DESIGN STANDARD DS 32

Pump Stations - Mechanical
FOREWORD

Mechanical Design Standards are prepared to ensure that the Water Corporation’s staff, consultants and contractors are informed as to the Water Corporation’s design standards and recommended practices. Design standards are intended to promote uniformity so as to simplify design and drafting practice and have as their ultimate objective the provision of safe and functional plant at minimum whole of life cost.

The Water Corporation design standards and recommended practices described in this design standard have evolved over a number of years as a result of design and field experience and these have been investigated and documented.

Users are invited to forward submissions for continuous improvement to the Principal Engineer, Mechanical who will consider these for incorporation into future revisions.

Manager, Infrastructure Design Branch

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

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REVISION STATUS

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1 SCOPE AND GENERAL

1.1 Scope

Design Standard DS 32 sets out the Corporation’s mechanical standards, guidelines and preferred engineering practices for design of minor and major pump stations for water supply, wastewater and drainage applications. Minor and major pump stations are defined in the relevant sections of DS 30-01 and DS 30-02. The various major sections contained in this Standard have been arranged in alphabetical order to assist the reader in finding relevant information.

1.2 Purpose

The Corporation has been out-sourcing most of its infrastructure design work since 1995. Prior to the year 2000 the Corporation had used the services of a single consultant for most of its design work. In 2000 the Corporation appointed a panel of consultants to share the engineering design of its infrastructure. At the same time it issued a suite of engineering design standards for use by the consultants.

The Corporation’s mechanical design standards are documented in its DS 30 Standards series. Designers shall comply with these standards for the design and specification of mechanical components of assets being acquired for the Corporation.

The purpose of the DS 30 Standards series is to provide:

(a) Standards and guidelines applicable in the design of Corporation assets,
(b) Explanatory or specific design information,
(c) Information relating to Corporation preferences and practices which have evolved from over a century of experience in the water industry.

1.3 Design Process

The mechanical design process to be followed by Designers is documented in the Corporation’s Engineering Design Process Manual.

1.4 Standards

All materials and workmanship shall comply with latest revisions of the relevant codes and standards. Water Corporation Strategic Product Specifications (SPS), or in their absence the latest editions of Australian Standards, or Water Services Association of Australia (WSAA) Codes, shall be referenced for design and specification. In the absence of relevant Australian Standards or WSAA Codes, relevant international or industry standards shall be referenced.

1.5 Referenced Documents

The referenced documents are listed in Appendix A.

1.6 Mandatory Requirements

The use of the imperative “shall” denotes a mandatory requirement. Use of verbs other than “shall” such as “will”, “should”, “may” indicates recommended practice.
1.7 Nomenclature

1.7.1 Engineering Definitions and Relationships
For definitions of the terminology and relationships referred to in this Standard the reader is referred to the Engineering Definitions and Relationships section of DS 30-01.

1.7.2 Preferred Terminology
For preferred mechanical terms to be used in Corporation designs, the reader is referred to the Preferred Terminology section of DS 30-01.

1.7.3 Abbreviations
For abbreviations referred to in this Standard the reader is referred to the Abbreviation section of DS 30-01.

1.7.4 Standard Units and Relationships
The units and relationships used for mechanical designs shall be in accordance with those specified in the SI Units, Relationships and Prefixes section of DS 30-01.

1.7.5 Drawing Symbols
A comprehensive list of mechanical drawing symbols for pipework and valves is referenced in DS 80.
2 DESIGN CONSIDERATIONS

In addition to the following design criteria, the Designer shall also refer to relevant parts of DS 30-02, DS 31-01, DS 31-02 and DS 35.

2.1 General

The following aspects (where relevant) shall be considered in pump station design. The list is for guideline purposes and should not be considered exhaustive.

2.1.1 Design Requirements

(a) Design shall not involve the use of any prototype design or component;
(b) Designs shall embody functionality, maintainability and reliability;
(c) System and product designs shall meet all statutory safety regulations and requirements.

2.1.2 Site Layout and Building

(a) Site layouts and pump station buildings shall provide for adequate, clear, and safe access to all equipment and plant for operation and maintenance purposes;
(b) Pump station building ventilation and crane requirements shall be determined;
(c) Bypass pipework requirements shall be determined;
(d) Fuel or process chemical (solid, liquid or gaseous) storage and transportation facilities shall comply with statutory requirements.

2.1.3 Selection of Equipment

(a) Standard “off the shelf equipment” shall be used where applicable e.g. strategic products;
(b) Equipment shall be fit-for-purpose;
(c) Equipment shall be sized in accordance with relevant mass balance, process flow diagrams (PFD's), process and instrumentation diagrams (P&ID's), and process data sheets;
(d) Major equipment shall be selected on a minimum life-cycle cost basis using the Corporation's Annual Assessed Charges (AAC) formula as further detailed in the Annual Assessed Charges section of this Standard and where applicable taking into account associated operation and maintenance costs. Other equipment shall be selected with consideration to energy efficiency;
(e) Engineered products e.g. pumps, valves, surge vessels shall be verified as acceptable for the specified operating duty ranges and service;
(f) Where relevant only authorized product shall be used in accordance with the Product Atlas contained in DS 36.

2.1.4 Operation and Maintenance

(a) Designs shall satisfy all operating and maintenance requirements for vendor supplied equipment.
(b) The extent of condition monitoring equipment for pumpsets and ancillary equipment shall be determined in accordance with Corporation requirements and the Condition Monitoring and Protection section of this Standard;
(c) SCADA requirements shall be determined in accordance with Corporation policy, standards and requirements;
(d) Consideration shall be given to the interchangeability of components and commoning of equipment to reduce spares inventory and allow ease of maintenance.
2.1.5 Redundancy
(a) Redundancy shall be provided for in all critical equipment in order to provide 100% availability unless otherwise authorised by the Corporation;
(b) Emergency or standby power supply requirements shall be determined in accordance with Corporation policy and requirements.

2.2 Options
In accordance with the requirements of the Corporation’s Engineering Design Process Manual designs shall be subject to consideration of options and alternatives for all aspects of the design when making major decisions. The following list of options is provided for guideline purposes and should not be considered exhaustive:

2.2.1 Alternative Solutions
The Designer should investigate questions such as whether the pump station is really required or whether there are alternative options or solutions available e.g. defer, upgrade or reuse an existing pump station, grade out via main sewer etc.

2.2.2 Site Selection
The Designer shall investigate whether the pump station site is optimal with respect to issues such as:
(a) Aesthetics;
(b) Applicability to the surrounding locality;
(c) Environmental sensitivity;
(d) Neighbourhood noise and intermittent noise from items such as valve closures etc;
(e) Odours of a permanent or temporary nature;
(f) Pipeline route and costs;
(g) Power supply availability and strength;
(h) Pump station sizing;
(i) Safe access from adjacent roadways;
(j) Site costs;
(k) Value for money.

2.2.3 Building and Equipment
The Designer shall investigate whether the size or type of pump station is suitable or would an alternative be more appropriate in terms of:
(a) Whether the pump station is appropriately sized in terms of realistic growth projections;
(b) Conventional building versus open air style;
(c) Above ground versus partial or fully below ground;
(d) Open pit style;
(e) Submersible sewage pump station versus drywell;
(f) Annular sewage drywell versus follow-the-flow style;
(g) Whether the structure, cladding and architecture are appropriate to the surroundings;
(h) Whether the pump type selected is appropriate and optimal e.g. latest technology.
2.3 Information Required

2.3.1 Information Required for Mechanical Design
The following engineering information (where relevant) shall be determined prior to commencing the design:

(a) Initial pump duty flow rates (L/s or ML/d);
(b) Initial pump duty heads: static; dynamic; suction (m);
(c) Future pump duty flow rates (L/s) (in the next ten years);
(d) Future pump duty heads (m) (in the next ten years);
(e) The estimated operating hours per year, (or Annual pumped quantity);
(f) Approximate distribution of running hours by month;
(g) Maximum allowable shutdown hours;
(h) Alternative modes of operation;
(i) System hydraulic characteristic curve (verified and signed);
(j) Delivery main longitudinal cross section;
(k) Suction main longitudinal cross section;
(l) Maximum surge pressure (m).

2.3.2 Information to be Determined by Mechanical Design
The following engineering information shall be determined during mechanical design:

(a) Number of duty pumpsets to be installed initially;
(b) Number of standby pumpsets to be installed initially;
(c) Number of duty pumpsets to be installed in the next ten years;
(d) Number of standby pumpsets to be installed in the next ten years;
(e) Strategic importance of the pump station.

2.3.3 Information to be Supplied for Electrical Design
The following information needs to be made available for electrical design to commence:

(a) Pump - duty kW;
(b) Pump - non-overloading kW;
(c) Pump torque-speed curve;
(d) Number of pumpsets to be installed initially;
(e) Number of pumpsets to be installed in the next ten years;
(f) Pump station maximum kW demand immediately;
(g) Pump station maximum kW demand in the next ten years;
(h) Nominal speed of pumpsets;
(i) Whether indoor or outdoor pumpsets are proposed;
(j) The estimated operating hours per year, and approximate distribution of running hours by month;
(k) Estimated number of motor starts per hour or day;
(l) Pump type and pump station configuration.
2.4 **External Influences**
External influences such as adjacent pump stations, reservoirs, tanks and control valves shall be determined.

2.5 **System Resistance Curves**
The Designer shall develop system resistance curves by:
(a) Determining static head and variation e.g. for maximum and minimum system resistance curves;
(b) Determining system resistance;
(c) Adjusting the curve for external influences such as control valves etc.

2.6 **Pump Station Duty**
The pump station duty or the operating envelope (for more complex applications) shall be determined, and shall be based on but not restricted to:
(a) An appropriate period into the future for the pump station design life;
(b) An appropriate design period into the future for the initially selected pumpsets;
(c) Projected average and peak flows, preferably by use of field based testing information as a basis to verify flow projections;
(d) Provision in the pump station design to accommodate periodic upgrades in flow capacity via:
   (i) increased pump impeller sizes;
   (ii) larger capacity pumps or;
   (iii) additional (future) pumpsets
   (iv) a combination of the above.
(c) Complete coverage of the pump station duty or operating envelope may require either fixed or variable speed pumping incorporating:
   (i) single or multiple pumps;
   (ii) multistage pumps;
   (iii) parallel pumping;
   (iv) series pumping;
   (v) a combination of the above.
(f) The NPSHa shall be calculated for the individual pump capacity determined for the initial and final pump size to ensure that initial and ultimate pump duties can be accommodated by the pump station and associated pipework. Manifold head losses shall be adjusted for multiple pump operation.
3  GENERAL DESIGN FACTORS

This section details the design factors that should be applied (where relevant) during the design of conventional water and sewage pump stations and is arranged in alphabetic order.

3.1  Air Entrapment

For information relating to air entrapment in and removal from pipework and pipelines refer to the Air Valves section contained in DS 31-02.

3.2  Alignment of Machinery

For information relating to alignment refer to the Alignment of Machinery section contained in DS 38-01.

3.3  Ambient Conditions

The ambient operating conditions shall be determined in accordance with the Site Conditions section of DS 30-02.

3.4  Ancillary Equipment

For information relating to the design of the following pump station ancillary plant refer to the relevant sections of DS 35:

(a) Air Compressors;
(b) Air Conditioning;
(c) Blowers;
(d) Cranes;
(e) Engines;
(g) Fans;
(h) Generating sets;
(i) Sump Pumps;
(j) Surge Vessels.

3.5  Annual Assessed Charges (AAC)

For information relating to AAC reference should be made to the Annual Assessed Charges section of DS 30-02.

3.6  Backflow Prevention

All designs shall comply with the Backflow Prevention Devices section contained in DS 31-02.

3.7  Balancing

The balancing requirements for mechanical equipment in a pump station shall be in accordance with the Balancing section of DS 30-02.

3.8  Baseplates

For information relating to the design and construction of baseplates refer to the Baseplates section of DS 30-02.
3.9 **Bearings**

For information relating to bearings refer to the Bearings section of DS 30-02.

3.10 **Bores**

3.10.1 **Construction**

The Designer shall consider the following:

(a) Borehole casing should be corrosion resistant (e.g. GRP);

(b) Corporation boreholes are generally screened at an aquifer at the bottom of the borehole casing, or at an intermediate level, or both as appropriate;

(c) Slotted boreholes are not favoured because of the likelihood of pulling solid particles into the borehole.

3.10.2 **Water Temperature**

The Designer shall consider the following:

(a) High bore water temperature can be a factor for deep lineshaft borehole pumps where differential expansion of the shafting with respect to the column could cause pump damage. Differential expansion will occur after pump start or pump stop until the water temperature stabilizes either hot or cold respectively;

(b) Borehole operating temperature shall be taken into account when selecting the motor for submersible electric borehole pumps to ensure it is rated for that service.

3.10.3 **Pumpset Considerations**

The Designer shall consider the following:

(a) Cascading bores provide water inflow above the pump setting. This can be a problem for submersible electric borehole pumps due to lack of cooling water flow past the motor. Under these circumstances a motor shroud is required to be fitted over the pumpset in order to force inflow water past the motor to cool it;

(b) Bores shall be properly developed before installation of the pumpset in order to minimise the amount of solid particles to be pumped which have the potential to produce severe wear on the pump components. The maximum acceptable sand content discharged from bores for drinking water purposes shall not exceed 5 mg/L.

**NOTE:**

1. Information source – National Groundwater Association (US) and United States EPA

3.10.4 **Pump Sizing for Specific Aquifers**

The following pump sizes generally apply to the nominated aquifers:

(a) 5 MLD for superficial bores;

(b) 10 MLD for Leederville aquifers to DN 500 casing size;

(c) 20 MLD for Yarragadee aquifer to DN 350 casing size.

**NOTE:** Materials for pumps with capacities > 13 MLD shall be sand/abrasion-resistant.

3.11 **Buildings**

For information relating to the mechanical aspects relating to the design of buildings refer to the Buildings section of DS 30-02.
3.12 Coatings

For general information relating to coatings refer to the Coatings section of DS 30-02. For specific pumpset coatings refer to the relevant pump strategic product specification located in DS 36.

3.13 Condition Monitoring and Protection

Pump protection equipment is detailed in the following and summarized in the related Pump Station Condition Monitoring table contained in this section of the Standard.

NOTE: For condition monitoring and protection related to vacuum sewage pump stations refer to the Vacuum Sewage Pump Stations section of this Standard.

3.13.1 Borehole Low Pumping Water Level (PWL)

Boreholes shall be equipped with a level transmitter to provide low PWL alarm and protection functionality. This alarm and protection function shall prevent the pump from pumping ‘on the snore’ (which could otherwise occur if the water level was to drop to the suction inlet).

NOTE: Pumping ‘on the snore’ causes snatch loading on the pumpset rotating element with high risk of component failure due to mechanical damage and/or motor overheating due to lack of cooling water flow past it.

3.13.2 Pump Low-Flow/No-Flow

Pump stations shall have an alarm and protection function for a low-flow or no-flow condition. Functionality may be provided by a flow switch where appropriate e.g. not for sewage. In this instance the flow switch requires 5 pipe diameters of straight pipe upstream and downstream in order to minimise destructive turbulence that could otherwise cause paddle failure. However arranging this length of straight pipe in a pump station is not always feasible.

Other alternatives to the no flow switch are:

(a) Non-return valves with extended spindles which operate a limit switch;
(b) Magnetic flowmeters for single duty/standby applications only, or where one flowmeter per pump is used;
(c) Low power transmitter;
(d) Differential temperature flow switch e.g. IFM SI 2000.

NOTE: RTD’s shall not be used for low-flow or no-flow detection or protection of pumps because they are unreliable. They will not detect no-flow conditions with a closed suction or discharge valve in conjunction an empty or partially empty pump or intermediate pipework.

3.13.3 Pump Low Suction Pressure

Major pump stations shall be provided with an alarm and protection function which shall be configured to shut down the pump in the event of a low suction pressure event via a pressure switch installed in the suction offtake.

3.13.4 Pump Station Low Suction Pressure

Major pump stations shall be provided with an alarm, protection and monitoring function which shall be configured to shut down the pump station in the event of a low suction pressure event via a pressure transmitter installed in the suction manifold.

3.13.5 Pump Low Delivery Pressure

Major pump stations shall be provided with an alarm and protection function which shall be configured to shut down the pump in the event of a low delivery pressure event via a pressure switch installed in the delivery offtake.

NOTE: Low delivery pressure can contribute to high delivery flow being experienced by a centrifugal pump which could be the result of a pipe burst downstream. Such an incident could reduce the downstream head to a point where the pump or pumps could be operating at the extreme RHS of their characteristic curve. This can cause
over pumping with associated motor overloading and cavitation of the pump. Condition monitoring of this event is covered by pump and pump station low delivery pressure detection devices.

### 3.13.6 Pump Station Low Delivery Pressure

Major pump stations shall be provided with an alarm, protection and monitoring function which shall be configured to shut down the pump station in the event of a low delivery pressure event via a pressure transmitter installed in the delivery manifold.

### 3.13.7 High Bearing Temperature

For major pump stations pump antifriction bearings shall be fitted with resistance temperature detectors (RTD’s) that are set to shut down the pump in the event that the temperature exceeds a set point, which is normally 65°C.

Where required each bearing housing shall be supplied with a thermometer pocket, complete with a resistance thermometer element. The resistance thermometer elements shall:

(a) Be three wire platinum element types with 6 mm OD stainless steel sheath and Grade B accuracy in accordance with BSEN 60751;

(b) Have a resistance of 100 ohms at 0°C (i.e. require a PT 100 RTD);

(c) Have a length of the resistance elements when correctly installed so that the element sheath protrudes 50 mm beyond the thermometer pocket gland;

(d) Be supplied with a resistance element lead length of not less than 50 mm.

### 3.13.8 Pump Station Well Flooding

Major drywell pump stations shall be provided with an alarm and protection function, configured to shut down the pump station in the event of flooding of the well.

### 3.13.9 Pump Station Pit Flooding

Major pump stations which have pumpsets installed in a pit arrangement shall be provided with a level switch alarm to indicate flooding within the pit.

### 3.13.10 Mechanical Seal Feedwater Low-Pressure Alarm

A mechanical seal feedwater low-pressure alarm for sewage pumps shall be used to detect partial or total loss of feedwater pressure (which could be either via the water service or reclaimed effluent).

NOTE: An ‘alarm only’ function is required to flag a failure condition as failure of the mechanical seal feedwater should not cause any real problems in the short term. This is because the seal should still be fed by sewage to provide cooling and lubrication. Shutting down a sewage pump in the event of feedwater failure could cause an unnecessary incident, particularly for a strategic pump station. The situation on start up similarly applies. The mechanical seal should be vented to prevent gas formation at the seal faces.

### 3.13.11 Vibration Monitoring

Vibration monitoring and protection is generally not considered to be necessary except for the following instances:

(a) Submersible sewage pumps greater than ≥ 150 kW;

(b) For large drywell pump sets ≥ 2 MW however it may be prudent to consider vibration monitoring for sewage pumps less than this e.g. 1 MW;

(c) Large high speed blowers.

Submersible sewage pumps ≥ 150 kW shall be fitted with the Corporation’s ‘SmartVib’ vibration detector or equivalent configured to provide alarm and shutdown protection.

For pump rotational speeds below 500 rpm displacement transducers should be provided as velocity and acceleration types are ineffective.
3.13.12 **Corporation ‘SmartVib’ Vibration Monitoring Device**

The following technical data applies to the Corporation’s SmartVib vibration monitoring and protection device:

- **Name of device:** SmartVib
- **Measurement:** RMS velocity
- **Input Power Supply:** 24 volts, 50 mA
- **Sensor Output:** 4 – 20 mA
- **Frequency Range:** 10 – 2000 Hz, 3 dB points
- **Vibration Range:** 0.3 – 25 mm/s RMS
- **Temperature Range:** -10°C to 70°C (85°C on request)
- **Enclosure Rating:** IP 67 to AS 60529
- **Enclosure Material:** 316 stainless steel
- **Cable:** 3 core unscreened
- **Pin Connections:**
  - Pin 1: +24 V DC
  - Pin 2: Ground 0V
  - Pin 3: 4 – 20 mA vibration output
  - Pin 4: 4 – 20 mA temperature output

3.13.13 **Motor Ventilation Fan Low Delivery Pressure**

Major pump stations fitted with external cooling air feed to electric motors and VSDs or to their immediate area shall be provided with a low or no air-flow alarm operated via a pressure switch.

