



Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 35

Ancillary Plant - Mechanical

VERSION 1
REVISION 6
MAY 2022

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 WA OSH Regulations 1996 (Division 12, Construction Industry – consultation on hazards and safety management) 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 \(dmirs.wa.gov.au\)](https://dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the 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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REVISION STATUS

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

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DESIGN STANDARD DS 35

Ancillary Plant - Mechanical

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1 SCOPE AND GENERAL

1.1 Scope

Design Standard DS 35 sets out the Corporation's mechanical design standards, guidelines and preferred engineering practice for ancillary plant for water supply, wastewater and drainage applications. The various major sections contained in this Standard have been arranged in alphabetical order to assist the reader in finding relevant information.

DS 35 is the first part of a two part standard, the other part being:

- DS 35-01 Surge vessels.

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 Australia (WSAA) Codes, shall be referenced for design and specification. In the absence of relevant Australian or WSAA Codes, relevant international or industry standards shall be referenced.

1.5 Referenced Documents

A full list of Australian, International and Corporation standards, codes and technical specifications referenced in this Standard and the DS 30 series of standards, is contained in 'Appendix A: Referenced Documents' section of DS 30-01.

1.6 Mandatory Requirements

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

1.7 Nomenclature

1.7.1 Definitions and Relationships

For definitions of the terminology and relationships referred to in this Standard the reader is referred to the Glossary in DS 30-01.

1.7.2 Preferred Terms

For preferred mechanical terms to be used in Corporation designs, the reader is referred to the Glossary in DS 30-01.

1.7.3 Abbreviations

For abbreviations referred to in this Standard the reader is referred to the Glossary in 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 DS 30-01.

1.7.5 Drawing Symbols

A comprehensive list of mechanical drawing symbols for mechanical equipment is contained in DS 80.

2 DESIGN CONSIDERATIONS

Refer to the relevant requirements contained in DS 30 for 'Design Report Development' (Simple Mechanical Works) or 'Concept Design Development' (Major Mechanical Works) for design development.

3 GENERAL DESIGN CRITERIA

The following general design criteria have been provided for assistance to the Designer. The design factors are located in related mechanical design standards and are referenced accordingly.

3.1 Alignment of Machinery

The alignment of machinery shall be in accordance with the 'Alignment of Machinery' section of DS 38-01.

3.2 Ambient Conditions

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

3.3 Backflow Prevention

Designs shall comply with the 'Backflow Prevention Devices' section contained in DS 31-02.

3.4 Balancing

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

3.5 Baseplates

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

3.6 Bearings

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

3.7 Buildings

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

3.8 Coatings

For general information relating to coatings refer to DS 95.

3.9 Condition Monitoring and Protection

Condition monitoring and protection design shall be in accordance with the 'Condition Monitoring and Protection' section of DS 30-02.

3.10 Confined Space

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

3.11 Corrosion Mitigation

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

3.12 Fasteners

Structural fasteners shall comply with the ‘Fasteners for Structural Applications’ section of DS 30-02 and the Bolted Structural Joints section of DS 38-01. Flange fasteners shall comply with the requirements of DS 38-02.

3.13 Financial Impact Statement

For information relating to financial impact statements refer to the ‘Financial Impact Statement’ section contained in DS 30-02.

3.14 Flanged Connections and Flange Bolting

Flanged connections and flange bolting shall be in accordance with DS 38-02..

3.15 Foundation Blocks

Foundation blocks shall comply with the ‘Foundation Blocks’ section of DS 30-02.

3.16 Guards

Guards shall comply with the ‘Guards’ section of DS 30-02.

3.17 Materials

For general information regarding elastomers and metals refer to the ‘Materials – Elastomeric’ section contained in DS 30-02 and the Glossary.

3.18 Mechanical Work

Mechanical work shall comply with DS 38-01.

3.19 Noise

For information related to noise refer to the ‘Noise’ section of DS 30-02.

3.20 Occupational Safety and Health

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

3.21 Security

For requirements related to security the Designer should refer to the ‘Security’ section of DS 32-01.

3.22 Signage and Labels

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

3.23 Site Conditions and Selection

For general information relating to site conditions refer to this ‘Site Conditions and Selection’ section contained in DS 30-02.

3.24 Stairways, Landings, Walkways and Ladders

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

3.25 Statutory Authorities

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

3.26 Surge Vessels

For information relating to surge vessels refer to DS 35-01.

3.27 Transmission Drives

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

3.28 Valves

For information on valves refer to the relevant parts of DS 31-02.

3.29 Vibration

The vibration values, for mechanical equipment in a major plant, shall be designed to a minimum. The acceptable limits for particular equipment are detailed in the ‘Vibration’ section of DS 30-02.

3.30 Welding

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

3.31 Workmanship

For general information relating to workmanship refer to the ‘Workmanship’ section contained in DS 30-02.

