordance with the relevant Unitywater electrical specification (Electrical Installations at Treatment Plants and Electrical Installations at Network Sites).
- 10.2.20.2 All electric motors shall be provided with a built-in means of thermal monitoring and protection for motor windings and bearings. Protective devices shall be in accordance with AS 60947.8. Motors shall be selected and rated to cover the maximum power absorbed by the pump over its entire operating range.
- 10.2.20.3 Electronic soft starters, with by-pass functionality are required for all motors above 4 kW, unless the drive is specified as VSD.
- 10.2.20.4 The Soft Starters selected shall be capable of controlling the start and stop ramp rates to reduce the starting current and prevent damage to the driven plant during starting and stopping.
- 10.2.20.5 Motors shall be suitable de-rated for operation with, and matched to, a variable frequency drive.

### 10.3. Centrifugal Pumps

#### 10.3.1 *End suction pumps – Dry mount*

- 10.3.1.1 End suction pumps shall comply with WSA 130 – 2011 Industry Standard for ISO End Suction Centrifugal Pumps.
- 10.3.1.2 End suction pumps shall include a spacer coupling to enable the withdrawal of the impeller and shaft assembly without disturbing the drive or casing (back pull out type).
- 10.3.1.3 Unless specified otherwise the delivery flange on back pull out pumps will be vertical upwards.
- 10.3.1.4 Pump casings shall have a 20 mm diameter tapped hole for bleeding air from the casing.
- 10.3.1.5 Pump casings shall be fitted with a drain plug.
- 10.3.1.6 Packed glands or mechanical seal shall be fitted with a drain as determined by the Superintendent.

#### 10.3.2 *Grit pumps – Dry mount*

- 10.3.2.1 Grit pumps shall be close-coupled units suitable for pumping grit laden water, furnished with totally recessed impeller of the vortex pattern to prevent the fouling of solids and fibrous materials on the impeller. All internal clearances shall provide for a free passage of 100 mm to preclude the clogging of the pump and suction lines.
- 10.3.2.2 The pump shall be of Ni-Hard construction, with Ni-Hard impeller and equipped with mechanical seals.
- 10.3.2.3 The shaft shall be solid stainless steel through the mechanical seal to eliminate corrosion and abrasive rust particles. Removable shaft sleeves will not be acceptable if the shaft under the sleeve does not meet the specified 47.6 mm (1-7/8") minimum diameter. Carbon steel shafts are not acceptable.
- 10.3.2.4 The impeller shall produce a turbine-like flow pattern within the casing, generating flow. To prevent grit from entering the seal area, all impellers less than full diameter shall be trimmed with the back shroud remaining at full diameter so that a minimum clearance from shroud to casing is maintained. Both the end of the shaft and the bore of the impeller shall be tapered to permit easy removal of the impeller from the shaft.

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- 10.3.2.5 The pump shall be arranged so that the complete rotating element can easily be removed from the casing without disconnecting the electrical wiring or disassembling the motor, impeller, back-plate or seal.
- 10.3.2.6 The pump shall be sealed against leakage by a single mechanical seal, constructed to be automatically drained. The seal shall be of carbon and ceramic materials with the mating surface lapped to a flatness tolerance of one light band. The rotating ceramic element shall be held in mating position with the stationary carbon seal by (a) stainless steel Grade 316 spring(s).

### 10.3.3 Submersible pumps

- 10.3.3.1 Submersible pumps shall comply with WSA 101 - 2008 Industry Standard for Submersible Pumps for Sewage Pumping Stations. In addition to that standard and this Specification, the following provisions shall apply to submersible pumps.
- 10.3.3.2 Submersible pumps shall be supplied complete with a discharge pedestal (duckfoot bend) and a guide-rail mounting bracket, unless noted otherwise. Refer to drawing SEQ-SPS-1300-2 regarding Unitywater's requirements for type of pedestal.
- 10.3.3.3 Refer to Clause 10.2.12 regarding the flange drilling pattern. Where the flange drilling pattern on the pump discharge differs from the flange drilling pattern on the locking plate, an adapter plate shall be provided to accommodate the differences, or the locking plate may be drilled to suit the pump. Refer to form F10209 - Pump Flange Drilling Instruction for flange dimensional data.
- 10.3.3.4 Where a submersible pump is to be fitted to a Forrers discharge pedestal, the pump manufacturer is to verify that the pump will have enough clearance between the pump suction and the wet-well floor. Where clearance is insufficient, then a special adapter piece incorporating the difference in elevations is to be supplied. Special adapter piece shall be suitably rated for loads generated by the pump.

**Table 28 – Forrers Pump Pedestal Dimensions**

Discharge Line size	Pedestal height – centreline of pump discharge to base of pedestal – [mm]
DN75	140
DN100	203
DN150	270
DN200	474 – Single square guide rail
DN200	279 – Double round guide rail
DN250	302
DN300	280

- 10.3.3.5 All components shall be of materials suitable for submergence in the specified fluid.
- 10.3.3.6 The impeller and casing shall be designed to suit the specified amount of fluid contaminants including solid particles. This may include wear resistant materials and open impeller design. The impeller-to-shaft attachment shall be suitable for withstanding reverse rotation that may be applied to clear blockages via an automatic pump control system.
- 10.3.3.7 For submerged conditions, the motor shall be designed to operate at full load with cooling effect due to immersion in the pumped fluid. The temperature of the fluid in which the pump is immersed shall be taken as being up to 30°C.

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- 10.3.3.8 For non-submerged conditions, the motor shall be designed and adequately rated to operate at full load in air with convective cooling, i.e. without additional cooling effect due to immersion in the pumped fluid.
- 10.3.3.9 Where a closed-loop cooling system is provided, the motor shall be fitted with a jacket containing glycol or similar coolant. The coolant shall be cooled via a heat exchanger on the back-plate of the volute or similar arrangement. Motors which use the pumped medium or an external water supply circulating around a cooling jacket shall not be acceptable.
- 10.3.3.10 For either arrangement, the temperature of the pumped fluid shall be taken as being up to 30°C.
- 10.3.3.11 For pumps with a motor rated power of more than 7.5 kW, or motor size agreed by the vendor, water-in-oil sensors shall be provided to detect water leakage into the oil chamber.
- 10.3.3.12 Thermal switches shall be provided to detect over-temperature in the motor.
- 10.3.3.13 Motor/sensor leads shall be sealed to the motor by a compression gland. The cable sheath shall be suitable for continuous submergence and oil and grease resistant. The cable shall be long enough to allow for one re-termination and in any case shall be a minimum of 15 metres long.
- 10.3.3.14 Where separate sensor leads are provided, their compression glands are to be in close proximity to the motor lead compression glands. Sensor lead compression glands positioned at the drive-end of the motor are not acceptable.
- 10.3.3.15 Where the size of a pump is sufficient, hand-hole cleanouts shall be provided on the casing to facilitate clearing out of accumulated debris.
- 10.3.3.16 Sump pumps shall be equipped with a suction screen of aperture less than maximum sphere size which can be pumped.
- 10.3.3.17 Where pumps are installed in a wet-well configuration, pump installation shall include a heavy-duty stainless steel Grade 316 lifting chain to AS 4797 for each pump unit. A stainless steel Grade 316 'D' shackle shall be provided on the chain end for connection to the pump unit. The chain shall be supplied with a proof load certificate and shall be sized appropriately.
- 10.3.3.18 Wet-well pump installations shall include a stainless steel Grade 316 hook to fix the lifting chain to an easily reached access point in the wet-well access cover opening.

### 10.4. Vertical Multistage Pump Sets

#### 10.4.1 Baseplate

- 10.4.1.1 A common baseplate shall accommodate the pump and drive units, pipework, valves, fittings and proprietary control panel associated with the pump set. The baseplate shall incorporate the necessary adjusting devices to allow accurate alignment of the pump/motor coupling. The mounting pads for the pump and drive shall be milled/machined flat and level. The motor shall be positively located so that they can be readily removed and replaced into position without requiring extensive coupling alignment checks.
- 10.4.1.2 The baseplate shall be manufactured from carbon steel and shall be hot dip galvanized in accordance with System 23, Section 14.4 of this Specification. The baseplate shall be stress relieved after welding and prior to galvanizing.

