Engineering

Technical Standard

TS 0220 – Requirements for Pump Specification, Procurement and Testing

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Government of South Australia

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Users of this Standard accept sole responsibility for interpretation and use of the information contained in this Standard. Users should independently verify the accuracy, fitness for purpose and application of information contained in this Standard.

Only the current revision of this Standard should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

This technical standard incorporates the new document numbering system. Additionally, this technical standard supersedes TS146b – Requirements for Pump Specification, Procurement and Testing and the Preparation of Pump Datasheets.

Updates referencing current standards (AS ISO documents) have been made to this edition of the technical standard.

- **AS ISO 9906:2018** in replacement of AS 2417 - 2001
- **ISO 10816-7** in replacement of AS 2625.1 - 2003

Additionally, G2.5 balancing to ISO1940-1:2003 is now the new minimum requirement for water pumps. A change in the document referenced in Clause 3.6.3 Impeller.

Rationalisation of the document where commonality exists between water and wastewater pump specification and design criteria has also been made to this edition.

Change and updates to Section 4, Pump Testing have been made, aligning TS 0220 with current ISO and AS document references.

Document Controls

Revision History

Revision	Date	Author	Comments
1.0	08/12/2023	Gordon Holmes	Final issue Developed from the previous edition (TS146b, Rev3) authored by Mark Stephens.

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1 Introduction

SA Water is responsible for the construction, testing and commissioning of an extensive amount of engineering infrastructure such that it is safe and fit for purpose.

This standard has been developed to assist in the design, specification, selection, construction, operation, maintenance, and management of this infrastructure.

1.1 Purpose

The purpose of this standard is to detail minimum requirements with respect to pumps used by SA Water, to ensure suitable levels of performance in the design, specification, selection, procurement, construction, installation, operation and maintenance of pump infrastructure to attain the required asset life and outcomes for SA Water's customers.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
ANSI	American National Standards Institute
AS/NZS	Australian/New Zealand Standard
DN	Nominal Diameter
EPA	Environment Protection Agency
FEA	Finite Element Analysis
FFT	Fast Fourier Transform
ISO	International Standard Organisation
kW	Kilowatt
L/s	Litres per second
m	Metre
mm	Millimetre
NPSHa	Net Positive Suction Head Available
NPSHr	Net Positive Suction Head Required
RPM	Revolutions Per Minute
SA Water	South Australian Water Corporation
TEFC	Totally Enclosed Fan Cooled
TG	SA Water Technical Guideline
TS	SA Water Technical Standard
VFD/VSD	Variable Frequency/Variable Speed Drive
WHS	Work Health and Safety
WSA/WSAA	Water Services Association/Water Services Association of Australia

1.3 References

1.3.1 Australian and International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
ANSI/HI 11.6	Rotodynamic Submersible Pumps
AS 1214-1983	Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread series)
AS 2382-1981	Surface roughness comparison specimens
AS 3894.1-2002	Site testing of protective coatings - non-conductive coatings - continuity testing - high voltage ('brush') method
AS 3894.3-2002	Site testing of protective coatings - determination of dry film thickness
AS 4024.1601-2006	Safety of machinery - Design of controls, interlocks and guarding - Guards - General requirements for the design and construction of fixed and movable guards
AS 4024.1602-2006	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
AS 4024.1603-2006	Safety of machinery - Design of controls, interlocks and guards - Prevention of unexpected start-up
AS 4024.1604-2006	Safety of machinery - Design of controls, interlocks and guarding - Emergency stop - Principles for design
AS 4680-4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS ISO 9906:2018	Rotodynamic pumps – Hydraulic Performance acceptance tests – Grades 1, 2 and 3.
AS/NZS 4020-2005	Testing of products for use in contact with drinking water
AS/NZS 4087-2011	Metallic flanges for waterworks purposes
AS/NZS 3709-1989 (ISO1940-1:2003)	Vibration and shock - balance quality of rotating rigid bodies **Note:** ISO standard to be used – Mechanical vibration – balance quality requirements for rotors in a constant (rigid) state – Part 1
ISO 10816-7	Rotodynamic pumps for industrial applications, including measurements on rotating shafts
ISO 281	Rolling bearings — Dynamic load ratings and rating life
WSA 03-2011 v3.1	Water Supply Code of Australia
WSA 04-2022 v3.1	Sewage Pumping Station Code of Australia
WSA 101-2008	Industry Standard for Submersible Pumps for Sewage Pumping Stations
WSA 130-2011	Industry Standard for ISO End Suction Centrifugal Motor Pumps
WSA 131-2011	Industry Standard for ISO End Suction Centrifugal Motor Pumps

1.3.2 SA Water Documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Number	Title
DS 0200	Mechanical Datasheets
TS 0101	Safety in Design
TS 0109	Infrastructure Design
TS 0132	Operating and Maintenance Manuals
TS 0300	Supply and Installation of Low Voltage Electrical Equipment
TS 0376	Classification and Design for Electrical Equipment in Hazardous Areas
TS 0420	Welding Requirements (Metals)
TS 0800	Materials in Contact with Drinking Water
TS 146b	Mechanical Requirements for The Commissioning and On-Going Monitoring of Pumps and Associated Equipment

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
Accepted	Determined to be satisfactory by SA Water's Representative
Constructor	The organisation that can be responsible for the design, procurement, construction, testing and commissioning of pumping infrastructure for SA Water whether it be a third party independent contractor or subcontractor under contract to SA Water or an in-house entity. The Constructor engaged by SA Water to carry out construction works (i.e. major and/or minor framework partners (MFP), independent contractor or SA Water Workshops).
Contract Documents	A set of documents supplied to Constructor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes
Designer	The organisation responsible for designing infrastructure for SA Water whether it be a third party under contract to SA Water, or an in-house entity A Designer is a person who effects design, produces designs or undertakes design activities as defined in the *Work Health and Safety Act 2012 (SA)*. The word design, refers to the requirement of Designers and/or Constructors to determine the pump(s) requirements for safe and reliable operation and ease of maintenance, inclusive but not limited to pump hydraulic and mechanical selection, pump/motor physical size attributes, installation, pump hydraulic control configurations to achieve the required hydraulic and operational reliability outcomes.
Manufacturer	A person, group, or company that owns and operates a manufacturing facility that provides materials for use in SA Water infrastructure
Power level	In this Technical Standard, is taken to mean the input shaft power to the pump
Responsible Discipline Lead	The engineering discipline expert responsible for TS 0220 defined on page 3 (via SA Water's Representative)

Term	Description
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g., AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Shall and Should	In this Standard the word "shall" indicates a requirement that is to be adopted in order to comply with the Standard. The word "should" indicates practices which are advised or recommended.
Supplier	A person, group or company that provides goods for use in SA Water infrastructure
TDRF	Technical Dispensation Request Form. This form is part of SA Water's Technical Dispensation Request Procedure which details the process by which those required to comply, or ensure compliance, with SA Water's technical requirements may seek dispensation from those requirements.
Terminology	• Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Constructor. • Directions, instructions and the like, whether or not they include the expression "the Constructor shall" or equivalent, shall be directions to the Constructor, unless otherwise specifically stated. • Where a submission, request, proposal is required and it is not stated who the recipient should be, it is to be provided to SA Water's Representative for review. • Each word imparting the plural shall be construed as if the said word were preceded by the word "all". • Each word implying persons shall, where appropriate, also be construed as including corporations. • "Authorised", "approval", "approved", "selected", "directed" and similar words shall be construed as referring to the authorisation, approval, selection or direction of SA Water's Representative in writing. • "Allow" shall mean that the cost of the item referred to is the responsibility of the Constructor. • "Provide" shall mean "supply and install". • "Submit" shall mean "submit to SA Water's Representative or their nominated delegate". • Submissions, requests, proposals are to be provided at least 7 working days prior to work commencing or material ordering (unless noted otherwise). • "Informative" shall mean "provided for information and guidance"
Works	Elements of a project which require design and/or construction

2 Scope

This Technical Standard is applicable to all water, recycled water and wastewater pumps as detailed below:

- Centrifugal, axial, column, in-can, multistage, self-priming and all other types of water pumps.
- Submersible type centrifugal pumps and ancillary equipment for use in wastewater pumping stations.
- Submersible, dry well submersible, line shaft and all other types of wastewater pump except those excluded below.

However, the following pump types are excluded from the scope of this Technical Standard:

- Sludge handling pumps in water and wastewater treatment plants with solids > 1.0%
- Dosing pumps (positive displacement pumps) for chemical processes

TS 0220 incorporates pump types detailed across several WSA codes, except those specifically excluded by this clause.

WSA 130 (and/or WSA 131) shall be applied, in addition to TS 0220, for pump types and sizes outside the scope of WSA 130 (and/or WSA 131) if technically relevant. In the event of inconsistency between the requirements of WSA 130 (and/or WSA 131), the Responsible Discipline Lead shall be contacted for direction.

