WATER
CORPORATION

Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 32

Pump Stations – Conventional Water and Sewage - Mechanical

VERSION 1
REVISION 4

JUNE 2023

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Mechanical Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

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Water Corporation accepts no liability for any loss or damage that arises from anything in the Standards/Specifications including any loss or damage that may arise due to the errors and omissions of any person. Any person or entity which relies upon the Standards/Specifications from the Water Corporation website does so that their own risk and without any right of recourse to the Water Corporation, including, but not limited to, using the Standards/Specification for works other than for or on behalf of the Water Corporation.

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Any interpretation of anything in the Standards/Specifications that deviates from specific Water Corporation Project requirements must be referred to, and resolved by, reference to and for determination by the Water Corporation's project manager and/or designer for that particular Project.

REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS

SECT.	VER./ REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	1/0	31.12.05	All	Reformatted	EJP	AAK
1	1/1	01.02.06	15	Clause 1.7 amended	EJP	AAK
1	1/2	21.07.06	14	Clause 1.2 amended	EJP	AAK
1	1/4	15.03.13	15-17	Clause 1.1-1.3, 1.5-1.7 amended	EJP	SE
2	1/0	31.12.05	All	Reformatted	EJP	AAK
2	1/1	01.02.06	16, 17	Clause 2.1, 2.2 amended	EJP	AAK
2	1/3	01.05.07	16, 17	Review and edit	EJP	AAK
2	**1/4**	**15.03.13**	**17-22**	**Section amalgamated with previous Section 3. Various clauses deleted or transferred to other sections. Clauses 2.1, 2.3, 2.7, 2.9, 2.10, 2.11, 2.13, 2.15, 2.16, 2.23, 2.24 amended, Clause 2.25 added; Bores, ‘SmartVib’ removed, Condition Monitoring transferred to Section 9,**	**EJP**	**SE**
3	0/1	01.07.01	1	3 title modified, 3.4-3.12 changed to Section 4	EJP	AAK
3	1/0	31.12.05	All	Reformatted; 3.1, 3.2	EJP	AAK
3	1/1	01.02.06	20	Clauses 3.2 to 3.4 and 3.13.12 amended, 3.21 added	EJP	AAK
3	1/3	01.05.07	20 - 24, 26, 27-36	Review and edit, Clauses 3.2, 3.10.2, 3.13.2, 3.17, 3.30.1 amended	EJP	AAK
3	**1/4**	**15.03.13**	**23-36**	**Previously Section 4. Clause 3.1-3.3, 3.5-3.9 amended. Clause 3.4 transferred. Clause 3.5 added. Submersible Electric Borehole Pumps deleted**		**SE**
3	**1/4**	**10.11.16**	**26**	**3.5.4 added requirement to consider pumping configuration and specific speed**	**MB**	**SE**
4	0/1	01.07.01	2-4	New Section, CM deleted, 4.6.1-4.6.8, Table 4.1,4.14.1(i), 4.14.6(d) modified	EJP	AAK
4	0/2	30.09.05	All	Yatesmeter tapings changed to direct thermodynamic tappings	EJP	AAK
4	1/0	31.12.05	All	Reformatted	EJP	AAK
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7	0/1	01.07.01	All	7.3.1(e) added, 7.3.3, 7.3.4, 7.3.10, 7.3.11 modified	EJP	AAK
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7	1/0	31.12.05	All	Reformatted	EJP	AAK
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8	1/4	13.03.13	66-76	Previously Section 10. Clause 8.4, 8.6 amended. Clauses 8.1 - 8.3 added. Clause 8.5 relocated and amended	EJP	SE
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DESIGN STANDARD DS 32

Pump Stations – Conventional Water and Sewage - Mechanical

CONTENTS

Section *Page*

SCOPE AND GENERAL

1.1 Scope

Design Standard DS 32 is the first part of a three part standard which provides design requirements for various pump station types. The other parts of the Standard comprise

- DS 32-01 Pump Stations – Borehole – Mechanical,
- DS 32-02 Pump Stations – High Level Area Booster Pump Stations – Mechanical.

Design Standard DS 32 sets out the Corporation's mechanical standards, guidelines and preferred engineering practices for design of conventional water supply and sewage pump stations and associated plant.

1.2 Purpose

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 Designer shall comply with the requirements of the relevant mechanical design process contained in DS 30.

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

Corporation Standards and Specifications, and Australian Standards and International Standards referred to throughout this document are listed in full in Appendices A and B of DS 30-01.

1.6 Notation

Statements governed by the use of the word 'shall' are mandatory or 'normative' requirements of the Standard. Statements expressed by the use of the words 'should" or 'may" are 'informative' but not mandatory and are provided for information and guidance. Notes in the Standard text are informative. Notes forming part of Standard Tables are normative.

1.7 Nomenclature

1.7.1 Engineering Definitions and Relationships

Definitions relating to terminology used in the DS 30 Standard series are contained in section 2 ‘Engineering Definitions and Relationships’ 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 Acronyms and Symbols

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 GENERAL DESIGN CRITERIA

2.1 General

This section details the design criteria that should be applied (where relevant) during the design of pump stations and is arranged in alphabetic order for referencing convenience. It also includes explanatory notes and information both for record purposes and assistance to the reader. In addition to the following design criteria, the Designer shall also refer to relevant parts of DS 30, DS 30-01, DS 30-02, DS 31-01, DS 31-02, DS 32-01, DS 32-02, DS 35, DS 38-01 and DS 38-02..

2.2 Ambient Conditions

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

2.3 Backflow Prevention

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

2.4 Baseplates

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

2.5 Buildings

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

2.6 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 referred in DS 36.

For more information on coatings refer to DS 95.

2.7 Condition Monitoring and Protection

Condition monitoring and protection is detailed in the Electrical and Instrumentation section of this Standard.

2.8 Confined Space

For information relating to confined space refer to the DS 30-02 Confined Space section.

2.9 Driving Machines

2.9.1 General

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

2.9.2 Electric Motors

Electric motor selection shall be in accordance with 'Electric Motors' contained in the Electrical and Instrumentation section of this Standard.

2.9.3 Diesel Engines

Diesel engine pump drivers shall be selected in accordance with the following:

2.9.3.1 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.

2.9.3.2 Engine Rating

Engines 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.

2.10 Financial Impact Statement (FIS)

For information relating to FIS reference should be made to the Financial Impact Statement section of DS 30-02.

2.11 Flanges, Bolting and Gaskets

Flanges, bolting and gaskets shall be in accordance with DS 38-02 respectively.

2.12 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.

2.13 Guards

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

2.14 Major and Minor Pump Stations

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

2.15 Materials

For general information regarding materials e.g. elastomers and metals, and materials for sea water refer to the relevant Materials sections contained in DS 30-02. Materials for specific pump components shall be compatible in terms of durability and corrosion and abrasion resistance with the medium to be pumped. Materials in contact with potable water shall comply with AS/NZS 4020. Refer to the Water Quality clause contained in this Standard for the water quality data required.

2.16 Noise

2.16.1 General

Designers should refer to the Noise section contained in DS 30-02 for general information regarding noise e.g. OSH regulations, environmental protection regulations, daily noise dose, neighbourhood noise levels etc.

Noise related compliance requirements for installed pumpsets are addressed below.

2.16.2 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.

2.16.3 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.

2.16.4 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 submersible sewage type pumps depending on the application;

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

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

2.17 Pipework

For information on valves refer to the Pump Station Pipework section of this Standard and DS 31-01.

2.18 Signage and Labels

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

2.19 Stairways, Landings, Walkways and Ladders

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

2.20 Transmission

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

2.21 Valves

For information on valves refer to the Pump Station Valves section of this Standard and DS 31-02.

2.22 Variable Speed Drives (VSD)

2.22.1 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.

2.22.2 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.

2.22.3 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.

2.22.4 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.

2.23 Vibration

2.23.1 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.

2.23.2 Monitoring and Protection

Refer to the Electrical and Instrumentation section of this Standard relating to Condition Monitoring and Protection, for vibration monitoring and protection clauses.

2.24 Water Hammer

The Designer shall comply with the relevant parts of Section 6 - Water Hammer contained in DS 60 and the following

2.24.1 System Analysis

The system shall be analysed using a recognised water hammer computer modeling program 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.

2.24.2 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) Mains 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 e.g. $t_c > 2L/C_p$);

(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.

2.24.3 Surge Vessels

Surge vessels shall be designed and manufactured in accordance with DS 35-01.

2.25 Water Quality

The Designer shall provide full water quality data for the medium to be pumped including abrasives (sand content) and water temperature to enable the manufacturers to select appropriate product materials with respect to corrosion and abrasion resistance. Typical information required would be:

(a) Physical parameters:

- Water type e.g. source, drinking, effluent seawater etc,
- Maximum water temperature - ºC,
- Sand content - mg/L (refer Note).

NOTE: **A**nalysis of sand content in the water is not routinely performed but should be provided where there is evidence that sand could be an issue particularly relating to boreholes.

(b) Chemical constituents

- pH,
- Alkalinity (as CaCO3) – mg/L,
- Calcium - mg/L,
- Chloride - mg/L,
- Hardness,
- Iron - mg/L,
- Magnesium - mg/L,
- Nitrogen - mg/L,
- Potassium - mg/L,
- Silica - mg/L,
- Sodium - mg/L,
- Sulphate - mg/L,
- Total filterable solids (TFSS) by summation.

2.26 Welding

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

3 WATER PUMP STATIONS

3.1 General

Water pump stations (as distinct from sewage pump stations) are used for pumping clear water or clear effluent in water supply, wastewater and drainage applications.

Centrifugal pump types utilised 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 are generally used for Corporation water pump stations as further detailed in this section.

For requirements related to buildings refer to the General Design Criteria section of this Standard. For pipework and valves, miscellaneous pump types and electrical and instrumentation refer to relevant sections of this Standard.