3.13.14 **Summary of Requirements**

The following table summarises the pump alarm and protection functions required for minor and major pump stations.
Table 3.1 Pump Station Condition Monitoring

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<td>A, P</td>
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<td>A, P</td>
<td></td>
<td>Flow switch, magnetic flowmeter, low power transmitter</td>
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<td>Pressure switch</td>
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<td>Pressure switch</td>
</tr>
<tr>
<td>Pump station low delivery pressure protection and monitoring</td>
<td>A, P, M</td>
<td></td>
<td>Delivery manifold pressure transmitter</td>
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<tr>
<td>Bearing temperature high alarm and protection</td>
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<td>Pump station well flooding</td>
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<td>Pump station pit flooding (sump level high alarm as required)</td>
<td>A</td>
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<tr>
<td>Mechanical seal feedwater low pressure alarm</td>
<td>A</td>
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<td>Pressure switch</td>
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<td>Pump high vibration alarm (as required)</td>
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</tr>
<tr>
<td>Ventilation fan low delivery pressure alarm (as required)</td>
<td>A</td>
<td></td>
<td>Pressure switch</td>
</tr>
</tbody>
</table>

**LEGEND:**

A – Alarm; P – Protection; M - Monitoring

**NOTES:**

1. Borehole PWL monitoring and protection
2. For large drywell sewage pumps only
3. Corporation’s SmartVib device required for submersible sewage pumpsets ≥ 150 kW
4. kW size refers to individual pump size not pump station size
5. For submersible sewage pumps in Minor PS column
6. For water pumps ≥ 2 MW and sewage pumps ≥ 1 MW
7. Includes submersible sewage pumps ≥ 150 kW

3.14 **Confined Space**

For information relating to confined space refer to the DS 32-02 Confined Space section.

3.15 **Corrosion Mitigation**

For information regarding corrosion mitigation refer to the Corrosion section in DS 30-02 and the Glossary.

3.16 **Driver Selection**

In most instances pumps will be driven by electric motors which will be subject to suitable power supplies being available. Alternative drivers would normally be internal combustion diesel engines. This would normally be the case where electric power supplies are not available or where standby equipment is to be used for pumping during power supply interruptions.

The selection of the electric motor and diesel engine pump drivers shall be in accordance with the following:
3.16.1 Torque Speed Curves
A torque speed curve shall be developed by the Designer taking into account the specific speed of the pump, the system resistance curve and any relevant valve operation during the starting run-up.

3.16.2 Electric Motor Rating
(a) Generally for electric motors driving pumps with a “non-overloading” power demand curve, the motor MCR kW rating shall not be less than 110% of the pump maximum “non-overloading” kW demand;
(b) However, if winding over temperature protection is provided, the S1R rating of the motor shall exceed only 110% of the pump maximum duty demand kW, should this be less than the value determined in accordance with (a) above.

Pump Duty: \( P_d = \frac{QgH}{1000} \times \eta_p \)

Where:  
\( P_d = \) pump duty power in kW  
\( Q = \) flow in L/s  
\( g = \) gravity in m/s\(^2\)  
\( H = \) head in m  
\( \eta_p = \) pump efficiency

(c) The 10% margin specified above provides for a:
   (i) 5% margin of error in respect to pump load requirements;
   (ii) 5% derating if the motor is to be connected directly to the supply mains to allow for a phase voltage unbalance up to 2%;
   (iii) 5% derating if the motor is to be connected to a PWM variable speed controller to allow for the harmonic currents generated by the controller;
(d) Further information is contained in Clause 4.1 Motor Rating in DS 21;
(e) Maximum duty kW should make due allowance for:
   (i) possible errors in the design versus actual system curve and;
   (ii) for maximum duty kW requirements for minimum head conditions.

3.16.3 Engine Selection
The engine shall be selected in accordance with the power requirements specified in AS 4594 using the relevant derating requirements for altitude, temperature and humidity.

After derating and application of any service factors for the transmission e.g. belt or gearbox the maximum available reserve power available should not exceed 10%. Excessive reserve power can lead to light loading of the engine and for diesel engines this can cause glazing of the cylinders, causing piston blow by and loss of power.

Engine selection shall comply with the requirements detailed in the Diesel Engines section of DS 35.

3.17 Fasteners
Structural fasteners shall comply with the Fasteners for Structural Applications section of DS 30-01 and the Bolting Structural Joints section of DS 38-01. Flange fasteners shall comply with DS 38-03.

3.18 Foundation Blocks
Foundation block and grouting information is contained in the Foundation Blocks section of DS 30-02. Grouting shall comply with DS 38-01.
3.19 **Flanges and Gaskets**

Flanges and gaskets shall be in accordance with the Flanged Connections and Flange Gaskets sections of DS 31-01 respectively.

3.20 **Guards**

For general information relating to guards refer to the Guards section of DS 30-02.

3.21 **Lubrication**

Lubrication and lubricants shall be in accordance with the Lubrication Section of DS 30-02.

3.22 **Major and Minor Pump Stations**

Classification of major and minor pump stations is detailed in DS 30-01 and DS 30-02.

3.23 **Materials**

For general information regarding elastomers, metals and materials for sea water refer to the relevant Materials sections contained in DS 30-02. Materials for specific pump components are detailed in the relevant sections for water, borehole and sewage pumps of this Standard.

3.24 **Mechanical Seals**

For information relating to mechanical seals and packed glands refer to the relevant parts of the Seals section of DS 30-02.

3.25 **Mechanical Workmanship**

Refer to the Installation section in DS 38-01 for further information.

3.26 **Noise**

3.26.1 **General**

Designers should refer to the Noise section contained in DS 30-02 with respect to pump station design for:

(a) General information regarding noise;
(b) Noise related compliance requirements for installed equipment.

3.26.2 **Daily Noise Dose (DND) for Personnel**

Refer to the requirements of the Noise section contained in DS 30-02 for DND requirements.

3.26.3 **Noise Levels for Production Pumps**

(a) For 4 pole speed pumps each pump and motor set shall have a combined sound power level not greater than 98dB(A) referred to $10^{-12}$ W and based on a nominal sound power level for the motor only of 100dB(A);

(b) For 2 pole speed pumps each pump and motor set shall have a combined sound power level not greater than 103dB(A) referred to $10^{-12}$ W and based on a nominal sound power level for the motor only of 100dB(A);

(c) In the event that the motor sound power level, as tested, varies from 100dB(A), the client will adjust the combined pump and motor sound level accordingly and the revised value shall be supplied to the contractor for the Works prior to pump testing.
3.26.4 **Noise Levels for Engineered Pumps**

Each pump and motor set shall have a combined sound power level not greater than 103dB(A) referred to \(10^{-12}\) W and based on a nominal sound power level for the motor only of 100dB(A). In the event that the motor sound power level, as tested, varies from 100dB(A), the Principal’s Representative will adjust the combined pump and motor sound level accordingly and the revised value shall be supplied to the contractor for the Works prior to pump testing.

3.26.5 **Noise Level Testing**

Pumps shall be tested in accordance with AS 1217.7 for compliance with the noise levels referred to in the preceding clauses.

The noise level test procedures and reporting requirements shall comply with AS 1217.7.

3.26.6 **Neighbourhood Noise Levels**

Refer to the requirements detailed in the Noise section contained in DS 30-02 for Neighbourhood noise levels.

3.26.7 **Noise Reduction Strategies**

The following noise reduction strategies shall be considered:

(a) Where practicable locate the pump station to an area where there is less sensitivity to environmental noise;

(b) Endeavour to minimise the pumpset and machinery noise and vibration levels during selection of the equipment e.g. by use of slow speed pumps, low slam NRV’s;

(c) Provide sound attenuation of the pump station;

(d) Where diesel standby is proposed in the event of power failure, consider use of additional storage as an alternative, if practicable;

(e) A diesel standby shall be installed in a sound attenuated enclosure (outside installation);

(f) Use of submersible borehole or sewage type pumps depending on the application;

(g) A below ground or partially buried pump station may be appropriate.

Sound enclosures shall not be fitted over large pumpsets as a sound attenuation strategy.

3.27 **Occupational Safety and Health**

For detailed Occupational Safety and Health requirements the Designer should refer to the Occupational Safety and Health section in DS 30-02.

3.28 **Packed Glands**

For information relating to packed glands and mechanical seals refer to the Seals – Mechanical section of DS 30-02.

3.29 **Pipework**

For additional information to that contained in the Pipework section of this Standard refer to the DS 31-01 Pipework - Mechanical Standard.

3.30 **Pump Station Layout**

3.30.1 **Horizontal Water Pump Station**

Designers shall consider the following requirements for horizontal water pump stations:
(a) Provision of a pump station building and overhead traveling crane unless otherwise specified by the client;

**NOTE:** A building and crane would generally be required, particularly for large pump stations.

(b) A brick, concrete or metal-clad building depending upon the location, environment, aesthetics and noise constraints;

(c) An open style pump station (no building) if it is appropriate (e.g. remote locations) for minor and small major pump stations;

(d) Equipment to be housed in pump station buildings:
   (i) pumpsets and switchboards;
   (ii) suction and discharge offtake pipework;
   (iii) discharge manifold where the switch room is located on the pump discharge side of the building;
   (v) gantry crane;
   (vi) ancillary equipment e.g. compressors.

(e) End suction or horizontal axial-split casing centrifugal pumps unless otherwise specified by the client;

(f) Suction manifold located outside the building;

(g) Pumps and pipework set at a lower level than the switchboards to minimise the chance of flooding of electrical components;

(h) A pump station of sufficient size to accommodate the ultimate size of pumps and number of pumps, or be able to be extended to facilitate accommodation of additional units;

(i) Suction and delivery manifolds sized for the ultimate pump station duty if appropriate;

(j) Provision of personnel facilities such as toilets, washbasin and an equipped workspace in consultation with the client.

### 3.30.2 Vertical Water Pump Station

A similar layout and other requirements apply for vertical water pump stations to those specified in the Horizontal Water Pump Station section above, with the following exceptions:

(a) A smaller pump station footprint than for vertical water pump stations;

(b) Provision of a drywell or drywells with a building spanning it at ground level;

(c) Vertical radial or vertical axial-split casing style pumps;

(d) Separate dry wells if the pumps are required to be protected against flooding;

(e) Special consideration for lifting of the large pump components for maintenance.

### 3.30.3 Horizontal Sewage Pump Station

A similar layout and other requirements apply for horizontal sewage pump stations to those specified in the Horizontal Water Pump Station section above, with the following exceptions:

(a) Use of a suction bellmouth rather than a suction manifold offtake for the pump suction pipework inlet;

(b) Use of end suction centrifugal pumps with a pre-frontal screw type impellers unless otherwise specified by the client.

### 3.30.4 Vertical Sewage Pump Station

A similar layout and other requirements apply for vertical sewage pump stations to those specified in the Horizontal Water Pump Station section above, with the following exceptions:
(a) Reference to suction and discharge manifolds may not be relevant;

(b) Submersible sewage pump station options;
   (i) combined wetwell/drywell with a building spanning the top at ground level, or
   (ii) drywell incorporating a ‘follow the flow’ suction configuration with a building spanning
        the top at ground level, or
   (iii) wetwell containing submersible electric pumps mounted on a guide rail system.

(c) Drywell sewage pump station options:
   (i) vertical axial-split casing style pumps, or
   (ii) end suction centrifugal pumps, or
   (iii) submersible electric centrifugal pumpsets rated for continuous operation in air. These
        pumps are limited in size e.g. ~700kW and tend to have lower efficiencies. The
        Corporation does not favour using this type of pump in sizes > 150 kW.

(d) Flood protection strategies:
   (i) location of the pumps in separate cells;
       NOTE: This introduces problems with accommodation of stairways and landings in each cell which
            increases cost because of duplication and extra space requirements.
   (ii) motors mounted at ground level with lineshaft drives connecting to the pumps at the
        bottom of the drywell.
       NOTE: This arrangement would only be favoured for large pump stations e.g. > 500 kW pumps.

(e) Special consideration for lifting of the large pump components for maintenance particularly if
    lineshafts are being used for the transmission.

3.31 Pump Testing
The following factory testing shall be conducted for all pumps supplied for Corporation assets.

3.31.1 Production Pumps
Production pumps shall be tested in accordance with AS 2417 Grade 2.

3.31.2 Engineered Pumps
Engineered pumps shall be tested in accordance with AS 2417 Grade 1.

3.31.3 Pump Test Requirements
Pump test requirements shall include the following factors:
(a) Tests shall confirm the guaranteed performance values for duty flow, head, efficiency, and
    NPSHr;
(b) A drop in performance of 3% in head will determine the NPSHr value at different flows;
(c) Tests shall be carried out from the lower head limit of the pump guaranteed performance curve
    to the shut off head.

3.31.4 Casing Hydrostatic Test Requirements
Hydrostatic test requirements for pump casings shall comply with the following:
(a) Pump casing assemblies shall be hydrostatically tested with water to a pressure of 1.5 times the
    pump flange rating;
(b) Hydrostatic tests shall be conducted for a minimum period of 5 minutes during which time there
    shall be:
(i) no leakage from the casing, casing joints and flanges;
(ii) no permanent distortion of the casing.

(c) Hydrostatic testing requirements may be modified for sewage pumps, subject to approval by the Corporation, in accordance with Pump Pressure Ratings clause in the Sewage Pump Design Criteria section of this Standard.

### 3.31.5 Instrumentation and Tolerances

Instrumentation and their tolerances shall comply with the following:

(a) All instrumentation used in acceptance testing to AS 2417 shall be certified by the National Association of Testing Authorities Australia (NATA), or an approved equivalent body in an overseas country, as complying with the required measurement tolerance for that instrumentation as stipulated in AS 2417.

(b) Tolerances as defined in the test code will be allowed within the guarantee range.

### 3.31.6 Test Curves

All test curves developed shall utilize SI units.

### 3.31.7 Vibration Testing

The pump vibration shall be tested and shall comply with the Vibration clause of this section of the Standard.

### 3.31.8 Sound Level Testing

The sound power level of the pumps shall be tested and shall comply with the Noise clause of this section of the Standard.

### 3.31.9 Thermodynamic Pump Performance Testing

Refer to the Thermodynamic Pump Testing Tappings in the Pipework section of this Standard.

### 3.32 Pumpset Orientation

#### 3.32.1 Horizontal

The pumpset orientation shall be horizontal for conventional water pump stations providing there are no restrictions with respect to:

(a) Accommodating the pump station footprint at site and;

(b) Satisfying the NPSHa at the pump suction.

#### 3.32.2 Vertical

The pumpset orientation may be vertical for major water pump stations where NPSHa requirements and/or a requirement to minimise the pump station footprint to reduce construction cost dictates. These requirements would normally be associated with dam pump stations.

### 3.33 Pumpset Selection

#### 3.33.1 Number of Pumps

The Designer shall determine the number and type of pumpsets to meet the pump station duty or the operating envelope (for more complex applications) based on but not restricted to:

(a) Endeavouring to cover normal demand with a single duty pumpset;
(b) Limiting the number of pumps required to 2 to 3 duty pumps to meet peak demand however this may be difficult for a large operating envelope.

3.33.2 Pump Selection

The Designer shall consider the following factors in selecting the pumps:

(a) Pumps shall be appropriate both in terms of the hydraulic design and pump type. Incorrect selection in either category will cause less than optimal O & M performance;

(b) Pumps shall be optimally sized to meet the pump station duty requirements;

(c) The pump selected shall be as close as possible to the best efficiency point (BEP) for the calculated pump duty;

(d) Use of pumps that are overly undersized or oversized shall be avoided as follows:

(i) the pump may operate outside its allowable operating range. For practical purposes the allowable operating range for conventional centrifugal pumps should be restricted to between 50% to 110% of the BEP;

(ii) for borehole pumps the allowable operating range should be restricted to 90% to 110% of the BEP;

(iii) oversized pumps operating too far to the right of their BEP will experience relatively low efficiency and may suffer from cavitation as they stretch to meet the system curve. This results in poor flow performance, casing and impeller damage, excessive vibration and premature bearing failure;

(iv) undersized pumps operating too far to the left of their BEP will experience relatively low efficiency and may suffer from recirculation (refer DS30-01 Glossary). This results in cavitation damage of the casing and impeller, high radial loads on the shaft, excessive noise and vibration, high bearing temperature and premature bearing failure.

(e) In the event that a pump duty falls between pump sizes the larger pump should be selected in favour of the smaller one e.g. pump selection marginally to the left of the BEP is normally preferred to one marginally to the right of the BEP;

(f) Pumps should be supplied with impellers that can be trimmed in order to allow operation as close as possible to the BEP (not applicable to some submersible sewage pump impellers as used in Type 40 and Type 90 pump stations, which are not designed for trimming).

(g) Designers shall take into account water temperature e.g. borehole pump motors could be affected for high bore water temperatures.

3.33.3 Pump Characteristic Curves

The Designer shall comply with the following requirements:

(a) The pump H-Q characteristic curve shall fully cross both the minimum and maximum system resistance curves;

(b) The pump H-Q characteristic curve shall be stable or in the event that this is not feasible the system curves shall fall within the stable part of the pump characteristic curve;

(c) The system resistance curves shall only intersect the pump H-Q characteristic at one point for each curve.

(d) The pump NPSHr for the worst operating case scenario shall comply with the NPSHr clause below. The worst case scenario would normally occur at the minimum system curve for single pump operation at maximum operating speed;

(e) The pump should be selected with an impeller size no larger than 90% of the maximum impeller size that the pump casing can accommodate to allow for small system upgrades;
(f) Large engineered centrifugal pumps should have pump efficiencies at the specified duty of between 80% to 90% and in most applications should be closer to 90%;

(g) The pump required operating speed or speed range shall be determined and shall not exceed 4 pole speed for engineered pumps;

(h) The type of pump determined shall be a function of pump specific speed and orientation required.

3.33.4 NPSH Requirements

The NPSHa shall be calculated for the current and anticipated future upgraded pump station design and shall be no less than one (1) metre greater than the relevant pump NPSHr for all operating flow conditions.

3.33.5 Pump Direction of Rotation

Pump direction of rotation shall be referenced by looking at the coupling end of the pump. Pump driver direction of rotation shall be compatible with the pump direction of rotation.

3.34 Redundancy

3.34.1 Maintenance Regime

Maintenance requirements for the pump station shall be determined and documented as part of the design. The maintenance regime will impact on the level of built-in redundancy in the pump station operation and the design needs to address this. Maintenance of and built-in redundancy for sewage pump stations is particularly important as sewage pump stations have much higher maintenance requirement than for water pump stations.

3.34.2 Duty/Standby

Pump stations are essential elements of the water supply or sewerage system and accordingly full duty and standby capacity shall be incorporated into the design of the station unless otherwise specified by the client.

For a multi-pump configuration, additional pumpsets should be included in the installation such that the failure of any one pumpset will not reduce or change the operating range or capacity of the station.

Major sewage pump stations shall have 100% redundancy capability even when one pumpset fails. Accordingly a spare rotating element shall be available immediately for replacement into a failed pump for axial-split or back pullout types. In the case of a submersible pump station or submersible pumps used in a drywell application a spare pumpset shall be available to be fitted immediately to replace the failed unit.

Designers shall identify the pump station criticality and provide appropriate redundancy.

3.34.3 Spare Pump or Rotating Element

For critical operational scenarios where repair times are likely to be unacceptably long, in addition to installed standby pumpsets, spare pumps, spare rotating element, impellers or spare parts shall be provided for as follows:

(a) A spare pump might be a useful strategy for small production pumps in critical or remote pump stations in lieu of spare parts;

(b) A spare rotating element shall be supplied for all engineered pumps;

(c) Where future duty impellers are proposed then these impellers shall be provided at the outset;

(d) The spare initial impeller should be of the larger diameter so that in the event that it is not required it can act as the final duty spare. In the unlikely event that it is required for the initial
duty it can readily be trimmed. Water pumps are less likely to suffer wear or damage compared with sewage pumps, so it is likely the spare impeller will not be required on the initial duty;

(c) In special applications where the full duty operation of the station is not so critical, and 100% redundancy may be either cost prohibitive or unnecessary, it may be acceptable to provide for appropriate levels of spare equipment or parts in order to meet the pump station’s operational levels of service.

(f) For axial-split casing pumps the spare rotating element shall comprise:

(i) impeller/s with wear rings fitted and locked in position on the shaft complete with bearing locknuts.

(ii) supplied separately and packaged for long term storage:

1 - set of casing wear rings (a complete set for the pump)
1 - set of neck rings
1 - set of mechanical seals
1 - pump half coupling bored, with keyway and key to fit pump shaft
1 - set of shaft bearings (if not locally available)

(g) The spare rotating element for axially-split pumps shall be fitted to all associated pump casings during factory inspection and testing to ensure proper fitment and shall be rotated by hand to confirm free movement.