WSA 101 shall be applied, in addition to TS 0220, for pump types and sizes outside the scope of WSA 101 if technically relevant. In the event of inconsistency between the requirements of WSA 101 and TS 0220, the Responsible Discipline Lead shall be contacted for direction.

The interrelationship between TS 0220 and the WSA codes cited in Section 1.3 are shown in Figure 1 below.

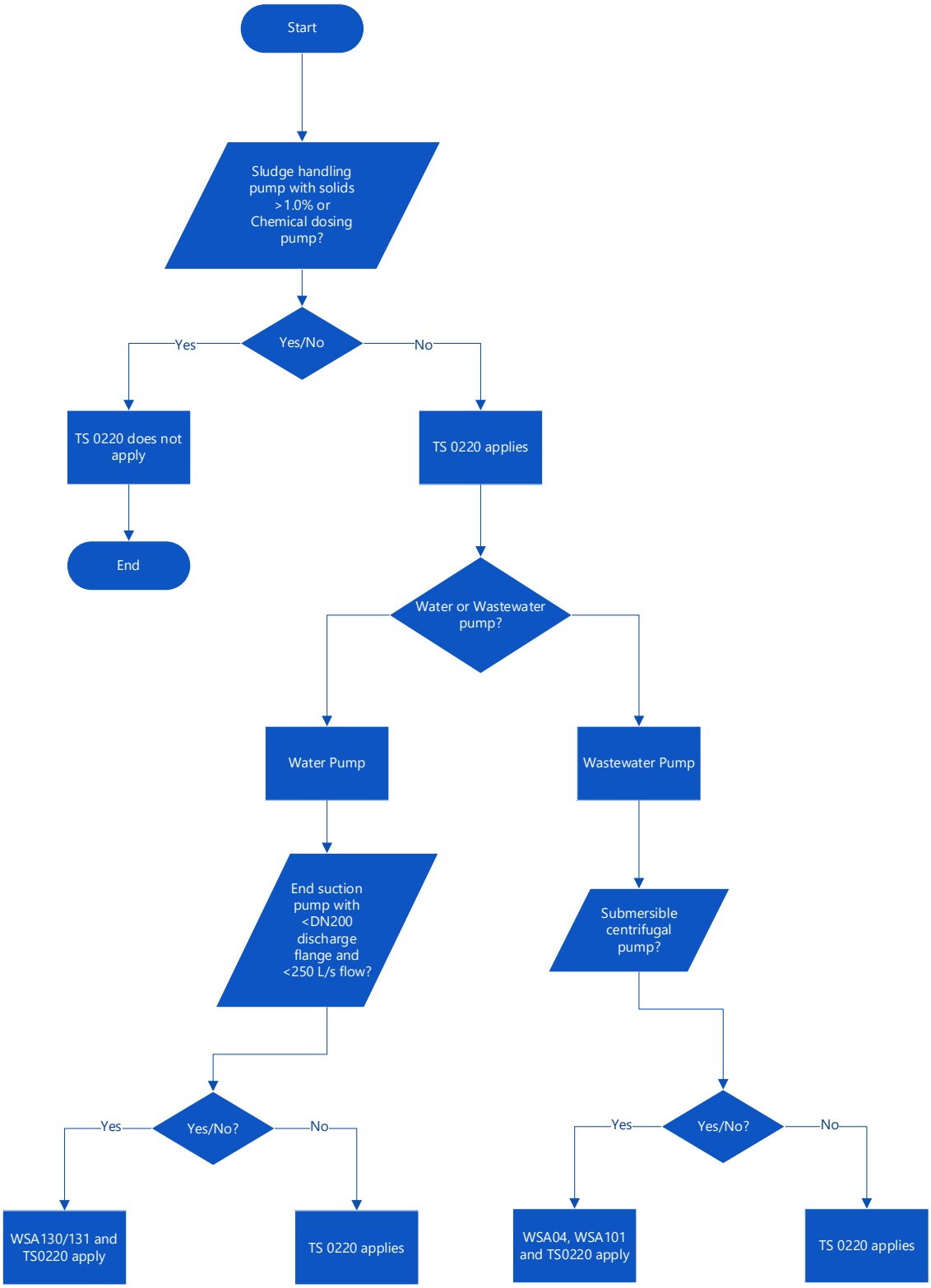

Figure 1 - Relationship between TS 0220 and WSA codes

The requirements of TS 0220 apply to Designers, Constructors and/or pump vendors. It is recognised that the roles of Designers, Constructors and/or pump vendors vary in the specification, procurement, testing and preparation of datasheets for pumps within different contractual frameworks (e.g., Designers typically prepare datasheets for issue to pump vendors who then return the datasheet with either statements of compliance, non-compliance or other comments). All contracts must provide for the requirements of TS 0220 to be met by either Designers, Constructors and/or pump vendors.

2.1 Technical Dispensation

Departure from any requirement of this Technical Standard shall require the submission of Technical Dispensation Request Form (TDRF) for the review and approval (or otherwise) of SA Water Principal Engineer listed in Page 3, on a case-by-case basis.

The Designer shall not proceed to document/incorporate the non-conforming work before the Principal Engineer has approved of the proposed action in writing via the Technical Dispensation Request Form (TDRF).

SA Water requires sufficient information to assess dispensation requests and their potential impact. The onus is therefore on the proponent to justify dispensation request submissions and provide suitable evidence to support them.

Design works that are carried out without being appropriately sanctioned by SA Water shall be liable to rejection by SA Water and retrospective rectification by the Designer/Constructor.

3 Specification & Design Requirements

The word design, as used in this Technical Standard, refers to the requirement of Designers and/or Constructors to determine the pump(s) requirements for safe and reliable operation and ease of maintenance, inclusive but not limited to pump hydraulic and mechanical selection, pump/motor physical size attributes, installation, pump hydraulic control configurations to achieve the required hydraulic and operational reliability outcomes.

3.1 General

A pump specification for procurement shall be formed against the technical and design requirements of this Technical Standard.

A standard form datasheet shall be developed and supplied to pump vendors in the form of a returnable schedule. Example datasheets are included in the appendix to TS 0220 including datasheets for:

- Potable Water Pumps
- Raw Water Pumps
- Dry Well Submersible Pumps
- Wet Well Submersible Pumps
- Line Shaft Pumps

Pump vendors must return the datasheet with all requested information supplied and completed or a detailed explanation if information is not provided.

The requirements in TS 0300 for pump motors are to be included in the specification of pumps.

The required pump design life is provided in TS 0109.

The required pump warranty is 1 year minimum from the time at which the pump is first operated, after the commissioning completion and first in-service operation, and not from the time of delivery. Commercially negotiated extensions for longer warranty periods are preferred.

The pump vendor shall be informed if the pump motors are to be operated using Variable Speed Drives (VSDs) so that harmonic currents and voltage stresses on the motors can be considered by the pump vendor.

3.2 Pump Curves

For pumps with either fixed speed motors or variable speed driven motors (i.e. VSD), pump curves shall be provided by the pump vendors showing the:

- Head Versus Flow
- Efficiency
- NPSHr
- Absorbed Power

For the pump over the full range of potential operation from shutoff head to the highest flow (lowest head) operation that is warranted by the vendor for operation at 100% speed.

For pumps with variable speed drives connected to their motors, pump curves shall be provided by the pump vendors showing the:

- Head Versus Flow
- Efficiency
- NPSHr
- Absorbed Power

For the pump over the full range of potential operation from shutoff head to the highest flow (lowest head) operation that is warranted by the vendor for operation at 90%, 80%, 70%, 60% and 50% speed.

The vendor must superimpose the head versus flow relationships for the nominated pumps over the system curves provided by the Designer and/or Constructor within their pump specification and/or technical datasheet.

Operation above 100% speed (over speeding) shall not be permitted (and not relied on to cater for anticipated routine operational circumstances).

Operation at 50% speed shall be confirmed with the vendor to ensure that this can be achieved. Operation below 50% speed (25Hz) shall not be permitted unless specifically confirmed and warranted by the vendor.

Minimum and maximum flows for continuous operation shall be shown on all pump curves for all operating speeds.

Where a pump vendor is unable to supply curves for variable speed operation of a pump but is supplying the pump as a variable speed pump, affinity laws must be used to calculate the pressure versus flow relationships for the pumps at the above listed operating speeds. The pump vendor should then be requested to confirm the calculated pressure versus discharge relationships.

Affinity law equations:

$$\frac{Q_1}{Q_2} = \left(\frac{n_1}{n_2}\right) \quad \frac{H_1}{H_2} = \left(\frac{n_1}{n_2}\right)^2 \quad \frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^3$$

where Q = flow, H = head, P = power and n = rotational speed

The accuracy of the affinity law for pump power is affected by changes in efficiency with pump size and shall not be used unless authorised and confirmed as accurate by the pump vendor.

For both fixed speed and variable speed pumps, input shaft power curves shall be obtained from the vendor for the maximum operating speed.