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

The Corporation uses various water pump station types and associated pump types depending on the particular application as detailed in the following.

3.2 Pump Station Layout

3.2.1 Horizontal Water Pump Stations

Use of horizontal pumpsets for water pump stations would comprise the majority of conventional water pump station applications. The exceptions would be vertical multistage centrifugal pumps used in high level area booster pump stations (HLAB) covered exclusively in DS 32-02 (Draft) and borehole pump stations covered exclusively in DS 32-01.

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) bridge 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.

3.2.2 Vertical Water Pump Stations

Use of vertical pumpsets for water pump stations would comprise the minority of water pump station applications (except for HLAB and borehole PSs) and would be mainly confined to dam pump station applications.

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.

3.3 Pumpset Orientation

3.3.1 Horizontal Pumpsets

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.

3.3.2 Vertical Pumpsets

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.

3.4 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 period into the future for the life of initially selected pumpsets;

(c) Projected average and peak flows, preferably based on field testing data to verify the flow projections;

(d) Provision in the pump station design to accommodate periodic upgrades in flow capacity via:

  (i) increased pump impeller sizes; or

  (ii) larger capacity pumps, or

  (iii) additional (future) pumpsets;

  (iv) a combination of the above

(e) Complete coverage of the pump station duty or operating envelope may require 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 duties can be accommodated by the pump station and associated pipework. Manifold head losses shall be adjusted for multiple pump operation.

3.5 Pumpset Selection

3.5.1 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.

3.5.2 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.

3.5.3 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 however pumps may operate outside their pump operating range as follows:

  (i) generally the pump operating range (POR) for conventional centrifugal pumps should be restricted to between 70% to 115% of the BEC for continuous operation, and between 50% to 120% of BEC for intermittent operation, however the range may be influenced by the specific speed for a particular pump and accordingly specific applications should be subject to approval by the pump manufacturer;

  (ii) generally the POR for submersible electric centrifugal pumps (and vertical turbine) should be restricted to between 90% to 110% of the BEC for continuous operation, and between 80% to 115% of BEC for intermittent operation, and for the reasons mentioned above, specific applications should be subject to approval by the pump manufacturer 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) pumps operating too far to the left of their BEP will experience relatively low efficiency and may suffer from excessive recirculation (refer DS 30-01 Glossary). This could result 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) Water temperature.

(h) The pump configuration and pump design specific speed shall be taken into consideration to optimise pumping efficiency. Refer to Appndix A for guidance on maximum attainable pump efficiency as presented by the Hydraulic Institute (converted to metric units).

3.5.4 Pump Performance (H-Q) 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) 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%;

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

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

3.5.5 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.

3.5.6 NPSH Requirements

The pumps shall be selected to have an NPSHR less than the system NPSHA under all operating conditions. (Note that the NPSHR includes both Manufacturer’s and site margins as required to ensure satisfactory operation).

The NPSHR shall be the numerical sum of NPSH3 value at BEC provided by the Manufacturer and the NPSH margin. The NPSH margin shall be the greater of the values determined as follows:

1. One (1) metre head (Refer Note 1).

2. As recommended by the Manufacturer.
3. As determined according to the 'Gulich' method based on impeller eye diameter (refer Figure 3.1).

If stated in the Purchasing Schedule, the Corporation will, under special circumstances, accept a NPSH margin determined by means of acceptable erosion rate using Figure 3 2.

NOTES:

1. For minor pump stations this method of calculation would be all that is required.
2. For flow rates less than BEC, the minimum NPSHR shall be that calculated for BEC (refer Figure 3.3).
3. For flow rates greater than BEC, the minimum NPSHR shall be the NPSH3 for that flow, plus the NPSH margin determined for BEC (refer Figure 3.3).

Figure 3 1 - Minimum NPSH margins (Gulich method)

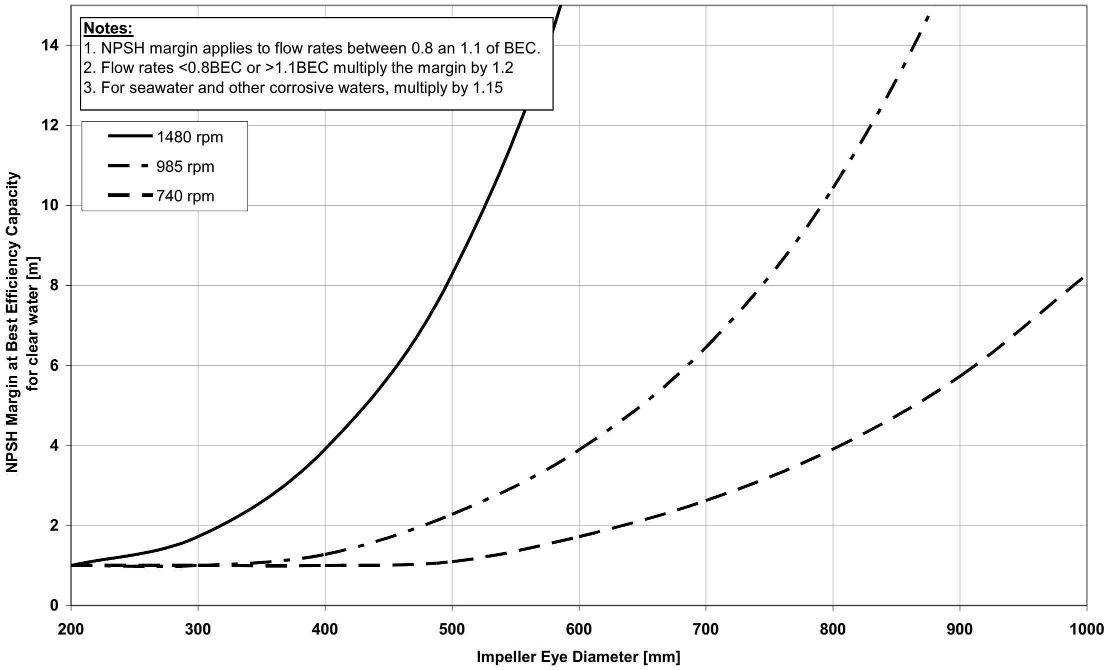


Figure 3 2 – Minimum NPSH margins (erosion limits method)

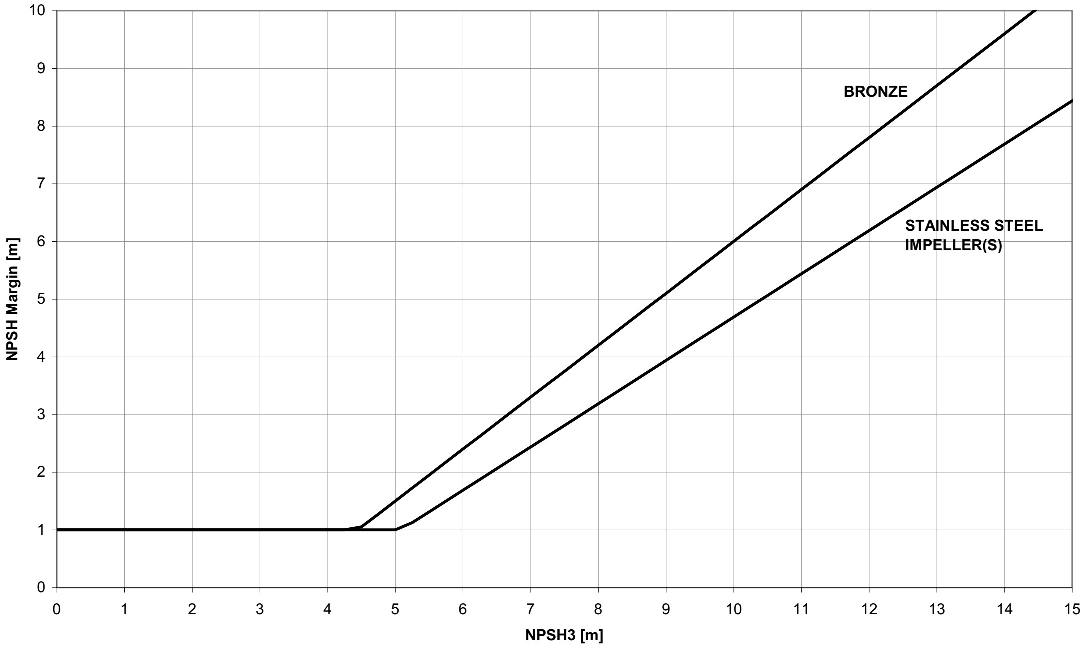
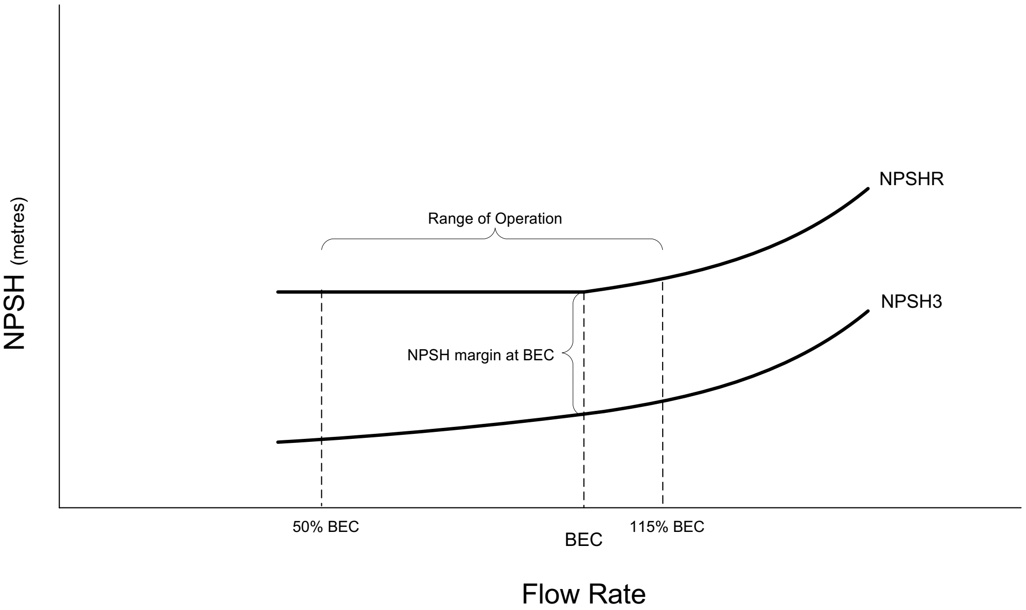


Figure 3.3 - Relationship of flow rate to NPSH over range of operation



3.6 Clearwater Pump Types

3.6.1 General

Horizontal and vertical mixed flow centrifugal pumps as detailed in the following are generally used for Corporation clearwater pump stations.