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### 10.4.2 Piping

- 10.4.2.1 Piping shall be designed in accordance with Section 7 of this Specification and AS 4041.
- 10.4.2.2 Each pump shall be provided with suction and discharge isolation valves and a non-return valve.
- 10.4.2.3 Piping shall allow easy removal of equipment for servicing or replacement. Sufficient flexibility shall be provided in the pipework to enable each pump to be removed and replaced without disturbing the adjacent pumps or shutting down the system. If necessary, a removable spool shall be provided between the suction isolation valve and the pump so that the pump impeller can be removed.
- 10.4.2.4 Suction lines to the pumps shall be as short as possible. The suction line shall be arranged to allow a balanced flow to the eye of the impeller. Suction line sizes shall be at least one size larger than the pump discharge line.
- 10.4.2.5 Piping shall be either stainless steel Grade 316 or polyethylene tubing and shall be installed so that any condensate drains from the pipe to a suitable condensate collection point with an automatic drain. The piping shall be arranged to eliminate all vapour pockets.
- 10.4.2.6 Piping shall be supported and flexible enough to prevent damage due to vibration and to minimise the pump load transmitted to the pump.

### 10.4.3 Diaphragm Tank

- 10.4.3.1 Booster sets shall include a diaphragm tank, sized to ensure effective operation of the booster set under all operating conditions, including delivery of low flows without excessive pump starts and stops, and smooth transition of flows across the full range.
- 10.4.3.2 The diaphragm tank shall be complete with a pressure gauge, relief valve and pressure charging point.

## 10.5. Positive Displacement Pumps

### 10.5.1 Pump Drive

- 10.5.1.1 The maximum pump speed shall be selected for reliable and maintenance free operation.
- 10.5.1.2 The maximum motor speed shall not exceed 1500 rpm for operation at 50 Hz.
- 10.5.1.3 The pump shall be driven by a geared motor from an approved supplier. Belt drive between the pump and motor shall not be acceptable. The gearbox shall be capable of transmitting the maximum motor output torque and shall have a minimum American Gear Manufacturers Association (or equivalent) service factor of 1.5 for all pumping duties.
- 10.5.1.4 The gearbox shall incorporate accessible oil filling and drain plugs that allow in situ oil removal/replenishment without excessive spillage. A means of checking the oil level shall be provided.
- 10.5.1.5 The gearbox shall be adequately supported to prevent excessive vibration under all operating conditions.

### 10.5.2 Dry running

- 10.5.2.1 If necessary, for the protection of the pump in dry running conditions, the Contractor shall provide protective devices and systems to prevent damage to the pump. These may include methods to detect no flow and provide a signal to the PLC for pump shut down.

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### 10.5.3 Solids handling capability

- 10.5.3.1 The pump shall be sized to handle materials which may be contained in the sludge/wastewater being pumped without blockages. These materials may include:
- debris such as plastic bags;
  - fibrous solids and stringy materials;
  - grit and other abrasive solids;
  - mineral and other oils.
- 10.5.3.2 The pump shall be non-clogging and non-ragging.

### 10.5.4 Rotary Lobe-General

- 10.5.4.1 The pumpset shall be of the close coupled design without motor and gearbox flexible couplings and mounted on a structural steel baseplate and frame.
- 10.5.4.2 The pumpset shall be of twin rotor design with lobed rotors mounted on separate parallel shafts, counter rotating within the pump casing. Shaft rotation shall be synchronised to ensure that no contact occurs between the rotors and/or the rotors and the pump casing.
- 10.5.4.3 At the duty point, the speed of rotation of the lobes shall be less than 300 rpm and the tip speed of the rotors shall be less than 2.5 m/s to minimise wear from grit. The pump shall be capable of passing solids of up to 70 mm diameter.
- 10.5.4.4 The pumpset shall be capable of dry running, without damage, for extended periods of time. The pumpset may be subject to intermittent and alternate dry and wet running on a regular basis and shall be designed to cater for the surging that this type of operation involves. The pump drive motor shall be capable of and be rated for accepting the shock loading.
- 10.5.4.5 The pumpset shall be designed to permit pumping in either direction.

### 10.5.5 Rotary Lobe - Rotors

- 10.5.5.1 The rotors shall be replaceable in-situ.
- 10.5.5.2 The rotors shall be retained in position by torque locking assemblies and splines. Any special tools required for the removal, adjustment and installation of rotors shall be supplied with each pumpset.
- 10.5.5.3 The rotors and shaft shall be marked to ensure correct alignment/synchronisation on re-installation.

### 10.5.6 Rotary Lobe- Gears

- 10.5.6.1 Timing gears shall be precision manufactured, involute form spur or helical gears. The gearbox shall be designed to accommodate any thrust forces generated by the timing gears.

## 10.6. Progressive Cavity Pumps

- 10.6.1 The pump shall be direct coupled to a motor/gearbox unit to suit the range of pump duties. The complete drive unit shall have an ingress protection rating of IP55 or higher. The pump and drive unit shall be mounted on a common fabricated steel baseplate, complete with all necessary guards. All components shall be conservatively selected to suit the specified type of duty with continuous operation.
- 10.6.2 The motor power output rating shall exceed the power required at maximum duty and worst operating condition by 30%.

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- 10.6.3 The drive assembly shall enable easy dismantling of the pump. The drive shaft and mechanical seal, where fitted, shall be replaceable without the need to dismantle the bearing housing. If a coupling rod and joints are used, they shall be sealed for life.
- 10.6.4 The pump casing shall be able to be rotated in 90° steps.
- 10.6.5 The pump shall be provided with the following:
- A suitable check valve on the discharge pipework; and
  - Protection against running against a closed discharge, i.e. discharge pressure relief valve or discharge pressure switch.

### 10.7. Peristaltic Pumps

- 10.7.1 The casing shall be provided with a bolted, removable front cover to enable the rotor, hose and bearing assemblies to be removed without disturbing inlet/outlet pipework. The casing shall incorporate the bearing housing, which shall be accessible via a removable cover plate.
- 10.7.2 A burst hose/tube monitoring facility shall be provided.
- 10.7.3 Connections shall be provided on the rear of the casing to prevent accidental damage/facilitate the removal of the front cover.
- 10.7.4 Adjustment of the flow rate shall be achieved by variation of the speed of rotation of the pump.

### 10.8. Dosing and Metering Pumps

#### 10.8.1 General

- 10.8.1.1 Automatic dosing pump operation shall be provided.
- 10.8.1.2 Dosing pumps operating in parallel shall be of identical size. Mismatched pumps shall not be allowed.
- 10.8.1.3 On AC motor driven dosing pumps the minimum operating speed shall be no less than 10 Hz or 15 strokes per minute.
- 10.8.1.4 Dosing pumps shall be selected based on achieving flow requirements up to and including average flow/average dose at no more than 85% of their maximum speed. Speed can be increased above 85% for flow above this, i.e. maximum flow/maximum dose.
- 10.8.1.5 Operation outside of the limits stated in this Specification for the relevant pump types will only be permitted with prior approval of the Superintendent.
- 10.8.1.6 Dosing pump systems shall be provided with facilities for manual venting/priming.
- 10.8.1.7 Sodium hypochlorite pumps shall be installed adjacent to solenoid bleed valves to permit automatic degassing, unless the pump is fitted with an integral automatic degassing system.
- 10.8.1.8 Dosing pump steady state accuracy shall be within  $\pm 2\%$  over the full dosing range. The steady state accuracy is the variation between the measured flow at any one point compared to measurements taken again with all parameters remaining unchanged and constant, e.g. speed, stroke, chemical, temperature, pressure, etc.
- 10.8.1.9 Dosing pump repeatability shall be within  $\pm 3\%$  over the full dosing range. The repeatability is the variation between the measured flow at a given pump setting compared to the measured flow when returned to the same setting.
- 10.8.1.10 Dosing pump linearity shall be within  $\pm 3\%$  over the full dosing range. The pump characteristics shall be such that the change in pumped flow rate for different pump settings, e.g. speed or stroke, is linear, i.e. the change in pump flow shall be directly proportional to the change in the relevant pump setting.