Shutoff head may not be specified for some classes of wastewater pumps. In this case, the vendor must stipulate the conditions under which the pump must be started and stopped (see Section 3.4).

Impeller size offered and maximum impeller size (100% speed curves) shall be provided by the pump vendor.

Pump curve inflections are not preferred and pumps with such inflections should not be selected unless it is clearly demonstrated by the vendor that the inflections will not lead to problematic operation. A pump curve "inflects" where head is not continuously rising as flow decreases. An inflection can be gradual over a larger flow range (e.g., for an end suction pump where the head at the best efficiency point is greater than the head at shutoff) or sharp over a smaller flow range (e.g., for high head and efficiency split case centrifugal pumps where head can dip down with decreasing flow, over a proportion of the pump operating range, and then recover at shutoff).

For both fixed speed and variable speed pumps, Net Positive Suction Head required (NPSHr) curves, as defined in AS ISO 9906 and distinct from NPSH3, shall be provided by the vendor for all operating speeds.

The Net Positive Suction Head required (NPSHr) for a pump shall be provided by the pump vendor for all feasible operating conditions including:

- Minimum Flow Operation For Fixed Speed Operation
- Maximum Flow Operation For Fixed Speed Operation
- Minimum Speed Operation At Lowest Flow For Variable Speed Applications
- Maximum Speed Operation At Highest Flow For Variable Speed Applications
- Maximum speed operation at highest pressure (if different from that at highest flow) for variable speed applications

The vendor must superimpose the calculated Net Positive Suction Head available (NPSHa) values provided in the specification and datasheet over the Net Positive Suction Head required (NPSHr) curves for the nominated pumps and confirm pump operation will not be limited by either the available or required NPSH.

Self-priming pumps can be used to lift water or wastewater from reservoirs, tanks or non-pressurised pipes subject to vendor requirements and limitations to the diameter and length, and height above water level, of suction pipework. The maximum self-priming pump start lift above storage water level must be determined from the pump vendor for all possible operating conditions ranging from minimum to maximum flow pumping for fixed speed pumps and minimum flow and pressure to maximum flow and pressure for variable speed pumping.

The speed corresponding to maximum suction lifts must be obtained from the pump vendor to determine if faster than normal pump operation is required for a self-priming pump to prime before the pump can slow back down to its normal operating speed.

NPSHr and suction lift requirements must not be confused, and each must be determined separately to determine the suitability of a self-priming pump for any application.

3.3 Pump Efficiency

For both fixed speed and variable speed pumps, pump efficiency curves shall be obtained from pump vendors for the pump over the full range of potential operation from shutoff head to the highest flow (lowest head) operation warranted by the vendor for operation at 100% speed.

For variable speed pumps, pump efficiency curves shall be provided by the pump vendor for the pump over the full range of potential operation from shutoff head (if available) to the highest flow (lowest head) operation warranted by the vendor for operation at 90%, 80%, 70%, 60% and 50% speed.

The pump efficiency shall be clearly and separately identified from the motor efficiency.

3.4 Starting and Stopping Pumps

The rate of speed increase and time over which a pump:

- Starts from 0% speed and reaches Q_{min}
- Stops from Q_{min} and reaches 0% speed
- Starts from 0% speed and reaches 100% speed
- Stops from 100% speed and reaches 0% speed

must be agreed with the vendor before procuring a pump in addition to the vendor providing the following information:

- Any vendor restrictions to pump operation at flows below Q_{min} while a pump is starting must be identified in terms of the maximum time the pump can operate below Q_{min} while ramping up and the maximum and minimum rate at which the change from zero to Q_{min} flow needs to occur

- Any vendor restrictions to pump operation below Q_{min} flows while a pump is stopping must be identified in terms of the maximum time the pump can operate below Q_{min} while ramping down and the maximum and minimum rate at which the changes from Q_{min} to zero flow needs to occur
- Any vendor restrictions to pump operation above the maximum flow rate nominated on the pump curve (for fixed and variable speed pumps), and at any operating speed (for variable speed pumps), in terms of the maximum permissible flow exceedance and the length of time over which the flow exceedance occurs, during pump start up, or during pump transitions where multiple pumps are operated in parallel.
    - If this mode of operation is required, then this must be clearly identified in the specification and datasheet and the pump vendor must accept these pump start-up or transition conditions (e.g., pumps may need to start in low static head systems with short term operation to the right hand side of the pump curve limit until sufficient dynamic head develops for the pump to operate on its curve)
- The maximum vibration levels from the pump during starting and stopping (i.e., under dynamic operating conditions) in addition to operation at the duty point and maximum speed (under steady operating conditions)

If a pump is to be operated at shutoff head (no flow) during normal starting and stopping operation, then this must be communicated to the pump vendor to ensure the pump supplied will perform adequately under such operating conditions.

All the above information is critical in determining the system hydraulic control philosophy, likely pump vibration performance and the surge/transient pressure characteristics of the system across the full range of pump operating conditions.

3.5 Pump Configurations

3.5.1 Parallel Pumps

If a parallel pump configuration is intended then the pump vendor must be informed, by the Designer and/or Constructor, of the number of parallel pumps and the operating flow and pressure range for each pump when 1, 2, 3 …. n pumps are operating in parallel (with the maximum number of parallel operating pumps being n).

The pump vendor is to be informed, by the Designer and/or Constructor, whether n pumps in parallel are delivering flow to hydraulically common or separate discharge pipe manifolds. This information must be reflected in the system curves supplied to the pump vendor.

If different pumps are to operate in parallel but with the same common discharge pressure then the pump vendor is to be informed, by the Designer and/or Constructor, of this intended operation and the control setpoints, and system protections, intended to ensure neither of the different pumps is subject to reverse flows (if delivering flow to a hydraulically common discharge manifold).

3.5.2 Series Pumps

If pumps configured in series are intended then the pump vendor must be informed, by the Designer and/or Constructor, and told the number of pumps to be operated in series. Use of any more than two pumps a series configuration requires submission of a TDRF by the Designer (with pump vendor support), with works not to proceed further until this is approved by SA Water.

The pump vendor must also confirm:

- That the pressure rating of the casing of each series pumps is sufficient to withstand the pressure created by upstream (suction side) pumps and
- The required system hydraulic conditions and control setpoints for pumps configured in series during starting, stopping and steady state operation.

The starting and stopping sequence of the two or more staged pumps must be specifically addressed by the pump vendor with the following identified:

- Time from start of first pump (and full dead head pressure is reached) to the start of second pump (and third etc... pumps if applicable)
- Ramp time for the second pump to reach first pump's flow (and third etc... pumps if applicable)
- Ramp time for the second pump to stop and for first pump to reach full dead head pressure (and third etc... pumps is applicable)
- Time from the stop of the second pump (under full dead head pressure) to the stop of the first pump (and third etc... pumps if applicable)
- Alternatively, time from start of both series pumps together to Q_{min} (including any lag from the first to second pumps)
- Time from the stop of both series pumps together from Q_{min} to zero flow (including any lag from the second to first pumps)
- Total time for flow to be established through the series pump train
- Total time for flow through the series pump train to be stopped

The vendor shall also declare the effect on the cavitation, noise and vibration performance of the pump operating in series in addition to the performance of the pumps operating as single pumps.

3.5.3 Multistage Pumps

Multistage pumps may be specified for water pumping applications where the discharge pressure requirement is difficult to achieve using single stage pumps or where significant efficiency gains can be made by using multistage pumps.

It is not anticipated that multistage pumps will be used for wastewater pumping applications unless the discharge pressure requirement for the pumps exceeds the range of single stage wastewater pumps. If multi-stage pumping is used for wastewater pumping applications, then single stage wastewater pumps are to be used in combination rather than any multistage impeller pump.

3.6 Water Pump Specifications

The following sections detail parameters that are to be specifically identified in pump specifications, with items listed to be raised and closed out with pump vendors by the Designer. Confirmation in writing that this has occurred shall be provided to SA Water's Representative before any pump is procured, which constitutes a **HOLD POINT** under this Technical Standard.

In addition, the pump curve number, model number, manufacturer and country of origin must be stated as identified in the specification and datasheet.

3.6.1 Water Quality Parameters

The following physical and chemical water quality parameters must be identified in all specifications and datasheets. Sensitivity to particulate matter in the pumped water must be addressed by the pump vendor in the specification and datasheet for all pumps.

Pumps must be able to achieve the design life specified in TS 0109 when exposed to, and operated in, the physical and chemical environments defined in the specification datasheet. This includes, but is not limited to the following:

- Whether water is raw or treaded
- Solids content (and size or grading of solids if applicable)
- Temperature range
- Water density
- Percentage of entrained air (if applicable)
- pH
- Conductivity
- Total Dissolved Solids
- Chlorides
- Free chlorine
- Mono-chloramines
- Other chemicals

All components of pumps that come into contact with potable water must comply with the requirements of TS 0800.