3.6.2 End Suction Centrifugal Pumps

3.6.2.1 Applications

End suction centrifugal pumps in bare shaft or motor-pump configuration are used for minor pump station applications for clearwater pumping and for motor sizes 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.

3.6.2.2 Summary of Features

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

Table 3.1 – ISO End Suction Centrifugal Pump Features

Item	Feature
Application	Minor pump stations
Type	Production (‘off the shelf’)
Orientation	Horizontal
Style	ISO end suction centrifugal
Ports	Offline, flanged
Volute/casing	Centrally aligned self venting discharge nozzle
	Radially-split
	Single stage
	Single volute
Impeller	Single entry; closed type
Housing	Back pullout (refer Note)
Seal	Mechanical - Single inside-mounted or single balanced cartridge type
Lubrication	Oil (bare shaft only) or grease
Electric motor or engine driven	Close coupled (motor-pump) or long coupled
	2 pole, 4 pole and multi-speed

NOTE: The back pullout feature allows volute to remain in-situ during bearing housing/impeller removal providing a spacer type flexible coupling is fitted between pump and motor.

3.6.2.3 Technical Specifications

Horizontal ISO end suction centrifugal pumps shall comply with SPS 500 and end suction centrifugal motor pumps shall comply with SPS 501.

3.6.3 Vertical Multi-Stage Centrifugal Pumps

3.6.3.1 Applications

This type of pump is used for general pumping of clearwater for minor pump station and high level area booster pump station (refer Note) applications where relatively low flow and high heads are required. Continuously immersed pump materials 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.

NOTE: Separately covered in DS 32-02.

3.6.3.2 Summary of Features

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

Centrifugal Pump Features

Item	Feature
Application	Minor pump stations
Type	Production (‘off the shelf’)
Orientation	Vertical
Style	End suction centrifugal
Ports	Inline flanged suction and discharge ports
Stage casing	Radial flow, non self venting
	Radially-split
	Single or multi-stage
Impeller	Single entry; closed type
	Overhung or fully supported impellers available (refer Note 1)
Housing	Top pullout (refer Note 2)
Seal	Balanced cartridge type mechanical seal
Lubrication	Grease
Electric motor	Close coupled above pump shaft end
	2 pole and multi-speed via VSD

NOTES:

1. Single (overhung) or two bearing (fully supported).
2. Allowing volute to remain in-situ during bearing housing/impeller removal.

3.6.3.3 Technical Specification

Vertical multi-stage centrifugal pumps shall comply with SPS 506.

3.6.4 Tangential Discharge Centrifugal Pumps

3.6.4.1 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.

3.6.4.2 Features

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

Table 3.3 – Tangential Discharge Centrifugal Pump Features

Item	Feature
Application	Major pump stations and water treatment plants
Type	Engineered
Orientation	Horizontal
Style	End suction centrifugal
Ports	Offline, flanged
Volute	Tangential discharge (refer Note),
	Non self venting
	Radially-split
	Single -stage
	Single volute
Impeller	Single entry; closed type
	Overhung e.g. single bearing
Housing	Non back pullout
Seal	Mechanical - Single inside-mounted or single balanced cartridge type
Lubrication	Oil or grease
Electric motor or engine driven	Long coupled
	4 pole motor

NOTE: Nozzle oriented either vertically or horizontally overshot.

3.6.5 Axially-Split Casing Pumps

3.6.5.1 Applications

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

3.6.5.2 Features

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

Table 3.4 – Axially-Split Centrifugal Pump Features

Item	Feature
Application	Minor and major pump stations
Type	Engineered, medium flow-medium head, medium flow-high head
Orientation	Horizontal or vertical (dams)
Style	Axially split casing centrifugal
Ports	Online (single stage), offline (multi-stage), flanged
Volute	Axial-split casing (refer Note),
	Non self venting
	Single or multi-stage
	Single or double (balanced) volute
Impeller	Double entry (single stage); closed type
	Fully supported e.g. two journal or anti-friction bearings
Casing	Non back pullout
Seal	Balanced cartridge type mechanical seals
Lubrication	Grease
Electric motor or engine driven	Long coupled
	4 pole (or less) and multi-stage

NOTE: Allows removal of the top casing in order to replace the rotating element without disturbing the remainder of the pump

3.6.5.3 Technical Standards

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

3.6.6 Centrifugal Pump Materials

3.6.6.1 Component Materials

The basic material requirements for centrifugal pumps are contained in the relevant strategic product specifications contained in DS 36.

3.6.6.2 Glands and Mechanical Seals

For information relating to packed glands and mechanical seals refer to the relevant pump strategic product specification or in lieu the Seals – Mechanical section of DS 30-02.

3.6.6.3 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. AS 1565

C93500 leaded tin bronze is susceptible to chlorine attack if chlorine is being injected immediately upstream of the pump and should be substituted by AS 1565 C90250 as a minimum requirement.

3.6.7 Sump Pumps

For information regarding sump pumps refer to 'Sump Pumps' contained in the "Miscellaneous Pumps' section of this Standard.

3.6.8 Pump Pressure Ratings

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

Table 3.5 – Pump Pressure Ratings

Pressure	Pressure Class Rating			
	PN 14	PN 16	PN 21	PN 35
Maximum allowable operating pressure - kPa	1400	1600	2100	3500
Hydrostatic test pressure - kPa	2100	2400	3150	5250

3.7 Pump Testing

Factory testing shall be conducted for all pumps supplied for Corporation assets. Except as may be otherwise stated in relevant pump strategic product specifications, the tests shall be carried out in accordance with ISO 9906 for Grades 1 and 2 tests (as required) at the manufacturer's works using "clean cold water" complying with Clause 17.3.1(b) of AS 4037. The Test curves generated shall be in metric units with head in metres and flow in litres per second.

NOTE: Generally production pumps (e.g. less than 100 kW) would be subject to less stringent testing requirements (Grade 2) than for engineered pumps (Grade 1).

3.7.1 Production Pumps

Production pumps shall be tested in accordance with ISO 9906 Grade 2B pump test acceptance grade. Tests shall be conducted at the rated speed and test curves generated to confirm the guaranteed point acceptance grade for:

- Rate of flow;
- Total head;
- Power input.
- Efficiency.

Tests shall be carried out from the lower head limit of the pump guaranteed performance curve progressively moving towards the shut off head. At least six points along the characteristic curve including the shut-off head shall be taken. The pump test requirements detailed in Clause 3.7.3 shall apply as applicable.

3.7.2 Engineered Pumps

Engineered pumps shall be tested in accordance with ISO 9906 for Grade 1E pump test acceptance grade. Tests shall be conducted at the rated speed and test curves generated to confirm the guaranteed point acceptance grade for:

- Rate of flow;
- Total head;

- Power input.
- Efficiency.

Tests shall be carried out from the lower head limit of the pump guaranteed performance curve progressively moving towards the shut-off head. At least ten (10) points along the characteristic curve shall be taken. The pump test requirements detailed in Clause 3.7.3 shall apply as applicable.

3.7.3 Pump Test Requirements

The following pump test requirements shall apply:

(a) The head-flow characteristic, including the shut-off head shall extend to at least 115% of the Guarantee Duty Point, or 115% of the Best Efficiency Capacity, whichever the greater.

(b) Where the tests are to be undertaken for variable speed pumps, the head-flow characteristic shall also be determined for the maximum and minimum intended operating speeds.

(c) The power absorbed by the pump, and the pump efficiency shall be calculated, for each of the above-stated test points.

(d) Where required determination of the NPSH3 characteristic curve, extending from 80% of the Best Efficiency Capacity to at least 115% of the Primary Guarantee Duty Point, or 115% of the Best Efficiency Capacity, whichever the greater. At least five (5) points along the characteristic curve shall be taken.

(e) The NPSH test method shall be the constant flow method. For the purpose of this Standard a drop in performance of 3% in total differential head from a condition of no loss of head due to cavitation shall determine the NPSH3 value at each test flow. The number of readings taken shall be as necessary to determine the shape of the individual ‘horsetail’ curve.

3.7.4 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.

3.7.5 Instrumentation and Tolerances

Instrumentation and their tolerances shall comply with the following:

(a) All instrumentation used in acceptance testing to AS 9906 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 9906.

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

3.7.6 Test Curves

All test curves developed shall utilize SI units.

3.7.7 Vibration Testing

The pump vibration shall be tested and shall comply with the Vibration clause contained in the General Design Criteria section of this Standard.

3.7.8 Sound Level Testing

The sound power level of the pumps shall be tested and shall comply with the Noise clause contained in the General Design Criteria section of this Standard.

3.7.9 Thermodynamic Pump Testing (TPT)

Where practicable use of the thermodynamic pump performance monitoring system (Yatesmeter or equivalent) shall be accommodated via associated tapping points, which shall be provided for a direct thermodynamic test probe for all water and sewage pumps complying with the following:

- Pump sizes 50 kW or larger with a total head greater than 25 m (refer Note), or
- Pumps that run continuously or for long periods of time.