3.35 Signage and Labels
For general information relating to signage and labels refer to the Signage and Labels section of DS 30-02.

3.36 Stairways, Landings, Walkways and Ladders
For general information relating to stairways, landings, walkways and ladders refer to this section contained in DS 30-02.

3.37 Statutory Authorities
Designs shall take into account compliance with the requirements of statutory authorities shown in the Statutory Authorities section of DS 30-02.

3.38 Testing
Pump testing is required for production and engineered pumps in accordance with the relevant pump strategic product specification.

3.39 Transmission
Guidelines and requirements for transmissions and couplings are detailed in the Transmission section of DS 30-02.

3.40 Valves
For information on valves refer to the Valves section of this Standard and DS 31-02.
3.41 Variable Speed Drives (VSD)

3.41.1 Constant Speed versus Variable Speed

Constant speed pumping should always be the primary strategy with variable speed pumping only considered where necessary and as further mentioned below;

(a) Pumping sewage for major pump stations generally lends itself more readily to two speed or variable speed in order to cater for variations in peak daily flows and summer and winter flows;

(b) Follow-the-flow pumping requires variable speed operation in order to pace sewage inflow requirements for the pump station;

(c) Variable speed is necessary to provide coverage of operating envelopes with large head and flow variations in the system that otherwise could not be covered by constant speed pumps;

(d) Variable speed may be used for surge mitigation on startup and shut down for long pipeline applications providing a water hammer analysis identifies that this would be an appropriate strategy. However use of a variable speed drive (VSD) is not a panacea for all water hammer situations.

(e) For variable speed sewage pumping the pump manufacturer shall confirm the suitability of the pumps for non-clog continuous operation over the full speed range or operating envelope.

3.41.2 Variable Speed and Pump Efficiency

Designers shall ensure that:

(a) Pumps are not selected to operate down to Zero Q Speed (refer DS 30-01 Glossary). As a rule pumps should not be operated at less than 30% of best efficiency capacity (BEC) and a speed reduction below 50% of BEC should not be undertaken without obtaining the pump manufacturer’s documented approval;

(b) Variable speed pumps are selected so that the maximum duty point is to the right of the best efficiency point (BEP) in order that the pump will operate through the range of best efficiencies, at the various duty speeds less than the maximum.

3.41.3 Operational Limits

The Designer shall specify the operating limits of the variable speed pump as follows.

(a) In determining the minimum allowable speed of the pump, consideration shall be given to the head generated by any other pumps operating in parallel with the pump in question.

(b) Pumps shall not be operated at a speed greater than the maximum shown on the manufacturer’s curves without obtaining the manufacturer’s documented approval;

(c) Pumps shall not be operated at their critical speed.

3.41.4 VSD versus Control Valve

An alternative to variable speed for smaller pump stations may be the use of control valves but invariably capital and operating costs in terms of wasted power disadvantages them in favour of VSDs. Accordingly this aspect should be evaluated by the Designer in determining suitability of a control valve compared with variable speed operation.

3.42 Vibration

3.42.1 Vibration Limits

Mechanical equipment vibration values shall be designed to a minimum. The acceptable limits for particular equipment are detailed in the Vibration section of DS 30-02.
3.42.2 Monitoring and Protection

Refer to Vibration Monitoring in the Condition Monitoring and Protection section of this Standard.

3.43 Water Hammer

3.43.1 System Analysis

The system shall be analysed using a recognised water hammer computer modeling program e.g. WATSYS or equivalent to determine the extent to which pressure surges are likely to develop during:

(a) Pump shut down or start up;
(b) Operation of other pump stations in the system;
(c) Power failure conditions;
(d) Changes in demand;
(e) Changes in system valves.

3.43.2 Surge Prone Conditions

The Designer shall address the following conditions (which are likely to produce undesirable pressure surges in the system) where they are present:

(a) Where column separation is likely;
(b) Where high points exist in the pressure main hydraulic profile;
(c) Pressure mains that require automatic air valves;
(d) Long mains with a steep gradient followed by a long shallow gradient;
(e) Flow velocity in excess of 1.2 m/s;
(f) Valve closure time less than \( t_c \) (refer to Slow Closure in DS 30-01 Definitions and Relationships);
(g) Valve closure time less than 10 seconds;
(h) Long pressure mains with high static heads where rapid pump shut down can occur either during normal operation or power failure induced.

3.43.3 Design Criteria

The design criteria that should be considered for a water hammer analysis should include:

(a) Where vapour column separation is likely to occur during normal transient conditions resulting from system changes from one steady state condition to another;
(b) Where negative pressures are likely to exceed the maximum allowable value for the pipe;
(c) Where negative pressures are likely to produce vacuum conditions in the pipeline;
(d) Where slamming and bouncing of non-return valves are likely.

3.43.4 Surge Mitigation Strategies

Adverse pressure surge severity should be addressed using appropriate mitigation strategies, which may include:

(a) Selection of pipework and equipment which is rated to handle the maximum surge;
(b) Design of system valves for slow closure e.g. \( t_c > 2L/C_p \);
(c) As determined after a water hammer analysis of the system, selection and optimal location of surge mitigation devices as referred to in the following.
3.43.5 **Flywheels**

Flywheels can be used to minimise low pressure fluctuation (downsurge) in the discharge manifold caused by power failures and rapid pump shutdown. However use of flywheels is normally restricted to relatively small pump stations.

3.43.6 **Surge Vessels**

(a) A surge vessel located at the pump station can also be used to minimise downs urge in the discharge manifold caused by power failures and rapid pump shutdown.

(b) Surge vessels are not preferred for sewerage systems.

(c) Pump discharge non-return valves near surge vessels shall be determined by the surge analysis. Non slam valves shall be used for high deceleration rates e.g. \( >5 \text{ m/s}^2 \) – refer Non Slam Non-Return Valves section in DS 31-02.

(d) The volumetric capacity for a surge vessel should be based on preventing any air exiting the air vessel, with a 20% volume allowance for control level settings and a 10% allowance against vortex action.

3.43.7 **Control Valves**

Control valves cannot be used to control downs urge but may be appropriate for controlling high pressure fluctuation e.g. upsurge.

3.43.8 **Soft Starting Pumps**

Soft starting and pumps using variable speed drives which ramp up and ramp down the pump speed can be a useful surge mitigation strategy.

3.43.9 **Air Cushions**

Air cushions at appropriate locations in the discharge pipeline may be required. The volumetric capacity for an air cushion should be based on the maximum air volume not exceeding 50% of the total volume in the vertical column.

3.43.10 **One-Way Tanks**

One-way tanks may be required at appropriate locations in the main.

The volumetric capacity for a one-way tank should be based on the water volume loss not exceeding 50% of the tank’s effective volumetric capacity.

3.43.11 **Air Valves**

Air valves are a simple and low cost method of preventing pipeline pressures falling below atmospheric however they are not a preferred method of surge control particularly for major pump stations. Air valves should only be used for local surge considerations. For information regarding air valve design criteria refer DS 31-02.

3.44 **Welding**

For information relating to welding and brazing refer to the Welding section of DS 30-02.
4 WATER PUMPS

4.1 General

Water pumps (as distinct from sewage and sludge pumps) relate to pumps used for pumping clear water or clear effluent in water supply, wastewater and drainage applications.

The centrifugal pump type required for a particular application can be determined from the pump specific speed (as defined in DS 30-01 Glossary), which will classify it in terms of the impeller characteristic e.g. radial, mixed flow or propeller. Radial or mixed flow centrifugal pumps of the following types should generally be used for conventional Corporation water pump stations. Refer also to relevant sections of this Standard such as the General Design Factors, and Pipework and Valves.

For installation of centrifugal pumps refer to the Pumps section of DS 38-01.

4.2 End Suction Centrifugal Pumps

4.2.1 Applications

This type of pump in bare shaft or motor-pump types shall be used for minor pump station applications for clearwater pumping and for motor kW ratings generally not exceeding 75 kW.

NOTE: Adequacy of shaft stiffness for large impeller overhang should be considered particularly for motor- pumps used in the larger sizes and higher head applications. Lack of shaft stiffness could cause excessive shaft deflection and consequently produce high impeller and casing seal ring wear, and mechanical seal problems.

4.2.2 Features

The Designer should note the features of ISO end suction bare shaft pumps and end suction motor-pumps which are:

(a) Production style pump used on minor pump stations;
(b) Horizontal orientation;
(c) End suction centrifugal
(d) ISO configuration with centrally aligned discharge nozzle;
(e) Radial-split casing;
(f) Single or multi-stage;
(g) Single entry impeller in open, semi open or closed types;
(h) Overhung impeller e.g. single bearing;
(i) Back pullout allowing volute to remain in-situ during bearing housing/impeller removal (providing a spacer type flexible coupling is fitted);
(j) Mechanical seal (preferred);
(k) Oil (bare shaft only) or grease lubrication;
(l) Close coupled (motor-pump) or long coupled;
(m) 2 pole, 4 pole and multi-speed.

4.2.3 Technical Specifications

Horizontal ISO end suction centrifugal pumps shall comply with SPS 500 and end suction centrifugal motor pumps shall comply with SPS 501.
4.3 Vertical Multi-Stage Centrifugal Pumps

4.3.1 Applications

This type of pump should be used for general pumping of clearwater for minor pump station applications where relatively low flow and high heads are required. Pump materials for Corporation applications shall be corrosion resistant e.g. cast iron components are not acceptable as they are susceptible to graphitic corrosion and formation of iron tubercles which clog waterways.

4.3.2 Features

The Designer should note the following list of features relating to the vertical multi-stage centrifugal pump type:

(a) Production style pump used on small pump stations;
(b) Vertical orientation;
(c) Non self-priming;
(d) Inline suction and discharge ports;
(e) Single or multi-stage;
(f) Single entry impeller;
(g) Overhung impeller and fully supported impeller types available e.g. single or two bearing;
(h) Top pullout allowing volute to remain in-situ during bearing housing/impeller removal;
(i) Cartridge type mechanical seal;
(j) Close coupled;
(k) 2 pole speed electric motor mounted above the pump end.

4.4 Tangential Discharge Centrifugal Pumps

4.4.1 Applications

The tangential discharge style of end suction centrifugal pump should be used for general pumping of clearwater for major pump station in high flow, low head pumping applications such as large transfer and filter backwash service in water treatment plants.

4.4.2 Features

The Designer should note the following list of features which relate to the tangential discharge end suction centrifugal pump type:

(a) Engineered pump for major pump stations;
(b) End suction centrifugal style;
(c) Horizontal orientation;
(d) Radial-split casing;
(e) Tangential discharge nozzle oriented either vertically or horizontally overshot;
(f) Single stage;
(g) Single entry impeller;
(h) Overhung impeller e.g. single bearing;
(i) Mechanical seal (preferred);
(j) Long coupled;
4.5 Axial-Split Casing Pumps

4.5.1 Applications
This type of pump should be used for general pumping of clearwater for major pump stations for both horizontal and vertical orientation.

4.5.2 Features
The Designer should note the following list of features which relate to axial-split casing centrifugal pumps:

(a) Engineered centrifugal pumps used on major pump stations;
(b) Medium flow-medium head and medium flow-high head applications;
(c) Axial-split casing which allows removal of the top casing in order to replace the rotating element without disturbing the remainder of the pump;
(d) Horizontal or vertical (dams) orientation;
(e) Single or multi-stage;
(f) Double entry impeller;
(g) Two journal or anti-friction bearing supports for impeller;
(h) Mechanical seal (preferred);
(i) Long coupled (or transmission shaft driven for very large vertical pumps);
(j) 4 pole speed or less.

4.5.3 Technical Standards
Horizontal axial-split casing centrifugal pumps shall comply with SPS 515.

4.6 Centrifugal Pump Materials

4.6.1 Component Materials
The basic materials for centrifugal pumps shown in the following table shall represent the minimum standard and designation acceptable.

**NOTE:** Alternative materials to those listed may be used providing they are equivalent in performance particularly with respect to strength, corrosion-resistance and durability.

4.6.2 Casing and Impeller Wear Ring Material Options
There are four options shown in Table 4.1 as follows:

Option 1 – Is the standard trim for cast iron and ductile iron pumps.
Option 2 – Special trim for cast iron and ductile iron pumps where chlorine is injected upstream.
Option 3 – Standard trim for stainless steel pumps.
Option 4 – Alternative trim for stainless steel pumps.
Table 4.1 – Materials for Water Pumps

<table>
<thead>
<tr>
<th>Component</th>
<th>Material†</th>
<th>Standard</th>
<th>Designation (and Hardness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casings</td>
<td>Grey cast iron</td>
<td>AS 1830</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Ductile iron</td>
<td>AS 1831</td>
<td>ISO/JS/400-15V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/JS/500-7V</td>
</tr>
<tr>
<td></td>
<td>Stainless steel¹</td>
<td>AS 2074</td>
<td>H5C L-NiCuCr</td>
</tr>
<tr>
<td></td>
<td>Austenitic cast iron</td>
<td>AS 1833</td>
<td>15-6-3</td>
</tr>
<tr>
<td>Impeller</td>
<td>Phosphor bronze</td>
<td>AS 1565</td>
<td>C90250</td>
</tr>
<tr>
<td></td>
<td>Stainless steel¹</td>
<td>AS 2074</td>
<td>H5C</td>
</tr>
<tr>
<td>Wear rings⁵,⁶</td>
<td>Option 1</td>
<td>Casing</td>
<td>Leadged tin bronze</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impeller</td>
<td>Phosphor bronze</td>
</tr>
<tr>
<td></td>
<td>Option 2</td>
<td>Casing</td>
<td>Stainless steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impeller</td>
<td>Austenitic cast iron</td>
</tr>
<tr>
<td></td>
<td>Option 3</td>
<td>Casing</td>
<td>Stainless steel²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impeller</td>
<td>H3C</td>
</tr>
<tr>
<td></td>
<td>Option 4</td>
<td>Casing</td>
<td>Stainless steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impeller</td>
<td>H3B</td>
</tr>
<tr>
<td>Shaft</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>431</td>
</tr>
<tr>
<td>Shaft bearing locknuts</td>
<td>Carbon steel</td>
<td>AS 1443</td>
<td>-</td>
</tr>
<tr>
<td>Seal plate studs</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>Mechanical seal ³,⁸:</td>
<td></td>
<td></td>
<td>(Refer components below)</td>
</tr>
<tr>
<td>• Stationary face</td>
<td>Solid silicon carbide, Ceramic</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Rotating face</td>
<td>Carbon</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Drive keys</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>• O-rings</td>
<td>Nitrile or Buna N</td>
<td>AS 1646</td>
<td>70 IRHD</td>
</tr>
<tr>
<td>• Flange</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>• Springs</td>
<td>Hastelloy C®</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Cyclone separator</td>
<td>Nylon</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Seal plate stud nuts</td>
<td>Ledged gunmetal</td>
<td>AS 1565</td>
<td>C83600</td>
</tr>
<tr>
<td>Fitted studs</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>431, 316</td>
</tr>
<tr>
<td>Fixing and fitted bolts, forcing screws and dowels; Nuts for fixing and fitted studs and bolts; Water thrower³</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>70 IRHD</td>
</tr>
<tr>
<td>Internal coating</td>
<td>Coatings shall comply with the Pump Coatings table of DS 30-02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. A stainless steel pump casing and impeller would require economic justification.
2. C93500 is susceptible to chlorine attack and should not be used if chlorine is being injected immediately upstream of the pump. The pump shall be fitted non-corrosive, non-galling wear rings for these conditions.
3. Where cartridge seals are used the water slinger is not required because of space limitations and the seal locking-ring acts as a slinger.

4. Materials contained in Strategic Product Specifications for specific pump types shall prevail.

5. Adjustable end or face plates in lieu of wear rings may be approved by the Corporation e.g. open impellers.

6. Casing wear ring and impeller wear ring combinations shall be selected with dissimilar materials or hardness to avoid the potential of galling. Refer to the clause relating to Casing and Impeller Wear Rings Material Options above.

7. Refer to Stainless Steel Fasteners and Galling contained in DS 30-02.

8. For information relating to mechanical seals refer to the Seals – Mechanical section contained in DS 30-02.

9. HBW refers to Brinell hardness.

4.6.3 Chlorine Upstream Injection
Chlorine should not be injected upstream of centrifugal pumps at a rate in excess of 2 mg/L otherwise accelerated corrosion of susceptible components and premature failure of the pump will occur.

4.7 Submersible Electric Borehole Pumps

4.7.1 Applications
This type of pump is used for general pumping in minor and major borehole pump or booster pump applications. Refer to the Booster Pump Application clause in this section of the Standard for further information on booster pumps. General information on bores is contained in the Bores section of this Standard.

4.7.2 Features
The Designer should note the following list of features which relate to submersible electric borehole pumps used by the Corporation:
(a) Production and engineered pumps used on minor and major borehole pump applications respectively;
(b) Radial-split stage casings each incorporating a diffuser and bearing;
(c) Vertical or horizontal (above-ground booster) orientation;
(d) Single or multi-stage;
(e) End suction;
(f) Mixed flow impellers (also radial for low flows);
(g) Two journal bearing supports for each impeller (except for small pumpsets);
(h) In-built non-return valve at pump outlet;
(i) Close-coupled to a submersible electric motor;
(j) 2 pole, 4 pole or multispeed;
(k) Mechanical seal for motor;
(l) Suspended on discharge column or an inflatable packer (columnless);
(m) Low operating noise level.

4.7.3 Technical Standards
Multi-stage submersible electric borehole pumps shall comply with SPS 507.

4.7.4 Submersible Borehole Pumpset Equipment
Submersible borehole pumpset and ancillary equipment should generally comprise the following:
(a) A submersible electric pumpset fitted with shroud (if applicable);
(b) For column type boreholes the pumpset should be suspended on a corrosion resistant delivery column to which is strapped the electric drop cable (refer also Pump Delivery Column section below); or

(c) For columnless boreholes the pumpset shall be supported by an inflatable packer in conjunction with a stainless steel tube connecting the pump to the surface which is required to support the electric drop cable and for pump for installation and removal purposes (refer Pump Delivery Column section below);

(d) Electric drop cable and pump earth cable;

(e) Drawdown tube (bubbler);

(f) Pumping water level (PWL) alarm and low level protection transmitter;

(g) Motor temperature transmitter (as required);

(h) Bore water temperature transmitter (as required);

4.7.5 Non-Return Valve

The pumpset shall be fitted with an integral purpose-designed non-return valve at the pump outlet unless the manufacturer confirms in writing it is unnecessary.

4.7.6 Air Release and Vacuum Break Valve

The Designer shall comply with the following requirements relating to air release and vacuum break valves:

(a) An air release and vacuum break valve (air valve) shall be fitted at the headworks between the discharge bend and pipeline non-return valve.

(b) Boreholes that are at risk of headworks flooding shall vary from the above requirement in that an ‘air release only’ air valve shall be used in lieu of a conventional air valve, as further detailed in the Sealing of Borehole Headworks section below.

NOTES:

1. The air valve prevents water column separation and vacuum formation in the discharge column when the water rest level (WRL) is lower than the top of casing (TOC).

2. Water column separation can cause damaging water hammer on pump start up when the advancing water column meets the stationary bulk of water in the pipeline upstream of the headworks non-return valve. Use of an air valve breaks the vacuum in the column and admits air which acts as a cushion during pump start thus reducing the pressure spike when the advancing water column meets the stationary pipeline water.

3. Use of an integral pump non-return valve tends to prevent formation of the vacuum but in the event of it leaking a partial vacuum would form above it.

4. For information relating to air valves refer to the Air Valves section of the DS 31-02 Standard.

4.7.7 Motor Shroud

The Designer shall comply with the following motor shroud requirements:

(a) A motor shroud shall be fitted where velocity of water flow past the motor is less than the minimum flow requirements specified by the manufacturer e.g. normally < 0.5 to 0.75 m/s;

(b) Where a submersible pump is placed at a level lower than a cascading screened aquifer a motor shroud shall be fitted in order to direct flow past the motor for cooling;

NOTE: Flow would otherwise be directed over the pump end only with the potential for motor overheating.