4 AIR COMPRESSORS

4.1 General

Air compressors fall into two categories namely positive displacement or centrifugal types. Positive displacement compressors are either reciprocating or rotary screw types. Design of compressed air systems should be based on minimum whole of life costs for compression with reliability as a key requirement. For further information related to compressed air systems refer to the ‘Compressed Air’ section contained in this Standard.

4.2 Air Compressor Ratings

The typical operating range of the various compressor types is shown in the following table:

Table 4.1 – Typical Air Compressor Pressure and FAD Ratings

Compressor Type	Typical Pressure Range – bar (g)	Typical FAD Range – L/s
Reciprocating compressor	7 – 345	3 – 1400
Rotary screw compressor	4 – 28	14 – 2800
Centrifugal compressor	3 – 18	20,000 – 500,000

NOTE: For typical blower performance ratings refer to the section on ‘Blowers’ in this Standard

4.3 Location

Compressors shall be located:

- (a) In accordance with the manufacturer’s recommendations;
- (b) So that adequate cool, clean cooling-air is admitted to the air cleaner and cooling fan;
- (c) To provide adequate reject air dissipation without adverse effects on ventilation in the building or recycling into the air cleaner or cooling fan;
- (d) To provide adequate operation and maintenance clearances to enable work to be carried out without having to remove the compressor or electric motor;
- (e) With adequate lighting for servicing and maintenance;
- (f) Indoors unless they are rated for outdoor service in accordance with the manufacturer’s specification. For outdoor service they should be housed in an enclosure complying with the ‘Enclosure’ clause contained in section 11 of this Standard.

4.4 Oil Carry-Over

Standard air compressors produce a small oil carry-over which may be unacceptable for some applications. Examples would be where compressors are used in conjunction with Corporation water supplies such as surge vessels or Dynasand filters. Compressors can be fitted with high performance filters in series which can reduce oil carry-over to <0.003 ppm producing almost medical air quality.

An alternative to filtering out oil carry-over is to use oil free air compressors.

4.5 Reciprocating Air Compressors

4.5.1 General

Reciprocating air compressors:

- (a) Are used for high efficiency, relatively low to moderate mass flow rate applications, and can provide relatively high pressure e.g. by staging;
- (b) Consist of a piston or pistons (multi-stage) driven by a crankshaft operating inside air-cooled cylinder/s;
- (c) Have a relatively large number of working parts;
- (d) Are available in oil lubricated, or oil free types (for small sizes and pressures);
- (e) Are used by the Corporation generally for relatively small plant air supply or make up air for surge vessel applications on intermittent duty;
- (f) For service air, compressors are rated at 7 bar nominal delivery pressure;
- (g) For surge vessels compressors have a higher delivery pressure rating e.g. 20 bar, 30 bar and 40 bar;
- (h) Are rated for continuous service.

4.5.2 Free Air Delivery

Free air delivery (FAD) of a compressor is the volume of air delivered measured at atmospheric pressure. Increasing the delivery pressure produces a corresponding reduction in FAD. To compensate, two or more stages of compression may be used with inter-cooling provided between each stage and/or after-cooling. The requirement to provide staging is determined by the volumetric efficiency of the compressor, which is defined as the ratio of the free air delivery to the swept volume.

4.5.3 Compressor

The compressor design should be:

- (a) Heavy duty, single or multi-stage, single acting reciprocating type;
- (b) Fitted with precision roller and shell bearings;
- (c) Air-cooled, fitted with a high capacity airfoil type cooling fan and deep finned cylinders and cylinder head;
- (d) Fitted with inter-stage cooling and preferably after-cooling;
- (e) Designed for a minimum of 15,000 hours continuous duty;
- (f) Splash type oil lubrication with an oil filter, oil filler, drain and sight glass;
- (g) Provided with an un-loader to facilitate no-load starting;
- (h) Fitted with a cyclopac replaceable air intake filter;
- (i) Fitted with an outlet filter to allow removal of dust or other particles and where applicable oil particles e.g. where the air is in contact with potable water such as surge vessel applications.

4.5.4 Receiver

- (a) The air receiver:
 - (i) serves as a reservoir for the storage of compressed air in order to provide for sudden or momentary peaks in demand that may otherwise exceed the capacity of the air compressor;
 - (ii) absorbs any pressure surges or pulsations in the delivery pipework thus providing a stable flow into the service pipework;

- (iii) serves to facilitate precipitation of condensate into the vessel thus reducing the chances of carry over into the supply and distribution pipework;
 - (iv) should be piped so that the inlet pipe enters at the bottom of the receiver in order to precipitate condensate and exit dry air at the top of the receiver into the supply and distribution pipework.
- (b) Air receivers shall be:
- (i) manufactured from carbon steel and designed, manufactured and tested in accordance with AS 1210;
 - (ii) coating internally and externally with either a zinc rich epoxy or hot dip galvanized in accordance with DS 95;
 - (iii) provided with mounting feet drilled to accommodate foundation bolts of a minimum size M16;
 - (iv) fitted with a pressure relief valve and pressure gauge.

4.5.5 Baseplate

The baseplate for the reciprocating compressor and electric motor generally forms an integral part of the superstructure of the air receiver. Separate baseplates shall comply with the 'Baseplates' section of DS 30-02.