Refer to the TPT Tappings (Clause 5.2.6) in the Pipework section of this Standard for details of the tappings requirements.

NOTE: Conventional site pump tests provides accuracies of the order of 3% whereas the TPT provides accuracy to ½% but below heads of 25 m there is no real advantage using TPPT over conventional testing.

3.8 Redundancy

3.8.1 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.

3.8.2 Duty/Standby

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

For a multi-pump configuration, additional pumpsets (standby) 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.

In special applications where the full duty operation of the station may not be critical, and where 100% redundancy may be either cost prohibitive or unnecessary, it may be acceptable to provide for a spare pump or spare parts in order to meet the pump station’s operational levels of service, in lieu of additional installed standby capacity.

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

3.9 Spares Parts

For critical pump stations, where extended turn-around or repair times are likely to be unacceptable, spare pump(s), rotating element(s), impeller(s) and associated spare parts shall be purchased with the pumpsets in accordance with the following.

3.9.1 Spare Pump(s)

A spare pump (Note 1) may be considered a suitable risk management strategy for:

(a) Production pumps in critical or remote pump stations in lieu of spare parts,

(b) Critical major pump stations utilizing engineered pumps whereby a spare pump would be procured in lieu of, or in addition to spare parts, in order to reduce turn-around time (refer Notes 2 and 3).

NOTES:

1. In addition to standby capacity covered in the Redundancy Clause above.
2. The cost of a spare pump or pumps for major pump stations would generally represent only a small percentage of the overall project cost so they should be seriously considered for critical pump stations. Spare electric motors do not seem to attract the same budgetary scrutiny yet the pump is an equally essential part of the system,
3. Additional critical spare parts should be considered necessary to refurbish any pump replaced by the spare pump e.g. impeller(s).

3.9.2 Spare Rotating Element(s) and Spare Parts

(a) A spare rotating element or at least its critical components e.g. impellers may be considered necessary for engineered pumps.

NOTES:

1. Items such as pump shafts and wear rings can be manufactured locally as required however turn-around time may become an issue for critical pump stations.
2. The spare rotating element or impellers may not be used for many years e.g. 15 -20 years and it is highly likely spares may no longer be available from the manufacturer, particularly impellers other than what may have been initially ordered with the pumps as spares.

(b) For axially-split casing pumps the spare rotating element would normally comprise:

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

(ii) items 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).

(iii) if specified by the client, the spare rotating element for axially-split pumps shall be assembled and 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.

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

(d) The spare initial impeller(s) 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;

(e) Rotating elements and spare parts shall be properly packed in a robust packing case designed for transport and long term storage of the spare components in dusty and moist environments. The pump shaft shall be secured on supports within the packing case.

4 SEWAGE PUMP STATIONS

4.1 General

Sewage pump stations are used for pumping wastewater e.g. raw sewage and sludge as distinct from water pump stations which are used for pumping clear water, dirty water and clear effluent.

Centrifugal pump types utilised 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 should generally be used for conventional Corporation sewage pump stations.

For requirements related to buildings refer to the General Design Criteria section of this Standard. For pipe work and valves, miscellaneous pump types and electrical and instrumentation refer to relevant sections of this Standard.

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

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

4.2 Pump Station Layout

4.2.1 Horizontal Sewage Pump Stations

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

However there are rare occasions where this orientation is used by the Corporation. In these instances 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 screw impeller end suction centrifugal pumps which have non-clog characteristics in order to minimize pump ragging problems.

4.2.2 Vertical Sewage Pump Stations

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

A similar layout and other requirements apply for vertical sewage pump stations to those specified in the previous Horizontal Water Pump Station section, 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 sewage 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 considered 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.

Requirements and information for vertical sewage pump stations are contained in the following sections relating to ‘Circular and Rectangular Wet Well / Dry Well Sewage Pump Stations’.

4.3 Sewage Pumpset Orientation

4.3.1 Circular Vertical Wet Well PS

This pump station type comprises circular wet wells each equipped with vertical submersible electric pumps 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.

4.3.2 Circular Vertical Wet /Dry Well PS

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.

4.3.3 Circular Vertical Dry Well PS – Follow-the-Flow

This pump station type comprises a circular dry well with conventional vertical centrifugal pumps using follow-the-flow philosophy.

4.3.4 Wet /Dry Well PS versus Dry Well Follow-the-Flow PS

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.

4.3.5 Rectangular Horizontal Wet/Dry Well PS

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.

4.3.6 Rectangular Vertical Wet /Dry Well PS

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.

4.4 Pump Station Duty

The pump station duty shall be determined in accordance with the relevant parts of Clause 3.4.

4.5 Pumpset Selection

Selection of sewage pumps shall comply with Clause 3.5 of this Standard except for references to the requirement for impellers to be trimmed which may not be applicable to some submersible sewage pump types for minor pump stations e.g. Types 40 and 90 pump stations.

4.6 Sewage Pump Types

4.6.1 General

Horizontal and vertical mixed flow centrifugal pumps as detailed in the following are generally used for Corporation sewage pump stations.

4.6.2 Screw Impeller Sewage Pumps

4.6.2.1 Applications

The screw impeller centrifugal pump is used by the Corporation for general pumping of sewage for minor and major sewage pump stations and vacuum sewage pump stations. These pumps have very good solids handling (developed in the 1940’s for pumping fish unharmed); Pumps are available in immersible, submersible and end suction types. Immersible/submersible pumpsets are used in Corporation’s vacuum sewage pump stations. Bare shaft pump applications are specifically related to horizontal drywell service.

4.6.2.2 Summary of Features

The following table summarises the features of the

Table 4.1 –Screw Impeller Sewage Pump Features

Item	Features	
	Immersible/Submersible	**Horizontal Bare Shaft**
Application	Minor e.g. vacuum sewage	Major
Type	Production	Engineered
Orientation	Vertical or horizontal	Horizontal
Style	End suction centrifugal	End suction centrifugal
Ports	Offline, flanged	Offline, flanged
Volute	Radially-split	Radially-split
	Non self venting	Non self venting

Item	Features	
	Immersible/Submersible	**Horizontal Bare Shaft**
	Single stage	Single stage
	Single volute	Single volute
Impeller	Single entry open screw	Single entry; open screw
	Overhung e.g. single	Overhung e.g. single bearings
Housing	Back pullout	Back pullout
Seal	Mechanical seal	Balanced cartridge type mechanical seals
Lubrication	Grease	Grease
Electric motor	Close coupled	Long coupled
	2 or 4 pole	4 pole (or less)

4.6.3 Submersible Sewage Pumps

4.6.3.1 Applications

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

4.6.3.2 Features

This type of pump is generally used for submersible sewage pump stations for raw sewage and sludge as follows:

(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);

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.

Table 4.2 – Submersible Sewage Pump Features

Item	Feature
Application	Minor and major pump stations (refer pump station types above)
Type	Production ('off the shelf') and Engineered
Orientation	Vertical
Style	Compact, self-contained submersible type, end suction centrifugal
Ports	Offline suction and discharge flanged ports
Volute	Radial flow, non self venting
	Radially-split
	Single stage
	Single volute
Impeller	Single entry; closed type
	Overhung e.g. single bearing support
Housing	Top pullout, submersible and drywell mount

Item	Feature
Seal	Oil filled seal chamber with two mechanical seals
Lubrication	Grease
Electric motor	Submersible
	Close coupled with integral motor/pump shaft
	2 pole, 4 pole and multi-speed

4.6.3.3 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.

4.6.3.4 Large Submersible Sewage Pump Issues

The Corporation has experienced problems with some of its large submersible sewage 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 sewage pumpsets have had a history of premature catastrophic failure in the Corporation;

(b) Submersible sewage pumpsets tend to have lower efficiencies than drywell pumpsets;

(c) Submersible sewage pumpsets tend to have a higher maintenance frequency;

(d) Dual lifting or lowering cranes are required for simultaneous lifting or lowering of submersible sewage 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 sewage 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) Submersible sewage pumpset 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 sewage pumpset higher vibration levels can lead to premature failure of components;

(i) Redundancy requirements cannot be met without carrying a complete spare submersible sewage pumpset when a pumpset requires overhaul;

(j) Removal of wet well covers to gain access to submersible sewage pumpsets and control equipment potentially exposes the environment to significant odours;

(k) Life cycle costing should be employed when considering large wet well submersible sewage pump stations versus drywell pump stations.

4.6.3.5 Technical Specification

Submersible sewage pumps shall comply with SPS 503.

4.6.4 Radially-Split Drywell Sewage Pumps

4.6.4.1 Applications

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

4.6.4.2 Summary of Features

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

Table 4.3 – Radally-Split Drywell Sewage Pump Features

Item	**Feature**
Application	Major pump stations
Type	Engineered
Orientation	Vertical
Style	Radially-split casing end suction centrifugal
Ports	Offline, flanged
Volute	Radially-split
	Non self venting
	Single stage
	Single or double (balanced) volute
Impeller	Single entry, closed type
	Overhung impeller e.g. single bearing
Housing	Squat with bridge style bearing housing (for large sizes);
	Back pull out (BPO)
Seal	Split mechanical seal
Lubrication	Grease
Electric motor	Long coupled
	4 pole (or less) and multi-stage

4.6.5 Axially-Split Drywell Sewage Pumps

4.6.5.1 Applications

Axially-split drywell sewage pumps are used for general pumping of sewage for major drywell sewage pump station applications (where preferred radially-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.