(c) Motor shrouds shall be manufactured from corrosion resistant materials and should be slightly less than the pumpset length (e.g. 100 mm) to prevent damage from standing on the motor end of the pumpset, which could otherwise occur during installation and removal.
4.7.8 Pump Delivery Column

Borehole pumpsets shall be either fitted with a rigid column pipe; or a flexible column; or for larger pumpsets with an inflatable packer utilising the borehole casing as the delivery column. Pump column shall be corrosion resistant and comply with one of the following types:

(a) FRP twist and lock type e.g. ‘Permaglass’ pump column incorporating ‘Kwik-Lok’ couplings (or equivalent);
(b) ‘Wellmaster’ flexible column (or equivalent);
(c) Stainless steel flanged pipework (where space permits)
(d) Columnless installation using the bore casing as the column in conjunction with an inflatable packer. This may be appropriate for larger boreholes and pumpsets e.g. Yarragadee Bores.

Column design shall comply with the manufacturer’s requirements (where relevant).

NOTES:

1. The original ‘Wellmaster’ flexible column of size DN 100 and larger had the limitation of being unsuitable for use in boreholes where the depth exceeded 50m. This was because of the potential for the drop cable restraining strap to stretch due to the relatively large cable size and length. This could cause the restraining straps to become loose, fall off and become ingested into the pump.

2. The current ‘Wellmaster’ cable strap system has been redesigned to eliminate the cable strap problem. The new design of the ‘Wellmaster’ column has been trialed by the Corporation over a number of years and there have been no further incidents of the original problem. Hence, the limitations of the original ‘Wellmaster’ column documented in previous Design Standards are not applicable to the current ‘Wellmaster’ column.

3. Where flexible column (e.g. Wellmaster) is used a small hole should be drilled in the pumpset non-return valve to allow the water in the column to drain back allowing the column to deflate. This facilitates column removal without damage that could otherwise occur if it was full of water and pulled horizontally over the rollers at the surface.

4.7.9 Submersible Borehole Pump Headworks

The pumpset headworks shall incorporate the following pipework and fittings:

(a) A casing to column cap fitted to the top of casing to prevent ingress of contaminants into the bore;
(b) A discharge bend with integral lifting point fitted to the discharge column;
(c) Pipework above ground shall be manufactured from copper, stainless steel or MSCL as appropriate;
(d) A non slam and anti-shock air valve (refer to Air Release and Vacuum Break Valves above and the Air Valves section of DS 31-02) shall be fitted immediately downstream of the discharge bend at the surface;
(e) A non-return valve downstream of the air valve with an isolating butterfly valve fitted downstream of it;
(f) An offtake at right angles located between the discharge bend and the headworks non-return valve, which terminates at ground level, fitted with an isolating valve (to be used for scour purposes);
(g) A tapping point upstream and downstream of the headworks non-return valve;
(h) A flowmeter (refer to the relevant flowmeters clauses in DS 31-02) shall be fitted downstream of the non-return valve but upstream of the isolating valve unless otherwise specified by the client;
(i) ‘No flow’ or ‘low flow’ protection in accordance with the Condition Monitoring and Protection section of this Standard.
4.7.10 Sealing of Borehole Headworks

Compliance with Australian Drinking Water Guidelines requires the Corporation address the issue of potential contaminants such as insects, small animals and floodwater entering boreholes. Traditionally cable and other entry points have been provided with generous slots in the top cover which has allowed relatively easy entry of potential contaminants into the borehole. This is no longer acceptable and accordingly all entry points in borehole headworks shall be sealed considering the following:

(a) The casing top cover for submersible electric borehole pump installations shall be sealed via cable glands;

(b) Sealing of bore headworks for lineshaft turbine pumps shall require a sealed discharge head mounting plate in conjunction with cable glands for airline (bubbler), transmitter port, dip port (fitted with plug);

**NOTE:** It is not considered practicable to further seal the gland section of the discharge head. A footvalve fitted prior to the pump inlet would eliminate backflow and reduce concern with respect to potential contamination of the gland entry point.

(c) For flood prone installations the air release and vacuum break valve shall be replaced with an 'air release only' valve in conjunction with an integral pumpset outlet non-return valve in order to prevent the formation of a vacuum in the column.

4.7.11 Borehole and Pumpset Location

Location of boreholes with respect to each other and the position of the pumpset in the bore are important factors in determining optimal long term performance as follows:

(a) Where a borehole is equipped within close proximity of another operating borehole, due consideration shall be taken into account of the interference to each other’s cone of depression (or zone of influence) and effect on long term drawdown, when determining the pumpset placement setting.

(b) Placement of a borehole pump suction inlet shall be a minimum of 5 metres below the long term drawdown level or PWL.

4.7.12 Booster Pump Applications

The Designer shall consider the following:

(a) Submersible pumpsets are not restricted to use in boreholes and can be used in vertical or horizontal orientation for the following applications, subject to Corporation approval:

(i) In tanks or reservoirs;

(ii) As booster pumps for water supply applications;

(b) Horizontal booster pumpsets are normally installed in a pressure containing casing connected to suction and delivery manifolds. Alternatively the pumpset can be installed in line e.g. without manifolds. The pumpset should be fitted with pump and motor support clamps to act as slides when assembling into the booster casing. The casing shall be fitted with a cable gland or glands to seal the entry points.

(c) The pumpset and booster casing (modified borehole casing) can also be installed vertically in-ground to reduce the footprint and noise;

(d) Advantages of these booster pump configurations are:

(i) minimal space requirements;

(ii) no building requirements for the pumpsets;

(iii) no concrete foundation blocks required;

(iv) low noise characteristics;

(v) flood proof.
Designers should consult the manufacturer where horizontal applications are proposed as there may be limitations or special requirements for the proposed pumpset e.g. there may be a limit on the number of stages etc.

4.8 **Sump Pumps**

4.8.1 **Applications**

Sump pumps shall be used in water and sewage pump stations for the following purposes:

(a) To remove gland drainage water from water or sewage pumps;
(b) To remove fluid spillage as a result of maintenance tasks involving pump, valve or pipework removal;
(c) To protect the pump station pumpsets from external flooding particularly where they are installed below the natural surface, or to protect against internal flooding as a result of failure of pump or pipework components or other cause.

4.8.2 **Features**

Features of sump pumps for wastewater service are contained in the Submersible Sewage Pump section of this Standard. Features of sump pumps for dirty water or drainage service are generally covered in the following:

(a) Relatively small production pumps;
(b) Compact, self-contained submersible type;
(c) End suction;
(d) Vertical orientation;
(e) Radial-split casing;
(f) Single stage;
(g) Single entry impeller;
(h) Overhung impeller e.g. single bearing support;
(i) Oil-filled seal chamber with mechanical sealing;
(j) Close-coupled 2-pole submersible motor with float control.

4.8.3 **Sump and Pipework Design**

Sump pumps and control equipment shall be installed in a sump. The pump station floor shall be graded to facilitate drainage to the sump. The sump shall be fitted with an expanded metal grating which shall be hot dip galvanized in accordance with the relevant part of the Coatings section contained in DS 30-02.

The sump pump shall be readily demountable for removal and servicing via a flanged or ‘Camlock’ discharge connection. The discharge pipework shall incorporate a swing check non-return valve and an isolating gate valve downstream of the non-return valve. The non-return valve shall be installed no closer than 5 pipe diameters from the pump discharge outlet. The pump discharge outlet into a sewage pump station wet well shall be located above the operating fluid level.
4.8.4 Sump Pump Design

Designers shall take into account the following requirements with respect to sump pumps:

(a) Where relatively clear water (classified as dirty water compared with sewage) is to be pumped then purpose-designed submersible drainage type sump pumps should be used; or

(b) Where excessive solids and grit are likely to be present then submersible electric (non-clog) sewage type pumps should be used;

(c) Submersible drainage sump pumps shall embody the following requirements:
   (i) vertical orientation;
   (ii) submersible electric operation;
   (iii) materials complying with (d) below;
   (iv) non-clog impeller capable of a soft solids passage including 5 mm to 50 mm long fibres;
   (v) rated to operate in water temperatures up to 30 °C;
   (vi) automatic control shall be via an integral ball type float incorporating a mercury switch;
   (vii) suitable for operating intermittently when the motor is not submerged.

(d) Component materials for submersible drainage sump pumps should comply with the requirements shown in the Centrifugal Pump Materials section of this Standard. However the following deviations may be acceptable subject to client approval:
   (i) non-corrosive materials equivalent to a minimum grade 304 stainless steel;
   (ii) engineered plastic components;
   (iii) component materials coated in accordance with the Coatings Section of DS 30-02;
   (iv) polyurethane internal coatings;

(e) Submersible sewage type sump pumps are more suitable for handling sand and grit as mentioned above. For drywell sewage pump stations submersible sewage type sump pumps should be used in order to accommodate solids that may be present in a sewage spill. Materials for sump pumps for sewage applications shall comply with the requirements of SPS 503;

(f) Pumps shall be soft wired;

(g) Pumps shall be lightweight type, or otherwise fitted with a lifting arrangement to facilitate removal for servicing.

4.9 Pump Pressure Ratings

The pump casing and flange rating should comply with the pressure class as shown in the following table.

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Pressure Class Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum allowable operating pressure - kPa</td>
<td>PN 14</td>
</tr>
<tr>
<td>Hydrostatic test pressure - kPa</td>
<td>2100</td>
</tr>
</tbody>
</table>
5 SEWAGE PUMPS

5.1 General

Sewage pumps relate to pumps used for pumping raw sewage and sludge. This is as distinct from water pumps which are used for pumping water, dirty water and clear effluent.

The centrifugal pump type required for a particular application can be determined from the pump specific speed (as defined in DS 30-01 Glossary), which will classify it in terms of the impeller characteristic e.g. radial, mixed flow or propeller. Centrifugal pumps of the following types should generally be used for conventional Corporation sewage pump stations. Refer also to relevant sections of this Standard such as the General Design Factors, and Pipework and Valves.

The Corporation uses various sewage pump station types and associated pump types depending on the specific application as described in the following.

5.2 Pumpset Orientation

5.2.1 Horizontal

A horizontal pumpset orientation is not normally used for conventional sewage pump stations because of the requirement to accommodate an incoming sewer at depth.

However on the odd occasion where this orientation is used by the Corporation, the pumpset and pipework layout would be similar to a conventional water pump stations. The suction offtakes differ in that they would be fitted directly into a sewage collection tank or tanks incorporating suction bellmouths rather than via a suction manifold (e.g. Claisebrook PS).

Preferred pumps in this application would be horizontal pre-frontal screw end suction pumps which have non-clog characteristics in order to minimize pump ragging problems.

5.2.2 Vertical

As mentioned, pumpset orientation is normally vertical for major sewage pump stations in order to accommodate the sewer at depth, in conjunction with optimising pump NPSH\(a\) and minimising the footprint to reduce construction costs.

5.3 Circular Well Sewage Pump Stations

5.3.1 Wet Well

This pump station type comprises circular wet wells each equipped with a submersible electric pump and designated for Corporation purposes as follows:

(a) Type 6, Type 10, Type 40 and Type 90 sewage pump stations covering a flow range of 4.5 L/s to 90 L/s as detailed in DS 51;

(b) Type 180 and Type 350 being 180 L/s and 350 L/s respectively.

Type 40 and 90 pump stations are minor sewage pump stations and are the most common type used by the Corporation. For pump stations with submersible pumps greater than 150 kW refer to the Large Submersible Pump Issues section of this Standard.

5.3.2 Wet /Dry Well

This pump station type comprises a combined external wet well annulus surrounding a central dry well which is equipped with vertical close-coupled centrifugal pumps.
5.3.3 **Dry Well**
This pump station type comprises a circular dry well with conventional vertical centrifugal pumps using follow-the-flow philosophy.

5.3.4 **Wet /Dry Well Versus Dry Well Follow-the-Flow**
A comparison of circular wet well/dry well pump stations versus circular dry well pump stations using follow-the-flow philosophy for large pump stations is discussed in the following:
(a) Wet wells tend to be subject to accumulation of fats, scum, sand and debris such as rags which may require regular and expensive cleaning;
(b) Wet wells are subject to degradation of the concrete from sulphide attack;
(c) Cast iron wet well penstocks tend to fail prematurely due to corrosion;
(d) Wet well suction design for large major pump stations tend to be more complex than follow-the-flow.
Accordingly follow-the-flow offers potential advantages with respect to these issues over a wet well arrangement for large major pump stations.

5.4 **Rectangular Well Sewage Pump Stations**

5.4.1 **Wet /Dry Well – Horizontal**
This pump station type comprises a rectangular suction tank or well with an adjacent dry pump station. The drywell is equipped with conventional horizontal long-coupled centrifugal pumps of the pre-frontal screw impeller type.

5.4.2 **Wet /Dry Well – Vertical**
This pump station type comprises a rectangular wet well/dry well with conventional vertical close-coupled centrifugal pumps such as used for effluent pump stations at water treatment plants.

5.5 **Sewage Pump Selection**
For selection of sewage pumps refer to Pumpset Selection in the General Design Factors section of this Standard except for references to:
(a) Borehole pumps which are not relevant and;
(b) The requirement for impellers to be trimmed which is not applicable to some submersible sewage pump types for minor pump stations e.g. Types 40 and 90 pump stations.

5.6 **Sewage Pump Type**
Normally determining the pump specific speed would classify the type of centrifugal pump required for the particular application. However horizontal and vertical mixed flow centrifugal pumps of the following types are generally used for sewage pump stations.

5.7 **Pre-Frontal Screw Sewage Pumps**

5.7.1 **Applications**
The pre-frontal screw centrifugal pump is used by the Corporation for general pumping of sewage for minor and major sewage pump stations and vacuum sewage pump stations. The applications are specifically related to horizontal drywell service.
5.7.2 Features

Features of the horizontal end suction pump of the pre frontal screw impeller type are:

(a) Engineered pumps with very good solids handling (developed in the 1940’s for pumping fish unharmed);
(b) Radial-split casing;
(c) Single stage;
(d) Frontal screw on the impeller increases solids handling capability without ragging;
(e) Mechanical seal (preferred);
(f) Long coupled or close coupled;
(g) 2 or 4 pole speed.

5.8 Submersible Sewage Pumps

5.8.1 Applications

This type of pump is used for general pumping of sewage for minor and major sewage pump station applications.

5.8.2 Features

This type of pump is generally used for submersible sewage pump stations for raw sewage and sludge (generally up to 150 kW as previously mentioned). This type of pump is often used in drywell pump stations in lieu of conventional drywell pumpsets as they afford flood protection capability. The following summarises feature of this type of pump:

(a) Production pumps which are used on smaller pump stations e.g. Type 6, 10, 40 and Type 90;
(b) Engineered pumps used on larger pump stations e.g. Type 180 and Type 350 (not preferred);
(c) End suction;
(d) Vertical orientation;
(e) Radial-split casing;
(f) Single stage;
(g) Single entry impeller;
(h) Overhung impeller e.g. single bearing support;
(i) Oil filled seal chamber with two mechanical seals;
(j) Close coupled;
(k) 2, 4 pole and multi-speed;
(l) Submersible and drywell mount.

5.8.3 Rating

The minimum output rating of submersible sewage pumps shall be 3 kW; this is because Corporation experience has been that lower rated motors have a tendency to nuisance trip on minor overloads. Pumps shall be designed for continuous rating if they are to be operated in air even for short periods of time. Continuous rating shall imply a forced internal cooling system. The cooling system should be forced water, oil or equivalent coolant circulation, with integral heat exchanger for large pumps e.g. > 150 kW.
5.8.4 Large Submersible Pump Issues

The Corporation has experienced problems with some of its large submersible electric pumpsets (e.g. >150 kW). Accordingly when considering use of large submersible sewage pump stations the Designer should carefully consider their disadvantages in comparison with drywell pump stations which are listed as follows:

(a) Large submersible pumpsets have had a history of premature failure in the Corporation;
(b) Submersible pumpsets tend to have lower efficiencies than drywell pumpsets;
(c) Submersible pumpsets tend to have a higher maintenance frequency;
(d) Dual lifting or lowering cranes are required for simultaneous lifting or lowering of submersible pumpsets and associated large and relatively stiff power cables, which involve a fairly high degree of difficulty and careful lifting procedures;
(e) Problems that develop with submersible pumpsets or control equipment are not necessarily obvious as they are contained in a closed wet well. This can lead to progressive undetected deterioration and ultimate catastrophic failure, which can result in extensive station downtime;
(f) Electric motor and power cables are exposed to a wet and constantly moving environment increasing the potential for insulation breakdown;
(g) Submersible sewage pumpsets have higher vibration levels than for drywell pumpsets due to their less rigid mounting arrangement;
(h) Submersible pumpsets higher vibration levels can lead to premature failure of components;
(i) Redundancy requirements cannot be met without carrying a complete spare submersible pumpset when a pumpset requires overhaul;
(j) Removal of wet well covers to gain access to pumpsets and control equipment potentially exposes the environment to significant odours;
(k) Life cycle costing should be employed when considering large wet well submersible pump stations versus drywell pump stations.

5.8.5 Technical Specification

Submersible sewage pumps shall comply with SPS 503.

5.9 Radial-Split Drywell Sewage Pumps

5.9.1 Applications

Radial-split drywell sewage pumps are used for general pumping of sewage for major drywell sewage pump station applications.

5.9.2 Features

The following list summarises the pertinent features of radial-split centrifugal pumps:

(a) Engineered pumps;
(b) Radial-split casing;
(c) Back pull out (BPO);
(d) Single stage;
(e) Double volute (for large sizes);
(f) Single entry impeller;
(g) Overhung impeller e.g. single bearing;
(h) Squat with bridge style bearing housing (for large sizes);
(i) Mechanical seal (preferred);
(j) Long coupled;
(k) 4 pole speed maximum.

5.10 Axial-Split Drywell Sewage Pumps

5.10.1 Applications
Axial-split drywell sewage pumps are used for general pumping of sewage for major drywell sewage pump station applications (where preferred radial-split back pullout pumps are not available). Consideration should be given to the selection of a pump with favourable shaft stiffness, which is generally a weakness in this generation of pump because of their inherently large impeller overhang.

5.10.2 Features
The following list summarises the pertinent features of vertical end suction axial-split centrifugal pumps:
(a) Engineered pumps;
(b) Axial-split casing;
(c) Single stage;
(d) Single entry impeller;
(e) Overhung impeller e.g. single bearing;
(f) Long style bearing housing (for large sizes);
(g) Mechanical seal (preferred);
(h) Long coupled;
(i) 4 pole speed maximum.

5.11 Radial-Split versus Axial-Split Sewage Pumps

5.11.1 General
Traditionally the Corporation has preferred axial-split sewage pumps because it was considered they offered advantages over radial-split pumps. However more recent operational experience has not supported this, which has now led to a preference for the radial style pump for the reasons outlined in the following.

5.11.2 Axial-Split Pump Disadvantages
Axial-split pumpsets tend to have disadvantages, which should be considered by the Designer as detailed in the following:
(a) They generally require motor removal to enable lifting of the rotating element if the pump is not fitted with a lifting trolley and rails;
(b) They require the casing cover to be removed horizontally followed by the rotating element, which then has to be lifted vertically around the pump casing which produces a higher degree of difficulty when compared to the radial-split pump;
(c) They requires removal and reassembly of a significant number of components compared with relatively few components for the radial-split pump;
(d) The axial-split pump casing cover bolts around the vertical flange are more difficult to access compared with the horizontal ring of bolts that are set at a more convenient working height for the radial-split pump;
(e) Removal of the casing cover for the axial-split pump does not allow rag clumps to be readily accessed in the body as does the radial-split pump when lifted from the volute casing;

(f) Seal rings may be crushed when reassembling the axial-split pump whereas the BPO radial-split pump drops back simply on a spigot location;

(g) The main reason for removal of the rotating element is due to ragging. This problem is caused by clumps of rags forming in the wetwell which become lodged in the bellmouth and the impeller eye during pump operation. Although it is not a frequent occurrence it does occur and radial-split pumps generally take about half the time to de-rag e.g. 4 to 5 hours compared to axial-split pumps at approximately 8 hours;

(h) Scheduled maintenance should normally involve complete pump removal as the casings should be checked for wear and reinstatement of coating and in this instance there would be no advantage either way. Where only rotating elements are to be removed for servicing all of the above comments apply and the radial-split pump would take less time;

(i) Axial-split pumps are not of a squat design and because of their long vertical profile tend to suffer from increased vibration compared to the latest generation of squat radial-split pumps.

5.12 Drywell Sewage Pump Design

Designers should embody the following features in specifications for large sewage pumpsets e.g. >1500 L/s. These features are consistent with the latest generation of radial-split sewage pumps.