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### 10.8.2 Diaphragm Pumps

- 10.8.2.1 Variable stroke length diaphragm pumps shall be provided with integral automatic speed adjustment and manual stroke adjustment. Where specified on the equipment schedule or datasheet, automatic stroke adjustment shall be provided. The usable stroke adjustment turndown used when sizing variable stroke length diaphragm pumps shall be limited to 5:1 or 20-100% for mechanically actuated pumps and to 10:1 or 10-100% for hydraulically actuated dosing pumps.
- 10.8.2.2 Very small diaphragm type dosing pumps, i.e. solenoid driven type, incorporating automatic speed adjustment only (i.e. no stroke adjustment) shall be acceptable subject to their being able to meet the dosing range specified on the data sheet and the specified pump accuracy. Solenoid type dosing pumps shall be limited to a minimum of 30 strokes per minute.
- 10.8.2.3 Digital stepper-motor driven diaphragm type dosing pumps shall be provided with integral automatic speed adjustment. Continuous operation at 100% stroke rate is acceptable and turndown is limited only by the volume flow rate required for effective mixing and system control.
- 10.8.2.4 Where the specified duty cannot be achieved via a pump with a single head, pumps with multiple dosing heads, i.e. duplex or triplex pump heads, can be provided subject to the prior approval of the Project Manager.
- 10.8.2.5 Hydraulic driven diaphragm dosing pumps for very large or high-pressure applications shall be fitted with double diaphragms and diaphragm rupture detection systems.
- 10.8.2.6 Diaphragm pumps shall be arranged to facilitate easy and quick access to the pump's non-return valves to allow clearance of blockages.
- 10.8.2.7 Diaphragm pumps shall incorporate either a bleed valve or a means of safely depressurising the pump head to allow maintenance activities to be safely completed on the pump head.

### 10.8.3 Progressive cavity pumps

- 10.8.3.1 If the casing material is incompatible with the dosing chemical, the stator shall be designed to prevent the penetration of the dosing chemical between the stator and casing.
- 10.8.3.2 The casing design shall ensure that the rotor and drive end cover can be removed without dismantling the casing itself.
- 10.8.3.3 Installation shall be with the suction/inlet connection local to the drive shaft seal, i.e. they are suction on gland (SOG) type.
- 10.8.3.4 Pumps shall be provided with dry running protection. The device used shall sense either flow, temperature or the presence of the pumped fluid and shall be selected to best suit the proposed arrangement.

### 10.8.4 Peristaltic pumps

- 10.8.4.1 Peristaltic pumps shall include the following features:
- A means of relieving the pressure in the casing in the event of a hose/tube burst;
  - High/low lubricant level probes with low and high levels used to stop the pump;
  - Lubricant fill/drain points.

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### 10.9. Pump Testing and Commissioning Requirements

#### 10.9.1 Hydrostatic testing

- 10.9.1.1 All pumps shall be hydrostatically tested with water to 1.5 times the rated pressure of the pump before the unit is painted.
- 10.9.1.2 The test pressure shall be held for sufficient duration to verify that the pump is free from leaks and weeps during the test period.
- 10.9.1.3 Casings showing signs of weeping due to porosity shall be rejected.

#### 10.9.2 Pump performance testing

- 10.9.2.1 For pumps with a motor size of less than 30 kW, the manufacturer's type-testing certificate is acceptable and individual pump tests are therefore not required. Pump type-test certificates shall be submitted to the Superintendent where requested. The pump type-testing shall be in accordance with AS 2417 Grade 2 or equivalent standard ISO 9906 Grade 2.
- 10.9.2.2 For pumps with a motor size of 30 kW or more, individual non-witnessed pump tests shall be performed in accordance with AS 2417 Grade 2 or equivalent standard ISO 9906 Grade 2.
- 10.9.2.3 Where specified in the purchase order, the completed pump unit including the drive shall be test run on water at the supplier's nearest test facility within the eastern seaboard of Australia.
- 10.9.2.4 The performance of each pump shall be tested using the motor to be supplied under the Contract.
- 10.9.2.5 The duration of the test shall be sufficient to verify that the pump operates with no undue heating of bearings or vibration, other than that which is inherent to the style of pump under test.
- 10.9.2.6 Flow, head, power and other required parameter measurements shall be taken at several flow rates to provide a definable smooth curve for head, efficiency, absorbed power and motor electrical power (all versus flow rate) extending from zero flow to the maximum flow the pump will achieve against the system curve. Vibration testing is not required unless noted otherwise.

Where pumps are operated at variable speed, the test shall be repeated at the lowest speed and any other speed required to achieve the various duty points indicated on the pump data sheet.

- 10.9.2.7 The test flow rates shall include:
- zero flow;
  - the guaranteed duty point;
  - all secondary duty points;
  - maximum achievable flow.
- 10.9.2.8 The Contractor shall provide 14 days' notice of testing in writing to the Superintendent.
- 10.9.2.9 Witnessing of works tests will be at the discretion of the Superintendent, the additional cost of which shall be entered into the pricing schedule as an optional sum.
- 10.9.2.10 All costs associated with the inspection such as airfares, hotel accommodation, food and other miscellaneous expenses incurred by the Superintendent shall be to the Superintendent.
- 10.9.2.11 Test certificates containing all test results shall be submitted to the Superintendent following completion of testing. The pumps shall not be released for delivery prior to approval of the test results by the Superintendent.

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### 11. Blowers

#### 11.1. General

- 11.1.1 The blower shall incorporate the following equipment:
- Compressor;
  - Electric motor drive;
  - Baseplate for motor and compressor on flexible mounts;
  - Inlet filter complete with maintenance indicator and silencer;
  - Discharge silencer;
  - Acoustic enclosure;
  - Pressure gauge;
  - Pressure relief valve;
- 11.1.2 Design inlet air conditions shall be to 30°C at 60% RH with maximum temperature of 40°C and minimum of 5°C and an average barometric pressure of 1.013 bar.
- 11.1.3 The compressors shall not surge or exceed the nameplate motor rating at any of the above operating conditions.
- 11.1.4 Blowers shall be fitted with acoustic enclosures to achieve a noise level of less than 70 dB(A) at 1 metre. The enclosure shall be weather proof and capable of withstanding environmental effects for the design life of the blower.
- 11.1.5 The blower package should be constructed for a minimum service life of 25 years and at least 3 years of uninterrupted operation. The package and its accessories will be suitable for outdoor conditions. The enclosure shall be weather proof and capable of withstanding environmental effects for the design life of the blower.
- 11.1.6 The blower casing shall be made of cast iron and be designed for easy disassembly for inspection or replacement of parts.
- 11.1.7 The maximum allowable working pressure of the casing shall be at least 1.25 times the maximum specified discharge pressure and shall have a minimum design temperature of 250°C.
- 11.1.8 The compressor casing shall have an inlet and outlet flange connections. The inlet air shall be connected to the inlet air filter/silencer by a flexible connection. The outlet air shall be connected to the discharge nozzle by a flexible connection.
- 11.1.9 *Redundancy:* All blowers shall be provided in a duty/standby arrangement (minimum requirement) with both units 100% capacity. It may be acceptable to provide a less capacity for the standby unit if multiple units are provided, but the total capacity with any one unit out of action shall be equal to 100%.

#### 11.2. V-Belt Drive

- 11.2.1 The V-belt drive, were fitted shall have a safety factor of 1.5.

#### 11.3. Shafts

- 11.3.1 All shafts shall be of forged or hot rolled alloy steel. Shafts that have a finished diameter larger than 200 mm shall be forged steel. Shafts that have a finished diameter equal or less than 200 mm shall be forged steel or hot rolled barstock, providing that barstock meets all quality and heat treatment criteria established for shaft forgings. Shafts shall be machined throughout their entire length. Chrome plating of the shaft at the journal area is not acceptable.

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- 11.3.2 Hydrodynamic radial and thrust bearings shall be provided. Hydrodynamic radial bearings can be either of split or axially removable design for easy replacement. These bearings shall be equipped with anti-rotation pins and be secured in the axial direction.
- 11.3.3 Hydrodynamic thrust bearings shall be steel backed, babbitted and arranged for continuous pressurised lubrication. Integral thrust collars are preferred.
- 11.3.4 Air and oil shaft seals must achieve the following:
- contain compressed air inside the compressor casing;
  - prevent oil from entering the compressor casing and contaminating the compressed air;
  - prevent oil from leaking out of the gear box; and
  - prevent atmospheric air from entering any gear or compressor casing that could allow contamination of the oil system or compressed air by dirt or moisture.
- 11.3.5 Shaft seals shall be labyrinth type, carbon-ring type, mechanical face or a combination of these types.

### 11.4. Accessories

- 11.4.1 Each compressor and motor, coupled together, shall be mounted on a common steel base, properly braced to form a rigid support for the entire unit.
- 11.4.2 Individual external relief valves shall be provided for each positive displacement type blower. These valves only protect the air-end from over pressure.
- 11.4.3 Full flow filters with replaceable elements and filtration of 10 µm nominal or finer shall be supplied.
- 11.4.4 Filter cases and heads shall be suitable for operations at a pressure not less than the relief valve setting.
- 11.4.5 The pressure drop for clean filter elements shall not exceed 15% of the total allowable dirty pressure drop.