3.6.2 Configuration

The pump configuration must be identified in the specification and datasheet.

The location and type of couplings (e.g., flexible, semi-flexible, geared etc...) must also be identified together with alignment and balancing requirements for the couplings.

Couplings must be capable of transmitting 150% of the full starting torque of the motor and secured against circumferential and axial movement relative to the connected shafts.

Couplings must be dynamically balanced with the impeller and shaft as described in Section 3.6.3.

3.6.3 Impeller

Dynamic performance (and hydraulic balance) of the impeller must be verified by the pump vendor.

G2.5 balancing to ISO1940-1:2003 is the minimum requirement for water pumps. The impeller shall be statically and dynamically balanced at the maximum pump operating speed.

The impeller must be secured to the shaft in a way that prevents circumferential and axial movement and shall be hydro-dynamically balanced. The impeller and shaft assembly shall be dynamically balanced to G2.5 at the maximum pump operating speed. The overall combination of rotating elements comprising the final pump and motor train, including all other rotating elements (e.g., couplings, flywheels, etc...), shall be dynamically balanced to G2.5.

The geometry and number of vanes for the impeller are to be nominated by the pump vendor in the specification and the datasheet.

One piece construction is required (manufacture with more than one cast or fabricated layer comprising the impeller is not permitted). The manufacturing technique used in the casting or fabrication of the impeller must be nominated by the pump vendor.

The impeller material must be identified in the specification and datasheet and be such that the design life of the pump can be achieved given the identified physical and chemical properties of the water pumped.

Pump selection with smaller than maximum impeller size is to be considered if comparing two proposed pump offers with one including the maximum impeller for the range and one that has an intermediate impeller.

Any inherent hydraulic or mechanical characteristic of the impeller that may lead to a reduction in the design life of the pump, or impeller, below the requirement nominated in this standard must be disclosed by the pump vendor before procurement of the pump. For example, inherent characteristics of impellers with lower numbers of vanes and consequential potential cavitation, vibration, noise and lack of hydraulic balance must be declared by the pump vendor prior to procurement of the pump.

3.6.4 Volute

The type, geometry, material, coating (if any, depending on cast material) and method of fabrication (e.g., cast or plate fabricated) and wall thickness of the volute must all be nominated by the pump vendor in the specification and datasheet.

The allowable operating pressure for the volute, and suction and discharge flanges, must be identified and meet the minimum requirements identified in the specification and datasheet.

3.6.5 Wear Rings

The type, geometry, material and thickness of the wear rings must all be identified in the specification and the datasheet.

The following four considerations must be explicitly raised with the pump vendor by the Designer and/or Constructor so that the pump vendor can confirm that no detrimental performance will result due to:

- Corrosion between wear rings either in contact (or near contact) with each other or other dissimilar metals.
- Galling (or other damaging metallurgical phenomena) between wear rings that come into occasional contact when the wear rings are made of the same material or materials with insufficient differences in hardness (casing wear ring to have a Brinell hardness of greater than 50HB higher than the impeller wear rings).
- Erosion of the wearing rings due to solids present in the water (this also applies to wastewater applications in reference to clause 3.7.5 below).
- Chemical attack on the wear rings from the pumped water.

The vendor must raise any other issues that might detrimentally affect performance in addition to the three considerations listed above.

The wear ring clearance shall be specifically identified, if applicable, together with the operational requirements for adjustment.

Casing wear rings should not be able to rotate.

Wear rings (and other components intended for periodic replacement) shall be capable of being replaced on site (and not corrode or otherwise stick together).

3.6.6 Shaft

Balancing is to be in accordance with Clause 3.6.3.

The shaft shall be of one piece construction with separate shaft sleeves.

The shaft and shaft sleeve shall be machined with suitable tolerances at the location of mechanical seals and bearing surfaces.

The stiffness of the pump shaft shall be sufficient to ensure that, under for all operating conditions, pump, motor and any other components (whether rotating or stationary) cannot come into unintended contact and result in excessive vibration, wear or other damage to equipment.

Maximum shaft deflection, assessed for all operating conditions, shall be nominated by the pump vendor.

Operational and/or maintenance requirements for the seals must be identified by the pump vendor in the returned datasheets, including lubrication and access for maintenance requirements, per TS 0101.

The following items shall be nominated/declared by the pump vendor in the returned specification and datasheet. These items shall be assessed and confirmed as adequate by the Designer and/or Constructor, with evidence provided in accordance with Section 3.6 prior to procurement:

- Interlocking systems between shafts and shaft sleeves (e.g., pressed fit, threaded, nut, keyed or other)
- Keyed shaft to impeller interlocking systems
- Heat shrinking to connect the shaft to any other pump or motor component, if proposed.

3.6.7 Seals

Maintenance and adjustment free mechanical seals are preferred.

Single inside mounted or cartridge type mechanical seals are preferred. If the pumped water is potable then an internal flushing passage or externally piped flushing system can be specified. If the pumped water is raw water (or other non-potable water) then a separator upstream of the mechanical seal is required.

Use of gland packed seals shall not occur unless approved via the TDRF process, which shall be prepared and submitted by the Designer and/or Constructor.

The type of gland water required (if applicable) shall be specified by the pump vendor.

Operational and/or maintenance requirements for the seals must be identified by the pump vendor, including lubrication and access for maintenance requirements, in the returned datasheets prior to pump procurement.

3.6.8 Bearings

The L_{10} bearing rating fatigue life is to be >100,000 hours at the maximum operating speed unless otherwise approved by SA Water via a TDRF.

The L_{10} bearing rating fatigue life should be interpreted as formally defined in ISO 281 and is the life that 90% of bearings of the relevant type will exceed before the spalling area reaches 6mm2.

Thrust bearings, if required, shall be specified that are able to resist all axial loads and radial loads if applicable.

Bearings shall be able to accommodate variations in shaft geometry with temperature.

The materials used in the bearings are to be identified by the pump vendor.

Maximum and minimum operating and alarm temperatures for pump bearings are to be identified in the specification and the datasheet. Provisions for the monitoring of temperature within the pump, motor and all other bearings (e.g., flywheel) are to be identified by the pump vendor.

The maintenance requirements for the bearing systems are to be identified by the vendor in the returned datasheets prior to the procurement of the pump, with associated hazards to form part of safety in design documentation submitted in accordance with TS 0101. Bearings should be supplied pre-greased.

3.6.9 Lubrication Media

Requirements for food grade, or other potable water contact rated oils, for lubrication must be identified by the pump vendor in the returned datasheets prior to pump procurement.

The use of potable water or other water for lubrication must be identified by the pump vendor in the returned datasheets prior to pump procurement.

Requirements to ensure water is maintained in compartments within the pump outer housing or elsewhere must be identified by the pump vendor in the returned datasheets prior to pump procurement.

3.6.10 Operating Temperature, Motor Cooling & Starts Per Hour

Totally enclosed fan cooled (TEFC) motors are acceptable, subject to the environmental conditions in the pump station being maintained at the levels specified by the pump and motor vendor as required for the motor to be effectively cooled.

Water cooled motors are acceptable, subject to the specification for pipework, reservoir and pumps required for the water-cooling system, along with heat transfer calculations. This shall be assessed and confirmed as adequate by the Designer and/or Constructors, with evidence provided to the SA Water Representative that this has occurred, in accordance with Section 3.6 prior to procurement.

Class F motor insulation is the minimum requirement (Class H is preferred).

Motors shall be protected from overheating by monitoring temperature and setting temperature thresholds for shutting motors down.

3.6.11 Vibration Performance

Vibration levels must comply with the requirements of AS ISO 10816-7 for the relevant class and/or power level of any pump.

Pump vendors are required to state maximum vibration levels for pumps as identified in the specification and datasheet. A TDRF must be submitted by the Designer where a pump vendor is unable to state vibration level for approval to use such equipment.

The likelihood of any detrimental wear or damage to any pump due to excursions from the nominal pump operating range (low or high flow excursions) must be identified by the pump vendor in the returned datasheets prior to the procurement of the pump. When stating the likelihood of any detrimental wear or damage to any pump, the pump vendor is to consider:

- 20 operational excursions, with flow between zero and Q_{min} (from the pump curve), for a period of 180 seconds
- 20 operational excursions, with flow greater than Q_{max} (from the pump curve) and head greater than zero, for a period of 180 seconds

Requirements for vibration mitigation measures including isolators, flexible or fully rigid mounting systems, or stiffening of hold down bolts or baseplate elements, must be raised by Designers and/or Constructors with the pump vendor prior to procurement of the pump. Information regarding the suction and discharge pipework and associated pipeline restraint systems must be provided as an annexure to the datasheet to enable the pump vendor to assess the likely vibration performance of the pump once it has been installed in a pump station.

Resonant modes must be raised by Designers and/or Constructors with the pump vendor prior to the procurement of the pump to enable the pump vendor to assess the likelihood of a problematic natural frequency arising for the pump and motor once installed in a pump station.