5.12.1 Pump Casing

The pump casing should embody:

(a) Vertical orientation, radial-split casing, back pull out type, end suction centrifugal pump;

(b) A robust double volute casing and mounting, designed to withstand high shaking forces and vibration;

(c) A casing designed to position the impeller as low as possible to optimise NPSHa;

(d) A bridge type bearing housing supported by the casing feet designed to reduce overhang and therefore shaft deflection;

(e) Generous sized hinged access doors incorporated into the pump volute casing and suction bend for inspection purposes and clearance of blockages;

(f) Adjustable wear rings compensate for wear from the passage of sand in the system

(g) High-pressure water flush into the impeller/casing seal ring area in order to reduce ingress of abrasives.

5.12.2 Pump Shaft, Mechanical Seal and Bearings

The pump shaft assembly should embody:

(a) A stiff pump shaft which is able to withstand severe out-of-balance forces when passing significant objects. Shaft stiffness ratio should be less than 0.1 mm⁻¹. For further information on the shaft stiffness ratio refer to the Engineering Definitions and Relationship section of DS 31-01;

(b) A minimum distance from the impeller to the lower bearing to reduce shaft deflection, and associated whirling and vibration, which would impact adversely on bearings and shaft sealing;

(c) Split mechanical seals in lieu of packed glands in order to eliminate shaft sleeve wear and facilitate quick seal maintenance (e.g. without having to strip the pump);

(d) Conservatively sized roller-type bearings to withstand extreme shaking forces and vibration with a minimum L 10 design life of 100,000 hours;
5.12.3 Impeller
The impeller should embody:
(a) A large throughlet size in order to pass significant sized objects e.g. minimum of approximately DN 200;
(b) Balance vanes on the impeller that are more tolerant of erosion than other forms of balancing such as seal rings with either impeller balance holes or balance pipes;

5.12.4 Transmission
The pump drive transmission should incorporate a torque limiting coupling to protect overtorquing of transmission shafting.

5.12.5 Foundation Block
Pumpset foundation block design should accommodate a separate mounting for the electric motor at another floor level in order to reduce the foundation block mass and eliminate forces being imparted to the pump casing.

5.13 Drywell Sewage Pump Materials
Basic materials for drywell sewage centrifugal pumps are shown in the following table and are the minimum standard and grade acceptable. Alternative materials to those listed may be used providing they are equivalent in performance particularly with respect to strength, corrosion-resistance and durability.

NOTE: Submersible sewage pump material standards and grades are contained in SPS 503.

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Standard</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casings</td>
<td>Grey cast iron</td>
<td>AS 1830</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Ductile iron</td>
<td>AS 1831</td>
<td>ISO/JS/400-15V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/JS/500-7V</td>
</tr>
<tr>
<td>Casing wear ring³</td>
<td>Leaded tin bronze</td>
<td>AS 1565</td>
<td>C93500</td>
</tr>
<tr>
<td>Impeller and wear ring³</td>
<td>Phosphor bronze</td>
<td>AS 1565</td>
<td>C90250</td>
</tr>
<tr>
<td>Shaft</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>431</td>
</tr>
<tr>
<td>Shaft bearing locknuts</td>
<td>Carbon steel</td>
<td>1443</td>
<td>N/A</td>
</tr>
<tr>
<td>Seal plate studs</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>Mechanical seal¹:</td>
<td></td>
<td></td>
<td>(Refer components below)</td>
</tr>
<tr>
<td>• Stationary face</td>
<td>Solid silicon carbide</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Rotating face</td>
<td>Solid silicon carbide</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>• Drive keys</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>• O-rings</td>
<td>EPDM, NBR, FPM</td>
<td>AS 1646</td>
<td>70 IRHD</td>
</tr>
<tr>
<td>• Flange</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>316</td>
</tr>
<tr>
<td>• Springs</td>
<td>Hastelloy C®</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Seal plate stud nuts</td>
<td>Leaded gunmetal</td>
<td>AS 1565</td>
<td>C83600</td>
</tr>
<tr>
<td>Fitted studs²;</td>
<td>Stainless steel</td>
<td>ASTM A276</td>
<td>431⁴, 316⁴</td>
</tr>
<tr>
<td>Fixing and fitted bolts, forcing screws and dowels²;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts for fixing and fitted studs and bolts²</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Component | Material | Standard | Grade  
--- | --- | --- | ---  
Water thrower | Rubber | AS 1646 | 70 IRHD  
Internal coating | | |  
External coating | | Coatings shall comply with the Pump Coatings table of DS 30-02  

NOTES:
1. For information relating to mechanical seals refer to the Seals – Mechanical section contained in DS 30-02.
2. Stainless steel fasteners shall comply with the requirements contained in the Fastener section of DS 30-02.
3. Casing wear ring and impeller wear ring combinations shall be selected in dissimilar materials to avoid the potential of galling.
4. Refer to Stainless Steel Fasteners and Galling contained in DS 30-02.

5.14 Sewage Pump Pressure Ratings

5.14.1 General
The pump pressure rating should align with the pressures as shown in the following table.

<table>
<thead>
<tr>
<th>Pump Condition</th>
<th>Pressure Rating - kPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Working Pressure</td>
<td>1400</td>
</tr>
<tr>
<td>Hydrostatic Test Pressure</td>
<td>2100</td>
</tr>
</tbody>
</table>

5.14.2 Reduced Hydrostatic Pressure for Sewage Pumps
There may be a special case for reducing the casing hydrostatic test pressure for sewage pumps where the system pressures are considerable below the flange class rating. This would normally only apply to sewage pumps e.g. maximum head 35 m and flange rating for the pump is PN 14. In this instance the hydrostatic test pressure could be reduced to say 1400 kPa which would give a 4:1 safety factor providing of course the pump was not subject to upgrading to higher heads in the future. Approval of the Corporation shall be sought under these circumstances.

5.14.3 Sump Pumps
For information related to sump pumps for use in major sewage pump stations refer to the Water Pumps section of this Standard.
6  WATER AND SEWAGE PIPEWORK

6.1  General

Manifolds and associated offtake pipework generally form part of the pipework for major water pump stations. Sewage pump stations other than follow-the-flow generally utilize a separate suction bell mouth and suction offtake pipework, and discharge pipework that connects directly into the rising main.

NOTE: Offtake pipework refers to individual pump suction and discharge pipework.

6.1.1  Pipework Design Parameters

(a) Manifolds and offtakes shall be sized for the flow velocities specified in the table of flow velocities below;
(b) As a general guide the overall pressure drop across the pump station should not exceed ~1.5 m;
(c) Friction losses through the pump station shall be calculated using the appropriate resistance coefficient \( (K) \) factors for the pipework e.g.:

\[
h_f = K \frac{V^2}{2g}
\]

(Refer Definitions in DS 30-01 Glossary)

NOTE: \( K \) values are available from published pipework tables in pipe manuals.

6.1.2  Flow Velocities

As a general rule the maximum average flow velocities should be as shown in the following table.

<table>
<thead>
<tr>
<th>Manifold, Offtake and Other Pipework</th>
<th>Maximum Velocity m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction</td>
<td>1.5</td>
</tr>
<tr>
<td>Discharge</td>
<td>2.5</td>
</tr>
<tr>
<td>Bellmouth rim</td>
<td>1.1</td>
</tr>
<tr>
<td>Dam inlet screens</td>
<td>( \leq 0.3 )</td>
</tr>
</tbody>
</table>

6.2  Manifold and Offtakes

6.2.1  General

As mentioned suction and discharge manifolds are generally associated with water pump stations however where applicable the following shall apply to both water and sewage pump stations:

(a) Manifolds and offtake connection sizes should be designed to cater for the ultimate pump station duty;
(b) Manifolds should incorporate offtake tees and flanges with blank flange fitted for future pumps to be installed for the ultimate pump station capacity;
(c) Offtakes and pipework should be located above the floor level with all valves and fittings accessible for operation and maintenance. Valves and heavy pipework shall be individually supported.
(d) Discharge offtakes shall not connect to the underside of a sewage discharge manifold, which could otherwise cause passing solids to settle and clog the offtake.
(e) Manifolds and offtake pipework shall be designed to eliminate pockets that could trap air or gas. Pipework that may be vulnerable to air or gas entrainment shall be provided with either an air...
release and vacuum break valve (for water) complying with SPS 200 or a sewage air release and vacuum break valve complying with SPS 201.

(d) Where bypass pipework around the pump station is required it should be located outside the pump station and may be buried depending upon the non-return valve type to be used e.g. acceptable for non-slam or dual plate but not swing check;

(e) Manifolds and offtakes shall be positively restrained with appropriately sized thrust blocks to resist hydraulic forces and temperature effects. Restraint of Sintakote coated manifolds shall take into account the low coefficient of friction of the coating material.

6.2.2 Suction Pipework

(a) Suction pipework shall be designed to minimise swirling (and associated additional headloss) e.g. it should present as uniform a flow profile as practicable to the pump suction;

(b) Suction offtakes to the pumps should be at least one pipe size greater than the pump suction nominal diameter;

(c) Suction offtakes shall provide a straight pipe approach to the pump;

(d) Suction offtakes shall provide a minimum flow disturbance (valves etc) to the pump suction;

(e) Suction offtakes shall not be connected to the horizontal centerline (side) of the suction manifold. This is because of the potential for an air pocket to form along the top of the suction manifold at a level above the top of the offtake. The preferred method of side connection would be to locate the top of the offtake in line with the top of the manifold to eliminate air pocket formation. Alternatively the offtake could be located on the top of the manifold which is the most common configuration;

(f) "Y" type offtake connections ideally should be provided on the suction manifolds for major pump stations. "Y" type branch connections from the manifolds are preferred to 90° bends in order to reduce hydraulic losses;

(g) Ideally there should be no bends in the suction offtakes downstream of the Y connection as they produce an uneven flow profile. Also there shall be no bends at 90° to another bend (combination of horizontal and vertical displacement results in corkscrew flow into the pump suction which is undesirable);

(h) Suction manifolds should ideally be located outside the pump station building and installed below ground to minimise pump station width and associated cost;

(i) Suction isolating valves shall be fitted in:

(ii) the suction manifold upstream of the first offtake in order to isolate the pump station;

(iii) offtake pipework upstream of the pump, either inside or outside the building depending upon client preference;

(iv) accordance with the Valves section of this Standard.

6.2.3 Delivery Pipework

(a) Delivery manifolds for minor pump stations should generally be located outside the building in order to reduce building size and cost. However for major pump stations the delivery manifold may be located adjacent to or under the switch room floor where it spans the discharge side of the building;

(b) Designers ideally should allow provision of "Y" type branch connections on the delivery manifolds for major pump stations. "Y" type branch connections from the manifolds are preferred to 90° bends in order to reduce hydraulic losses;

(c) Discharge isolating valves shall be fitted in the delivery manifold downstream of the last offtake (in order to isolate the pump station) and also in the offtake pipework immediately downstream of the non-return valve. The discharge isolating valves downstream of the non-
return valves shall be located inside the pump station to facilitate ready adjustment when conducting pump tests;

(d) Discharge non-return valves shall be fitted in the offtake pipework downstream of the pump discharge;

(e) Valves shall be in accordance with the Water and Sewage Valves section of this Standard.

6.2.4 Pipework Materials of Construction

Manifolds and offtake pipework shall be manufactured from MSCL pipe in accordance with the requirements of DS 31-01.

Thin walled stainless steel shall not be used for manifolds and offtakes because of its inherent flexibility and difficulty to restrain hydraulic forces and also because of its susceptibility to cracking due to presence of chlorides in the water.

6.2.5 Pipework Tapping Points

A DN 100 tapping point fitted with a resilient seated sluice valve in accordance with SPS 272 shall be provided on the top of each suction and delivery manifold for major pump stations. Further tapping points shall be provided in suction and delivery manifolds and offtakes to accommodate condition monitoring and protection devices as specified in the Condition Monitoring and Protection section of this Standard.

6.2.6 Thermodynamic Pump Testing Tappings

A direct thermodynamic (Yatesmeter or equivalent) pump performance monitoring system and tapping points shall be provided for a direct thermodynamic test probe for all water and sewage pumps which are 50 kW or larger with a total head greater than 20 m, or pumps that run continuously for long periods of time.

Accordingly where required thermodynamic pump test tapping points shall be provided as follows:

(a) A single tapping button shall be provided 2 pipe diameters upstream of the pump suction flange and 2 pipe diameters downstream of the pump discharge flange. The tapping position can be on the top or the side of the pipe;

(b) The tapping shall be ½” BSP or larger fitted with a bronze or stainless steel nipple, and a bronze gate valve complying with AS 1628. The pipework shall be drilled with a minimum 13 mm diameter hole, which shall be concentric with the tapping button;

(c) A minimum distance of 730 mm from the nearest external obstruction to the pipe surface opposite the tapping shall be provided for fitting the Yatesmeter probe. There shall be a 100mm external clearance between the centre of the tapping and any obstruction upstream or downstream of the tapping (including any bolts on the flange);

(d) For pressures in excess of 100 m the Corporation should be consulted because thermowells may have to be fitted into the tapping points. This is to eliminate the possibility of the probes being projected out of the tapping points under high pressure.

6.2.7 Pipe Flanges

Flanges shall comply with the requirements of the Flanged Connections section of DS 31-01.

6.2.8 Flange Fasteners

Flange fasteners and bolting shall comply with the requirements of DS 38-03.

6.2.9 Gaskets and O-rings

Gaskets and O-rings shall comply with the requirements of the Flange Gaskets section of DS 31-01.
6.2.10 Pipework Dismantling Joints

Pipework dismantling joints and couplings shall be fitted to pumps in major pump stations as outlined in the Dismantling Joints section of DS 31-01.

6.2.11 Pipework Supports and Restraints

Pipework supports shall comply with the requirements of the Pipework Supports section detailed in DS 31-01 and the following.

Manifolds shall incorporate all restraints necessary to withstand hydraulic forces imposed by the pump and valves and maximum anticipated pressure surges.

The pump shall not be used as a restraint for hydraulic or mechanical loads e.g. taking thrust loading or for supporting pipework and valves.

Proprietary flanged adaptors incorporating tie bolts are available e.g. TEEKAY AXIFLEX.

6.3 Reducers

(a) Abrupt changes in manifolds and offtakes shall be avoided. Changes in pipe size shall be undertaken using tapered reducers in order to minimise hydraulic losses. Ideally the tapered reducer should have an included angle of between 10° to 15°;

(b) All horizontal or near horizontal reducers for the suction pipework shall be of level overt eccentric type in order to prevent the formation of air pockets;

(c) Discharge pipework reducers should normally be of concentric type. Other options may be acceptable but approval from the Corporation shall be obtained prior to inclusion in the design.

6.4 Bends

Long radius bends shall be used in suction and delivery pipework. Formed 90° bends have significantly higher losses than long radius bends and should not be used.

6.5 Bellmouths

(a) Bellmouths shall be designed to cater for the ultimate pump station duty as future upgrading would require major works to replace with a larger one;

(b) Horizontal intakes should incorporate a vortex suppressor;

(c) Horizontal intakes shall incorporate a suction bellmouth as follows:
   (i) the bell shall face downwards;
   (ii) the bellmouth bend shall be long radius;
   (iii) bellmouth rim shall be 1.5d (where d = pipe DN);
   (iv) submergence of rim shall be 1.5D (where D = rim diameter);
   (v) distance of rim above floor shall be 0.5D;
   (vi) the bellmouth entry (rim) velocity shall not exceed 1.1 m/s.

(d) For very large pump suctions, draft tubes should be considered.

6.6 Inlet Screens (Dams)

The ‘through velocity’ for screens or strainers shall comply with the Maximum Recommended Flow Velocities Table shown previously in this section of the Standard, in order to prevent debris being attracted and retained on the screen face.
7 WATER AND SEWAGE VALVES

This section of the Standard provides a guide to the selection of valve types for different applications specific to a pump station. For further detailed information on valves refer to DS 31-02.

7.1 Isolating Valves

Isolating valves shall be used for isolating the pump station or individual pumps or pipework ancillaries such as flowmeters to enable maintenance shutdowns. Large isolating valves should be used for open or closed service only and should be operated against balanced head (no flow) conditions e.g. with the pump shut down.

7.1.1 Manifolds and Pipework Valves

The following valve requirements shall apply to pump station manifolds and pipework:

(a) Manifold isolating valves shall be provided on suction (normally water pump stations) and discharge manifolds in order to isolate the pump station from the system e.g. water booster pump stations;

(b) The suction manifold isolating valve (normally water pump station) shall be full size unless downsizing does not adversely affect the pump NPSH performance;

(c) The suction isolating valve shall be fitted to the upstream side of the eccentric reducer and not directly to the pump suction flange. Accordingly suction isolating valves shall be sized for the pump suction reducer larger flange;

(c) Butterfly valves shall not be located within 3 - 5 pipe diameters of the pump delivery flange or any turbulence generator in order to avoid disc flutter;

NOTES:

1. Butterfly valves tend to act as flow straighteners (not relevant for sewage pump stations) but have a higher K factor than a sluice valve e.g. 0.3 versus 0.1 respectively

2. Discharge manifold isolating valve may be downsized to a maximum of 75% of the manifold diameter providing the losses do not impact adversely on the design or operating costs. However the extra costs associated with fitting reducers either side of the valve generally negates the cheaper downsized valve cost.

7.1.2 Water Pump Station Valves

Water pump station isolating valves shall be either ductile iron gate valves conforming to SPS 271, or SPS 272, or double flanged butterfly valves for waterworks purposes conforming to SPS 261 and the following:

(a) An isolating valve shall be provided on each pump suction offtake and on the downstream side of each non-return valve on the pump discharge pipework;

(b) Isolating valves shall be termination style e.g. double flanged to allow removal of the pump or non-return valve. Wafer style isolating valves shall not be used.

NOTE:

1. Use of general purpose butterfly valves (terminating lugged style) complying with SPS 260 is permissible but should be restricted to small minor pump stations and small submersible borehole pump headworks e.g. ≤ DN 150.

2. Gate valves are generally cheaper than butterfly valves up to approximately DN 500 after which butterfly valves tend to be cheaper. However gate valves are relatively bulky and heavier than equivalent butterfly valve sizes.

7.1.3 Sewage Pump Station Valves

Isolating valves for sewage pump stations shall conform to the following requirements:

(a) Gate valves for sewage pump stations shall conform to SPS 271 or SPS 272;
7.1.4 Bypass Valves
Where bypass valves are required they shall comply with the Bypass Valves section of DS 31-02.

7.2 Non-return Valves

7.2.1 General
Non-return valves shall be located the minimum distances downstream of pumps or turbulence causing devices as specified in DS 31-02 for the particular non-return valve type. The downstream distance is expressed in pipe diameters and varies for different non-return valve types. A non-return valve shall be provided downstream of a pump discharge as detailed in the following.

7.2.2 Water Pump Station Valves
The Designer shall consider the following when selecting water pump station valves:

(a) Cast iron swing check non-return valves conforming to SPS 223 should be used where extended shafts are required and where low response to reverse flow is acceptable.

NOTE: Tilting disc non-return valves shall not be used because of problems with their use as outlined in DS 31-02.

(b) Dual plate non-return valves are the most common non-return valve used in Corporation water pump stations (where hydraulic conditions dictate). They should be used for applications requiring rapid response to reverse flow conditions (providing extended shafts are not required). Dual plate non-return valves shall conform to SPS 226.

(c) Non-slam non-return valves are commonly used in Corporation major water pump stations where dictated by hydraulic transient analysis. They have a superior non-slam performance than dual plate non-return valves. Performance of non-slam non-return valves shall be based on deceleration values obtained from the hydraulic transient analysis in order to determine the appropriate spring closure rate. Non-slam non-return valves shall comply with SPS 230.

(d) Dual plate and non-slam non-return valves may be buried to avoid pit costs where circumstances are favourable e.g. bypass line around a pump station or in a pipeline external to the pump station.

(e) For further design information with respect to the above valves refer to the relevant parts of DS 31-02.

7.2.3 Sewage Pump Station Valves
The Designer shall consider the following when selecting sewage pump station valves:

(a) Cast iron swing check non-return valves shall be used in sewage pump station applications. Valves shall conform to SPS 223;

(b) The valves should not be installed in vertical sewage pipelines as they would be subject to settling of debris on the disc and therefore have a higher risk of fouling and malfunction;

(c) For very large sewage pump stations alternative non-return valves may be considered in lieu of the swing check type because of cost and availability. Alternatives such as relatively quick
closing hydraulically operated gate valves or plug valves with battery back up in the event of power failure can be used;

(d) For further design information with respect to the above valves refer to the relevant parts of DS 31-02.

NOTE: Dual plate, non-slam or tilting disc non-return valves shall not be used in sewage applications, as they would be subject to fouling and subsequent malfunction.