### 11.5. Air Intake Filter/Silencer

- 11.5.1 The supplier shall furnish a high efficiency air intake filter-silencer suitable for outdoor mounting, including a filter media fouling tell-tale.
- 11.5.2 Blowers shall be provided with a suction and discharge expansion joint to alleviate vibration, expansion and contraction stress between compressor and piping.
- 11.5.3 These expansion joints shall be capable of withstanding the suction and discharge pressure and temperature at all operating conditions.
- 11.5.4 Blowers shall be fitted with a discharge silencer shall be supplied to achieve specified noise level.
- 11.5.5 For Turbo Compressors, a blow-off valve shall be provided to allow unloaded start up and surge control. The valve shall be a wafer type butterfly valve, air actuated with open/closed limit switches. A blow off silencer shall be mounted on the discharge of the blow off valve pipework. The silencer shall be constructed of sound absorption material enclosed in a carbon steel outer shell.
- 11.5.6 Each blower shall be provided with a discharge check valve. The check valve shall be dual flap type with centre hinge and spring closure. Valves shall be wafer body type with plain face ends for flange mounting.

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- 11.5.7 The enclosure shall be provided with access doors or removable panels for access to internal parts that require routine inspection or attention. Removable panels shall be less than 30 kg and designed for removal and replacement by one person. The whole enclosure shall be removable for major overhaul of the machine.
- 11.5.8 Each compressor will have a control panel mounted on the base that will start, stop and operate the blower, provide detections of malfunctions and shut down the blower if needed. The panel shall be fully enclosed, watertight, completely piped and wired to other components of the package, requiring only connection to the purchaser's external piping and wiring circuits.

## 12. Compressors

### 12.1. General

- 12.1.1 The compressor shall incorporate the following equipment:
- 12.1.2 Compressor;
- Electric motor drive;
  - Baseplate for motor and compressor on flexible mounts;
  - Inlet filter complete with maintenance indicator and silencer;
  - Discharge silencer;
  - Acoustic enclosure;
  - Pressure gauge;
  - Pressure relief valve;
- 12.1.3 Each compressor will have a control panel mounted on the base that will start, stop and operate the compressor to modulate the flow to match demand. Compressor controls to provide detections of malfunctions and shut down the compressor if needed. The panel shall be fully enclosed, watertight, completely piped and wired to other components of the package, requiring only connection to the purchaser's external piping and wiring circuits.
- 12.1.4 Compressors shall be fitted with acoustic enclosures to achieve a noise level of less than 70 dB(A) at 1 metre. The enclosure shall be weather proof and capable of withstanding environmental effects for the design life of the compressor.
- 12.1.5 Where compressors are not fitted with integral air dryers, a separate downstream refrigerant type air dryer shall be provided. The air dryer shall be sized to deliver air below dew point at the compressor's rated flow.
- 12.1.6 The compressor discharge shall be fitted with automatic condensate drains on low points of the discharge piping and the air receiver. Condensate drains shall be solenoid operated Drukodrain or equal approved.

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### 13. Surge Vessels

#### 13.1. General

- 13.1.1 This specification covers large surge vessels intended for use on water and sewage pipelines. Small pressure tanks for pump station discharge pressure modulation are excluded.
- 13.1.2 Surge vessels shall be manufactured in accordance with AS1210 Pressure Vessels.
- 13.1.3 The hazard rating of the surge vessel shall be determined in accordance with AS 4343 and be stated in the pressure vessel documentation.
- 13.1.4 The corrosion protection for surge vessels shall be in accordance System 3, Section 14.4 of this Specification.
- 13.1.5 The air-water interface in the vessel shall be a free surface achieved by pressurising the headspace via a separate air compressor system. Diaphragm or dipping tube type surge vessels are not acceptable.
- 13.1.6 Water surge vessels may use an air compressor system with a single duty air compressor.
- 13.1.7 Sewage surge vessels shall use an air compressor system with two air compressors arranged in duty / standby configuration.
- 13.1.8 Sewage surge vessels shall be set out with longitudinal axis in the vertical orientation.

#### 13.2. Instrumentation

- 13.2.1 Sewage surge vessels shall have suitable nozzles to accommodate the following instrumentation:
- Pressure transmitter: Mounted on top of vessel
  - Air release actuated valve: Mounted on top of vessel
  - Level transmitter: DN80 vertical nozzle with VEGAPULS 63 Radar level sensor
  - Level switches: DN80 vertical nozzle with 3 off Omron BS-1 electrode holders
  - Pressure relief valve: DN80 vertical nozzle, with clear vertical conduit to valve inlet

#### 13.3. Access requirements for water surge vessels

- 13.3.1 An access platform shall be provided for gaining access to the instrumentation mounted on the top of the vessel.
- 13.3.2 Either a vertical ladder or stairway shall be provided to access the top platform.

#### 13.4. Access requirements for sewage surge vessels

- 13.4.1 Sewage surge vessels shall have a DN600 minimum manway positioned centrally at the top of the vessel. The manway cover shall be fitted with lifting lugs.
- 13.4.2 The inlet / outlet nozzle at the bottom of the vessel shall be connected to the pipework with a dismantling joint to allow adequate space for draining the vessel during internal cleaning operations.
- 13.4.3 An access platform shall be provided at the top of the vessel with sufficient space for opening the manway and gaining access for internal cleaning operations or personnel entry. All the top-mounted instrumentation shall be readily accessible from the platform.
- 13.4.4 Either a vertical ladder or stairway shall be provided to access the top platform.

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### 14. Corrosion Protection

#### 14.1. General Requirements

##### 14.1.1 Approvals

- 14.1.1.1 All coating materials used shall be of the type and quality described herein and shall have Australian Paint Approval Scheme (APAS) approval for the relevant application.
- 14.1.1.2 Where this specification is unsuitable for the application, then an equivalent system from WSA 201—2017 Manual for selection and application of protective coatings may be submitted for the approval of the Superintendent.
- 14.1.1.3 If equivalent products from alternative manufacturers are proposed to be used, then Schedules and data sheets for those products shall be submitted for the approval of the Superintendent. If requested by the Superintendent, sample panels of any proposed coating system shall also be supplied.

##### 14.1.2 Colour Code

- 14.1.2.1 Colours for top coats shall be as specified in the table below, or if not specified, as agreed by the Superintendent.

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**Table 29 - Colour Code for Top Coat on Corrosion Protected Equipment**

Item	Colour	No. to AS 2700
Tanks	Sand	Y44
Valves	Sapphire	B14
Pumps	Sapphire	B14
	Ultramarine Blue (RAL 5002) and Gentian Blue (RAL 5010) are accepted as equivalents to AS2700 Sapphire B14	
Designated spare pumps and ancillary equipment for spare pumps	Orange	X15
Blowers, Compressors, including ancillary equipment	Dark Grey	N64
Machine Bases	Mid Grey	N52
Structural steelwork	Light Grey	N33
Bulk mechanical equipment, bridges for settling tanks, gearboxes, general fabrications, etc.	Light Grey	N33
Equipment located in within sight of the general public such as vent poles, OCUs, switchboards and surge vessels	Mist Green	G54
Cranes and Crawl Beams	Vivid Yellow	Y13
Protrusions, low beams, trip hazards, etc.	Black / Vivid Yellow stripes	N61 / Y13
Guards	Vivid Yellow	Y13
Turning shafts, Couplings, Pulleys, etc.	Orange	X15
Electric Motors	Orange	X15
Terminal Boxes	Orange	X15
Emergency Stop	Signal Red	R13
Firefighting equipment and pipework	Signal Red	R13
Handrails Coating required only for steel. Aluminium, galvanized steel and stainless steel	Vivid Yellow	Y13
Stanchions for handrailing Coating required only for steel. Aluminium, galvanized steel and stainless steel to remain uncoated.	Black	N61

### 14.1.3 Operating conditions

- 14.1.3.1 The selection of corrosion protection systems shall be governed by the need for long periods of service without frequent maintenance and attention being necessary. All systems shall be capable of providing protection over the full operating range and plant design life across the range of climatic conditions.
- 14.1.3.2 Corrosion protection systems shall comprise standard commercially available materials proven in actual service conditions on similar duties, suitable for service in sewage and sludge treatment processes and environments. Particular attention shall be taken in the design to ensure minimum corrosion and wear of all protected surfaces.

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### 14.1.4 Health and Safety

- 14.1.4.1 Statutory health and safety requirements shall always be followed and environmental regulations observed. Site safety, health and work procedures shall be followed for any work which is carried out on construction sites.