If the pump vendor is unable to assist in either a vibration mitigation and/or resonance assessment, then this shall be considered in making pump selections if alternative vendors are able to offer such assessments.

Vibration levels should be determined at maximum power duty points during factory testing and after in-situ installation of the pumps (and associated equipment) in accordance with Section 3 of this Technical Standard.

Designers and/or Constructors shall confirm with the SA Water Representative whether the specification is to state that vibration monitoring equipment will be permanently installed to monitor the vibration performance of the pumps.

3.6.12 Dimensional & Structural Considerations

The size of the suction and discharge flanges of the pump must be nominated by the pump vendor in the specification and datasheet.

The relative orientations of the suction and discharge flanges must be identified including options for adjusting the relative suction and discharge positions (and any adverse effects on pump performance from such configuration adjustments).

The suction and discharge flanges of the pump must meet the requirements of AS4087.

The suction and discharge flanges of the pumps must be rated for the maximum and minimum system pressures experienced at the pump (under all operating conditions including surge).

Suction and discharge flange nozzle loads (axial, shear and bending) must be identified in the specification and datasheet. Connected suction and discharge pipework must be specified to prevent gravity, pressure thrust and thermal loads from acting above the load limits for the pump flanges.

The suction and discharge flanges, and pump casing, must be able to withstand the static and dynamic forces transmitted from the suction and discharge pipework as identified in the specification and datasheet.

Hold down anchors must be specified to resist all static and dynamic loads from the pump, motor and any other associated equipment. All proposed hold down systems and baseplate specifications for pumps with power ratings over 100kW require Finite Element Analysis (FEA) of the potential dynamic modes for the pump and motor over supporting base frame.

Details of supporting plates, plinths and frames are to be submitted by the pump vendor for all pumps. These details must nominate the geometry and mass of all elements, as well as the fixings (flexible or rigid), required to ensure that the vibration performance nominated in Clause 3.6.11 can be achieved.

Fabricated base frames for pumps, motors and associated equipment, which are supplied by pump vendors, are to be constructed with sufficient stiffness to avoid misalignment and displacement (including flexing) under load as well as with frame members and stiffeners such that no resonant vibration modes are caused by the interaction of the pumps, motors and associated equipment under any operating conditions. The base frames are to be fully welded in accordance with TS 0420.

The dimensional tolerances of the base frame are critical and must not be distorted during galvanising or otherwise upon installation.

All requirements, including in-fill grout within the frame, to achieve the required stiffness of the base frames must be identified by the pump vendor.

3.6.13 Noise Levels

Pump vendors shall be requested to provide the noise level information as identified in the specification and datasheet:

Table 1 - Noise Level Data Requirements

	Overall	***Octave band centre frequencies (dBA pressure) and (dB power)***							
		63Hz	***125Hz***	***250Hz***	***500Hz***	***1kHz***	***2kHz***	***4kHz***	***8kHz***
Sound pressure level (@1m)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Soundpower level	✓	✓	✓	✓	✓	✓	✓	✓	✓

The information provided by pump vendors shall be used to draw relative comparisons between the pumps presented and determine their suitability for installation for a particular project.

Designers shall submit a TDRF where use of a pump is proposed where a pump vendor is unable to provide the requested noise data.

3.6.14 Air Relief Valves

Where air relief is critical to pump performance, during start or otherwise, the pump vendor shall be requested to confirm this and the performance requirements for the air relief valve(s). Designer and/or Constructors shall note the installation of air valves presents an opportunity for drinking water contamination. Air valve use in drinking water applications must be risk assessed.

The following is added with reference to clause 3.7.14 for wastewater applications. Contamination risks to wastewater applications is not applicable, enabling air valves to be used where determined to be critical for pump performance, during starts/stops and/or managing pressure transient conditions.

3.6.15 Coatings

All applicable SA Water Technical Standards must be referenced, in both the specification and datasheet.

Belzona or equivalent internal coatings are preferred for internal pump coatings to reduce corrosion and loss of efficiency in the pumps. Internal coating of pumps with cast iron volutes is mandatory. An option for the internal coating of pumps with volutes made from materials other than cast iron must be requested of the pump vendor in the specification and datasheet.

External coatings are required and shall be nominated by the pump vendor, and shall be assessed and confirmed as adequate by the Designer and/or Constructors, with evidence provided in accordance with Section 3.6 prior to procurement.

Stainless steel pump volutes should be requested by the Designer and/or Constructor if internal pump coatings cannot be applied and the physical and/or chemical properties of the pumped water (or wastewater in reference to clause 3.7.15) are likely to result in corrosion and a reduction in design life to less than 25 years.

3.6.16 Hydraulic Requirements

The following hydraulic requirements shall be identified in the specification and datasheet:

- Maximum and minimum suction head (under all operating conditions)
- Maximum (e.g., shutoff) and minimum differential head (under all operating conditions)
- Pump curves (from pump vendor) satisfying system curves and all required duty points
- Pump efficiency curves
- Pump NPSHr curves
- Priming lift height and pump operating speed information for self-priming pumps
- Fixed speed or variable speed drive (VSD) operation
- Parallel or series pump configurations

The nominated duty points at which the pump is intended to operate shall be nominated as follows:

- Where the system only requires the nomination of a single duty point, this will be the guaranteed point for testing (refer to Section 3) and the point at which tendered pumps are compared.
- Where a system requires a range of operating conditions, a number of duty points shall be nominated, such that the system and pump operation is properly defined, and guaranteed duties points identified to ensure all operating conditions will be met. These will be the guaranteed points for testing (refer to Section 3) and the points at which tendered pumps are compared.

The following parameters shall be nominated by the pump vendor for each duty point:

- Flow
- Total pump head
- Efficiency
- Input shaft power
- NPSHr

The minimum immersion depth for submersible pumps (used in either water or wastewater applications) shall be nominated by the pump vendor so that vortex formation and air entrainment into the pump can be avoided. The minimum immersion depth shall be specified by the pump vendor for pump cooling requirements.

3.6.17 Safety

The pump curve number, model number, manufacturer and country of origin must be stated as identified in the specification and datasheet.

Pumps shall be supplied with Operation and Maintenance Manuals, and hazards identified and addressed in accordance with TS 0101 and relevant South Australian WHS legislation, regulations and codes of practice.

Guards must be provided for otherwise exposed rotating elements in accordance with the Australian Standards referenced in Section 4 of this standard and ensuring hazards identified are suitably addressed in accordance with TS 0101 and relevant South Australian WHS legislation, regulations and codes of practice.

Lifting lug locations and capacities and weight of components must be stated as identified in the specification and datasheet.

Rotating elements must be restrained from axial, radial, rotational or any other form of movement during transportation.

3.7 Wastewater Pump Specifications

The following sections detail parameters that are to be specifically identified in pump specifications, with items listed to be raised and closed out with pump vendors by the Designer. Confirmation in writing that this has occurred shall be provided to SA Water's Representative before any pump is procured, which constitutes a **HOLD POINT** under this Technical Standard.

In addition, the pump curve number, model number, manufacturer and country of origin must be stated as identified in the specification and datasheet.

3.7.1 Wastewater Quality Parameters

The following physical and chemical wastewater quality parameters must be identified in all specifications and datasheets. Sensitivity to particulate matter in the pumped wastewater must be addressed by the pump vendor in the specification and datasheet for all pumps.

Pumps must be able to achieve the design life specified in TS 0109 when exposed to, and operated in, the physical and chemical environments defined in the specification datasheet. This includes, but is not limited to the following:

Physical Composition

- Solids content (and size or grading of solids if applicable)
    - **100mm minimum diameter solids must be passed** by the pump if above 15kW size and otherwise 80mm minimum diameter solids must be passed (refer to Section 3.7.3 below).
    - Pumps must be able to pump, without clogging, unscreened sewage including frangible solids, hard solids (e.g., grit, sand and stones), fibrous solids and mineral and other oils as stated in WSA 101-2008.
- Temperature range
- Wastewater density
- Percentage of entrained air or gas
- Rheology of wastewater pumped (sludge or other similar fluids)

Chemical Composition

- pH
- Conductivity
- Total Dissolved Solids
- Chlorides
- Free chlorine
- Free gases
- Other chemicals

If the chemical composition gives rise to free gases and the potential for an explosive atmosphere, the pump vendor must take this into account, per the requirements of TS 0376.

3.7.2 Configuration

The requirements of Section 3.6.2 shall be applied, noting that couplings must be dynamically balanced with the impeller and shaft as described in Section 3.7.3.

3.7.3 Impeller

3.7.3.1 Balancing, Construction & Materials

Dynamic performance (and hydraulic balance) of the impeller must be verified by the pump vendor.

G6.3 balancing to ISO1940-1:2003 is the minimum requirement for wastewater pumps. The impeller shall be statically and dynamically balanced at the maximum pump operating speed.