4.6.5.2 Summary of Features

The following list summarises the pertinent features of vertical end suction axial-split centrifugal pumps:

Table 4.4 – Axially-Split Drywell Sewage Pump Features

Item	**Feature**
Application	Major pump stations
Type	Engineered
Orientation	Vertical
Style	Axially-split casing end suction centrifugal
Ports	Offline, flanged
Volute	Axial-split casing
	Non self venting
	Single stage
	Single volute
Impeller	Single entry; closed type
	Overhung impeller e.g. single bearing
Housing	Long style bearing housing (for large sizes)
	Non BPO
Seal	Split mechanical seal
Lubrication	Grease
Electric motor or engine driven	Long coupled
	4 pole (or less)

4.6.6 Radially-Split versus Axially-Split Sewage Pumps

4.6.6.1 General

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

4.6.6.2 Axially-Split Pump Disadvantages

Axially-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 radially-split pump;

(c) They require removal and reassembly of a significant number of components compared with relatively few components for the radially-split pump;

(d) The axially-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 radially-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 radially-split pump when lifted from the volute casing;

(f) Seal rings may be crushed when reassembling the axially-split pump whereas the BPO radially-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 radially-split pumps generally take about half the time to de-rag e.g. 4 to 5 hours compared to axially-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 radially-split pump would take less time;

(i) Axially-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 radially-split pumps.

4.6.7 Major 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 radially-split sewage pumps.

4.6.7.1 Pump Casing

The pump casing should embody:

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

(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.

4.6.7.2 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 30-01;

(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;

4.6.7.3 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;

4.6.7.4 Transmission

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

4.6.7.5 Foundation Block

Pumpset foundation 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.

4.6.7.6 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 4.5 – Materials for Sewage Pumps

Component	Material	Standard	Grade
Casings	Grey cast iron	AS 1830	ISO 185/JL/250
	Ductile iron	AS 1831	ISO/JS/400-15V
			ISO/JS/500-7V
Casing wear ring[3]	Leaded tin bronze	AS 1565	C93500
Impeller and wear ring[3]	Phosphor bronze	AS 1565	C90250
Shaft	Stainless steel	ASTM A276	431
Shaft bearing locknuts	Carbon steel	1443	N/A
Seal plate studs	Stainless steel	ASTM A276	316
Mechanical seal[1]:	(Refer components below)		
• Stationary face	Solid silicon carbide	N/A	N/A
• Rotating face	Solid silicon carbide	N/A	N/A
• Drive keys	Stainless steel	ASTM A276	316
• O-rings	EPDM, NBR, FPM	AS 1646	70 IRHD
• Flange	Stainless steel	ASTM A276	316

Component	Material	Standard	Grade
- Springs	Hastelloy C®	N/A	N/A
Seal plate stud nuts	Leaded gunmetal	AS 1565	C83600
Fitted studs[2]; Fixing and fitted bolts, forcing screws and dowels[2]; Nuts for fixing and fitted studs and bolts[2]	Stainless steel	ASTM A276	431[4], 316[4]
Water thrower	Rubber	AS 1646	70 IRHD
Internal coating	Coatings shall comply with the Pump Coatings table of DS 30-02		
External coating			

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.

4.6.8 Sewage Pump Pressure Ratings

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

Table 4.6 – Pump Pressure Ratings

Pump Condition	Pressure Rating - kPa
Maximum Working Pressure	1400
Hydrostatic Test Pressure	2100

4.6.9 Sump Pumps

For information related to sump pumps for use in major sewage pump stations refer to the Miscellaneous Pump Types section of this Standard.

4.7 Pump Testing

4.7.1 General

Pump testing shall comply with the relevant requirements of Clause 3.7 of this Standard.

4.7.2 Hydrostatic Test 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.

4.8 Redundancy

4.8.1 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 requirements than for water pump stations and the consequence of failure can be severe both environmentally and politically.

4.8.2 Duty/Standby

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

For a multi-pump configuration, additional pumpsets (standby) 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.

In special applications where the full duty operation of the station may not be critical, and where 100% redundancy may be either cost prohibitive or unnecessary, it may be acceptable to provide for a spare pump or spare parts in order to meet the pump station’s operational levels of service, in lieu of additional installed standby capacity.

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

4.9 Spare Parts

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:

4.9.1 Spare Pump(s)

Major sewage pump stations shall have 100% redundancy capability even when one pumpset fails. Ideally a spare pump should be available for critical for drywell pump stations pumps or alternatively a spare rotating element shall be available for immediate replacement into a failed pump.

In the case of a major submersible sewage pump station or where submersible sewage pumps are used in a drywell application a spare submersible sewage pumpset shall be available to be fitted immediately to replace the failed unit.

A spare pump (Note 1) may also be considered a suitable risk maintenance strategy for:

(a) Production pumps in critical or remote pump stations in lieu of spare parts,

(b) Critical major pump stations utilizing engineered pumps whereby a spare pump would be procured in lieu of, or in addition to spare parts, in order to reduce turn-around time (refer Notes 2 and 3).

NOTES:

1. In addition to standby capacity covered in the Redundancy Clause above.
2. The cost of a spare pump or pumps for major pump stations would generally represent only a small percentage of the overall project cost so they should be seriously considered for critical pump stations. Spare electric motors do not seem to attract the same budgetary scrutiny yet the pump is an equally essential part of the system,

3. Additional critical spare parts should be considered necessary to refurbish any pump replaced by the spare pump e.g. impeller(s).
4. A spare rotating element or at least its critical components e.g. impellers may be considered necessary for engineered pumps (items such as pump shafts and wear rings can be manufactured locally if necessary);

4.9.2 Spare Rotating Element(s) and Spare Parts

(a) A spare rotating element or at least its critical components e.g. impellers (and possibly wear rings) may be considered necessary for engineered pumps.

NOTES:

1. Items such as pump shafts and wear rings can be manufactured locally as required however turn-around time may become an issue for critical pump stations.
2. The spare rotating element or impeller may not be used for many years e.g. 15 -20 years and it is highly likely spares may no longer be available from the manufacture, particularly impellers other than what may have been initially ordered with the pumps as spares.

(b) The spare rotating element would normally comprise:

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

(ii) items 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 (as applicable);
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).

(iii) the spare rotating element shall be interchangeable with all associated duty and standby pump casings e.g. if specified proving tests during factory inspection shall be conducted to ensure proper fitment, and shall be rotated by hand to confirm free movement.

(c) Where future duty impellers are proposed they should be provided as part of the pump supply contract;

(d) Where specified 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.

(e) Rotating elements and spare parts shall be properly packed in a robust packing case designed for transport and long term storage of the spare components without contamination in dusty and moist environments. The pump shaft shall be secured on supports within the packing case.

4.10 Efficiency Degradation

Wastewater pumps are particularly vulnerable to efficiency degradation from erosion of wear rings, producing increased clearances and reduced efficiency. Correct pump sizing, appropriate selection of wear ring materials and ongoing testing to monitor efficiency is required to optimise pump efficiency.

5 PUMP STATION PIPEWORK

5.1 General

This section is intended to cover water and sewage pump station pipework. Vacuum sewage pump station pipework is covered separately in the Vacuum Sewage Pump Stations section.

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.

5.1.1 Pipework Design Parameters

(a) Pipework including manifolds and offtakes should be sized so as not to exceed the flow velocities specified in the table of maximum recommended 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.:

$h_f = K\,V^2/2g$ (Refer Definitions in DS 30-01 Glossary)

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

5.1.2 Flow Velocities

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

Table 5.1 – Maximum Recommended Flow Velocities

Suction and Discharge Pipework	Maximum Velocity m/s
Dam inlet screens	≤ 0.3
Bellmouth rim	1.1
Suction pipework	1.5
Discharge pipework	2.5

Where design flows exceed the suction velocities shown in the above table the effect shall be modelled to prove there will be no adverse effects on the pump suction performance.

5.2 Manifold and Offtakes

5.2.1 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 entrapment 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.

(f) 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;

(g) 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.

5.2.2 Suction Pipework

The design shall comply with the following requirements (as applicable):

(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 90º 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:

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

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

  (iii) accordance with the Pump Station Valves section of this Standard.

5.2.3 Delivery Pipework

The design shall comply with the following requirements (as applicable):

(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 Pump Station Valves section of this Standard.

5.2.4 Pipework Materials of Construction

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

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 (refer Note).

NOTE: Refer to DS 32-01 and DS 32-02 for stainless steel pipework requirements relating to borehole pumps and high-level area booster pump stations respectively.

5.2.5 Manifold and 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 (as a minimum) 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 clauses contained in the Electrical and Instrumentation section of this Standard. The suction and delivery manifolds shall each be fitted with a suitably sized drain point and resilient seated gate valve.

5.2.6 Thermodynamic Pump Testing Tappings

Requirements for thermodynamic pump testing are detailed in Clause 3.7.9 of this Standard. Where required thermodynamic pump test tappings 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 tappings 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.

5.2.7 Manholes for Internal Inspection Vehicles

(a) This clause specifically relates to the provision of manholes to allow access by internal inspection vehicles (vehicles) in order to facilitate pipework inspections. This clause is not intended to cover manhole requirements for personnel access. Entry by personnel into pipework should be avoided in favour of inspection by other means e.g. an internal inspection vehicle.

(b) Provision of manholes for vehicle access is a matter that should be addressed by stakeholders during the design stage with a view to assessing the need for vehicle inspection of critical items for operation and maintenance purposes.

(c) Manholes would not normally be required for offtake pipework as associated valves would generally be smaller and less critical and would normally be accessible by removing adjacent pipe specials.

(d) Provision of manholes would normally be confined to pump station manifolds and connecting pipework where inspection of large critical valves may be required e.g. large butterfly valves or dam guard valves in the case of dam pipework.

(e) For pipework size DN 250 to ≤DN 800, a minimum manhole size of DN 250 shall be provided (refer Note 1). For pipework ≥DN 900 a manhole size of DN 600 shall be provided (refer Note 2).

(f) Manholes shall be located on top of the pipework, and normally on the downstream side of butterfly valves in order that that their sealing effectiveness can be observed when the valve is in the closed position.