## 14.2. Surface Preparation

### 14.2.1 General

- 14.2.1 All surface defects, including cracks, laminations, deep pitting, weld splatter, slag, burrs, fins and sharp edges shall be removed. Surface defects revealed by the blast cleaning process shall be ground, filled or treated in the appropriate manner.
- 14.2.2 All edges and corners shall be de-burred to provide smooth, radiused surfaces or similar.
- 14.2.3 Surface contaminants, such as oil, grease, dirt and loose particles, must be removed in accordance with AS 1627.1 or SSPC-SP1 using a suitable solvent or oil emulsifier/alkaline degreaser as recommended by the coating manufacturer.
- 14.2.4 Care shall be exercised to protect and prevent damage or contamination of partially or entirely completed portions of the work, machinery, equipment and adjacent areas from overspray, abrasive and other possible damage likely to occur as a result of the work, by the erection of screens barriers, boardings, dropsheets, etc.

### 14.2.2 Abrasive blast cleaning

- 14.2.2.1 Surfaces shall be dry abrasive blast cleaned in accordance with AS 1627.4. Surfaces shall be cleaned to Class Sa 2½ (AS 1627.9) or SSPC-SP10, unless noted otherwise in the particular painting system.
- 14.2.2.2 The minimum surface profile height shall be 40-65 µm peak-to-valley, or less if required by coating manufacturer, but not more than the specified minimum dry film thickness of the primer. The surface profile shall be determined by a Keane-Taylor Surface Profile Comparator for grit blasted surfaces.
- 14.2.2.3 Acceptable materials for the abrasive blast are:
- Metallic: chilled iron grit. The abrasive shall be angular, free from dust and foreign matter. The maximum particle size shall not be larger than that passing through a 1.18 mm test sieve.
  - Non-metallic (silica free): aluminium oxide, zircon, rutile, garnet, or crushed hard non-silica containing rocks (e.g. diorite). Abrasives shall be hard and free from clay. Salt contamination shall not exceed 50 parts per million. The particle size shall be such that not more than 10% passes a 1.3 mm Australian Standard sieve and not more than 10% is retained on a 1.18 mm Australian Standard sieve. Suppliers shall note the limits placed on any radioactive substances in blast cleaning materials. Where copper slag is used, the surface shall be finished by a final clean-up blast using ilmenite or other approved material to remove traces of copper slag left on the surface.
- 14.2.2.4 Immediately after blasting operations and before coating, all surfaces shall be air blown with clean dry air (adequate driers and oil mist filters shall be used in air lines) and vacuum cleaned to remove all blast products and abrasives from the entire surface, giving particular attention to corners, intersections and horizontal areas where settlement of dust is most likely to occur.
- 14.2.2.5 If oxidation has occurred between blasting and application, the surface shall be reblasted to the specified visual standard.

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14.2.2.6 All free oil and moisture shall be effectively removed from the air supply lines of all blasting equipment, using adequate approved filters and driers. Free oil and moisture content in the air shall each not exceed 0.5 mg/cubic metre of free air.

### **14.2.3 Power tool cleaning**

14.2.3.1 The cleaning of metal surfaces with power tools shall comply with the requirements of AS 1627.2.

### **14.2.4 Hand tool cleaning**

14.2.4.1 The cleaning of metal surfaces with hand tools shall comply with the requirements of AS 1627.2.

### **14.2.5 Post cleaning**

14.2.5.1 Cleaned surfaces shall be kept free of all contamination before coating or galvanizing and shall not be touched by bare hands or other bare parts of the body. Any area inadvertently touched by bare parts of the body shall be immediately cleaned again.

14.2.5.2 All items of metal work to be painted or galvanized shall be so treated not more than four hours after surface preparation of each item has been completed.

14.2.5.3 Any uncoated surfaces that have been subjected to conditions that might induce condensation of water thereon or that have been left longer than the above specified two hours after blast cleaning shall be again blast cleaned before being coated.

## **14.3. Painting**

### **14.3.1 Handling and storage**

14.3.1.1 All coating materials shall be delivered to the site of application in the original unopened containers bearing the manufacturer's labels and instructions and thereafter stored in cool shaded places.

### **14.3.2 Application**

14.3.2.1 All painting and coating operations shall be performed in a neat, thorough, workmanlike manner.

14.3.2.2 All paint and coating materials shall be in a thoroughly mixed condition at the time of application and may only be thinned in accordance with the manufacturer's instructions.

14.3.2.3 Effective controls shall be established to preclude operations in unsuitable weather conditions. Work shall not be performed:

- on surfaces wetted or likely to become wetted after blasting and before coating;
- on surfaces where the surface temperature is less than 3°C above the dew point of the surrounding air;
- when the wet bulb temperature in the immediate vicinity shows a difference of <7% from the dry bulb temperature (standard wet and dry bulb thermometer);
- when the extremes of surface metal temperature exceed 40°C or are lower than 10°C.

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### **14.3.3 Prime coating**

- 14.3.3.1 The first coat shall be applied as soon as possible after cleaning the surface, but in any case, not longer than four hours after cleaning.
- 14.3.3.2 The coating shall be applied to produce a smooth, even coating free of lumps, ripples, sags, runs, air holes and other defects and imperfections and shall be allowed to dry or harden to the paint manufacturer's requirements before the succeeding coat is applied. All deficiencies and defects shall be corrected.

### **14.3.4 Reinstatement of damaged coatings**

- 14.3.4.1 Coatings shall be fully inspected and marked-up to clearly identify damaged areas.
- 14.3.4.2 Reinstatement of the coating shall be in accordance with the manufacturer's recommendations and shall provide an equal level of protection to the structure as the original coating system.
- 14.3.4.3 The reinstatement systems and procedures shall be approved by the Superintendent before being applied.
- 14.3.4.4 The repaired areas shall be retested and allowed to cure as specified before placing the finished coating into service.

### **14.3.5 Quality control**

- 14.3.5.1 The following quality control procedures shall be performed daily, or at greater frequency as required during and after periods of surface preparation and coating application. The results of the tests shall be permanently recorded.

### **14.3.6 Surface cleanliness**

- 14.3.6.1 Australian Standard AS 1627.6 shall be used as a guide for assessing the respective degree of surface cleanliness. All surfaces shall be tested.

### **14.3.7 Profile**

- 14.3.7.1 The profile or Anchor Pattern shall be measured using a Clemtex Anchor Pattern Standard or approved equivalent standard. All surfaces shall be tested with reference to AS 3894.3.

### **14.3.8 Wet Film thickness**

- 14.3.8.1 A comb type Wet Film Gauge shall be used continuously during application to minimise the possibility of low dry film thicknesses.
- 14.3.8.2 All surfaces shall be tested with reference to AS 3894.3.

### **14.3.9 Dry film thickness**

- 14.3.9.1 All surfaces shall be tested to determine the dry film thickness with reference to AS 3894.3.
- 14.3.9.2 The thickness of each individual coating and the thickness of the coating system shall be recorded using a suitable non-destructive magnetic gauge producing a permanent (hard copy) printout for each item or structural member.
- 14.3.9.3 Instruments shall be calibrated in accordance with AS/NZS 1580.108.1 using non-magnetic shims on polished steel.
- 14.3.9.4 Defects are to be marked with school grade chalk, spirit pen, adhesive inspection labels or masking tape; crayon and paint are not acceptable.

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### 14.3.10 Identification

- 14.3.10.1 The following shall be recorded:
- Batch numbers of all coatings;
  - Item numbers coated with each batch;
  - Time and date each item was coated.

### 14.3.11 Pinholes

- 14.3.11.1 The dry, fully cured coating shall be checked for pinholes and holidays in accordance with AS 3894.1.
- 14.3.11.2 All testing carried out shall be documented and shall be available upon request.

### 14.3.12 Handling and packaging

- 14.3.12.1 Suitable precautions shall be taken in bundling, packing, crating and lifting to ensure that the protective treatment is not damaged during handling, transporting and installation. Soft slings shall be used unless adequate lifting lugs/eye bolts have been provided.

### 14.3.13 Reporting

- 14.3.13.1 A report of the painting contractor's quality control documentation shall also be completed to include, but not be limited to:
- General:
    - Names of the contractor and the responsible personnel;
    - Dates when work was carried out;
  - Materials preparation:
    - Equipment and techniques used;
    - Materials receipt condition;
    - Type and calibration of instrument used.
  - Environmental conditions:
    - Weather and ambient conditions;
  - Painting periods;
  - Surface preparation:
    - Condition of surface before preparation;
    - Tools and methods used to prepare surface;
  - Condition after preparation;
  - Paints and painting:
    - Information on systems being applied;
    - Mixing and testing prior to application;
    - Paint application techniques;
    - Application rates (actual);
  - Testing:
    - Type of quality control checks carried out, and results;
    - Compliance or otherwise with specification.
- 14.3.13.2 Reporting shall be in accordance with AS 3894.10 to AS 3894.14.