The impeller must be secured to the shaft in a way that prevents circumferential and axial movement (unless axial movement is a design function required for choke clearing in a wastewater pump) and shall be hydro-dynamically balanced. The impeller and shaft assembly shall be dynamically balanced to G6.3 at the maximum pump operating speed. The overall combination of rotating elements comprising the final pump and motor, including all other rotating elements, shall be dynamically balanced to G6.3 unless G2.5 is offered in which case the latter is preferred.

The geometry and number of vanes for the impeller are to be nominated by the pump vendor in the specification and the datasheet.

One piece construction is required (manufacture with more than one cast or fabricated layer comprising the impeller is not permitted). The manufacturing technique used in the casting or fabrication of the impeller must be nominated by the pump vendor.

The impeller material properties must be identified in the specification and technical datasheet and be such that the design life of the pump can be achieved given the identified physical and chemical properties of the wastewater being pumped. The understanding of how the pump will be operated, through the starting, stopping and any pump down routines identified by the Designer and/or Constructor.

Pump selection with smaller than maximum impeller size is to be considered if comparing two proposed pump offers with one including the maximum impeller for the range and one that has an intermediate impeller.

Any inherent hydraulic or mechanical characteristic of the impeller that may lead to a reduction in the design life of the pump, or impeller, below the requirement nominated in this standard must be disclosed by the pump vendor before procurement of the pump. For example, inherent characteristics of impellers with lower numbers of vanes and consequential potential cavitation, vibration, noise and lack of hydraulic balance must be declared by the pump vendor prior to procurement of the pump.

3.7.3.2 Non-clogging Performance

SA Water has a range of pumps across its network of wastewater pump stations, with the majority having duty/assist pumps with less than 15kW motors. There are a lesser number of pumps with 15-30kW motors and a lesser number again with over 30kW motors. The impeller designs available to reduce clogging vary between pump vendors and across these pump sizes. Typically, SA Water has vortex, shredder, grinder, line shaft channel, channel and other types of specialised non-clogging impellers.

Design characteristics of the impeller that reduce pump clogging must be explicitly advised by the pump vendor (if any). Vortex, shredder and/or grinder type pumps are available at smaller sizes (typically less than 15kW) and have somewhat good non- clogging performance but generally less hydraulic efficiency. Channel impeller designs are the most common with two or more vanes. These channel impellers are relatively hydraulically efficient but can be more prone to “soft” clogging and a relatively slow reduction in flow through the pump (i.e., a gradual build-up of solid materials within the wastewater stream on the pump impeller with the eventual formation of a choke in the pump volute). In some locations within the wastewater network, “hard” clogging can occur when larger solid accumulations form upstream of a pump station and then get caught in the pump impeller and volute leading to a relatively rapid reduction in flow through the pump.

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Some of SA Water's wastewater pump vendors have specialised proprietary impeller designs, for a range of their pumps, which improve non-clogging performance in wastewater flows with relatively high solids content. These pumps can reduce the number of "soft" clogging events in such networks because of impeller solids passing design features (not necessarily related to only the volute passing diameter).

The determination of whether a channel impeller is satisfactory for any particular pump station, or whether some other form of impeller design is required with enhanced non-clogging performance, must be made by the Designer with reference to factual information obtained from SA Water Operations regarding the historical performance of any existing pumps in the network at the pump station or nearby locations (the best information available must be obtained from SA Water Operations with the next nearest pump station being the worst case option).

The clogging frequency for any pump to be replaced, or otherwise for the nearest existing pump station and pump to any new pump, must be identified before specifying the maximum acceptable clogging frequency for any new pump. The maximum acceptable clogging frequency for any new pump must be less than 1 choke per 6 months or equal to the clogging frequency for any existing pump being replaced if this frequency is less than 1 choke per 6 months (e.g., if an existing pump is clogging at a frequency of 1 choke per 12 months, then any new pump must match this performance).

While the hydraulic efficiency of any impeller design is important, and must be taken into account, the non-clogging performance of the pump impeller is more important and adherence to the clogging frequency identified above is mandatory.

Methods of starting and stopping the pumps and the possible methods of managing the solid accumulation on the liquid surface of sump or wet well to reduce the risk of clogging or choke must be specifically advised by the pump vendor in writing in the returnable datasheets prior to the procurement of the pump.

3.7.4 Volute

The requirements of Section 3.6.4 shall be applied in full.

3.7.5 Wear Rings

The requirements of Section 3.6.5 shall be applied, replacing references to water with wastewater.

3.7.6 Shaft

The requirements of Section 3.6.6 shall be applied in full, however the balancing for wastewater pump application to be in accordance with the Clause 3.7.3.1.

3.7.7 Seals

Mechanical seal configurations for submersible pumps shall be in accordance with WSA 101-2008.

Maintenance and adjustment free mechanical seals are preferred.

Operational and/or maintenance requirements for the seals must be identified by the pump vendor in the returned datasheets, including lubrication and access for maintenance requirements, per TS 0101.

3.7.8 Bearings

The requirements of Section 3.6.8 shall be applied, except for the L_{10} bearing rating fatigue life, which shall be >50,000 hours.

3.7.9 Lubrication Media

The use of potable water, wastewater or other water for lubrication must be identified by the pump vendor in the returned datasheets prior to pump procurement.

Requirements to ensure wastewater is maintained in compartments within the pump outer housing or elsewhere must be identified by the pump vendor in the returned datasheets prior to pump procurement.

Requirements for trade waste approved grade oils for lubrication must be identified by the pump vendor in the returned datasheets prior to pump procurement.

3.7.10 Operating Temperature, Motor Cooling & Starts Per Hour

Submersible pumps may be cooled by immersion in the pumped wastewater. The pump vendor must supply the minimum immersion depth required to maintain the required pump motor cooling. The pump vendor must also supply the maximum number of hours the pump can be operated when not immersed and/or the motor de-rating when air cooled.

Dry well submersible pumps are to be specified with either:

- An internal closed loop using a water and/or glycol mix as a heat transfer fluid; or
- A cooling jacket with potable water pumped through it within the motor housing

Wastewater shall not be used as a cooling medium for dry well submersible pumps unless a TDRF is submitted by the Designer and approved by SA Water.

For line shaft, self-priming or other wastewater pumps, totally enclosed fan cooled (TEFC) motors are acceptable subject to the environmental conditions in the pump station being maintained at the levels specified by the pump and motor vendor for the motor to be effective cooled.

For line shaft, self-priming or other wastewater pumps, water cooled motors are acceptable providing the specification for the pipework, reservoir and pumps required for the water cooling system, along with heat transfer calculations are is supplied by the pump vendor to be assessed and confirmed as adequate by the Designer and/or Constructor, with evidence provided in accordance with Section 3.7 prior to procurement.

Pumps (all wastewater types) are to be able to start 15 times per hour as identified in the specification and datasheet.

A reduced number of starts per hour may be acceptable for larger pumps (>50kW) subject to approval via a TDRF.

Class F motor insulation is the minimum requirement (Class H is preferred).

Motors should be protected from overheating by monitoring temperature and setting temperature thresholds for shutting motors down in accordance with pump vendor requirements.

3.7.11 Vibration Performance

In addition to the requirements provided in Section 3.6.11, vibration levels for submersible pumps must also comply with those of ANSI/HI 11.6.

3.7.12 Dimensional & Structural Considerations

The size of the suction and discharge flanges of the pump must be nominated by the pump vendor in the specification and datasheet.

The relative orientations of the suction and discharge flanges must be identified including options for adjusting the relative suction and discharge positions (and any adverse effects on pump performance from such configuration adjustments).

In the case of submersible pumps which can be dropped into or lifted out of a discharge support, the pump and discharge flange shall be such that only a single plane moment is induced in the discharge support bend in accordance with WSA 101-2008.

The suction and discharge flanges of the pump must meet the requirements of AS4087.

The suction and discharge flanges of the pumps must be rated for the maximum and minimum system pressures experienced at the pump (under all operating conditions including surge).

Suction and discharge flange nozzle loads (axial, shear and bending) must be identified in the specification and datasheet. Connected suction and discharge pipework must be specified to prevent gravity, pressure thrust and thermal loads from acting above the load limits for the pump flanges.

The suction and discharge flanges, and pump casing, must be able to withstand the static and dynamic forces transmitted from the suction and discharge pipework as identified in the specification and datasheet.

Hold down anchors must be specified to resist all static and dynamic loads from the pump, motor and any other associated equipment. All proposed hold down systems and baseplate specifications for pumps with power ratings over 100kW require Finite Element Analysis (FEA) of the potential dynamic modes for the pump and motor over supporting base frame.

Details of supporting plates and plinths are to be submitted by the pump vendor for dry well submersible and line shaft wastewater pumps. These details must nominate the geometry and mass of all elements required to ensure that the vibration performance nominated in Clause 3.7.11 can be achieved.