4.5.6 Drive

A direct drive is preferred however vee belt drives are acceptable. Vee belt drives shall comply with the 'Transmission Drives' section of DS 30-02. All exposed rotating or hazardous components shall be provided with safety guards in accordance with the 'Guards' section of DS 30-02.

4.5.7 Electric Motor

The electric motor shall comply with the requirements of DS 22.

4.5.8 Ancillary Equipment

The following equipment may be considered necessary:

- (a) A silencing hood may be required to reduce noise levels;
- (b) Low oil level switch;
- (c) Automatic condensate drain may be fitted to the receiver.

4.6 Surge Vessel Air Compressor Requirements

The design shall incorporate two air compressors, one duty/one standby.

Each air compressor shall:

- (a) Be capable of delivering the required flow to the design working pressure at an ambient temperature of 50 °C i.e. take no longer than 24 hours or an agreed time with the client to fill vessel from zero pressure to the required design pressure
- (b) Be capable of a delivery pressures and free air delivery rates specified in the following table:

Table 4.2 – Typical Surge Vessel Compressor Ratings

Pressure Class - PN	Delivery Pressure Bar	Free Air Delivery L/s	Typical Compressor Specification (or equivalent)
16	20	2.9	Atlas Copco Model LT3-20 (2.2 kW, 3 hp) (or equivalent)
21	30	4.4	Atlas Copco Model LT5-30 (4 kW, 5.5 hp) (or equivalent)
35	40	4.1	BOGE Model SRHV 250-5 (7.5kW, 10 hp) (or equivalent)

- (c) Be a high pressure, heavy duty, two stage, single acting reciprocating type compressor designed for a minimum of 15,000 hours continuous duty;
 - (d) Be provided with an un-loader;
 - (e) Incorporate a close coupled 415 V AC electric motor;
- NOTE:** Where the cost of 3 phase equipment is considered excessive then single phase motors may be used subject to approval by the Corporation,
- (f) Fitted with an outlet filter to allow removal of dust particles down to 0.01 micron;
 - (g) Oil free or where not available fitted with an outlet filter to allow removal of oil content down to 0.01 ppm plus all required valves to and any after-cooling;
 - (h) Mounted on a fabricated baseplate and provided with a silencing hood;
 - (i) Be provided with a self contained DOL starter with local controls including:
 - (i) Local - Off - Remote selector switch;
 - (ii) Start and Stop pushbuttons;
 - (ii) voltage-free normally open contacts wired to terminals to allow remote monitoring of the Remote position of the selector switch, run and fault conditions;
 - (iii) a 24 volts DC control interposing relay wired to terminals to interface with the Corporation control system when selected for remote control.

The Corporation control system will incorporate alternate duty operation and call for a standby unit on detection of a compressor fault.

For information regarding surge vessel air charge and vent pipework refer to the relevant section contained in DS 35-01.

4.7 Rotary Screw Compressors

4.7.1 General

Rotary screw compressors:

- (a) Should be used for medium efficiency and moderate mass flow rate applications, and can provide medium discharge pressures e.g. by staging;
- (b) Provide compression via movement of air from the inlet to the outlet via two meshing helical screws;
- (c) Are available in lubricated (oil-flooded) or oil free (dry-running screw) designs;
- (d) Of the oil-flooded type provide heat removal and therefore can achieve equivalent compression to dry-running screw compressors with less numbers of stages;

- (e) Are used by the Corporation generally for relatively small process plant air supplies;
- (f) Shall be rated for continuous service.

4.7.2 Selection Guide

Guidelines for the selection of oil-flooded versus dry-running screw compressors are shown in the following table.

Table 4.3 – Selection Guide for Rotary Screw Compressors

Consideration	Oil-flooded Screw	Dry-running Screw
Process is not oil tolerant	Not suitable	Suitable
Optimal efficiency is required	Preferred	Less preferred
Condensate or liquid is present at the inlet	Suitable	Not Suitable
Particulates are present at the inlet	Not Suitable	Suitable
Minimal shaft leakage is required	Preferred	Less Preferred
Process gas forms carbon	Suitable	Not Suitable
Process gas polymerises	Suitable	Not Suitable

NOTE:

1. Oil-flooded screw compressors can provide discharge oil mist removal down to 100 ppm by volume by utilising oil mist filters.
2. An oil-coalescing stage in lieu of oil mist filters can reduce oil mist down to 10 ppm by volume and with further stages and carbon filters down to 1 part per billion.

4.7.3 Compressor

Compressor air-end should be air-cooled slow speed, heavy duty, ground profile helical screws, with shafts supported on precision heavy-duty roller bearings.

4.7.4 Protection Equipment

The following protection equipment should be provided:

- (a) Drive motor overload;
- (b) Screw over temperature;
- (c) Separator over temperature;
- (d) Incorrect direction of rotation;
- (e) Over pressure;
- (f) Fan motor overload.