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### 14.4. Corrosion Protections Systems

#### 14.4.1 *Summary table*

- 14.4.1.1 The corrosion protection systems are summarised in the following table. Further details are provided in the subsequent sections.

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**Table 30 - Corrosion Protection Systems**

System	Application	Coat	Paint*	DFT
1	Structural Steel – Mildly corrosive environment, not H <sub>2</sub> S, decorative top coat	1st	Intergard 251 Polyamide Cured Epoxy	75 µm
		2nd	Interfine 629 Anhydride Cured Acrylic	75 µm
		Total		150 µm
2	Structural Steel – Exposed or damp corrosive environment, not H <sub>2</sub> S	1st	Interzinc 52 Polyamide Cured Epoxy	75 µm
		2nd	Intergard 475HS Polyamide Cured Epoxy	200 µm
		Total		275 µm
3	Structural Steel – Highly corrosive environment, coastal, not H <sub>2</sub> S, decorative top coat	1st	Interzinc 52 Polyamide Cured Epoxy	75 µm
		2nd	Intergard 475HS Polyamide Cured Epoxy	250 µm
		3rd	Interthane 990 Aliphatic Acrylic Polyurethane	75 µm
		Total		400 µm
4	Structural Steel – Immersed in sewage, open to atmosphere	1st	Interzone 954 Polyamine Cured Epoxy	250 µm
		2nd	Interzone 954 Polyamine Cured Epoxy	250 µm
		Total		500 µm
5	Steel or Cast Iron – External, not H <sub>2</sub> S, light grey epoxy top coat	1st	Interzinc 52 Polyamide Cured Epoxy	75 µm
		2nd	Interplus 1180 Epoxy	125 µm
		3rd	Interplus 1180 MIO N33 Epoxy	125 µm
		Total		325 µm
6	Steel or Cast Iron – External, not H <sub>2</sub> S, decorative top coat	1st	Interzinc 52 Polyamide Cured Epoxy	75 µm
		2nd	Interplus 1180 Epoxy	125 µm
		3rd	Interthane 990 Aliphatic Acrylic Polyurethane	75 µm
		Total		275 µm
7	Steel or Cast Iron - Highly corrosive H <sub>2</sub> S environment open to atmosphere, pipes internally coated, not potable water	1st	Interzone 954GF or Amerlock 400 GF	200 µm
		2nd	Interzone 954GF or Amerlock 400 GF	200 µm
		Total		400 µm
8	Steel or Cast Iron – Immersed, internally coated, potable water	1st	Interline 975P Solvent Free Epoxy	400 µm
		Total		400 µm
9	Steel or Cast Iron - Highly corrosive environment, damp H <sub>2</sub> S	1st	Interline 984 Epoxy Phenolic	200 µm
		2nd	Interline 984 Epoxy Phenolic	200 µm
		Total		400 µm
10	Steel or Cast Iron - Highly corrosive environment, damp H <sub>2</sub> S - Rapid application	1st	Rust Bullet Industrial urethane coating	150 µm
		2nd	Rust Bullet Industrial urethane coating	150 µm
		Total		300 µm
11	Cast Iron Ceramic Coating, for abrasion resistance	1st	Ceramic based two-component epoxy of one colour	200 µm
		2nd	Ceramic based two-component epoxy of contrasting colour	200 µm
		Total		400 µm

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System	Application	Coat	Paint*	DFT
12	Cast Iron Coating, for erosion-corrosion resistance	1st	Hydrophobic two-component epoxy of one colour	200 µm
		2nd	Hydrophobic two-component epoxy of contrasting colour	200 µm
		Total		400 µm
13	Steel or Cast Iron - Thermal Bonded Polymer		Thermal-bonded polymeric coating	350 µm
14	Steel or Cast Iron - Fusion Bonded Epoxy		Fusion Bonded Epoxy	350 µm
15	Steel Pipes – External Surfaces (Buried)		Sintakote	1600 µm
16	Steel or Cast Iron Pipes – Cement Mortar Lining		Steel or Cast Iron Pipes – Cement Mortar Lining	
17	Electrical Machines	1st	Interprime 198 Alkyd	75 µm
		2nd	Interfine 629 Anhydride Cured Acrylic	75 µm
		Total		150 µm
18	Electrical Switchgear Cubicles	1st	Acid wash and Chromate pe-treatment	N/A
		2nd	Dulux Duralloy powder coating or Taubmans powder coating	80 µm
		Total		80 µm
19	PVC Pipes	1st	Low Sheen Acrylic	25 µm
		2nd	Low Sheen Acrylic	25 µm
		3rd	High Gloss Alkyd Enamel	25 µm
		Total		75 µm
20	Minor Metallic Piping Systems – External Surfaces	1st	Epoxy Primer	30 µm
		2nd	High Gloss Alkyd Enamel	25 µm
		3rd	High Gloss Alkyd Enamel	25 µm
		Total		80 µm
21	Stainless Steel Surfaces		Stainless steel components pickled and passivated to ASTM A380	N/A
22	Stainless Steel Surfaces, electropolished		Stainless steel components with electropolished finish	N/A
23	Hot-dip Galvanising		Hot-dip Galvanising	To standard
24	Electroplated Metal Coatings		Electroplated coatings, Nickel, Chromium or Zinc	To standard
25	Wax-based anti corrosion coating		Wax-based, general purpose, corrosion preventive compound, Tectyl 506 or equal approved.	300 µm

\*\*Where brand names are used in this Specification, equivalent paints may be used subject to approval by the Superintendent.

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### 14.4.2 System 1: Structural steel – Mildly corrosive environment, not H<sub>2</sub>S, decorative top coat

- 14.4.2.1 **Applicability:** This system is for the painting of structural steelwork in mildly corrosive conditions without H<sub>2</sub>S (AS/NZS 2312 atmospheric corrosivity category A) and where non-chalking or specific colour top coat is required.
- 14.4.2.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.
- 14.4.2.3 **1st Coat:** Two component epoxy primer containing zinc phosphate pigment (Intergard 251 or approved equivalent) to a minimum dry film thickness of 75 µm.
- 14.4.2.4 **2nd Coat:** Two pack high gloss acrylic (Interfine 629 or approved equivalent) finish to a minimum dry film thickness of 75 µm.

### 14.4.3 System 2: Structural Steel – Exposed or damp corrosive environment, not H<sub>2</sub>S

- 14.4.3.1 **Applicability:** This system is for the painting of structural steelwork in exposed or damp conditions without H<sub>2</sub>S which can be abrasive blast cleaned (AS/NZS 2312 atmospheric corrosivity category C).
- 14.4.3.2 **Surface Preparation:** Oil or grease shall be removed in accordance with AS 1627.1 or SSPC-SP1 and abrasive blast cleaned to Sa 2½ (AS 1627.9) or SSPC-SP10. If oxidation has occurred between blasting and application, the surface shall be reblasted to the specified visual standard. Surface defects revealed by the blast cleaning process shall be ground, filled or treated in the appropriate manner.
- 14.4.3.3 **1st Coat:** Two component metallic zinc rich epoxy primer (Interzinc 52 or approved equivalent) to a minimum dry film thickness of 75 µm.
- 14.4.3.4 **2nd Coat:** Two component, high build, high solids epoxy (Intergard 475HS or approved equivalent) to a minimum dry film thickness of 200 µm.

### 14.4.4 System 3: Structural steel – Highly corrosive environment, coastal, not H<sub>2</sub>S, decorative top coat

- 14.4.4.1 **Applicability:** This system is for the painting of structural steelwork in high corrosivity conditions without H<sub>2</sub>S which can be abrasive blast cleaned (AS/NZS 2312 atmospheric corrosivity category D) and where non-chalking or specific colour top coat is required.
- 14.4.4.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.
- 14.4.4.3 **1st Coat:** Two component metallic zinc rich epoxy primer (Interzinc 52 or approved equivalent) to a minimum dry film thickness of 75 µm.
- 14.4.4.4 **2nd Coat:** Two component, high build, high solids epoxy (Intergard 475HS or approved equivalent) to a minimum dry film thickness of 250 µm.
- 14.4.4.5 **3rd Coat:** Recoatable aliphatic acrylic polyurethane (Interthane 990 or approved equivalent) finish, to a minimum dry film thickness of 75 µm.