7.2.4 Pipework Drain Valves

Drain valves shall be fitted in sewage suction and discharge pipework downstream and upstream of the isolating valves respectively. For large pipework the discharge drain valve should be able to dump as much as possible back into the wet well.

7.3 Air Vent Valves

Manual air vent valves shall be provided on pumps that don’t naturally vent. This is in order to release accumulated air particularly during initial priming during commissioning or after servicing. Automatic air vent valves shall be provided if accumulation of air or gas is an ongoing problem.

7.4 Backflow Prevention Devices

Backflow prevention shall be addressed in accordance with the Backflow Prevention Devices section of DS 31-02.
8 VACUUM SEWAGE PUMP STATIONS

8.1 General
Vacuum sewage pump stations shall comply with the relevant requirements of this Standard, the WSA 06 Code and the following.

8.2 Building
Buildings shall comply with the relevant part of the Buildings section contained in DS 30-02 and provision of the following:

(a) Noise attenuated inlet and outlet ventilation that limits the internal temperature in accordance with the Buildings - Ventilation section contained in DS 30-02. Noise attenuation shall comply with the neighbourhood noise levels at the site boundary taking into account future growth and type of development in accordance with the Noise section contained in DS 30-02;

(b) Double doors for vehicle tray access fitted with an emergency crash barrier and manufactured from double skinned foam filled colorbond steel or equivalent for acoustic attenuation. The double doors should not face the prevailing weather side;

(c) A manually operated overhead travelling gantry crane sized to span all equipment in accordance with the Materials Handling section of WSA 06. Monorails and roof mounted hooks shall not be used.

**NOTE:** Monorails and roof mounted hooks are unsatisfactory being unwieldy and cumbersome to use requiring multi lifts and dragging of equipment and they don’t span all equipment.

(d) An area immediately inside the double doors sufficient to allow entry of a vehicle tray (1 tonne) to facilitate loading of equipment via the crane and sufficiently wide to allow passage of personnel past the vehicle.

8.3 Vacuum Tank
In addition to the requirements of WSA 06 the following requirements shall apply to the vacuum tank:

(a) Horizontal stainless steel tank in accordance with ASTM A240M grade 316;

(b) Access to the tank is a confined space issue. For top access the tank shall be designed to facilitate entry via personnel lifting equipment or by using the gantry crane. Side access may be more efficient from a cleaning perspective;

(c) The drain in the bottom of the tank shall be a DN 200 minimum outlet fitted with DN 200 gate valve located in the area where the solids are deposited as per the WSA 06 requirement;

(d) The vacuum tank shall be provided with a pump-out connection and associated pipework.

8.4 Vacuum Pumps
Vacuum pumps are detailed in the Vacuum Pumps section of this Standard.

8.5 Sewage Pumps
Sewage pumps used for removal of sewage from the vacuum tank shall comply with the Submersible Sewage Pumps section of this Standard and the following:

(a) Sewage pumps shall be of the submersible sewage type rated continuously for drywell operation;

(b) Sewage pumps shall have low NPSHr. Pre-frontal screw centrifugal pumps are preferred as they have demonstrated acceptable performance in terms of cavitation and vibration;
(c) Sewage pumps should be fitted with electrical de-contactors located above pump station floor level.

8.6 Pipework

Pipework shall be designed in accordance with the requirements contained in WSA 06, DS 31-01 and the following:

8.6.1 General

The Designer shall ensure that for all pipework used in the vacuum sewage station:

(a) The pipe material is compatible with the service conditions e.g. temperature, corrosion etc;
(b) Dismantling joints are provided where required to facilitate removal of pumps, valves and ancillary equipment.

8.6.2 Vacuum Pump Pipework

Pipework for vacuum pumps shall be designed for minimal dismantling prior to removal of pumps. Vacuum pump pipework including isolation and non-return valves shall not be located directly above the pumps which could interfere with pump removal.

8.6.3 Vacuum Tank Pipework

Vacuum tank emergency pump-out pipework shall be brought to the surface outside the station and located for access by a road tanker.

8.6.4 Sewage Pumps Pipework

Pipework for the sewage pumps shall be designed for minimal dismantling prior to removal of the pumps. Sewage pump isolation valves, non-return valves and ancillary piping shall not be located directly above pumps which could interfere with pump removal.

Discharge pipework for the sewage pumps shall be vertically oriented immediately downstream of the discharge isolating valve to facilitate access around the pumps.

8.6.5 Make-up, Seal, Reject and Overflow Water Pipework

It is important that liquid ring vacuum seal and cooling water pipework is properly configured and accordingly it shall comply with the following:

(a) A service water pipe shall be connected to the make-up water tank via a high level inlet fitted with a float valve on the downstream side;
(b) A pipeline shall be connected from the make-up water tank low level outlet to the vacuum pump to provide sealing and cooling water. A non-return valve shall be fitted in the pipeline upstream of any recycled water connection from the water separator to prevent reverse flow of gas back into the make-up water tank;
(c) The service water pipe shall also be connected to each vacuum pump via a common manifold pipe in order to provide flushing water to the mechanical seals. The mechanical seal flushing pipework shall be configured as follows:
   (i) A pressure switch shall be fitted in the common pipe manifold upstream of the vacuum pump seal flushing offtakes to provide shutdown protection in the event of disruption to the service water supply,
   (ii) An isolating solenoid valve shall be located immediately downstream of each vacuum pump seal flushing offtake. The solenoid valves shall be configured to open 20 seconds prior to starting the vacuum pumps in order to allow pre-flushing of the seals;
(d) Where required a recycled water pipe shall be connected from the gas/water separator to the vacuum pump cooling water pipe downstream of the non-return valve mentioned above and shall incorporate a throttling valve;

(e) A low level reject water and gas pipe shall be connected from the vacuum pump to the gas/water separator (vacuum pump discharge pipework);

(f) An overflow pipe shall be connected from the make-up water tank to the basement sump. The invert of the overflow outlet shall be set at the vacuum pump shaft centerline;

(g) An overflow pipe shall be connected from the gas/water separator to the basement sump fitted with the S-trap. The invert of the overflow outlet shall be set at the vacuum pump shaft centerline.

8.6.6 Gas/Water Separator Outlet Size

An outlet which is one size larger than the vacuum pump discharge outlet shall be provided at the top of the gas/water separator column when more than one pump is required to operate at a time. This is to prevent problems such as excessive backpressure and noisy resonance.

8.6.7 Pipework Drains

In order to facilitate drainage of the condensate, grading of the vacuum lines shall be provided as appropriate.

8.7 Valves and Appurtenances

Valves and magnetic flowmeters shall be designed in accordance with the requirements contained in WSA 06, DS 31-02 and the following:

8.7.1 Vacuum Pipework Valves

Valves for vacuum pipework shall comply with the following requirements:

(a) Vacuum tank inlet isolating valves shall be either electrically operated or preferably ¼-turn lever-operated eccentric plug valves in order to speed up closure, which can be very time consuming e.g. for stations with up to 6 inlet lines;

   NOTE: Plug valves are available in manual lever operation to DN 200 inclusive. For sizes above this they are fitted with gearboxes e.g. DN 250 has 16 turns open-to-close.

(b) Vacuum pump isolating valves shall be lugged lever-operated general purpose butterfly valve complying with SPS 260. Isolating valves of the termination style shall be supplied for each vacuum pump so that vacuum pumps can be removed for service without interrupting the system;

(c) Vacuum pump non-return valves shall be dual plate wafer style in accordance with SPS 226;

(d) A DN 50 sewage vacuum interface valve shall be used to drain the basement level sump and shall be located at the upper level.

8.7.2 Sewage Pump Pipework Valves

Valves for sewage pump pipework shall comply with the following requirements:

(a) The pump suction and delivery isolating valves shall be resilient seated gate valves complying with SPS 272;

(b) The pump delivery non-return valves shall be of the swing check resilient flap type complying with SPS 223.

8.7.3 Vacuum Interface Valves

Vacuum interface valves used in the collection chambers shall be DN 80 complying with SPS 245.
8.7.4 Magnetic Flowmeter
The magnetic flowmeter with downstream isolating valve and dismantling joint shall be located in the pump station to obviate pit costs or direct burial.

8.8 Condition Monitoring, Protection and Instrumentation
Condition monitoring, protection and instrumentation shall be provided in accordance with the relevant parts of DS 30-02 and the following:

8.8.1 Condition Monitoring and Protection
The following condition monitoring and protection equipment shall be provided:
(a) Vacuum pump continuous running alarm;
(b) Low vacuum alarm;
(c) High vacuum tank sewage level alarm;
(d) Vacuum pump fault alarm;
(e) Sewage pump fault alarm;
(f) High vacuum tank sewage inhibit alarm and protection;
(g) Feedwater failure alarm and protection;
(h) Pump low flow/no flow (undercurrent) protection;
(i) Rotary vane exhaust filter pressure gauge monitor and alarm (as applicable);
(j) Rotary vane low oil level protection (as applicable).

8.8.2 Instrumentation
The following instrumentation shall be provided:
(a) Vacuum gauges on each vacuum tank inlet pipe;
(b) Vacuum gauge from vacuum pump suction manifold;
(c) Gauge tapping on the vacuum pump exhaust manifold to monitor backpressure;
(d) Multitrode or Vega (radar) level sensing equipment for the vacuum tank;
(e) Rotameter fitted to each liquid ring vacuum pump pipework to verify water seal flow rate;

8.9 Access
Stairways, walkways, landings and ladders shall comply with the relevant section contained in DS 30-02 and the following:
(a) A stairway shall be provided for access to the basement level and not a vertical rung-type ladder;
(b) Overhead access to the vacuum tank inlet valves and vacuum tank top shall be provided regardless of whether they are electrically actuated. Access shall be via an expanded metal walkway extended at the upper level and not by having to descend to the basement level and then climb steps up to the valves;
(c) Removable panels are required to access all vacuum tank top equipment and nozzles e.g. Multitrode and manhole etc;
(d) Access shall be provided around the sewage pumps without having to climb over pipework;
(e) A minimum clearance of 600 mm shall be provided around the back end of the vacuum tank;
(f) All mechanical and electrical operational equipment shall be readily accessible e.g. alarm diallers.

(g) An upper level self-closing gate shall be provided in the handrail to facilitate removal of equipment from the basement e.g. the sewage pumpsets. The gate shall incorporate provision for bolting closed when not in use which would be most of the time.

8.10 Standby Generating Set

Where required a standby generating set shall be located outside the building in a sound, weather, and vandal proof enclosure, and in accordance with the WSA 06 and the Generator section of DS 35.

8.11 Odour Control

The requirements for odour control shall comply with WSA 06 except for the biofilter which shall be an ODOURRIDER™ type. The biofilter shall be sized for the ultimate pump station duty.

8.12 Identification of Equipment and Hazards

All hazard signage and equipment identification shall be provided.

8.13 Pump Station Facilities

In addition to the facilities specified in WSA 06 the following shall be provided within the pump station:

8.13.1 Toilet

Toilet facilities complying with the requirements contained in WSA 06 shall be provided in the pump station unless otherwise specified by the client;

8.13.2 Work Bench

The workbench referred to in WSA 06 shall be 1500 mm x 750 mm minimum size and equipped with vacuum sewage valve repair and test facilities.

8.14 Materials and Corrosion

Materials used in contact with the process fluids and gases shall be compatible and corrosion resistant and shall comply with the relevant Materials and Corrosion section contained in DS 30-02.

8.15 Lighting

Internal lighting shall comply with the relevant part of DS 22. External lighting shall be provided above the pump station entrance door, generator set and biofilter.
9 VACUUM PUMPS

9.1 General

Vacuum pumps (referred to as Generators in WSA 06) shall comply with the following requirements and WSA 06. The Corporation uses the liquid ring, rotary vane and multi-claw vacuum pump types in its vacuum sewage pump stations, and the requirements of each is covered in the following.

9.2 Selection

Selection of a particular type and brand of vacuum pump should take into account the following factors:

9.2.1 Water Availability and Quality

Water availability and quality requires consideration as they could determine the appropriate type of vacuum pump that should be used:

(a) Water availability may be an issue for liquid ring type vacuum pumps;
(b) Water usage rates for liquid ring type vacuum pumps vary considerably;
(c) Temperature of water can be an important factor for liquid ring type vacuum pumps;
(d) Quality of water which can be an important factor for flat port liquid ring type as water containing >50 mg/L CaCO₃.

9.2.2 Life-Cycle Costing

Net Present Value and O&M costs can show considerable variance between the different types and different sizes of vacuum pumps.

9.2.3 Air/Water Ratio

Vacuum pump sizing based on 6:1 air to water ratio tends to be too small especially when multiple valve failure occurs which tends to overwhelm the pump performance and prevent a second valve firing. Accordingly 10:1 air to water ratio is considered more realistic.

9.2.4 Oil Carryover

The potential for oil carry-over from the rotary vane vacuum pump type causing adverse effects on odour scrubbing bacteria.

9.2.5 Warranty

Warranty may also be a factor in considering a particular pump’s suitability (3 years on the cone type vacuum pumps versus 12 months for others).

9.3 Operating Range

For vacuum sewerage systems the vacuum pump operating range generally covers flows of 100 m³/h to 1000 m³/h between vacuum set points of -50 kPa to -80 kPa.

9.4 Liquid Ring Vacuum Pumps

The liquid ring vacuum pump basically comprises a rotor, which operates in a body partially filled with a sealing liquid. The rotor incorporates a series of vanes and is offset from the body axis. Water is introduced and forms a sealing ring around the pump body with the rotor vanes due to the centrifugal force imparted by the rotor. During a single rotation liquid fills then nearly empties each rotor chamber formed by the rotor vanes and this produces a pumping action due to the offset axes. Vacuum inlet and atmospheric discharge ports provide flow paths for admission and exhaust of the gas mixture.
being transported. Heat formed during compression is dissipated into the liquid and some of the liquid discharges through the exhaust. Makeup water replaces water losses to the exhaust. Liquid ring vacuum pump performance is sensitive to elevated sealing water temperatures. The efficiency degrades with elevated water temperatures. The Corporation uses two types of liquid ring vacuum pumps namely flat-sided rotor pumps and conical rotor pumps.

9.5 Flat-Sided Rotor Vacuum Pumps

9.5.1 Features
This type of vacuum pump rotor incorporates a precision, flat side at one end, which runs with a close clearance adjacent to a precision, flat stationary porting plate fitted to the body. Inlet and outlet ports in the plate communicate axially with the rotor chambers through open sides on the rotor. The rotor is supported on a shaft, which runs in antifriction bearings and sealing is achieved using a mechanical seal.

9.5.2 Advantages
Advantages of flat-sided rotor vacuum pumps are:
(a) Simple and robust with relatively few components;
(b) Have minimal wear between the rotor and body;
(c) Not affected by moisture in the gas;
(d) Low maintenance for corrosion resistant bodied types;
(e) Not subject to contamination of the exhaust which could otherwise destroy odour eating bacteria downstream.

9.5.3 Disadvantages
Disadvantages of flat sided rotor vacuum pumps:
(a) Are not as efficient as conical rotor pumps
(b) Are sensitive to elevated sealing water temperature, which causes significant reduction in efficiency. A radiator may be required for elevated seal water applications in order to provide cooling;
(c) Are sensitive to hard water and water softening may be required to treat the water to acceptable quality e.g. > 50 mg/L CaCO₃;
(d) Grit can cause wear of the port plate and rotor end;
(e) Cast or ductile iron bodies are sensitive to corrosion and require to be coated with an approved epoxy;
(f) Require a make up water system which means ongoing water usage;
(g) Have higher rates of water usage than conical rotor pumps particularly in the larger sizes;
(h) Are sensitive to backpressure, which can cause motor overloading.

9.6 Conical Rotor Vacuum Pumps

9.6.1 Features
Conical rotor vacuum pumps are reportedly tolerant of hard water up to 300 mg/L CaCO₃.

This type of vacuum pump rotor incorporates precision surfaces at the inner edges of the rotor vanes, which run with close clearance adjacent to a precision stationary-porting cone. The cone, which is located at one end combines inlet and outlet ports, which communicate almost radially with the rotor.
chambers through the conical inner open profile of the rotor. The rotor is supported on a shaft, which runs in antifriction bearings and sealing is achieved using a mechanical seal.

9.6.2 Advantages

Advantages of conical rotor vacuum pumps are:
(a) Simple and robust with relatively few components;
(b) More efficient than flat sided liquid ring pumps producing better performance and lower power requirement;
(c) No wear between rotor and body
(d) Not affected by moisture;
(e) Low maintenance;
(f) Conical ports less sensitive to wear compared to flat sided liquid ring pumps;
(g) Wetted components are available in corrosion resistant materials e.g. stainless steel body;
(h) Not subject to contamination of the exhaust which could destroy odour-minimising bacteria downstream.

9.6.3 Disadvantages

Disadvantages of conical rotor pumps are:
(a) They are sensitive to elevated sealing water temperature which causes significant reduction in efficiency. A radiator may be required for elevated seal water applications in order to provide adequate cooling;
(b) Are sensitive to hard water so that water softening may be required to treat the water to an acceptable quality;
(c) They require a make up water system which means ongoing water usage and system management;
(d) Sensitive to backpressure which can cause motor overloading.

9.6.4 Conical Rotor versus Flat-Sided Rotor Pumps

In general terms the conical rotor pump would seem to be more desirable from a technical perspective than the flat-sided rotor pump.

9.7 Liquid Ring Pump Materials

Liquid ring pump components should be manufactured from the following materials:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Standard</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td>Stainless steel</td>
<td>ASTM A351M</td>
<td>CF3M</td>
</tr>
<tr>
<td>Heads</td>
<td>Stainless steel</td>
<td>ASTM A351M</td>
<td>CF3M</td>
</tr>
<tr>
<td>Rotor</td>
<td>Gunmetal</td>
<td>AS 1565</td>
<td>C90250</td>
</tr>
<tr>
<td></td>
<td>Stainless steel</td>
<td>ASTM A351M</td>
<td>CF3M</td>
</tr>
<tr>
<td>Cones (where applicable)</td>
<td>Stainless steel</td>
<td>ASTM A351M</td>
<td>CF3M</td>
</tr>
<tr>
<td>Bearing housings</td>
<td>Cast iron</td>
<td>AS 1830</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Ductile iron</td>
<td>AS 1831</td>
<td>ISO/JS/400-15V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/JS/500-7V</td>
</tr>
</tbody>
</table>
### 9.7.1 Liquid Ring Pumpset

The vacuum pumpset shall comprise a liquid ring vacuum pump direct coupled to a 415V, 50 Hz electric motor complying with AS 1359. The motor power factor shall be >0.8 and efficiency >0.85 at ¾ load. The motor should be continuously rated for at least 120% of the duty load and 110% of the maximum load, and fitted with winding thermistors in each phase. The pump and motor shall be mounted on a baseplate in accordance with the Baseplates section of DS 30-02 and fitted with a coupling guard.

**NOTE:** Direct-coupled vacuum pumps can be removed by fitters without requiring electric motor cables to be disconnected and accordingly should be hard wired.

### 9.7.2 Seal Water Supply System

A seal water supply shall be provided comprising a backflow prevention device (for potable water supply), water softener (as required), makeup water tank, cooling water radiator (as required), flow rate rotameter, solenoid isolating valve and flow control valve. The recirculation water flow rate should be based on a water inlet temperature of 10 ºC.

### 9.8 Rotary Vane Vacuum Pumps

#### 9.8.1 Operating Principle

Operation of the rotary vane vacuum pump is based on the rotary vane principle. The rotary vane pump incorporates an eccentrically mounted rotor fitted with sliding vanes that rotates in a stator or cylinder. The eccentricity of the rotor forms a sickle shaped space and the vanes separate the sickle shaped space into chambers. The chambers facilitate air induction during one rotation and compression during the next. The exhaust passes through an oil separator returning the oil to an oil reservoir. Pressure differentials cause continual movement of oil into and out of the compression chamber to provide an oil recirculation lubrication system.

Rotary vane pumps should operate at a temperature of 80 ºC for optimal efficiency and this normally requires a run time of 20 minutes. Accordingly rotary vane pumps should not run on an alternate duty mode.

#### 9.8.2 Features

Rotary vane pumps shall incorporate the following features:

(a) An exhaust valve;
(b) An oil demister;
(c) An exhaust filter, pressure gauge and servicing alarm;
(d) Oil reservoir;
(e) Oil sight glass
(f) Oil filter;
(g) Oil mist eliminator;
(h) Oil filler and drain.
9.8.3 Advantages

The rotary vane vacuum pump doesn’t require service water and therefore is not subject to the requirement for water system components and their ongoing maintenance, water usage, high water temperature and water quality issues.