Items (c) to (f) relate to items for larger compressors e.g. $\geq 55\text{kW}$

4.7.5 Service Indicators and Instrumentation

The following indication equipment should be provided:

- (a) Hour-meter;
- (b) Oil level sight glass;
- (c) Oil-filter element condition;
- (d) Air-oil separator element condition;

- (e) Intake air-filter element condition;
- (f) Operating pressure;
- (g) Screw discharge temperature.

Items (c) to (e) relate to items for larger compressors e.g. $\geq 55\text{kW}$

4.7.6 Indicator Lights

The following indication lights should be provided:

- (a) Power on;
- (b) Unit running;
- (c) On standby;
- (d) Screw over-temperature;
- (e) Motor overload;
- (f) Overpressure;
- (g) Separator over temperature;
- (h) Thermistor trip;
- (i) Fan motor overload;
- (j) Phase failure/reversal;
- (k) Oil filter contaminated;
- (l) Separator element contamination;
- (m) Intake filter contamination

Items (f) to (m) relate to items for larger compressors e.g. $\geq 55\text{kW}$.

4.7.7 Filters/Separators

The following filters and separator should be provided:

- (a) Two stage air filtration e.g. cyclone pre-separator and filter; or for larger units three stage air filtration e.g. pre-filter mats, cyclone pre-separator and filter e.g. $\geq 55\text{kW}$;
- (b) Oil filter with anti drain valve and by pass protection;
- (c) Three stage air/oil separator e.g. cyclone separation with shielded separator and low oil foaming characteristics and oil carry over $\leq 3\text{ppm}$ for all operating conditions.

4.7.8 Suction Un-loader

A multi-function suction un-loader shall be provided that:

- (a) Unloads the compressor for reduced starting loads;
- (b) Provides balanced air to eliminate cavitation;
- (c) Eliminates the requirement for an air end check-valve and oil stop valve.

4.7.9 Coolers

The following cooler requirements should be provided:

- (a) Air coolers should be aluminium block designed for operation in $50\text{ }^{\circ}\text{C}$ ambient temperatures;
- (b) After-cooling air discharge to limit the air discharge air temperature to $8\text{ }^{\circ}\text{C}$ above ambient;
- (c) A thermostatic valve that minimises oil temperature during periods of light load.

4.7.10 Enclosures

Baseplates and enclosures should comply with the relevant parts of the 'Baseplates and Enclosures' clauses contained in section 11 of this Standard. Enclosures should be acoustically designed to limit the sound pressure to 80 dBA.

4.8 Centrifugal Compressors

Centrifugal compressors are split case multi-stage, axial flow compressors, which are designed for high flow and medium pressure applications. These compressors will not be covered in detail in this Standard as they are designed for larger applications than would generally be used in the Corporation.

5 AIR-CONDITIONING

5.1 General

This section covers electric motor driven:

- (a) Refrigerated package air-conditioners of either the single unit type or the split system type, with or without heating capability (depending on client requirements);
- (b) Evaporative air-conditioning equipment.

5.2 Standard

Designers shall utilise the method of assessment and performance of the air-conditioners in accordance with the following:

- (a) Single unit or split system refrigerated air-conditioners shall comply with AS/NZS 3823.1.2;
- (b) Evaporative air-conditioners shall comply with AS 2913.

5.3 Noise Levels

Air-conditioners shall comply with the following maximum sound pressure levels:

Indoor - 45 dB(A) at 1 metre from the outlet;

Outdoor - 55 dB(A) at 1 metre from the air-conditioning unit;

Measurement and testing shall comply with the Noise section of DS 30-02.

5.4 Construction

5.4.1 Equipment Enclosures

Air-conditioning enclosures shall be manufactured:

- (a) From materials and finishes that are corrosion-resistant;
- (b) For weatherproof service where they are intended for outdoor use;
- (c) With sufficient reinforcing to prevent flexing and drumming;
- (d) With panels that will facilitate removal of major components;
- (e) With panels that will allow access for inspection and maintenance;
- (f) So that removable panels provide an airtight seal and incorporate reusable fasteners and soft gaskets;
- (g) With adequate insulation to prevent condensation on external surfaces under operational conditions.

5.4.2 Condensate Trays

Condensate trays shall be:

- (a) Provided under each cooling coil section, extending downstream to collect water carry-over, and under all components on which condensation is likely to occur;
- (b) Constructed from a stable and rigid corrosion resistant material e.g. stainless steel complying with ASTM A480M;
- (c) Insulated to prevent condensation on both internal and external surfaces of the unit enclosure, under all operational conditions;

- (d) Provided under outdoor reverse cycle units, which are not fitted with drain connections;
- (e) Provided with DN 20 outlet drain connections, screwed BSP.

5.4.3 Accessibility

Hermetic compressors shall be provided with access to the suction and discharge sides of refrigeration circuits. Condensers shall be installed so that access around them is provided for maintenance purposes.

5.4.4 Refrigeration System

Classification and safety requirements for refrigeration systems shall comply with AS/NZS 1677.

Copper tubes shall comply with the requirements contained in AS/NZS 1571.