### 14.4.5 System 4: Structural Steel – Immersed in Sewage, open to atmosphere

- 14.4.5.1 **Applicability:** This system is for the painting of structural steelwork immersed in sewage or subject to splashing by sewage without enclosed H<sub>2</sub>S and that can be abrasive blast cleaned. Typical application: Clarifier bridges, sludge hoppers, etc.
- 14.4.5.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.
- 14.4.5.3 **1st Coat:** Two component epoxy polyamine cured coating (Interzone 954 or approved equivalent) to a minimum dry film thickness of 250 µm.

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14.4.5.4 **2nd Coat:** Two component epoxy polyamine cured coating (Interzone 954 or approved equivalent) to a minimum dry film thickness of 250 µm.

### 14.4.6 System 5: Steel or Cast Iron – External, not H<sub>2</sub>S, light grey epoxy top coat

14.4.6.1 **Applicability:** This system is for the painting of structural steelwork in exposed or damp conditions without H<sub>2</sub>S which can be abrasive blast cleaned (AS/NZS 2312 atmospheric corrosivity category C) and where light grey top coat is required, some chalking is acceptable.

14.4.6.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.6.3 **1st Coat:** Two component metallic zinc rich epoxy primer (Interzinc 52 or approved equivalent) to a minimum dry film thickness of 75 µm.

14.4.6.4 **2nd Coat:** Two component, high build, high solids epoxy (Interplus 1180 or approved equivalent) to a minimum dry film thickness of 125 µm.

14.4.6.5 **3rd Coat:** Two component, high build, high solids epoxy (Interplus 1180 MIO N33 or approved equivalent) to a minimum dry film thickness of 125 µm.

### 14.4.7 System 6: Steel or Cast Iron – External, not H<sub>2</sub>S, decorative top coat

14.4.7.1 **Applicability:** This system is for the painting of structural steelwork in exposed or damp conditions without H<sub>2</sub>S which can be abrasive blast cleaned (AS/NZS 2312 atmospheric corrosivity category C) and where non-chalking or specific colour top coat is required.

14.4.7.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.7.3 **1st Coat:** Two component metallic zinc rich epoxy primer (Interzinc 52 or approved equivalent) to a minimum dry film thickness of 75 µm.

14.4.7.4 **2nd Coat:** Two component, high build, high solids epoxy (Interplus 1180 or approved equivalent) to a minimum dry film thickness of 125 µm.

14.4.7.5 **3rd Coat:** Recoatable aliphatic acrylic polyurethane (Interthane 990 or approved equivalent) finish, to a minimum dry film thickness of 75 µm

### 14.4.8 System 7: Steel or Cast Iron - Highly corrosive H<sub>2</sub>S environment open to atmosphere, pipes internally coated, not potable water

14.4.8.1 **Applicability:** This system is for painting of steel or cast iron in highly corrosive environments open to atmosphere with H<sub>2</sub>S present and for internal coating of pipes used for water or sewage but not potable water.

14.4.8.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.8.3 **1st Coat:** High solids epoxy mastic (Interzone 954GF, Dulux Amerlock 400 GF or approved equivalent) to a minimum dry film thickness of 200 µm.

14.4.8.4 **2nd Coat:** High solids epoxy mastic (Interzone 954GF, Dulux Amerlock 400 GF or approved equivalent) to a minimum dry film thickness of 200 µm.

### 14.4.9 System 8: Steel or Cast Iron – Immersed, internally coated, potable water

14.4.9.1 **Applicability:** This system is for painting of steel or cast iron, including internal coating of pipes used for water or effluent with potable water certification.

14.4.9.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification. The surface profile shall be a sharp, angular surface profile of 75-100 µm.

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14.4.9.3 **1st Coat:** Two component solvent free epoxy (Interline 975P or approved equivalent) to a minimum dry film thickness of 400 µm.

### 14.4.10 System 9: Steel or Cast Iron - Highly corrosive environment, damp H<sub>2</sub>S

14.4.10.1 **Applicability:** Steel or cast iron in highly corrosive environments, un-vented sewage applications in the presence of H<sub>2</sub>S, such as sewage pump station wet-wells.

14.4.10.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification. The surface profile shall be a sharp, angular surface profile of 75-100 µm.

14.4.10.3 **1st Coat:** Heavy duty epoxy phenolic (Interline 984 or approved equivalent) to a minimum dry film thickness of 200 µm.

14.4.10.4 **2nd Coat:** Heavy duty epoxy phenolic (Interline 984 or approved equivalent) to a minimum dry film thickness of 200 µm.

14.4.10.5 Where the abrasive blast profile of 75-100 µm is not practicable, the following alternative system may be used:

14.4.10.6 **1st Coat:** Complete surface preparation as above, with a sharp, angular surface profile of minimum 50 µm. Apply epoxy holding primer (Interline 982 or approved equivalent) to a minimum dry film thickness of 40 µm.

14.4.10.7 **2nd Coat:** Heavy duty epoxy phenolic (Interline 984 or approved equivalent) to a minimum dry film thickness of 400 µm. Total coating: 440 µm.

### 14.4.11 System 10: Steel or Cast Iron, Highly corrosive environment, damp H<sub>2</sub>S - Rapid application

14.4.11.1 **Applicability:** Steel or cast iron in highly corrosive environments, un-vented sewage applications in the presence of H<sub>2</sub>S, such as sewage pump station wet-wells where rapid application of the coating is required. Use is subject to approval by the Superintendent.

14.4.11.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.11.3 For applications where the curing time is critical, an accelerator additive may be added to the coating to reduce curing time down to 1 to 2 hours: Accelerator additive: Rust Bullet Rapid Fire may be added to Rust Bullet Industrial urethane coating to reduce curing time by approximately 80%. Refer Rust Bullet Rapid Fire data and application guidelines.

14.4.11.4 **1st Coat:** Rust Bullet Industrial urethane coating to a minimum dry film thickness of 150 µm.

14.4.11.5 **2nd Coat:** Rust Bullet Industrial urethane coating to a minimum dry film thickness of 150 µm.

### 14.4.12 System 11: Cast Iron Ceramic Coating, for abrasion resistance

14.4.12.1 **Applicability:** This system is for coating surfaces of cast iron, steel, bronze or brass components subject to extreme abrasion, such as sewage pump impellers, wear plates, back plates and the inside surface of volutes.

14.4.12.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.12.3 **1st Coat:** Ceramic based two-component epoxy of one colour to a minimum dry film thickness of 200 µm.

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14.4.12.4 **2nd Coat:** Ceramic based two-component epoxy of contrasting colour to a minimum dry film thickness of 200 µm.

- Approved ceramic based two-component epoxy vendors for general applications:
- AES FG Ceramic Repair Fluid
- Belzona 1321
- Devcon Brushable Ceramic
- METALCLAD CeramAlloy CL+AC
- Peerless Industrial Systems Pty Ltd. Item Code: 95010K
- 3M Scotchkote Epoxy Ceramic Surfacers FG 512

14.4.12.5 Approved ceramic based two-component epoxy vendors for un-vented sewage applications in the presence of hydrogen sulphide such as sewage pump station wet wells:

- Devcon Brushable Ceramic
- METALCLAD CeramAlloy CL+AC

### 14.4.13 System 12: Cast Iron Coating, for erosion-corrosion resistance

14.4.13.1 **Applicability:** This system is for coating surfaces of cast iron, steel, bronze or brass components subject to erosion-corrosion, such as water pump impellers, wear plates, back plates and the inside surface of volutes.

14.4.13.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.13.3 **1st Coat:** Hydrophobic two-component epoxy of one colour to a minimum dry film thickness of 200 µm.

14.4.13.4 **2nd Coat:** Hydrophobic two-component epoxy of contrasting colour to a minimum dry film thickness of 200 µm.

- Approved Hydrophobic two-component epoxy vendors:
- Belzona 1341 Supermetalgilde

### 14.4.14 System 13: Steel or Cast Iron Equipment – Thermal Bonded Polymeric Coating

14.4.14.1 **Applicability:** This system is for the protection of the external surfaces of steel or cast iron equipment installed either indoors or outdoors in the presence of H<sub>2</sub>S with a thermal-bonded polymeric coating.

14.4.14.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.14.3 **1st Coat:** Thermal-bonded polymeric coating (Rilsan PA11, Plascoat PPA 571 AQUA or approved equivalent) to a minimum dry film thickness of 350 µm applied in accordance with AS 4158.

### 14.4.15 System 14: Steel or Cast Iron Equipment – Fusion-bonded Epoxy

14.4.15.1 **Applicability:** This system is for the protection of the external surfaces of steel or cast iron equipment installed either indoors or outdoors in the presence of H<sub>2</sub>S with fusion bonded epoxy.

14.4.15.2 **Surface Preparation:** Surface preparation shall be in accordance with Section 14.2 of this Specification.