(g) DN 600 manholes shall comply with the drawings contained in DS 65.

NOTES:

1. This would enable inspection of both sides for butterfly valve sizes DN 600 and larger. A limitation would be the inability to close the valve whilst inspecting the furthest side (normally upstream) because of the cable trailing through it.
2. The larger manhole size would allow entry of a larger vehicle which would be able to elevate to a higher level. This would allow the camera to pan closer in order to provide a more detailed inspection of the top sealing surface of the valve. A DN250 manhole could be used in this application however vision of the top of the valve could be compromised by use of the smaller vehicle.

5.2.8 Pipe Flanges, Fasteners and Gaskets

Flanges, fasteners and gaskets shall comply with the requirements of DS 38-02 (Draft).

5.2.9 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.

5.2.10 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.

NOTE: Proprietary flanged dismantling joints incorporating tie bolts are available e.g. TEEKAY AXIFLEX.

5.3 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 10º to 15º;

(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 subject to approval from the Corporation.

5.4 Bends

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

5.5 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.

5.6 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.

6 PUMP STATION VALVES

6.1 General

This section is intended to cover water and sewage pump station valves. Vacuum sewage pump station valves are covered separately in the Vacuum Sewage Pump Stations section.

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 the valve types mentioned refer to DS 31-02.

6.2 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 fully open or fully closed service only and should be operated against balanced head (no flow) conditions e.g. with the pump shut down.

6.2.1 Manifold Isolating 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.

NOTE: 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.

6.2.2 Water Pump Station Offtake Isolating Valves

Water pump station offtake 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 or SPS 262 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.

(c) The suction offtake isolating valve(s) 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;

(d) 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. 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 for sizes up to approximately DN 500 above which butterfly valves tend to be cheaper. However gate valves are relatively bulky and heavier than equivalent butterfly valve sizes.
3. 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.

6.2.3 Sewage Pump Station Pipework Isolating 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;

(b) Knife gate valves with extended operating spindles for inlets to submersible sewage pump stations shall conform to SPS 259;

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

(d) Isolating valves shall be terminating style e.g. double flanged to allow removal of the pump.

NOTE: Butterfly valves are not suitable for use in sewage applications as the disc will become fouled and cause valve malfunction.

6.2.4 Bypass Valves

Where bypass valves are required to be fitted around isolating valves they shall comply with the Bypass Valves section of DS 31-02.

6.3 Non-return Valves

6.3.1 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.

6.3.2 Water Pump Station Non Return Valves

The Designer shall consider the following when selecting water pump station non return 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. 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.

6.3.3 Sewage Pump Station Non Return Valves

The Designer shall consider the following when selecting sewage pump station non return valves:

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

(b) Valves installed below a tee piece in a pump discharge riser may be subject to blockage due to the settlement of sand and debris when the pump has been removed for extended periods e.g. during maintenance. Accordingly horizontal orientation of pipework is preferred. However, where a vertical installation is unavoidable, provision shall be made to enable temporary flushing of blockages, via a tapping point fitted with a DN 20 isolating valve, located immediately downstream of the riser gate valve.

(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 should not be used in sewage applications, as they would be subject to fouling and subsequent malfunction.

6.3.4 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.

6.4 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 VACUUM SEWAGE PUMP STATIONS

7.1 General

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

7.2 Building

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

7.2.1 Noise Attenuation

(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 Clause contained in the General Design Criteria section of this Standard;

(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.

7.2.2 Manual Handling

(a) A manually operated overhead travelling bridge 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.

(b) 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.

7.2.3 Facilities

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

(b) 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.

(c) 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.

7.2.4 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 handrailing 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.

7.2.5 Signage and Labelling

All hazard signage and equipment identification for the building and site shall be provided.

7.3 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 bridge 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.

7.4 Sewage Pumps

Sewage pumps used for removal of sewage from the vacuum tank shall comply with the Submersible Sewage Pumps clauses contained in the Sewage Pump Station section of this Standard (as applicable) 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.

7.5 Vacuum Pumps

7.5.1 General

Vacuum pumps (referred to as Generators in WSA 06) shall comply with the following requirements and WSA 06. The Corporation uses both rotary claw and rotary vane vacuum pump types in its vacuum sewage pump stations and the requirements of each are covered in the following. Rotary claw vacuum pumps are preferred because of their simplicity and robust characteristics however their operating range does not fully cover the Corporation's requirements necessitating the use of the rotary vane type vacuum pumps for higher vacuum loads.

NOTE: Liquid ring vacuum pumps are no longer used on new Corporation vacuum sewage pump stations because their water management system requires high ongoing maintenance, water usage, high water temperature and water quality issues compared to the dry running and oil-recirculation systems employed by the rotary claw and rotary vane vacuum pumps respectively.

7.5.2 Selection

The Designer should refer to DS 36 for details of the rotary claw and rotary vane vacuum pumps that have been authorized for use on Corporation assets. Selection of a particular type and brand of vacuum pump should take into account the following factors:

7.5.2.1 Life-Cycle Costing

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

7.5.2.2 Oil Carryover

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

7.5.2.3 Vacuum Pump Preference

Where a rotary claw vacuum pump meets the duty requirement (e.g. ≤ 500 m^3/hr) it shall be selected over the equivalent rotary vane vacuum pump.

7.5.3 Operating Range

For vacuum sewerage systems the vacuum pump operating range generally covers flows between 100 m^3/h and 1000 m^3/h between vacuum set points of -50 kPa to -80 kPa.

7.5.4 Rotary Claw Vacuum Pumps

7.5.4.1 General

Rotary claw vacuum pumps are used in vacuum sewage pump stations to address the disadvantages previously outlined that relate to the other types of vacuum pumps. Accordingly rotary claw vacuum pumps are preferred over the rotary vane vacuum pump types. Rotary claw vacuum pumps can provide flows up to 500 m^3/hr.

7.5.4.2 Principle of Operation

The rotary 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.

7.5.4.3 Features

The rotary claw vacuum pump shall incorporate 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;

(e) Close-coupled flange mounted electric motor;

(f) Silencer and acoustic enclosure

(g) Polyester type inlet filter.

7.5.4.4 Advantages

The rotary claw vacuum pump has the following advantages:

(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

7.5.4.5 Disadvantages

(a) It could be argued that the rotary claw pump has the added complexity and cost of a gearbox;
(b) Rotary claw pumps are relatively noisy (although the rotary vane type is also noisy); and
(c) Has a limited flow range compared to rotary vane vacuum pumps.

7.5.4.6 Materials of Construction

Rotary claw pumps should be manufactured from the following materials:

Table 7.1 – Rotary Claw Pump Materials

Component	**Material**	**Standard**	**Designation**
Pump housing and end covers	Cast iron	AS 1830	ISO 185/JL/250
Rotary claw rotor	Ductile iron	AS 1831	ISO 1083/JS/400-15S
			ISO 1083/JS/500-7S
Shafts	Carbon steel	-	-
Rotor retainer	Carbon steel	-	-
Retainer fastener	Carbon steel	-	-
Shaft O-ring seals	Viton®	-	-
Discharge silencer	Stainless Steel		
Internal coating	All exposed component surfaces in the pump chamber shall be coated with molybdenum disulphide to a minimum 1.5 micron thickness.		
External coating	Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer's standard.		

7.5.4.7 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.

7.5.4.8 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.

7.5.4.9 Rotary Claw Pumpset

The rotary claw pumpset shall comprise a rotary claw vacuum pump, close coupled to a 415V, 50 Hz flange-mounted electric motor complying with DS 22 and Electrical Type Specification DS 26-06 for Standard Cage Induction Motors. The pump and motor shall 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.

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

7.5.5 Rotary Vane Vacuum Pumps

7.5.5.1 General

Rotary vane vacuum pumps:

(a) Are used by the Corporation for the larger vacuum duties as previously mentioned;

(b) Shall be air-cooled, single stage, oil-recirculating type and rated for continuous operation;

(c) Can provide flows up to the 1000 m^3/hr referred to above.

7.5.5.2 Principle of Operation

The rotary vane vacuum 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 vacuum pumps run at relatively high temperatures and 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 be run on an alternate duty mode unless an oil heater is fitted (larger units).

7.5.5.3 Features

Rotary vane pumps shall incorporate the following features:

(a) Oil mist eliminator and level switch;

(b) Oil cooler;

(c) Oil reservoir, drain plug, filler plug, sight glass;

(d) Oil heater (vacuum pumps $\geq$400 m^3/hr);

(e) Oil demister;

(f) Oil filter (automotive spin-on type);

(g) Exhaust valve;

(h) Exhaust filter;

(i) Vibration isolators.

(j) Polyester type inlet filter.

7.5.5.4 Accessories

The following rotary vane pump accessories shall be provided:

(a) Gas ballast valve to absorb gases containing water vapour;

(b) Oil filter pressure gauge;

(c) Synthetic oil to address high pump temperature.

7.5.5.5 Advantages

The rotary vane vacuum pump is only used to meet higher duty applications which cannot be met with rotary claw pumps.

7.5.5.6 Disadvantages

The rotary vane pump has the following disadvantages:

(a) High operating temperature (80 ºC) 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 rotary claw pumps and have a relatively high number of components;

(e) It is subject to continuous wear between rotor vanes and the 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) The exhaust could be subject 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;

(k) Optimal efficiency requires an operating temperature of 80 ºC and this may not be readily achievable.

7.5.5.7 Materials of Construction

Rotary vane vacuum pumps should be manufactured from the following materials:

Table 7.2 – Rotary Vane Vacuum Pump Materials

Component	**Material**	**Standard**	**Designation**
Casing	Cast iron	AS 1830	ISO 185/JL/250
	Aluminium	AS 1874	Per Standard as appropriate
	Cast steel	AS 2074	Appropriate grade
Rotor	Carbon steel	AS 1448	-
Vanes	Kevlar or carbon composites	-	-
Seals - Lip	Nitrile or Viton®	AS 1646	-
Exhaust valve	Carbon steel	AS 1448	-
External coating	Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer’s standard.		