Insulation shall be manufactured from elastomeric foam.

Reverse cycle air-conditioning units shall incorporate the following:

- (a) An effective outdoor facility for coil defrost condensate;
- (b) A refrigerant reversing valve.

5.5 Packaged Air-conditioning Units

5.5.1 General

Designs for room air-conditioners shall provide packaged air-conditioners comprising a compressor, condenser and evaporator coils associated fans and electrical controls all housed in one unit.

The air-conditioner units shall incorporate an inside fascia, which shall be designed to provide a supply air diffuser, return air grille and filter, and user controls.

5.5.2 Wall Mounted Air-conditioner Types

Refers to externally mounted units housed in a vertical cabinet, connected through the wall with the room, either free-flow or with ductwork.

5.5.3 Window and Wall Types

Refers to single chassis-mounted units housed in a metal cabinet fixed internally in an opening in a window or wall.

5.6 Split System Air-conditioning Units - Non-ducted

5.6.1 General

Designs for split type room air-conditioners shall provide packaged air-conditioners comprising:

- (a) Indoor supply air units, complete with evaporator coil and replaceable filters;
- (b) Outdoor compressor, condenser and associated fans;
- (c) Interconnecting refrigeration piping;
- (d) Insulation sufficient to prevent condensation;
- (e) All electrical, safety and operating controls.

5.6.2 Cassette Indoor Units

Cassette indoor units comprise an above-ceiling type with only the faceplate visible within the room, and require a return grille and filter, internal access and perimeter air distribution system, and condensate pump.

Control is via a remote thermostat and control module on a wall in each room to control the unit serving that room.

5.6.3 Wall Mounted Indoor Units

Wall mounted indoor air supply units comprise a slim-line construction, with adjustable louvre blades to allow horizontal to 45° downwards air discharge and require a return grille and filter, internal access and perimeter air distribution system, and condensate pump if required.

The unit is installed with allowances for removal of filters and maintenance works in accordance with manufacturers' requirements. Control is via a remote thermostat and control module on a wall below the unit.

5.6.4 Floor Mounted Indoor Units

Floor mounted indoor air-conditioning units are a slim-line console type for vertical or angled upwards air discharge, with thermostat and a control module within the unit.

5.6.5 Outdoor Units

The split system outdoor unit shall be:

- (a) Rated for outdoor conditions;
- (b) Fully self contained with compressor, condenser and main electric controls;
- (c) Fully weatherproof;
- (d) Manufactured from corrosion resistant materials;
- (e) Mounted on anti-vibration mountings;
- (f) Fitted with steel cover plates over connecting pipework. Steel cover plates shall be either hot dip galvanised to AS/NZS 4680 or coated in accordance with Coating Specification B1.

5.7 Ducted One Piece Air-conditioning Units

Ducted one-piece air-conditioning units shall be provided as complete packaged units consisting of cooling coil, supply air fan, condensing unit and electrical components mounted in an enclosure.

5.7.1 Ductwork

5.7.1.1 General

Designers shall include all ductwork and associated equipment including variable volume boxes, attenuators or acoustic louvres and hoods.

Ductwork for air handling systems in buildings shall comply with AS 4254.

5.7.1.2 Materials

Ducting shall comply with zinc coated steel sheet conforming to coating AS 1397 Class G2/Z275.

5.7.1.3 Fasteners

Fasteners shall comply with the following:

- (a) Rivets shall be of the expanding solid end type, aluminium base alloy or Monel®;
- (b) Self-tapping, and self-drilling and self-tapping screws shall be bright zinc plated;
- (c) Self-drilling and self-tapping screws shall only be used where the base material into which they screw is thicker than 1.5 mm, and are unlikely to be removed or replaced;
- (d) Bolts, nuts, washers and drop rods shall be hot dip galvanised in accordance with the requirements of the Coatings section contained in DS 38-02. Washers shall be fitted under nuts and bolt heads.

5.7.1.4 Air Balance

Ductwork shall incorporate sufficient number of sets of suitably sized holes in ductwork for testing and balancing of the system. The holes shall be sealed with rubber grommets in low-pressure ductwork and with cover plates in medium and high-pressure ductwork.

After balancing the balancing devices should be locked and permanently marked to indicate the balanced positions.

5.7.2 Fire Protection

Sprayed coatings shall be a cement spray system with hard-set finish.

Composite panels or ducting shall be fibre-cement reinforced with bonded zinc coated steel sheet conforming to AS 1397 coating Class G2/Z275.

5.7.3 Flexible Connections

5.7.3.1 General

Flexible airtight connections shall be used to isolate fans and air handling unit casings from adjacent ductwork.

5.7.3.2 Design and Installation

The flexible connection shall be:

- (a) Designed with sufficient slack to ensure free movement and vibration isolation under the maximum operating and static conditions;
- (b) Fitted to properly aligned components;
- (c) Designed for simple removal without having to dismantle adjacent ductwork or plant;
- (d) Connection fittings or frames shall not protrude into the airflow such that they are detrimental to airflow performance.