14.4.15.3 **1st Coat:** Thermosetting Epoxy Powder (Axalta NAP-GARD 7-2501 or approved equivalent) to a minimum dry film thickness of 350 µm applied in accordance with the manufacturer's recommendations.

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### 14.4.16 System 15: Steel Pipe – External Surfaces (buried)

- 14.4.16.1 **Applicability:** This system is for the protection of the external surfaces of buried steel pipes in the presence of H<sub>2</sub>S.
- 14.4.16.2 **Proprietary Product:** Sintakote 1.6 mm thick.

### 14.4.17 System 16: Steel or Cast Iron Pipes – Cement Mortar Lining

- 14.4.17.1 **Applicability:** This system is for the cement mortar lining of the internal surface of steel or cast iron pipes and specials.
- 14.4.17.2 **Method:** All pipes and specials shall be lined with cement mortar to a finished thickness as specified. Cement shall comply with AS 3972 Type SR. Materials for lining, methods of application and curing of the lining shall be in accordance with AS 1281. In the lining of pipes and specials, the Supplier may use a mixture of Portland cement and fly ash blended in proportions not exceeding 10% by weight of fly ash and approved by the Superintendent. The Supplier shall not incorporate any admixture into the cement mortar without the approval of the Superintendent.

### 14.4.18 System 17: Electrical Machines

- 14.4.18.1 **Applicability:** This system is for the painting of motors and mechanical equipment (AS/NZS 2312 atmospheric corrosivity category A).
- 14.4.18.2 **Surface Preparation:** Oil or grease shall be removed in accordance with AS 1627.1 or SSPC-SP1. Surfaces shall be lightly sanded and free of dust and dirt prior to application of coatings.
- 14.4.18.3 **1st Coat:** Fast dry universal alkyd primer (Interprime 198 or approved equivalent) to a minimum dry film thickness of 75 µm.
- 14.4.18.4 **2nd Coat:** Two pack high gloss acrylic (Interfine 629 or approved equivalent) finish to a minimum dry film thickness of 75 µm.

### 14.4.19 System 18: Electrical Switchgear Cubicles

- 14.4.19.1 **Applicability:** This system is to provide a high gloss, high quality system for electrical switchboards and cubicles, free from defects and able to withstand transport, handling and installation. The system is designed to be applied over sheet aluminium and shall provide at least a 25 year life without recoating.
- 14.4.19.2 **Surface Preparation:** After bending, welding, drilling and punching, the surface shall be lightly abraded with fine wet and dry paper where required. Oil or grease shall be removed in accordance with AS 1627.1 or SSPC-SP1.
- 14.4.19.3 **1st Coat:** Acid wash and Chromate pe-treatment.
- 14.4.19.4 **2nd Coat:** Thermosetting powder coating (Dulux Duralloy powder coating, Taubmans powder coating or approved equivalent) to a minimum dry film thickness of 80 µm.

### 14.4.20 System 19: PVC Pipes

- 14.4.20.1 **Applicability:** This system is for the painting of PVC pipes and fittings.
- 14.4.20.2 **Surface Preparation:** Surfaces shall be cleaned with methylated spirits, isopropanol or warm water and detergent and abraded with nylon pad, steel wool or P800 wet and dry paper.
- 14.4.20.3 **1st Coat:** Low sheen acrylic (Dulux Weathershield Low Sheen Acrylic for exterior plastics or approved equivalent) to a minimum dry film thickness of 25 µm.
- 14.4.20.4 **2nd Coat:** As per 1st coat.

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14.4.20.5 **3rd Coat:** (If required for colour coding) High gloss alkyd enamel (Dulux High Gloss Enamel or approved equivalent) to a minimum dry film thickness of 25 µm.

### 14.4.21 System 20: Minor Metallic Piping Systems – External Surfaces

14.4.21.1 **Applicability:** This system is for the painting of the external surfaces of minor pipe work manufactured from aluminium, copper, brass or galvanized steel.

14.4.21.2 **Surface Preparation:** Oil or grease shall be removed in accordance with AS 1627.1 or SSPC-SP1 and abraded with nylon pad, steel wool or P800 wet and dry paper to remove the oxide layer.

14.4.21.3 **1st Coat:** Epoxy primer (Dulux Luxepoxy 4 White Primer or approved equivalent) to a minimum dry film thickness of 30 µm applied immediately after degreasing. For galvanized surfaces, Dulux Galiron is an approved alternative.

14.4.21.4 **2nd Coat:** High gloss alkyd enamel (Dulux High Gloss Enamel or approved equivalent) to a minimum dry film thickness of 25 µm.

14.4.21.5 **3rd Coat:** As per 2nd coat.

### 14.4.22 System 21: Stainless Steel Surfaces

14.4.22.1 Stainless steel fabrications shall be passivated in accordance with ASTM A380, including the following procedure:

- The surface of the stainless steel shall be thoroughly degreased by solvents and, if necessary, rubbed down with a fine grade abrasive cloth or pumice stone;
- The item to be passivated shall be treated using an electrochemical weld cleaning unit in conjunction with an electrolyte solution made of non-harsh acid such as citric acid;
- After passivation, the items shall be thoroughly hosed with clean water. Care must be taken in choosing the wash down area and undertaking hosing to avoid uncontrolled discharge of citric acid.

### 14.4.23 System 22: Stainless Steel Surfaces – Electropolished

14.4.23.1 Stainless steel fabrications in highly corrosive environments, un-vented sewage applications in the presence of hydrogen sulphide such as sewage pump station wet-wells shall be firstly passivated in accordance with System 21.

14.4.23.2 After passivation, an additional electropolishing finish shall be applied.

### 14.4.24 System 23: Hot-dip Galvanising

14.4.24.1 Following completion of all welding, cutting, drilling and grinding operations, steel and iron work to be galvanised shall be degreased, pickled, washed, fluxed and dried before being hot-dip galvanised in accordance with AS 4680 to achieve a minimum zinc thickness according to the following table:

**Table 31 - Minimum Zinc Thickness for Hot Dip Galvanizing (extract from AS 4680)**

Steel Thickness (mm)	Local coating thickness (µm) min	Average coating thickness (µm) min	Average coating mass (g/m <sup>2</sup> ) min
≤1.5	35	45	320
1.5 ≤ 3	45	55	390
>3 ≤ 6	55	70	500
>6	70	85	600

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- 14.4.24.2 Care shall be taken to prevent hydrogen damage (embrittlement) to high tensile and high carbon steels during the pickling process.
- 14.4.24.3 All bolts, nuts and washers shall be hot dip spun galvanized and the threads of nuts re-run after galvanising.
- 14.4.24.4 Damaged areas on small fabricated components including brackets which have been welded or cut following galvanizing shall be regalvanised.
- 14.4.24.5 Damaged areas on large fabricated components which cannot be readily removed for regalvanising shall be repaired by either applying a minimum dry film thickness of 75 µm of a Eutectic-Castolin zinc alloy by means of Tero Dyn system 2000 or equivalent in order to produce a metallurgically bonded deposit or CIG Comweld Galvanizing Bar applied in accordance with the manufacturer's instructions.
- 14.4.24.6 Damaged areas on thin sheet metal products including cable trays shall be degreased, wire brushed and coated with two coats of single pack Zinc Rich Primer (Dulux Zinc Rich 1P or approved equivalent).

### 14.4.25 System 24: Electroplated Metal Coatings

- 14.4.25.1 Electroplating shall be either:
- nickel plus chromium plating;
  - cadmium plating; or
  - zinc plating;
- as stated in the nominating specification.
- 14.4.25.2 Each plating type shall comply with the following relevant Standard:
- AS1192 Electroplated coatings, Nickel and chromium;
  - AS1789 Electroplated coatings, Zinc on iron or steel;
  - AS1897 Electroplated coatings on threaded components (metric coarse series).

### 14.4.26 System 25: Wax-based Anticorrosion Coating

- 14.4.26.1 **Applicability:** This system is for any uncoated carbon steel drive shaft or a bearing race which is exposed to atmospheres where a painted coating is not practical.
- 14.4.26.2 **Surface Preparation:** Oil or grease shall be removed in accordance with AS 1627.1 or SSPC-SP1 and abraded with nylon pad, steel wool or P800 wet and dry paper to remove the oxide layer.
- 14.4.26.3 **Coating:** Exposed surfaces shall be coated with a wax-based, general purpose, corrosion preventive compound such as Tectyl 506 aerosol spray, or approved equivalent. Coating shall be applied immediately after degreasing to achieve a uniform minimum dry film thickness coating of 300 µm.