Details of supporting frames are to be submitted by the pump vendor for dry well submersible and line shaft wastewater pumps. These details must nominate the geometry and mass of all elements, as well as the fixings (flexible or rigid), required to ensure that the vibration performance nominated in Clause 3.7.11 can be achieved.

Details of duck-foot base mounting systems for submersible pumps (including dimensional drawings) must be supplied by the pump vendor to the Designer for assessment and must be consistent with requirements of SA Water Assets for base mounting and rail systems.

If a base frame is proposed by a vendor for a wastewater pump installation, then it must comply with the requirements identified in Clause 3.6.12 (for a water pump installation).

3.7.13 Noise Levels

The requirements of Section 3.6.13 shall be applied in full.

3.7.14 Air Relief Valves

The requirements of Section 3.6.14 shall be applied in full.

3.7.15 Coatings

The requirements of Section 3.6.15 shall be applied in full.

3.7.16 Hydraulic Requirements

The requirements of Section 3.6.16 shall be applied in full.

3.7.17 Safety

The requirements of Section 3.6.17 shall be applied in full.

4 Pump Testing

4.1 Factory Testing

The factory tests under Clauses 4.1.1 or 4.1.2 must be requested of the pump vendor.

Required tests shall be identified in the specification and datasheet by the Designer.

No pump, within the ranges identified in Clauses 4.1.1 or 4.1.2, shall be shipped from the factory until **all** of the items 1 to 4 below have been satisfied. This requirement is a **HOLD POINT** under this Technical Standard.

1) All required tests have been conducted
2) The results have been communicated to and confirmed by the Designer to be appropriate, successful and satisfying the design requirement/s.
3) Results and Designer confirmations of the results have been submitted to the SA Water Representative.
4) The submitted results have been accepted by the SA Water Representative, and the hold point formally released.

4.1.1 Factory Testing (Unwitnessed)

Unwitnessed pump test results (factory test results) are required by SA Water for all water and wastewater pumps with power levels below 200kW, unless witnessed tests for pumps less than 200kW are specifically requested by SA Water and/or the Designer.

Unwitnessed factory pump test results obtained by the pump vendor must be forwarded as described in Section 4.1, for the formal release of the hold point.

4.1.2 Factory Testing (Witnessed)

Witnessed pump test results (factory test results) are required by SA Water for all water and wastewater pumps with power levels above 200kW, unless a TDRF is submitted by the Designer and/or Constructor and subsequently approved by the Responsible Discipline Lead. This represents a **HOLD POINT** under this Technical Standard.

These witnessed tests must be coordinated for technical certainty, and the Constructor and/or pump vendor must provide at least 20 business days notice of upcoming factory testing so that arrangements can be made for witnessing of the tests.

- Independent third party witnessing of pump factory testing may be undertaken. Where proposed, such technical arrangements must be authorised by SA Water via a TDRF, and such requests shall be lodged by the Designer/Constructor/pump vendor at least 20 business days prior to the testing being undertaken.

Witnessed factory pump test results obtained by an independent third party, whether arranged by SA Water or the Designer/Constructor and/or pump vendor, must be forwarded as described in Section 4.1, for the formal release of the hold point.

Note: By authorising the use of independent third party witnessing, SA Water does not waive its rights to witness factory testing.

4.2 Pump Test Requirements

4.2.1 Test Grades

Pump tests shall be conducted in accordance with the requirements of AS ISO 9906 as follows:

- A Grade 1 test shall be performed for pumps (water or wastewater) with a power level **> 50kW (with a pump test acceptance grade and tolerance of 1B)**
- A Grade 2 test shall be performed for pumps (water or wastewater) with a power level **>10kW and ≤ 50kW (with a pump test acceptance grade and tolerance of 2B)**

For pumps (water or wastewater) with power levels either less than 10kW and/or between 10kW and 50kW and when multiple identical pumps with low system criticality are to be procured within a capital works upgrade, Designers and/or Constructors may consider the opportunity to conduct a batch test. Designers and/or Constructors must demonstrate their design and/or hydraulic system has redundancy coupled with understanding of system consequences of pumps not performing. Subject to the results of such batch testing SA Water may request further testing of procured pumps, thus proving an isolated performance test issue OR a broader systematic performance issue across all procured pumps.

For pumps (water or wastewater) below 10kW in shaft input power, SA Water defers to AS ISO 9906 (Clause 4.4.2).

It is noted AS ISO 9906, Flow (Q) and Head (H) are to be a pump test acceptance guarantee, whilst nominating efficiency (η) as only an optional guarantee. All pumps procured for drinking water and recycled water applications (i.e. clean water applications) shall be tested with the test parameter of efficiency being a guarantee test point according to the nominated test grade (as per this clause) and in accordance with AS ISO 9906.

SA Water may specify NPSH as a guaranteed performance requirement (for water and wastewater pumps). Such requirements shall be determined against the pump asset criticality and/or facility criticality, and the margin between $NPSH_R$ and $NPSH_A$ according to the design duty requirements and site. It is the responsibility of the Designer and/or Constructor to nominate and document within the standard issue pump technical datasheet the NPSH test type guarantee in accordance with the AS ISO 9906.

Efficiency as a guaranteed test point on wastewater pumps is not required.

4.2.2 Pump Test Parameters

The scope of the pump tests and details of the factory test rig configuration must be agreed to by the Designers, the pump vendor and/or the Constructor. Details of the final test scope and test rig configuration shall be issued to the SA Water Representative in writing for approval, and is to include (as a minimum):

- Operating test point at shutoff head (unless pump type does not enable this test)
- Operating test point at Q_{min} (for a fixed speed pump or 100% speed for a VSD driven pump)
- Operating test points at the nominated pump duty (guaranteed point) in accordance with AS ISO 9906.
- Operating test point at Q_{max} (for a fixed speed pump or 100% speed for a VSD driven pump)
- Four additional operating test points nominated by the SA Water Engineering or its nominated representative with two between the Q_{min} and nominated pump duty and two between the nominated pump duty and Q_{max} as listed in, or as an addendum to, the pump datasheet
- NPSHr shall be tested for the pump operating at the nominated pump duty using one of the methods nominated in AS ISO 9906 and Clause 4.2.1 above.

Submission and acceptance of the forgoing constitutes a **HOLD POINT** under this Technical Standard.

The test points must be sufficient to completely describe the shape of the pump curve. If there are inflexions or other changes in shape along the pump curve then a sufficient number of additional test points must be obtained to completely define the pump curve.

The following test parameters must be measured and reported at all test points (unless noted otherwise):

- Flow through the pump (L/s)
- Suction head (m), discharge head (m) and total dynamic head (m)
- Motor efficiency (%) – if a slave motor (i.e., not the motor to be used with the delivered pump) is used for the testing then motor efficiency does not need to be recorded
- Pump efficiency (%)
- Overall efficiency (%) – if a slave motor (i.e., not the motor to be used with the delivered pump) is used then the overall efficiency does not need to be stated
- Power use (kW)
- Operating speed (rpm)
- NPSHr or NPSH3 (m) (at the nominated pump duty)

All test parameters shall be plotted as curves (or on curves).

Where a pump vendor is supplying a pump and motor on a base frame, or pump motor and other associated rotating equipment on a base frame, the SA Water Representative shall be contacted to determine whether a factory string test is required.

4.2.3 Pump Vibration Tests

Below a power level of 50kW, the pump vendor shall supply estimates, based on real testing, production batch testing and/or field data for the pumps, of the maximum vibration levels that are expected if the pump, motor and all associated equipment are operated at the maximum power duty point, or other operating point that results in maximum vibration, as nominated in the specification and datasheet.

- SA Water has the capability to measure the vibration levels of installed equipment (in-situ testing) and may undertake such testing during the commissioning phase, in accordance with SA Water's technical standard TS146c, or after the pumps are in operational service but within the warranty period.

SA Water requires factory acceptance vibration tests on pumps supplied with power levels over 50kW.

Factory vibration acceptance tests shall be undertaken in accordance with ISO 10816-7. Once fully installed, in-situ vibration acceptance tests shall be undertaken in accordance with ISO 10816-7. Designers, pump vendors and/or Constructors shall ensure allowance is made to complete such vibration testing on pumps ≥ 50kW as noted in the pump technical datasheets and pump procurement specifications and this Technical Standard.

The vibration limits for the factory acceptance test and the in-situ acceptance test shall be as per ISO 10816-7 Table A.1.

SA Water's water transfer pumps (≥ 50kW) shall be designated as category 1, where a high level of reliability is required for customer supply and/or system integrity. Vibration evaluation zones shall align within the limits of Zones A and B (category 1) in accordance with ISO 10816-7.

SA Water considers vibration test results beyond quoted limits within ISO 10816-7 to be defective and will not accept / endorse or approve the factory release of the pump(s). The pump vendor is required to investigate the cause of any vibration test result deviation beyond allowable limits specified in ISO 10816-7 and this technical standard. Acceptance may be achieved by the pump vendor demonstrating through detailed vibration analysis (e.g., FFT analysis) by a suitably experienced and accredited vibration analyst that there are no faults with the pump or motor and that the deviation is caused by conditions specific to the factory test facility.