5.7.3.3 Materials

Flexible connection materials shall be heavy-duty waterproof vinyl, barium loaded (5kg/m²) fitted with a galvanized sheet metal covers if exposed to weather.

The flexible connection shall not be painted.

5.7.4 Dampers – Volume Control

5.7.4.1 General

Dampers or valves used in ductwork for balancing or isolation of airflow shall be manufactured from materials and construction compatible with the ductwork and the process conditions. All dampers shall be flanged for removal, and shall be supplied with a positively locking adjustment quadrant integral with the damper.

Volume control dampers shall be:

- (a) Capable of adjustment over the design airflow range without excessive self generated windage noise;
- (b) Free of rattles, fluttering or slack movement;
- (c) Adjustable without use of special tools;
- (d) Of face dimensions equal to the duct size;
- (e) Fitted with mating angle flanged cross joint connections.

5.7.4.2 Blades

Blades and connecting spindles shall comply with the requirements detailed in the following table.

Table 5.1 – Blade and Spindle Materials and Construction

Item	Material and Construction	
Blade Material	Steel	Aluminium
Minimum blade thickness:		
Single – mm	1.6 mm	2.4 mm
Double – mm	1.2 mm	1.8 mm
Maximum blade length – mm	1200 mm (with intermediate mullions as required)	
Single blade dampers minimum size:		
Single thickness blades – mm	300 mm long x 300 mm wide, or 300 mm diameter	
Single thickness blades (6 mm edge breaks – mm)	1200 mm long x 175 mm wide	
Double thickness blades – mm	1200 mm long x 300 mm wide	
Multi-blade dampers minimum size (6 mm edge breaks – mm)	1200 mm long x 175 mm wide	
Spindle material	Bright zinc plated steel	
Spindle construction	Secured to damper blades	
Spindle minimum diameter:		
Blade lengths ≤ 600 mm – mm	10 mm	
Blade lengths > 600 mm and < 1200 mm – mm	12 mm	

5.7.4.3 Bearings

Bearings shall be oil impregnated, sintered bronze ball bearings or engineering plastic sleeve bearings. Nylon bearings shall not be used for temperatures exceeding 50 °C. Access shall be provided for lubrication of damper bearings and bearing housings shall be riveted to the damper frames.

5.7.4.4 Linkages

Linkages shall be provided and fixed securely to the damper blades so that the blades rotate equally and close tightly without slip.

5.7.4.5 Damper Adjustment

Provision shall be made for adjusting the damper and locking it in position. The damper adjuster shall be located in an accessible position and shall be clearly and permanently marked with the “open” and “closed” positions.

5.7.5 Dampers - Motorised

Motorised dampers shall comply with the requirements for volume control type dampers above and the following.

5.7.5.1 Design

Motorised dampers shall be designed in accordance with the following:

- (a) Motorised damper leakage rates shall not exceed 25 L/s.m² at 1.5 kPa differential;

- (b) Dampers and damper motors shall be located in accessible positions for blade and motor maintenance and blade seal replacement;
- (c) Motorised damper mountings shall be sufficiently rigid to prevent flexing or distortion of the frame or ductwork during operation;
- (d) Where two sets of dampers are connected to a single motor the linkages shall allow either damper to be adjusted without the other being affected.

5.7.5.2 Materials and Construction

Side seals shall be aluminium or stainless steel.

Blade tip seals shall be neoprene or silicone rubber.

5.7.6 Dampers – Miscellaneous

5.7.6.1 Non Return Dampers

Non return dampers shall comply with the requirements for volume control dampers and shall be counterweighted so that it offers minimum resistance to airflow and closes by gravity.

5.7.6.2 Fire and Smoke Dampers

Fire and smoke dampers shall comply with AS 1682.1 and the following:

- (a) Provide a free cross section of at least 85% of the face area;
- (b) Be fitted with frangible bulb or fusible links for fire detection;
- (c) Be fitted with fusible links activated by either local heat or a low power external electrical impulse for smoke detection;
- (d) Incorporate readily removable and replaceable links for fire and smoke detection;
- (e) Incorporate readily removable access panels for maintenance of dampers and replaceable links for fire and smoke detection.

5.7.7 Access Panels

5.7.7.1 General

Personnel access panels shall be provided on either side of duct-mounted coils and at every 10 m of duct length to allow inspection and maintenance.

5.7.7.2 Sizes

Minimum clear opening of access panels shall be:

- (a) Personnel access: 450 mm x 600 mm;
- (b) Hand access: 200 mm x 300 mm.

5.7.7.3 Construction

Access panels should incorporate the following:

- (a) Double panel, deep-formed, zinc coated conforming to AS 1397 coating Class G2/Z275, insulated to match the duct, or filled with a minimum of 25 mm of mineral wool insulation;
- (b) Panel mounting frames should be rigid matching galvanized steel securely attached to the duct without protrusion into the air-stream;
- (c) Access panel seals should be silicone rubber or soft neoprene gaskets mechanically fixed to either the panel or the duct frame to ensure an airtight seal when latched in the closed position. Fire rated seal should be woven ceramic fibre material;
- (d) Latches should be wedge sash type with four latches required for personnel access panels and two latches for hand access panels;

- (e) Designed for minimum cold bridging.