9.8.4 Disadvantages

The rotary vane pump has the following disadvantages:

(a) High operating temperature (80 °C) which has ventilation implications;
(b) Relatively high noise levels;
(c) Optimal efficiency is at –80 kPa not -60 kPa;
(d) They are complex compared with liquid ring pumps and have a relatively high number of components;
(e) Continuous wear between rotor vanes and body;
(f) It is sensitive to backpressure, which can cause motor overloading and “dumping” of lubricating oil out of pump discharge filters;
(g) It is adversely affected by moisture;
(h) Requires moisture dropout pots to trap moisture which can fail and have maintenance implications;
(i) Relatively high maintenance;
(j) Could subject the exhaust to oil contamination especially if discharge filters are not replaced at scheduled intervals or if blocked. This may destroy odour scrubbing bacteria downstream and therefore should be fitted with charcoal filters if being used in conjunction with a biofilter or compost bed;
(k) Optimal efficiency requires an operating temperature of 80 °C and this may not be readily achievable.

9.8.5 Materials of Construction

Rotary vane pumps should be manufactured from the following materials:

Table 9.2 – Rotary Vane Pump Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Standard</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td>Cast iron</td>
<td>AS 1830</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Aluminium</td>
<td>AS 1874</td>
<td>Per Standard as appropriate</td>
</tr>
<tr>
<td>Rotor</td>
<td>Carbon steel</td>
<td>AS 1448</td>
<td>-</td>
</tr>
<tr>
<td>Vanes</td>
<td>Kevlar</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Seals - Lip</td>
<td>Nitrile</td>
<td>AS 1646</td>
<td>-</td>
</tr>
<tr>
<td>Exhaust valve</td>
<td>Carbon steel</td>
<td>AS 1448</td>
<td>-</td>
</tr>
<tr>
<td>External coating</td>
<td>Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer’s standard.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

9.8.6 Rotary Vane Pumpset

The rotary vane pumpset shall comprise an air-cooled rotary vane vacuum pump direct coupled to a 415V, 50 Hz electric motor complying with AS 1359. The motor power factor shall be >0.8 and efficiency >0.85 at ¾ load. The motor should be continuously rated for at least 120% of the duty load and 110% of the maximum load, and fitted with winding thermistors in each phase. The pump and
motor should be mounted on a baseplate in accordance with the Baseplates section of DS 30-02 and fitted with a coupling guard.

NOTE: Direct-coupled vacuum pumps can be removed by fitters without requiring electric motor cables to be disconnected and accordingly should be hard wired.

9.8.7 Water Condensation Chamber

A water condensation chamber (also known as a knockout pot and moisture trap) shall be fitted upstream of the vacuum pump inlet in order to prevent condensate from entering the vacuum pump.

NOTE: The condensation chamber contains stainless steel fibre, which promotes condensation of the vapour into condensate. It is then manually drained at an appropriate frequency although the process could be automated via a solenoid valve, timer and an alarm.

9.8.8 Exhaust Pipework

Exhaust pipework on the delivery side shall be graded so that any moisture or condensate drains away from the vacuum pump in order to prevent damage. A vertical exhaust stack shall be fitted with a rain cap to prevent rain entry and possible vacuum pump damage.

9.8.9 Rotary Vane versus Liquid Ring Vacuum Pumps

The rotary vane vacuum pump generally seems to be technically less attractive compared with liquid ring vacuum pumps considering:

(a) Rotary vane pumps are vulnerable to moisture transfer into the oil causing emulsification and catastrophic failure. Moisture transfer can result from condensation or carryover due to knockout pot failure;

(b) Possibility of oil carry-over in the event that servicing is not maintained and this could cause destruction of the odour-scrubbing bacteria in biofilter or compost beds;

(c) Published noise levels are higher for rotary vane than liquid ring vacuum pumps;

(d) Rotary vane vacuum pumps run relatively hot e.g. approximately 80 °C compared to liquid ring types. This relatively high operating temperature causes an extra heat load to be imparted into the building;

(e) Rotary vane pumps operate at optimal efficiency at 80 kPa vacuum. However Corporation systems operate closer to 60 kPa and at this value they operate at a much lesser efficiency;

(f) The rotary vacuum pump is being used to operate in conjunction with an unfriendly medium compared to liquid ring vacuum pumps.

9.9 Multi-Claw Pumps

9.9.1 General

Multi-claw vacuum pumps have recently been used in vacuum sewage pump stations and this has been driven by the opportunity to address the disadvantages previously outlined that relate to the other types of vacuum pumps. Accordingly multi-claw vacuum pumps are preferred over the liquid ring or rotary vane types.

9.9.2 Features

The multi-claw vacuum pump incorporates the following features:

(a) Dry operation of compression/vacuum chamber e.g. no sealing fluid required;

(b) Close clearance rotor claws with wear-free running e.g. no sealing vanes;

(c) Corrosion resistant vacuum pump end components;

(d) Oil lubricated gearbox and cooling fan;
9.9.3 Principle of Operation

The multi-claw vacuum pump comprises two contra-rotating claw-shaped rotors which rotate in a ported compression/suction chamber. The operating claws are synchronized via precision gearing to operate without contact (frictionless) and with very tight clearances. This produces high efficiency expulsion of the air through a suction port which develops the vacuum followed by compression of the expelled air in the chamber air via internal volume reduction and ultimate discharge as the rotors pass the outlet porting.

9.9.4 Advantages

The multi-claw vacuum pump has the following features which are an advantage over the traditional vacuum pumps:

(a) Simple and robust compact;
(b) Self contained pumpset;
(c) Minimal pump-end working parts;
(d) Frictionless wear-free pump end;
(e) Dry running pump-end;
(f) High efficiency;
(g) Unaffected by moisture or temperature;
(h) Low maintenance;
(i) No oil contamination of the exhaust gas into biofilter

9.9.5 Disadvantages

It could be argued that multi-claw pumps have the added complexity and cost of the gearbox and twin rotors which could represent a disadvantage compared to the other types of vacuum pumps. Multi-claw pumps are relatively noisy compared with other vacuum pump types.

9.9.6 Materials of Construction

Multi-claw pumps should be manufactured from the following materials:

Table 9.3 – Multi-Claw Pump Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Standard</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor housing and end covers</td>
<td>Cast iron</td>
<td>AS 1830</td>
<td>250</td>
</tr>
<tr>
<td>Multi-claw rotor</td>
<td>Ductile iron</td>
<td>AS 1831</td>
<td>ISO/JS/400-15V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ISO/JS/500-7V</td>
</tr>
<tr>
<td>Shafts</td>
<td>Carbon steel</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rotor retainer</td>
<td>Carbon steel</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Retainer fastener</td>
<td>Carbon steel</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shaft O-ring seals</td>
<td>Viton®</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Silencer</td>
<td>Stainless Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal coating</td>
<td>All exposed component surfaces in the pump chamber shall be coated with molybdenum sulphate to a minimum 1.5 micron thickness.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External coating</td>
<td>Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer’s standard.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.9.7 Multi-Claw Pumpset

The multi-claw pumpset shall comprise a multi-claw vacuum pump close coupled to a 415V, 50 Hz electric motor complying with AS 1359. The motor power factor shall be >0.8 and efficiency >0.85 at ¾ load. The motor should be continuously rated for at least 120% of the duty load and 110% of the maximum load, and fitted with winding thermistors in each phase. The pump and motor should be mounted on a baseplate in accordance with the Baseplates section of DS 30-02. The pumpset shall be fitted with a corrosion resistant silencer and shall incorporate a condensate drain.
10 CHEMICAL DOSE PUMPS

10.1 General
The Corporation uses chemical dose pumps widely in water and wastewater applications. Chemical dose pumps come in different types which to some extent can be process chemical specific depending on the characteristics of the chemical.

Dose pump types used by the Corporation are:
(a) Solenoid diaphragm pumps;
(b) Mechanical diaphragm pumps of the loss-motion and full movement types;
(c) Progressive cavity pumps.

10.2 Diaphragm Type Chemical Dose Pumps
As referred to above there are essentially three distinct types of diaphragm pumps available, each producing distinctly different output characteristics relating to:
(a) Fluid velocity;
(b) Acceleration;
(c) Pressure.

These characteristics affect metering pump efficiency, longevity and reliability, and may adversely affect stability of the fluid. The features of each pump type are summarized in the following information.

10.3 Solenoid Diaphragm Pump

10.3.1 General
The solenoid diaphragm or electronic metering pump is an electromagnetic device consisting of a solenoid, a method of stroke length control and provision of the electronics required to control stroke frequency.

10.3.2 Operation
The pumping operation is achieved by alternately energising and de-energising the solenoid to cause a solenoid plunger to operate a spring-loaded diaphragm, producing the discharge and suction strokes respectively. Stroke length is controlled by adjusting a mechanical stop, which sets the amount of diaphragm travel.

10.3.3 Pumping Characteristics
The pump characteristically imparts a very high acceleration to the fluid at the commencement of the stroke producing pressure spikes and pulsed flow velocity. This is not such a problem for relatively low flow situations because of the use of flexible hoses, which in combination with the robustness of most installations are able to withstand the continuous pulsing and pressure spikes. Applications with relatively large flows however are prone to large pressure spikes and flow pulsations which can translate to excessive noise, pump wear and component failure.

Use of solenoid pumps by the Corporation is mainly for cheap, low flow applications where control is simple and for chemicals that are relatively safe that do not require leak detection in the case of diaphragm rupture. In some cases a spare pump is mandatory in addition to the duty or duty/standby units due to their susceptibility to failure from voltage spikes.
10.3.4 **Materials**

Wet ends are available in a variety of materials to suit different chemical dosing applications. Valves shall be supplied with injection/backpressure valve assembly and a footvalve/strainer assembly and associated suction and discharge tubing. Valves supplied with tubing assemblies shall also be provided with a bleed valve assembly and return tubing and ≤ 38 L/h.

10.3.5 **Technical Specifications for Solenoid Diaphragm Pumps**

Solenoid diaphragm pumps are the simplest and cheapest types of chemical dose pump. The following table lists typical specifications applicable.

| Table 10.1 – Typical Technical Specifications for Solenoid Diaphragm Pumps |
|-----------------------------|--------------------------------------------------------------------------|
| **Item**                    | **Specification**                                                        |
| Manual control options      | On-line adjustable stroke rate and stroke length                         |
|                             | Direct and external pace with auto/manual selection option               |
| Automatic control options   | 4-20 mA and 20-4 mA current signals with 100% to 1% of incoming signal   |
|                             | Manual on-line adjustable stroke rate and stroke length                  |
|                             | Alarm indication for signal loss, full count, circuit failure, pulse overflow, pulse rate high and liquid low level |
|                             | Pulse signal variable by multiplying or dividing by 1 to 999 to handle peak and trough flow conditions |
| Turndown                    | Manual 100:1; Automatic 1000:1                                           |
| Flow/pressure range          | 0.5 L/h @ 2100kPa; to 80 L/h @ 130 kPa                                   |
| Accuracy                    | + 3% of maximum capacity                                                 |
| Viscosity range             | <3000 mPa s                                                              |
| Cooling                     | Air cooled via a finned, thermo-conductive solenoid enclosure             |
| Liquid end materials        | Glass-filled polypropylene (GFPPPL), PVC, styrene-acrylonitrile (SAN), polyvinylidene fluoride (PVDF), Teflon, Hypalon, Viton®, ceramic, alloys and 316 stainless steel |
| Liquid end sealing          | Seal-less liquid end                                                     |
| Tubing                      | Clear PVC and white polyethylene                                          |
| Solenoid protection         | Thermal overload with auto-rest                                          |
| Rating                      | Water-resistant for indoor and outdoor service                            |

**NOTE:** Pump manufacturers should be consulted to confirm specific information.

10.4 **Mechanical Diaphragm Pumps**

10.4.1 **Features**

Features of mechanical diaphragm pumps are:

(a) Variable speed electric motor option,
(b) Double simplex option,
(c) Proportional dosing,
(d) Positive displacement,
(e) Mechanical diaphragm pump.

Experience in Corporation has shown this type of dose pump to have superior service life over other types.
Whilst these pumps are capable of self-priming and operation to 3 m water suction head, a flooded suction shall be provided.

10.4.2 Low Head and Backsiphonage

Low discharge head or backpressure can create a problem for the pump because in order for it to meter accurately, the differential pressure between suction and discharge needs to be a minimum of 100 kPa (1 bar).

To facilitate this a combined backpressure/anti-syphon valve shall be fitted downstream of the pump discharge. The valve maintains positive seating of pump valve stacks and also prevents product from back syphoning through the liquid end of the pump.

Table 10.2 - Technical Specifications for Mechanical Diaphragm Pumps

<table>
<thead>
<tr>
<th>Specification</th>
<th>Loss Motion Type</th>
<th>Full Movement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>+ 2% of full scale over a 10:1 operating range</td>
<td></td>
</tr>
<tr>
<td>Feed rate adjustment</td>
<td>Infinitely variable 0 – 100%</td>
<td>Infinitely variable 0 – 100%</td>
</tr>
<tr>
<td></td>
<td>1.0% increments for % scale and vernier stroke length adjustment</td>
<td>0.25% increments for % scale and vernier stroke length adjustment</td>
</tr>
<tr>
<td></td>
<td>1 rev of knob ≡ 20% stroke length change</td>
<td>1 rev of knob ≡ 10% stroke length change</td>
</tr>
<tr>
<td>Flow head and capacity</td>
<td>4.7 L/h to 106 L/h at 100 kPa (10 bar)</td>
<td>4.7 L/h to 680 L/h at 120 kPa (12 bar) to 50 kPa (5 bar) respectively</td>
</tr>
<tr>
<td>Operating range</td>
<td>Stroke length adjustable over 10:1 range</td>
<td>Stroke adjustable over 0-100%</td>
</tr>
<tr>
<td></td>
<td>Stroke frequency adjustable over a 20:1 range</td>
<td>Stroke frequency adjustment over a 20:1 range</td>
</tr>
<tr>
<td></td>
<td>Min stroke and freq. Adj is 10%</td>
<td>Min stroke and freq. Adj is 10%</td>
</tr>
<tr>
<td>Total maximum combined turndown</td>
<td></td>
<td>200:1</td>
</tr>
<tr>
<td>Speed of response</td>
<td>Variable speed control response time &lt;3 secs from 0% to 100%</td>
<td>Variable speed control response time &lt;3 secs from 0% to 100%</td>
</tr>
<tr>
<td></td>
<td>Automatic stroke length control is 180 secs from 0 – 100%</td>
<td></td>
</tr>
<tr>
<td>Suction lift</td>
<td>Self-priming and operation with 3 m of water suction head (wetted valves, zero backpressure at full stroke and speed). A flooded suction is recommended</td>
<td></td>
</tr>
<tr>
<td>Temperature limits - liquid end:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient</td>
<td>PVC – 52 ºC;</td>
<td>PVC – 52 ºC;</td>
</tr>
<tr>
<td>Process</td>
<td>PVC – 52 ºC; Kynar – 62 ºC</td>
<td>PVC – 52 ºC; PVDF – 62 ºC</td>
</tr>
<tr>
<td>Control modes</td>
<td>Manual, remote control, start-stop, variable speed, flow proportional, direct residual and compound loop</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>415/230V 50 Hz TEFC or 230V 50 Hz TEFC – 4 pole motor</td>
<td></td>
</tr>
<tr>
<td>Materials:</td>
<td>As detailed below</td>
<td></td>
</tr>
<tr>
<td>- Gearbox</td>
<td>Cast iron to AS 1830 grade 250</td>
<td></td>
</tr>
<tr>
<td>- Liquid end adaptor</td>
<td>PVC</td>
<td>Cast iron</td>
</tr>
<tr>
<td>- Pump head</td>
<td>PVC and Kynar</td>
<td>PVC and PDVF</td>
</tr>
<tr>
<td>- Valve housings</td>
<td>Clear PVC, Grey PVC</td>
<td>Clear PVC, Grey PVC, PDVF</td>
</tr>
<tr>
<td>- Valve balls</td>
<td>316 SS, TFE, ceramic, glass and polyurethane (for slurry service)</td>
<td></td>
</tr>
<tr>
<td>- Valve seats</td>
<td>Hypalon and Viton®</td>
<td></td>
</tr>
<tr>
<td>- Diaphragms</td>
<td>TFE-faced, fabric reinforced, elastomer backed with steel backing plate</td>
<td></td>
</tr>
</tbody>
</table>
### Specification

<table>
<thead>
<tr>
<th></th>
<th>Loss Motion Type</th>
<th>Full Movement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mounting base</td>
<td></td>
<td>ABS</td>
</tr>
<tr>
<td>- UV resistance</td>
<td></td>
<td>Resistant</td>
</tr>
</tbody>
</table>

**NOTE:** Pump manufacturers should be consulted to confirm specific information.

#### 10.4.3 Limitations

Diaphragm pumps shall not be used for pumping polyelectrolyte. Diaphragm pumps produce adverse effects on polyelectrolyte due to separation of the fluid from the effects of rapid changes in acceleration and deceleration of the pump stroke.

Components such as O-ring seals shall be compatible with the product.

#### 10.5 Mechanical Diaphragm Pumps – Loss-Motion Type

##### 10.5.1 General

Loss-motion diaphragm pumps generally consist of an electric motor, a drive unit and a liquid end. The pump diaphragm can be actuated either mechanically or hydraulically via an intermediate fluid, and in the latter case pumps are also referred to as by-pass type designs.

##### 10.5.2 Operation

As with solenoid diaphragm pumps loss-motion diaphragm pumps utilise a spring-assisted return and a mechanical stop to set the diaphragm travel and therefore stroke length. Hydraulic actuated types utilise a piston, which displaces a fixed quantity of hydraulic fluid in order to operate the diaphragm. For stroke lengths less than 100% a quantity of hydraulic fluid is by-passed back to the reservoir, and for zero by-pass the piston provides full diaphragm stroke.

Loss-motion diaphragm pumps derive their name from the cam motion loss or hydraulic displacement loss that would otherwise be available to further displace the diaphragm. At full stroke length setting the pumps are not loss-motion.

##### 10.5.3 Pumping Characteristics

Loss-motion diaphragm pumps characteristically impart high acceleration to the fluid at the commencement of the stroke producing pressure spikes and pulsed flow velocity but not as severe as the solenoid diaphragm pump.

Loss-motion diaphragm pumps have a higher capacity and pressure capability than solenoid diaphragm pumps. Loss-motion pumps are not as accurate as full movement diaphragm pumps (see below).

#### 10.6 Mechanical Diaphragm Pumps – Full Movement Type

In full movement mechanical diaphragm pumps the diaphragm (or piston for hydraulic actuated types) is actuated by a rotating crankshaft, which is capable of having its eccentricity adjusted during operation to effect smooth stroke length change.

There are no diaphragm return springs. The diaphragm moves with simple harmonic motion producing a sinusoidal fluid velocity profile at all stroke lengths. Adjusting the stroke length simply alters the amplitude of the sine wave.

Full movement mechanical diaphragm pump designs provide greater reliability and longevity than solenoid or loss-motion types. The pump valves operate more efficiently because they have more time to respond to pressure changes. They are more accurate than loss motion types, particularly with viscous liquids.
10.7 Applications for Dose Pump Types

The following table details dose pump types applicable for chemicals commonly used on Corporation facilities.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Solenoid</th>
<th>Diaphragm</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium sulphate</td>
<td>Yes</td>
<td>Yes</td>
<td>Slurry characteristics of chemical require special valves</td>
</tr>
<tr>
<td>Ammonia solution</td>
<td>No</td>
<td>Yes</td>
<td>Full movement double simplex diaphragm metering pump to meet accuracy requirements</td>
</tr>
<tr>
<td>Ferric chloride ≤ 6 L/h</td>
<td>No</td>
<td>Yes</td>
<td>Lost motion double simplex diaphragm metering pump type</td>
</tr>
<tr>
<td>Fluorosilicic acid</td>
<td>No</td>
<td>Yes</td>
<td>Leak detection required only available on diaphragm type</td>
</tr>
<tr>
<td>Hydrochloric acid ≤ 6 L/h</td>
<td>No</td>
<td>Yes</td>
<td>Leak detection required on diaphragm type</td>
</tr>
<tr>
<td>Poly-aluminium-chloride</td>
<td>No</td>
<td>Yes</td>
<td>Full movement double simplex diaphragm metering pump</td>
</tr>
<tr>
<td>Poly electrolyte</td>
<td>No</td>
<td>No</td>
<td>Progressive cavity pump type required due to shear sensitivity</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sodium carbonate solution</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sodium hexametaphosphate (CALGON)</td>
<td>Yes</td>
<td>Refer comments</td>
<td>Solenoid type, only because of low flow rates. Spare pump required in addition to duty/standby</td>
</tr>
<tr>
<td>Sodium hydroxide (caustic soda)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sodium hypochlorite ≤ 6 L/h</td>
<td>Yes</td>
<td>Yes</td>
<td>&lt;20 L/h pumps should be fitted with degassing heads</td>
</tr>
<tr>
<td>Sodium silica fluoride</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sodium silicate ≤ 6 L/h</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>No</td>
<td>Yes</td>
<td>Full movement double simplex diaphragm metering pump – leak detection required</td>
</tr>
</tbody>
</table>

10.8 Fluorosilicic Acid (FSA) Dosing

10.8.1 General

For FSA applications electric motor driven diaphragm dosing pumps are considered superior to solenoid driven diaphragm dosing pumps due to the simple harmonic motion of momentum transfer to the pumped fluid. Solenoid pumps, with their stepped mechanical drive characteristic, are considered to be higher maintenance, being more prone to burst diaphragms and vapour locking and do not comply with the double diaphragm/pressure relief return requirements. The hazardous nature of FSA dictates that dosing pumps shall be designed for leak detection and containment.