Component	Material	Standard	Designation
Lubrication	Synthetic oil		

7.5.5.8 Rotary Vane Pumpset

The rotary vane pumpset shall comprise a single stage, air-cooled, rotary vane vacuum pump, close coupled to a 415V, 50 Hz flange-mounted electric motor complying with DS 22 and Electrical Type Specification DS 26-06 for Standard Cage Induction Motors. The pump and motor shall be mounted on a baseplate in accordance with the Baseplates section of DS 30-02.

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

7.5.5.9 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.

7.5.5.10 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.

7.6 Pipework

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

7.6.1 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.

7.6.2 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 vacuum pumps which could interfere with their removal.

7.6.3 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.

7.6.4 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 sewage pumps which could interfere with their removal.

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

7.6.5 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.

7.6.6 Pipework Drains

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

7.7 Valves and Appurtenances

Valves (other than vacuum interface valves) and magnetic flowmeters shall be designed in accordance with the requirements contained in WSA 06, DS 31-02 and the following:

7.7.1 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.

7.7.2 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.

7.7.3 Vacuum Interface Valves

Vacuum interface valves used in the collection chambers shall be DN 80 complying with SPS 245.

7.7.4 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.

7.8 Condition Monitoring and Instrumentation

Condition monitoring, protection and instrumentation shall be provided in accordance with the relevant parts of DS 30-02 and the Condition Monitoring section for Vacuum Sewage Pump Stations contained in the Electrical and Instrumentation section of this Standard.

7.9 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 Generating Sets (Stand-Alone) section of DS 35.

7.10 Odour Control

The requirements for odour control shall comply with WSA 06 except for the biofilter which shall be an expandable and modular type e.g. OdaTech®. It shall utilise a biomedia consisting of a custom blend of green materials. The minimum period for changing the biomedia shall be 2 years. The biofilter shall be sized for the ultimate pump station duty.

7.11 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.

For more information on coatings refer to DS 95.

8 MISCELLANEOUS PUMP TYPES

8.1 General

Miscellaneous pumps types referred to in this section of the Standard are used as required in conjunction with pump stations and water treatment plants and where relevant shall comply with the following.

8.2 Borehole Pumps

For information relating to bores and borehole pump stations refer to DS 32-01.

8.3 High Level Area Booster Pumps

High level area booster pump stations are detailed in DS 32-02.

8.4 Chemical Dose Pumps

8.4.1 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.

8.4.2 Diaphragm Type Chemical Dose Pumps

8.4.2.1 General

As mentioned 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.

8.4.2.2 Typical Applications for Diaphragm Type Dose Pumps

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

Table 8.1 – Applications for Diaphragm Type Dose Pumps

Chemical	Solenoid	Diaphragm	Comments
Aluminium sulphate	Yes	Yes	Slurry characteristics of chemical require special valves
Ammonia solution	No	Yes	Full movement double simplex diaphragm metering pump to meet accuracy requirements
Ferric chloride	≤ 6 L/h	Yes	Lost motion double simplex diaphragm metering pump type

Chemical	Solenoid	Diaphragm	Comments
Fluorosilicic acid	No	Yes	Leak detection required only available on diaphragm type
Hydrochloric acid	≤ 6 L/h	Yes	Leak detection required on diaphragm type
Poly-aluminium-chloride	No	Yes	Full movement double simplex diaphragm metering pump
Poly electrolyte	No	No	Progressive cavity pump type required due to shear sensitivity
Potassium permanganate	Yes	Yes	
Sodium carbonate solution	Yes	Yes	
Sodium hexametaphosphate (CALGON)	Yes	Refer comments	Solenoid type, only because of low flow rates. Spare pump required in addition to duty/standby
Sodium hydroxide (caustic soda)	Yes	Yes	
Sodium hypochlorite	≤ 6 L/h	Yes	<20 L/h pumps should be fitted with degassing heads
Sodium silica fluoride	No	Yes	
Sodium silicate	≤ 6 L/h	Yes	
Sulphuric acid	No	Yes	Full movement double simplex diaphragm metering pump – leak detection required

8.4.3 Solenoid Diaphragm Pumps

8.4.3.1 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.

8.4.3.2 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.

8.4.3.3 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.

8.4.3.4 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.

8.4.3.5 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 8.2 – Typical Solenoid Diaphragm Pump Features

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 (GFPPL), 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.

8.4.4 Mechanical Diaphragm Pumps

8.4.4.1 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.

8.4.4.2 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 8.3 - Typical Mechanical Diaphragm Pump Features

Specification	**Loss Motion Type**	**Full Movement Type**
Accuracy	+ 2% of full scale over a 10:1 operating range	
Feed rate adjustment	Infinitely variable 0 – 100%	Infinitely variable 0 – 100%
	1.0% increments for % scale and vernier stroke length adjustment	0.25% increments for % scale and vernier stroke length adjustment
	1 rev of knob ≡ 20% stroke length change	1 rev of knob ≡ 10% stroke length change
Flow head and capacity	4.7 L/h to 106 L/h at 100 kPa (10 bar)	4.7 L/h to 680 L/h at 120 kPa (12 bar) to 50 kPa (5 bar) respectively
Operating range	Stroke length adjustable over 10:1 range	Stroke adjustable over 0-100%
	Stroke frequency adjustable over a 20:1 range	Stroke frequency adjustment over a 20:1 range
	Minimum stroke and frequency adjustment is 10%	Minimum stroke and frequency adjustment is 10%
Total maximum combined turndown	200:1	
Speed of response	Variable speed control response time <3 seconds from 0% to 100%	Variable speed control response time <3 seconds from 0% to 100% Automatic stroke length control is 180 seconds from 0 – 100%
Suction lift	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	
Temperature limits - liquid end:		
Ambient	PVC – 52 ˚C,	PVC – 52 ˚C,
Process	PVC – 52 ˚C; Kynar – 62 ˚C	PVC – 52 ˚C; PVDF – 62 ˚C
Control modes	Manual, remote control, start-stop, variable speed, flow proportional, direct residual and compound loop	
Electrical	415/230V 50 Hz TEFC or 230V 50 Hz TEFC – 4 pole motor	
Materials:	As detailed below	
- Gearbox	Cast iron to AS 1830 grade 250	
- Liquid end adaptor	PVC	Cast iron
- Pump head	PVC and Kynar	PVC and PDVF
- Valve housings	Clear PVC, Grey PVC	Clear PVC, Grey PVC, PDVF
- Valve balls	316 SS, TFE, ceramic, glass and polyurethane (for slurry service)	
- Valve seats	Hypalon and Viton®	

Specification	**Loss Motion Type**	**Full Movement Type**
- Diaphragms	TFE-faced, fabric reinforced, elastomer backed with steel backing plate	
- Mounting base	ABS	
- UV resistance	Resistant	

NOTE: Pump manufacturers should be consulted to confirm specific information

8.4.4.3 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.

8.4.5 Mechanical Diaphragm Pumps – Loss-Motion Type

8.4.5.1 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.

8.4.5.2 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.

8.4.5.3 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).

8.4.6 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

8.4.7 Fluorosilicic Acid (FSA) Dosing

8.4.7.1 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.

8.4.7.2 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.

8.4.7.3 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.

8.4.7.4 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.

8.4.7.5 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.

8.4.7.6 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.

8.4.7.7 Corporation Historical Experience with FSA Dose Pumps

In conformance with the specification below, most of the Corporation fluosilicic 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.

8.4.8 Progressive Cavity Dose Pumps

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 below.

8.5 Progressive Cavity Pumps

8.5.1 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.

8.5.2 Features

Progressive cavity pumps embody the following features:

(a) Positive displacement;

(b) Rotor and stator element;

(c) Variable speed electric motor option;

(d) Constant non-pulsating flow with low shear characteristics;

(e) Capable of handling sludges, slurries, abrasives, viscous fluids, fibrous material and with some air entrapment;

(f) Orbital rotary motion at the rotor;

(g) Capable of handling solids up to 50 mm diameter;

(h) Capable of self priming to 8.5 m;

(i) Relatively low speed;

(j) Available in various drive configurations e.g. direct coupled, belt driven, direct coupled with gear reducer or gearmotor or hydraulic motor.

8.5.3 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.

8.5.4 Pump Requirements

8.5.4.1 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.

8.5.4.2 Direction of Rotation

Pumps are available in clockwise, anticlockwise or reversible rotation.

8.5.4.3 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.

8.5.4.4 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.

8.5.4.5 Speed

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

8.5.4.6 Number of Stages

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

8.5.4.7 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.

8.5.5 Technical Specifications

Pumps shall comply with SPS 525. Typical technical specifications for progressive cavity pumps are summarised in the table below.

Table 8.4 – Typical Technical Specifications for Progressive Cavity Pumps

Item	**Operating Parameter**
Process material	Low to high viscosity fluids; non-flowable products (e.g. screw and hopper configuration)
Number of stages available	Varies from 2 to 4
Shaft sealing	Packed gland with or without external flush, or mechanical seal
Speed range	Up to 1000 rev/min
Stator protection	Dry running protection using a thermoelectric device is available
Universal joint protector	A stainless steel protector protects the elastomeric joint sleeve from physical damage
Overpressure protection	Diaphragm contact pressure gauge
Overpressure protection with bypass and PRV	Delivery to suction bypass incorporating a PRV for continuous operation protection e.g. against a closed valve
Pump materials	Refer to SPS 525

NOTE: Refer to manufacturer for specific information relating to the application

8.5.6 Limitations

The following limitations apply to progressive cavity pumps:

(a) They shall not be fitted with isolating valves 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.