5.7.8 Air Grilles

5.7.8.1 General

Grilles or diffusers shall be of the proprietary type with certified performance data and comply with the following:

- (a) Manufactured from powder-coated steel or aluminium;
- (b) Acoustic performance to BS EN ISO 5135;
- (c) Free from distortion, bends, surface defects, irregular joints and exposed fastenings;
- (d) Mounting with secure and concealed fixings;
- (e) Incorporate flanges lining the corners, neatly mitred and with no joint gaps;
- (f) Provide volume control dampers, which are adjustable through the grille faces when used to terminate ducts not incorporating upstream dampers;
- (g) Dampers that are visible through the grille shall be painted matt black;
- (h) Plenum boxes shall be fitted for diffusers connected to flexible ductwork.

5.7.8.2 Louvre Ceiling Diffusers

Louvre ceiling diffusers shall comply with the following:

- (a) Multi-bladed, removable core, four-way airflow configuration, fitted with a blanking plate for one, two or three way airflow direction as required;
- (b) A reducer neck should be fitted if the outlet neck is smaller than the outlet necessary to suit the louvre face size;
- (c) Air volume control shall be provided by a damper located at the flexible duct connection to the main ductwork.

5.7.8.3 Return or Exhaust Grilles – Indoor

Return or exhaust grilles shall comply with the following:

- (a) Full chevron type with 50% minimum free area;
- (b) Louvres shall be single angled type at maximum centres of 19 mm of aluminium or plastic construction with removable core.

5.7.9 Sound Attenuators

Duct sound attenuators shall comply with the following:

- (a) Broad band insertion loss and generated levels shall comply with AS 1277;
- (b) Rectangular or circular type with or without an internal pod;
- (c) Manufactured from galvanized sheet steel case, with heavy density acoustic fill, covered by perforated metal.

5.7.10 Acoustic Louvres

Acoustic louvres shall comply with the following:

- (a) Manufactured from folded steel or aluminium sheet incorporating perforated acoustic blades filled with an inert non-combustible acoustic material;
- (b) Steel should be 1.6 mm minimum thickness, zinc coated conforming to AS 1397 coating Class G2/Z275;
- (c) Aluminium should be 2 mm grade 5005 aluminium sheet, powder coated;

- (d) Acoustic testing for sound transmission loss shall comply with AS 1191.

5.7.11 Insulation - Ductwork

5.7.11.1 General

The air-conditioning and ductwork design shall include insulation in accordance with relevant insulation technical data and the following requirements.

5.7.11.2 Mineral Wool and Glass Wool

Mineral wool comprises an entangled mat of fibrous product derived from molten rock or furnace slag whereas glass wool comprises an entangled mat of fibrous product derived from molten glass.

Mineral wool and glass wool shall comply with the following:

- (a) Resin bonded from a batt, board or blanket;
- (b) Comply with the requirements of AS 3742;
- (c) Have a maximum thermal conductivity of 0.036 W/mK at 20 °C;
- (d) Have a pH of 7 – 9 e.g. alkaline;
- (e) Be non-hygroscopic.

5.7.11.3 Adhesives

Adhesives used for bonding facing to the insulation shall comply with the following fire hazard indices:

- (a) Spread of flame index: 0;
- (b) Smoke developed index: 0.

5.7.11.4 Aluminium Foil Laminate

Aluminium foil laminate tensile strength shall comply with the following:

- (a) Machine direction: 14.5 kN/m;
- (b) Lateral direction: 9.8 kN/m.

5.7.11.5 Aluminium Foil Laminate Tape

- (a) Adhesive: non-toxic, high tack, pressure sensitive, synthetic type;
- (b) Liner: silicone coated paper;
- (c) Backing: aluminium foil laminate;
- (d) Minimum width: 75 mm;
- (e) Physical properties:
 - (i) tensile strength: 4.8 kN/m (average minimum);
 - (ii) peel adhesion at 180 °: 0.68 kN/m (average minimum);
 - (iii) maximum water vapour permeance: creased 2.26 ng/N.s and uncreased 1.13 ng/N.s.

6 BLOWERS

6.1 General

Rotary vane, rotary lobe, multi-stage, high speed and positive displacement blower types are referred to in this section. Axial flow and centrifugal fans are specifically referred to in the Fans section of this Standard.

6.2 Selection Guide

The typical operating range of the various blower types is shown in the following table.

Table 6.1 – Typical Blower Ratings

Blower Type	Typical Pressure Range – bar (g)	Typical FAD Range – L/s
Fans (refer to Fans section)	≤ 1.5	$\leq 100,000$
Rotary vane	≤ 1.5	0.5 – 40
Rotary lobe	≤ 2.0	18 – 140
Positive displacement blower (Roots)	≤ 1.5	8 – 12,500
Centrifugal multi-stage blower	≤ 1.7	10 – 24,000
Centrifugal high speed blower	≤ 1.5	10 – 24,000

NOTE:

1. For typical air compressor performance refer to the Air Compressors section of this Standard

6.3 Rotary Vane

Refer to rotary vane vacuum pumps contained in the ‘Vacuum Pumps’ section of DS 32.