10.8.2 Internal Pressure Relief

Pressure relief capability is considered to be an essential requirement associated with dosing FSA. Within a double diaphragm pump there is the capacity for the pressure relief facility to be incorporated for return into the transmission fluid. Although there is the capacity with some single diaphragm dosing pumps to fit an external pressure relief valve, this is considered to represent a higher risk. The double diaphragm method of relieving the transmission fluid from within the diaphragm chamber is considered much safer in operation, as well as maintenance. Routine or breakdown maintenance with
this type of pressure relief valve does not require the lengthy safety procedures normally associated with handling FSA.

10.8.3 Integral Leak Detection System

In the event of a diaphragm failure, double diaphragm dosing pumps employ double diaphragm containment protection in conjunction with a sensor to detect contamination of the transmission fluid. With containment and leak detection there is minimal exposure of personnel to FSA from diaphragm failure. In some units a cartridge type head is employed where one unit may be removed and another installed.

In the event of diaphragm failure some single diaphragm dosing pumps employ a drain line in order to release FSA from the head in conjunction with a conductivity sensor which activates when in contact with the escaping fluid. However it is considered this does not constitute ‘containment’ of the FSA. If on the other hand, the FSA is contained within the pump head this drain line may be sealed utilising a conductivity sensor. However, containment of the FSA within this chamber would expose the pump components to FSA. The stainless steel shaft, stainless steel backing plate and the PPO casing (20% glass fibre) are all non-resistant to FSA attack. Additionally, the design of this section of the pump would produce a high risk of exposure to FSA raising difficulties in ensuring adequate flushing of FSA from the pump prior to undertaking maintenance.

10.8.4 Stainless Steel Performance in FSA

Experience within the Corporation has yet to prove any stainless steel to be resistant to corrosion from FSA. This is further confirmed by reference to various corrosion resistance charts. Corrosion rates of some of the more exotic stainless steels are low, being quoted as >0.1 mm and <1.0 mm per year. However, in an application where this stainless steel MUST seal against the seat of a check valve, even low rates of corrosion will compromise the sealing capacity.

10.8.5 Non-Return Valve Balls

The Corporation has previously encountered problems with ceramic balls. Experience has been that the silica contained within the ceramic (and also within glass balls) is highly susceptible to corrosion from FSA. However, more recently a pump supplier has confirmed a capability to supply a ceramic material that has been tested successfully in FSA applications. Their ceramic was 99.999% pure - which infers a maximum silica content of 0.001%. Silica contents significantly higher than this e.g. 0.5% would have questionable corrosion resistance performance in FSA.

10.8.6 FSA Minimum Dosing Pump Specification

The basis of the technical specification for the current supply of fluosilicic acid dosing pumps to the Corporation are summarised as follows:

(a) The chemical dosing pump unit shall be of the positive displacement, mechanical diaphragm type pump with positive flow ensured through the use of ball-type check valves.

(b) The dose pump shall be fitted with a PVC pump head and a PTFE double diaphragm. The separation chamber shall be filled with oil and fitted with an internal pressure relief valve. The separation chamber shall contain any leaks and will incorporate a sensor to indicate diaphragm failure.

(c) The check valves on the suction and discharge of the unit shall be fitted with PTFE balls. All ‘O’ rings shall be manufactured from EPDM. (If the grade of Viton® is suitable for FSA, then this may also be acceptable).

(d) The dosing pump type shall be positive displacement movement via a cam or worm gear driven by a 3 phase, IP 55 rated motor. Electric solenoid driven actuation is not acceptable.

(e) The unit shall have a primary capacity for flow variation based on the variation of motor speed utilising a frequency controller with a turndown ratio of at least 10:1. Additionally, there shall be the capacity for flow adjustment utilising a servomotor on the stroke length controller with a turndown ratio of at least 10:1.
10.8.7 Corporation Historical Experience with FSA Dose Pumps

In conformance with the specification below, most of the Corporation fluosillicic acid dosing sites are fitted with Wallace & Tiernan PDTD2 and HATD3 pumps or the Alldos KM series double diaphragm dosing pumps. In addition, conformance to this specification is achieved by the Wallace & Tiernan Chemtube 200 tubular diaphragm metering pump, the LEWA Ecodos pump and the Wallace & Tiernan Encore 700.

NOTES:
1. There are approximately 20 sites (2002), housing more than 40 dosing pumps. A few of the early FSA sites, located in country locations, employ a single diaphragm dosing pumps with leak detection and leak containment within the pump housing.
2. PDTD shall mean piston driven tubular diaphragm.
3. HATD shall mean hydraulically actuated tubular diaphragm.

10.9 Progressive Cavity Dose Pumps

10.9.1 General

Progressive cavity pumps (helical rotor) should be used for pumping shock or pulse sensitive chemicals such as polyelectrolyte. For further details refer to the Progressive Cavity Pump Section of this Standard.

10.9.2 Features

Features of progressive cavity pumps are:
(a) Variable speed electric motor option;
(b) Constant non-pulsating flow;
(c) Positive displacement;
(d) Rotor and stator element.
11 PROGRESSIVE CAVITY PUMPS

11.1 General
The Corporation generally uses progressive cavity (helical rotor) pumps for water and wastewater treatment plants for dosing chemicals such as polyelectrolyte and pumping sewage sludge. Pumps are electric motor driven horizontal pedestal type.

11.2 Features
Progressive cavity pumps embody the following features:
(a) Positive displacement;
(b) Constant non-pulsating flow with low shear characteristics;
(c) Capable of handling sludges, slurries, abrasives, viscous fluids, fibrous material and with some air entrapment;
(d) Orbital rotary motion at the rotor;
(e) Capable of handling solids up to 50 mm diameter;
(f) Capable of self priming to 8.5 m;
(g) Relatively low speed
(h) Available in various drive configurations e.g. direct coupled, belt driven, direct coupled with gear reducer or gearmotor or hydraulic motor.

11.3 Operation
Progressive cavity pumps comprise a stator and rotor connected to a drive shaft which converts the orbital motion at the rotor into rotary motion at the driver.

The stator is elastomeric, and incorporates an internal helical screw type form with large pitch. The corrosion resistant steel rotor has a screw pitch that is half the pitch of the stator. The rotor seals against the stator and in so doing forms cavities. Rotation of the rotor causes the cavities in the stator to progress from the stator suction towards the discharge outlet and in so doing transports fluid axially through the pump i.e. hence progressive cavity.

11.4 Pump Requirements

11.4.1 Inlet/Outlet Configuration
The preferred orientation is for the discharge branch to be located at the non-drive end of the stator in order to minimise leakage into the environment that may otherwise occur if the discharge was at this gland or drive end.

11.4.2 Direction of Rotation
Pumps are available in clockwise, anticlockwise or reversible rotation.

11.4.3 Shaft Seal
Shaft sealing via gland or mechanical seal is available in many different options depending on the application and reference should be made to the manufacturer in making the appropriate selection.
11.4.4 Materials

The correct material combination depends on the application with specialised material requirements being required for some chemical dosing applications. Reference should be made to the manufacturer in making the appropriate selection.

11.4.5 Speed

Pump speeds up to 1000 rev/min can be tolerated however lower speeds are preferred e.g. <500 rev/min particularly for abrasives.

11.4.6 Number of Stages

Multistage pumps with up to four stages are available with a minimum of two stages recommended.

11.4.7 Drive Shaft Type

Pump rotor drive shafts are available in either flexible or whip shaft or universal drive types. Flexible shafts increase the length of the pump compared to universal drive shafts. Manufacturers should warrant rotor drive shafts for 10,000 hours operation providing protectors are fitted in the case of universal types. Premature failure of universals can be a problem with some shaft designs.

11.5 Technical Specifications

Typical technical specifications for progressive cavity pumps are shown in Table 11.1 below.

Table 11.1 – Typical Technical Specifications for Progressive Cavity Pumps

<table>
<thead>
<tr>
<th>Item</th>
<th>Operating Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process material</td>
<td>Low to high viscosity fluids; non-flowable products (e.g. screw and hopper configuration)</td>
</tr>
<tr>
<td>Number of stages available</td>
<td>Varies from 2 to 4</td>
</tr>
<tr>
<td>Shaft sealing</td>
<td>Packed gland with or without external flush, or mechanical seal</td>
</tr>
<tr>
<td>Speed range</td>
<td>Up to 1000 rev/min</td>
</tr>
<tr>
<td>Stator protection</td>
<td>Dry running protection using a thermoelectric device is available</td>
</tr>
<tr>
<td>Universal joint protector</td>
<td>A stainless steel protector protects the elastomeric joint sleeve from physical damage</td>
</tr>
<tr>
<td>Overpressure protection</td>
<td>Diaphragm contact pressure gauge</td>
</tr>
<tr>
<td>Overpressure protection with bypass and PRV</td>
<td>Delivery to suction bypass incorporating a PRV for continuous operation protection e.g. against a closed valve</td>
</tr>
<tr>
<td>Pump materials</td>
<td>As detailed below</td>
</tr>
<tr>
<td>Drive housing, suction and discharge branches</td>
<td>Cast iron to AS 1830 grade 250, 304 SS, 316 SS, 316Ti SS, low carbon steel, polyethylene</td>
</tr>
<tr>
<td>Stator</td>
<td>NBR, Purbunan, Hypalon, Buna-N, Viton®, EPDM, PTFE</td>
</tr>
<tr>
<td>Rotor</td>
<td>304 SS, 316 SS, 316Ti SS, Duplex SS, Hastelloy C4®, low carbon steel, high carbon steel</td>
</tr>
<tr>
<td>Rotor drive shaft</td>
<td>304 SS, 316 SS, 316Ti SS, Duplex SS, Hastelloy C4®, low carbon steel, high carbon steel, AISI 420 rubber lined, polyethylene</td>
</tr>
<tr>
<td>Tie bolts</td>
<td>Carbon steel, stainless steel</td>
</tr>
<tr>
<td>Water slinger</td>
<td>Corrosion resistant metal, high density plastic or synthetic rubber</td>
</tr>
</tbody>
</table>
11.6 Limitations

The following limitations apply to progressive cavity pumps:

(a) Progressive cavity pumps shall not have isolating valves fitted in the discharge pipework unless there is a relief valve fitted upstream of the isolating valve.

(b) They must not be run dry otherwise the stator and rotor will be damaged.

(c) They should be limited to a relatively low rotor speed when pumping abrasives in order to reduce wear e.g. < 500 rpm.

(d) Pump materials shall be appropriate for the particular service condition e.g. Grade 304 stainless steel should not be used in applications where chlorides or corrosive conditions are present.
12 APPENDIX A: REFERENCED DOCUMENTS

The following standards, manuals and documents are either reference or related material associated with this Standard.

12.1 Corporation Chemical Design Standards

The following represents a list of Corporation chemical design standards.

**DS**
- 70-01 Chlorine Buildings
- 70-02 Chlorine Leak Detectors
- 70-03 Emergency Shutoff Devices for use of Chlorine Containers
- 70-04 Emergency Safety Showers and Eyewash Stations
- 70-05 Chlorine Container Floor Scales
- 71-01 Fluorosilicic Acid (FSA) Storage and Dosing Facilities

12.2 Corporation Civil Design Standards

The complete list of Corporation civil design standards are contained in Appendix A: Referenced Documents section of DS 30-02. The following Corporation civil design standards are referenced in this Standard.

**DS**
- 51 Design and Construction of Wastewater Pumping Stations and Pressure Mains 4.5 to 90 Litres per Second Capacity
- 60 Water Distribution Standard

12.3 Corporation Design Process Standards

The following represents the Corporation design process standard and independent review documentation:

- Engineering Design Process Manual
- Independent Review Panel

12.4 Corporation Drafting Standard

The following Corporation drafting design standard is referenced in this Standard.

**DS** 80 Water Corporation WCX CAD Standard

12.5 Corporation Electrical Design Standards

The following represents a list of Corporation electrical design standards.

**DS**
- 20 Design Process for Electrical Works
- 21 Major Pump Station – Electrical
- 22 Ancillary Plant and Small Pump Stations
- 24 Electrical Drafting
12.6  Corporation Main Drainage Standard
The following details the Corporation’s main drainage standard.
- Urban Main Drainage Manual

12.7  Corporation Mechanical Design Standards
The complete list of Corporation mechanical design standards is contained in Appendix A: Referenced Documents section of DS 30-02. The following Corporation mechanical design standards are referenced in this Standard.

DS
30-01  Glossary - Mechanical
30-02  General Design Criteria - Mechanical
31-01  Pipework - Mechanical
31-02  Valves and Appurtenances – Mechanical
33  Water Treatment Plants – Mechanical
34  Wastewater Treatment Plants – Mechanical
35  Ancillary Plant - Mechanical
36  Strategic Product Specifications and Product Atlas – Mechanical
38-01  Installation – Mechanical
38-03  Flange Bolting

12.8  Corporation Site Security Standard
The following represents the Corporation site security standard.

DS
62  Standard for Security Treatments
Guidance Notes for Security Treatments – Including Guidance to Design Standard

12.9  Corporation SCADA Design Standards

DS
40-01  Control Philosophy
40-02  Naming Convention
40-03  I/O Addressing
40-04  I/O Lists
40-05  Scheme Control
40-06  Software Change Control
41-01  SCADA Server, Workstations and Ancillary Equipment
41-02 Citect Configuration
41-03 SCX6 Configuration
42-02 SCADA Radio Network Design
42-03 Scheme SCADA Radio Network Design
42-04 Communication Power Supply
43-01 DNP 3 Polling
43-02 Data Concentrator

**SCADA Technical Bulletins**
- Technical Bulletin 06-1
- Technical Bulletin 06-2

### 12.10 Corporation Cathodic Protection Standard

**DS**

91 Cathodic Protection Standard

### 12.11 Corporation Material, Coating and Welding Specifications

The following represents a complete list of Corporation technical specifications relating to material, coating and welding which are referred to in the DS 30 series of design standards.

- **PA** Protective Coating on Steel and/or Cast Iron
- **PB** IZS-80 - Inorganic Zinc Silicate Coating on Steel or Cast Iron
- **PC** EZ-100 - Epoxy Zinc Coating on Steel or Cast Iron
- **PD** IZS-EM-80/200 - Inorganic Zinc Silicate Primed, Epoxy Mastic Coating On Steel Or Cast Iron
- **PE** Deleted
- **PF** G.EM-85/200 - Epoxy Mastic Coating on Galvanised Steel
- **PG** ZPU-225/150 - Zinc Primed Polyurethane Coating for Sheetmetal Cabinets
- **PH** E-500 - Epoxy Coating on Steel or Cast Iron
- **PK** GE-85/500 - Epoxy Coating on Galvanised Steel
- **PL** GA-85/80 - Acrylic Coating on Galvanised Steel
- **PM** Inorganic Zinc Silicate Primed Acrylic Coating on Steel or Cast Iron
- **PN** Two Pack Acrylic on Galvanised or Zincalum Sheet Steel
- **PP** Flake Glass Filled Polyester Coating on Steel or Cast Iron
- **PQ** External and Internal Polyester Powder Coatings for Sheetmetal Cabinets
- **PR** Polyester Powder Coating on Steel or Cast Iron Pipes and Fittings
- **PS** IZS.AT-80/80 - Inorganic Zinc Silicate Primed, Two Pack Acrylic Coating on Steel or Cast Iron
- **PT** External Fusion Bonded Powder Coating on Zinc Anneal Sheetmetal
- **FRP** FRP Structural Material
- **WS–1** Metal Arc Welding
- **WP** Plastic Lining Welding Audit
CML Cement Motor Lining Requirements
WR-1 Tape Wrapping Requirements
WR-2 Heat Shrink Sleeve Requirements.

12.12 Corporation Strategic Product Specifications

Strategic Product Specifications have been developed by the Corporation in order to specify products of strategic importance that are used with reasonable frequency. Strategic Product Specifications reference Australian Standards where they exist, or failing that WSAA Standards, or have been developed in their own right where no applicable standards exist. The strategic product specifications referred to in the Design Standards are available in DS 36. A full list of the strategic product standards are shown below:

SPS
155 Metered Standpipes
200 Air Release and Vacuum Break Valves
201 Sewage Air Release and Vacuum Break Valves
220 Copper Alloy Swing Check Valves
223 Ductile Iron Swing Check and Tilting Disc Non-Return Valves
226 Dual Plate Non-Return Valves
230 Non-Slam Non-Return Valves
240 Automatic Control Valves
245 Vacuum Interface Valves
251 Mains Tapping Ball Valves
252 Metallic Ball Valves for General Purposes
254 Meter Ball Valves
255 Copper Alloy Gate Valves
259 Knife-Gate Valves
260 Butterfly Valves for General Purposes
261 Butterfly Valves for Waterworks Purposes
262 High Performance Butterfly Valves
271 Metal Seated Gate Valves
272 Resilient Seated Gate Valves
292 Screw-Down Hydrants
295 Penstocks
500 Horizontal ISO End Suction Centrifugal Pumps
501 End Suction Centrifugal Motor Pumps
503 Submersible Sewage Pumps
507 Multi-Stage Submersible Electric Borehole Pumps
515 Horizontal Axial-Split Casing Pumps
12.13 Water Services Association of Australia Codes

12.13.1 Codes

The following codes are referred to in the Design Standards and are available from Standards Australia.

WSA
02 Sewage Code of Australia
03 Water Reticulation Code of Australia
04 Sewage Pumping Station Code of Australia
06 Vacuum Sewerage Code of Australia

12.13.2 Water Industry Standards

The following standards are referred to in the Design Standards and are available from WSAA or from their website http://www.wsaa.asn.au.

WSA
101 Submersible electric pumps for sewage pumping stations
106 Kinetic air valves
109 Industry standard for flange gaskets and O-rings
112 Sewage air release and vacuum break valves
121 Biofilters for odour control

12.14 Australian Standards

A complete list of Australian Standards referenced in the DS 30 standards series is contained in Appendix A: Referenced Documents section of DS 30-02. The following Australian Standards are referenced in this Design Standard.

AS
1217.7 Acoustic – Determination of sound power levels of noise sources – survey method
1359 Rotating electrical machines – General requirements
1443 Carbon steels and carbon manganese steels – Cold-finished bars
1448 Carbon steels and carbon manganese steels – Forgings (ruling section 300 mm maximum)
1565 Copper and copper alloys - Ingots and castings
1627 Metal finishing – Preparation and pre-treatment of surfaces – Power tool cleaning
1628 Water supply – Metallic gate, globe and non-return valves
1646 Elastomeric seals for waterworks purposes
1830 Iron castings – Grey cast iron
1831 Ductile cast iron
1833 Austenitic cast iron
1874 Aluminium and aluminium alloys – Ingots and castings
2074 Steel castings
2417 Pumps – The International acceptance test codes
4594  Internal combustion engines – Performance
60529  Degrees of protection provided by enclosures (IP Code)

12.15  International Standards

A complete list of the international standards referenced in the DS 30 standards series is contained in Appendix A: Referenced Documents section of DS 30-02. The following international standards are referenced in this Standard.

**BSEN**
60751  Industrial platinum resistance thermometer sensors

**ASTM**
A276   Standard Specification for Stainless Steel Bars and Shapes
A 351M
END OF DOCUMENT