The vibration tests should be repeated at least once, and all measured data forwarded to the Designer for assessment.

- The pump vendor may comment on whether the factory test results are considered representative of the likely vibration performance of the pump and/or pump string once delivered and installed in-situation in a SA Water pump station.

Submission of the test results and corresponding Designer assessment shall be submitted to the SA Water Representative. Submission and acceptance of the vibration test results constitutes a **HOLD POINT** under this Technical Standard.

Additionally, SA Water requires vibration levels of the pump to be within the following zones for the duration of the pump warranty period:

- Within the Zone A Category 1 limit of ISO10816-7 at any speed for which the pump operates within its POR (preferred operating region).
- Within the Zone B Category 1 limits of ISO10816-7 at any speed for which the pump operates outside the POR but within the AOR (allowable operating region).

Preferred Operating Region (POR) – Operating region on the pump Flow-Head (Q-H) curve about the best efficiency point (BEP) whereby the hydraulic loads, vibration or flow separation will not significantly affect the service life of the pump. The POR shall extend between 70% and 120% of the flow at best efficiency point as a minimum, unless agreed otherwise with SA Water. The hydraulic efficiency and operational reliability of the pump(s) are substantially impacted or degraded when operating in this region of the Q-H curve.

Allowable Operation Region (AOR) – Operating region on the pump Flow-Head (Q-H) curve that is wider than the POR whereby continuous pump operation is permitted and will not seriously compromise the service life, but where bearing life may be reduced, and noise and vibration levels increased. The service life within the AOR may be lower than within the POR.

Pump vendors are to nominate AOR in the form of a completed returnable technical datasheet and/or provision of their pump performance envelope Q-H curve identifying the AOR.

4.2.3.1 Vibration Testing of Water Pumps

Water pump vibration testing shall be conducted in accordance with Clause 4.2.3 above and ISO 10816-7.

Where power level exceeds 1MW, the Responsible Discipline Lead shall be contacted for direction.

4.2.3.2 Vibration Testing of Wastewater Pumps

Wastewater pump vibration testing shall be referenced against the vibration limits as quoted in ANSI HI 11.6.

Under factory test conditions, the maximum vibration levels, measured with the pump, motor and all associated equipment being operated at the maximum power duty point, should be less than 9mm/s (rms) for submersible or dry well submersible wastewater pumps for all power levels from 50kW to 500kW (allowing for some flexibility in the restraint conditions for the equipment in the factory).

- If ANSI/HI 11.6 vibration limits are higher than 9mm/s (rms) then the later (lower) limit shall be adopted. If ANSI/HI 11.6 vibration limits are lower than 9mm/s then the lower ANSI/HI 11.6 limit shall be adopted.

Once installed in-situ with all restraints applied, the target maximum vibration levels, measured with the pumps, motor and all associated equipment being operated at the maximum power duty point, shall be less than 6mm/s (rms) for wastewater pumps. If ANSI/HI 11.6 vibration limits are higher than 6mm/s (rms) then the later (lower) limit shall be adopted. If ANSI/HI 11.6 vibration limits are lower than 6mm/s then the lower ANSI/HI 11.6 limit shall be adopted.

The vibration performance of the supplied equipment will be assessed in accordance with TS146c, and performance of multiple pumps operating simultaneously at any duty shall be confirmed in accordance with TS146c.

4.2.4 Pump Noise Tests

Noise tests are required for pumps supplied with power levels over 50kW or otherwise for pumps that are being installed in noise sensitive installations (e.g., where compliance with Environment Protection Agency (EPA) limits is required).

- If compliance with EPA limits is required, Designers and/or Constructors must make contact the SA Water Representative (often SA Water's Stakeholder team) to determine whether lower noise restrictions than stipulated by the EPA apply.

Noise level should be measured at both ends and each side of a pump train to confirm sound pressure levels at 1m from the pump train when operating at the maximum power duty point.

The noise testing undertaken by the vendor must be sufficient to provide sound pressure levels (@ 1m) and sound power levels, for the pump, motor and associated equipment when operated at the maximum power duty point, both overall and at the frequencies identified in Table 1 of this Technical Standard.

4.2.5 Other Tests

4.2.5.1 Extended Period Operation Test

Extended period operation tests may be required by SA Water for submersible and dry well submersible pumps with power levels over 50kW, and this will be nominated in the pump datasheet where such testing is to be undertaken.

4.2.5.2 Hydrostatic Testing

Hydrostatic testing for all pumps must be undertaken to the maximum rated casing pressure for the pumps and certified results provided to the SA Water Representative. No leakage from the pump or distortion of any component should occur during the hydrostatic test. If leakage or distortion does occur then the source or cause must be identified, rectifying work undertaken in the factory and a further hydrostatic test undertaken to confirm all leakage and/or distortion has been eliminated. The hydrostatic test pressure shall be applied for a duration of 20 minutes after the full test pressure has been reached.

4.2.5.3 Ancillary Equipment

The functionality of all permanently installed and/or integrated temperature probes for windings, bearings or any other motor or pump component shall be checked during the factory testing and results detailed on the test outputs from Section 4.2.2 of this Technical Standard.

4.2.5.4 Coatings

If external and/or internal coatings have been applied, testing and certification of the surface preparation, application method, coverage and thickness of the coating shall be provided by the pump vendor to the Designer and/or Constructor for approval. Written notification of the results (and the Designer's assessment, if applicable) must be provided to the SA Water Representative to confirm compliance with all relevant SA Water Technical Standards for coatings.

Where testing or certification does not comply with SA Water Technical Standards/Australian Standards, or coating defects/failures are identified, SA Water may request independent third-party testing and certification of the external and/or internal coatings and/or repairs (at the Constructor's expense).

5 Documentation

5.1 Design Drawings

Certified dimensional engineering drawings of pumps, motors and/or other associated rotating equipment (regardless of whether supplied as individual components or together as a pump string on a base-frame), must be provided within 4 weeks of entering into a contract for the procurement of the equipment, unless otherwise agreed via a TDRF.

Any specific pipe, spool or other section (suction box and guide vane geometry) used to establish particular flow conditions approaching a pump suction must be explicitly declared by pump vendors and certified dimensional engineering drawings of the pipe, spool or other section (suction box and guide vane geometry) provided before pump procurement.

5.2 Inspection and Test Plans

Inspection and testing documentation shall be requested from the pump vendor by the Designer and/or Constructor. Such documentation shall contain specific data and evidence of witnessed factory testing, coupled with certificates and other specific pump requirements, all as requested in project specification documentation and/or the technical datasheets for the pump procurement.

The ITP associated documentation shall contain the factory test results and/or certificates and other supporting information, such as charts and data plots. Once factory testing is completed, the completed ITP and documentation must be forwarded by the vendor to the SA Water Representative and the Designer, with review and confirmation of acceptance (or otherwise) to be provided by the Designer. The Designer shall ensure that all requirements of the pump specification and/or project specification and technical datasheet have been achieved based on the information contained within the ITP, other supporting data (or performance characteristics of the pump) and/or other information issued by the pump vendor.

5.3 Delivery Inspections and Testing

All pumps must be physically inspected upon delivery by Constructors and/or any other parties taking receipt of pump(s). Inspection shall check pump(s) for defects including (but not limited to):

- External and internal coating defects (e.g., FBE, Belzona, etc), through transportation. A thorough visual inspection at any point of transition between any coated surface and a stainless steel or alloy metal section
- Pump labelling errors
- Dimensional errors – flanges, bolt PCD, bolt hole diameters, overall dimensions inclusive of motor and coupling assembly
- Condition of any ancillary tubing and/or pilot control fittings and pipework.

Pump inspections shall occur on first receipt and acceptance of delivery and shall be completed by the Designer and/or Constructor, according to the procurement arrangements.

If defects are confirmed in the as-delivered pump(s) then the pump vendor must be notified immediately and requested to rectify the defects.

5.4 Operation and Maintenance Manuals

All pumps supplied to SA Water shall be provided with Operation and Maintenance manuals prepared in accordance with TS 0132 (inclusive of MDR's).

Appendix A : Schedules of Hold Points, Witness Points and Identified Records

A1 Schedule of Hold Points and Witness Points

Clause	Type	Description
3.6	Hold	Water Pump Details
3.7	Hold	Wastewater Pump Details
4.1	Hold	Factory Testing
4.1.2	Witness	Factory Testing (Witnessed)
4.2.2	Hold	Pump Test Parameters
4.2.3	Hold	Submission of Vibration Test Data

A2 Schedule of Identified Records

Clause	Description of Identified Record
4.2.4	Noise Test Results
4.2.5.2	Hydrostatic Test results
4.2.5.4	Coating Certification
5.1	Design Drawings
5.2	Delivery Inspections and Testing
5.3	Operation and Maintenance Manuals