8.6 Sump Pumps

8.6.1 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.

8.6.2 Sump Pump Design

8.6.2.1 General

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

(a) Pumps shall be soft wired;

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

8.6.2.2 Submersible Drainage Type 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.

(b) Submersible drainage sump pumps shall embody the following requirements:

- (i) materials complying with (c) below;
- (ii) non-clog impeller capable of a soft solids passage including 5 mm to 50 mm long fibres;
- (iii) 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;
- (v) suitable for operating intermittently when the motor is not submerged.

(c) Component materials for submersible drainage sump pumps should generally comply with the requirements of SPS 503. 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.

8.6.2.3 Submersible Sewage Type Sump Pumps

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

(b) 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;

8.6.3 Summary of Features

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

Table 8.5 – Sump Pump Features

Item	Features	
	Drainage	**Submersible Sewage**
Application	Used in pump station sumps	Used in pump station sumps
Type	Production (‘off the shelf’)	Production (‘off the shelf’)
Orientation	Vertical	Vertical

Item	**Features**	
	Drainage	**Submersible Sewage**
Style	Compact, self-contained submersible drainage type, end suction centrifugal	Compact, self-contained submersible sewage type, end suction centrifugal
Ports	Screened suction and discharge connection	Unscreened suction and flanged discharge connection
Volute	Radial flow, non self venting	Radial flow, non self venting
	Radially-split	Radially-split
	Single stage	Single stage
	Single volute	Single volute
Impeller	Single entry;, semi-open type	Single entry;, closed type
	Overhung e.g. single bearing support	Overhung e.g. single bearing support
Housing	Top pullout	Top pullout
Seal	Oil-filled seal chamber with mechanical sealing	Oil-filled seal chamber with mechanical sealing
Lubrication	Grease	Grease
Electric motor	Submersible	Submersible
	Integral motor/pump shaft	Integral motor/pump shaft
	2 pole with float control	2 pole with float control

8.6.4 Sump and Pipework Design

Sump pumps and control equipment shall be installed in the 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 AS/NZS 4680 and Coating Specification H2.

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.

9 ELECTRICAL AND INSTRUMENTATION

9.1 Electric Motors

The selection of the electric motor shall be in accordance with the Driving Machines Clause contained in the General Design Criteria section of this Standard and the following:

9.1.1 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.

9.1.2 Electric Motor Rating

Electric motors shall be rated in accordance with the relevant parts of DS 21 and DS 22.

9.2 Condition Monitoring and Protection

This section covers condition monitoring separately for both water and sewage pump stations and for vacuum sewage pump stations in accordance with the following. Instrumentation shall comply with DS 40-09.

9.2.1 Water and Sewage Pump Stations

Pump protection equipment for minor and major pump stations is detailed in the following and summarized in the related Pump Station Condition Monitoring table below.

Table 9.1 Pump Station Condition Monitoring

Condition	**Minor PS**[1]	**Major PS** [1]	**Detection Device**
Pump low flow/No flow protection	A, P	A, P	Flow switch, magnetic flowmeter, low power transmitter[2]
Pump low suction pressure protection	▨	A, P	Pressure switch
Pump station low suction pressure protection and monitoring	▨	A, P, M	Pressure transmitter
Pump low delivery pressure protection	▨	A, P	Pressure switch
Pump station low delivery pressure protection and monitoring	▨	A, P, M	Delivery manifold pressure transmitter
Bearing temperature high alarm and protection	▨	A, P	Resistance temperature detectors
Pump station well flooding	▨	A, P	Float switch
Pump station pit flooding (sump level high alarm as required)	▨	A	Level switch
Mechanical seal feedwater low pressure alarm	▨	A[2]	Pressure switch
Pump high vibration alarm (as required)	A[3], P[3]	A[4], P[4]	Velocity and displacement transducers as applicable
Ventilation fan low delivery pressure alarm (as required)	▨	A	Pressure switch

LEGEND:

A – Alarm; P – Protection; M - Monotoring

NOTES:

1. kW size refers to individual pump size not pump station size
2. For large drywell sewage pumps only

3. For submersible sewage pumpsets ≥ 150 kW
4. For water pumps ≥ 2 MW, submersible sewage pumps ≥ 150 kW and drywell sewage pumpsets ≥ 1 MW

9.2.1.1 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 should 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.

9.2.1.2 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 low suction pressure via a pressure switch installed in the suction offtake.

9.2.1.3 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 low suction pressure via a pressure transmitter installed in the suction manifold.

9.2.1.4 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 low delivery pressure via a pressure switch installed in the delivery offtake.

NOTE: Low delivery pressure can contribute to high delivery flow being experienced by a centrifugal e.g. as a 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.

9.2.1.5 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 low delivery pressure via a pressure transmitter installed in the delivery manifold.

9.2.1.6 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 e.g. 80ºC. The temperature set point shall be in accordance with the pump manufacturer’s recommendations.

Where required each bearing housing shall be supplied with a thermometer pocket, complete with a resistance thermometer element in accordance with DS 40-09.

9.2.1.7 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.

9.2.1.8 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.

9.2.1.9 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.

9.2.1.10 Vibration Monitoring

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

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

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

(c) Large high speed blowers.

For pump rotational speeds below 500 rpm displacement transducers should be provided as velocity and acceleration types are ineffective.

The Designer shall determine the mechanical vibration sensor requirements in conjunction with the supplier for the following parameters:

- Type of sensors e.g. displacement, velocity or acceleration;
- Number of sensors required;
- Location of sensors;
- Sensor tapping sizes.

9.2.1.11 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.

9.2.2 Vacuum Sewage Pump Stations

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

9.2.2.1 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) Pump low flow/no flow (undercurrent) protection;

(h) Rotary vane exhaust filter pressure gauge monitor and alarm (as applicable);

(i) Rotary vane low oil level protection (as applicable).

9.2.2.2 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.

10 Appendix A – Maximum Attainable Efficiencies for Single Volute Pump (Normative)

The Hydraulic Institute has published information on maximum attainable pump efficiency with respect to speed based on a variety of flow rates. This has been converted to metric units in Figure 10.1 below.

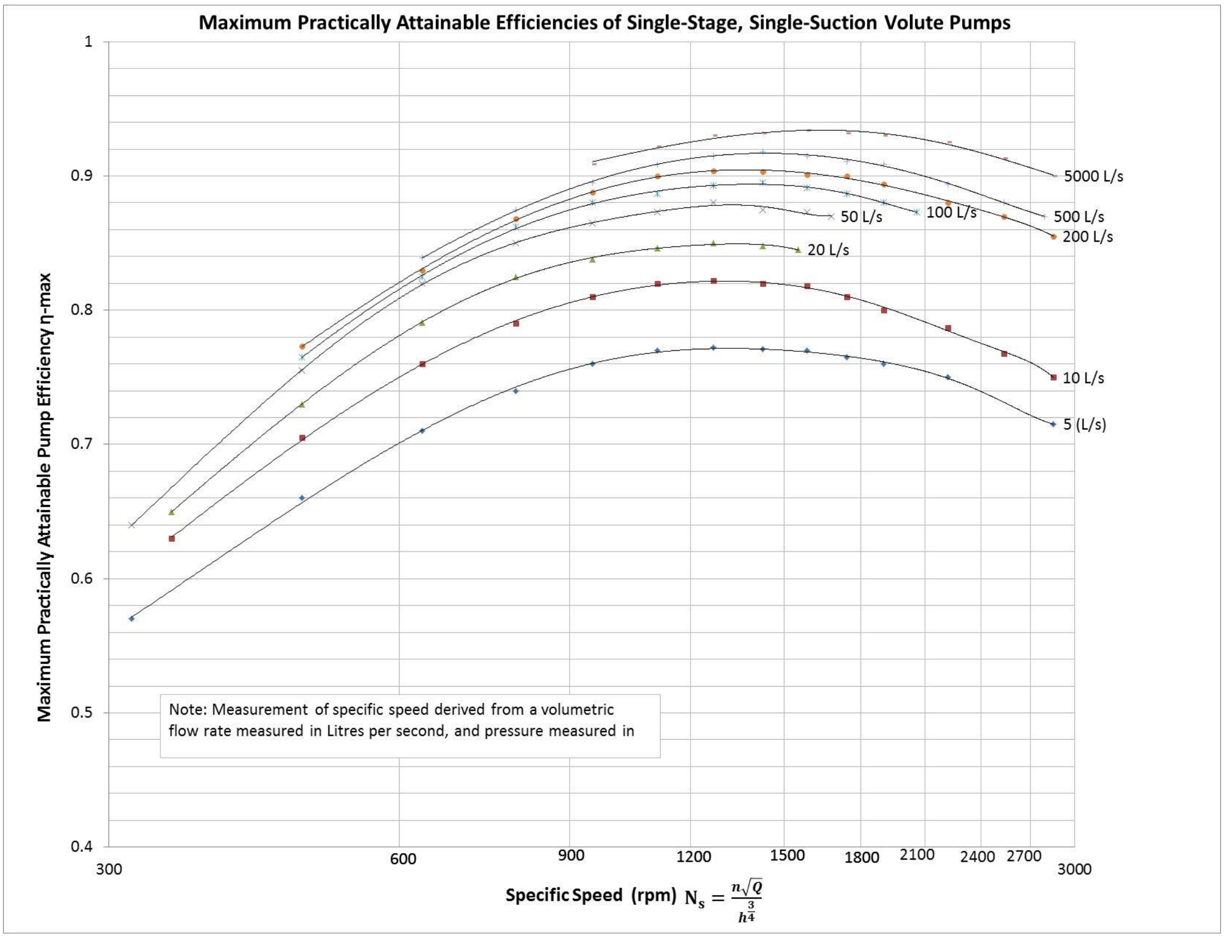


Figure 10.1 Maximum practical attainable Efficiencies with respect to speed for single volute pumps.

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