6.4 Rotary Claw

Refer to rotary claw vacuum pumps contained in the ‘Vacuum Pumps’ section of DS 32.

6.5 Multi-stage Centrifugal Blowers

6.5.1 General

Multi-stage centrifugal blowers (or exhausters) are used for the movement of relatively large quantities of air or gas at low pressure and for temperatures up to 150 °C. A typical Corporation use would be in wastewater treatment plants for aeration at ambient temperature.

6.5.2 Features

Multi-stage centrifugal blowers embody the following features:

- (a) Pressure energy is created from velocity energy generated through multiple stages via a rotating element operating at 2 pole motor speed e.g. 3,000 rpm;
- (b) Simple construction with minimal wearing parts e.g. wear is restricted to bearings and seals;
- (c) Capable of handling various gases e.g. air, CO₂, Nitrogen, Methane etc;
- (d) Multi-stage blowers are marginally less efficient than high speed single stage blowers however they are very competitive on whole of life cost comparison;

- (e) Low noise levels;
- (f) Flow control can be achieved by throttling via a butterfly valve or variable speed drive;
- (g) Air cleaner.

6.5.3 Construction

Multi-stage centrifugal blowers generally consist of the following:

- (a) Modular style construction;
- (b) Flanged inlet and outlet heads;
- (c) Vertically split stage casings incorporating baffle rings;
- (d) Heads and casings bolted together using high tensile tie bars;
- (e) A rotating element comprising a shaft, impellers with impeller eye labyrinth seals, balance piston to counteract thrust loads;
- (f) All mounted on high precision antifriction bearings with a L₁₀ rating for a 10 year minimum life and isolated from the air stream using carbon ring seals;
- (g) Inlet and outlet head shaft seals of the labyrinth or carbon ring types (for air);
- (h) Grease or atmospheric splash oil lubrication system (oil for larger flow capacity blowers);
- (i) Impellers available in full radial through to backward curved vane types.

6.5.4 Materials of Construction

Blowers should be constructed of the materials contained in the following table:

Table 6.2 – Typical Blower Materials for Clean Air

Component	Material	Standard	Grade
Inlet and outlet heads, stage castings	Grey cast iron	AS 1830	250
Bearing housings and labyrinth seals	Grey cast iron	AS 1830	250
Tie rods	Cold drawn steel	AS 1443	-
Shaft	Carbon steel	-	-
Impellers	Cast or Fabricated aluminium	AS 1874 -	-
Baffle ring	Nickel coated steel	-	-
Joint sealing compound	Silicone rubber	-	-
Casing	Carbon steel Grey cast iron	- AS 1830	- 250
Bearing housing, gearbox housing and labyrinth seals	Grey cast iron	AS 1830	250
Impeller and gearbox shafts	Fabricated steel, aluminium or Carbon fibre	-	-
Internal coating	ARC 855, Belzona 1341 'Super Metal Glide', Peerless Epigen 1311		
External coating	Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer's standard.		

6.6 High Speed Single Stage Centrifugal Blowers

High-speed single stage centrifugal blowers fulfill a similar role as for multi-stage centrifugal blowers but operate at a higher speed through a gearbox e.g. up to 12,000 rpm.

6.6.1 Features

HSSS centrifugal blowers embody the following features:

- (a) Air pressure energy is created from velocity energy generated by a fan and directed through a volute type casing via speed increaser type gearbox driven by a 2 pole motor speed e.g. 3,000 rpm;
- (b) Simple fabricated construction with higher wear characteristics than multi-stage centrifugal blowers due to higher speed and additional speed increaser gearbox;
- (c) Capable of handling various gases e.g. air, CO₂, Nitrogen, Methane, etc;
- (d) High-speed single stage centrifugal blowers are marginally more efficient than MS centrifugal blowers;
- (e) High pitch, high noise levels;
- (f) Flow control can be achieved by throttling via a control valve or variable speed drive;
- (g) Air cleaner.

6.6.2 Construction

Multi-stage centrifugal blowers generally consist of the following:

- (a) Fabricated casing and impeller construction;
- (b) Flanged inlet and outlet;
- (c) A rotating element comprising an impeller and shaft;
- (d) A separate gearbox containing high precision antifriction bearings with a L10 rating for a 10 year minimum life;
- (e) Inlet and outlet head shaft seals of the labyrinth or carbon ring types (for air);
- (f) Grease or atmospheric splash oil lubrication system (oil for larger flow capacity blowers);
- (g) Impellers available in full radial through to backward curved vane types.

6.6.3 Materials of Construction

Blowers should be constructed of the materials specified in the following table:

Table 6.3 – Typical Blower Materials for Clean Air

Component	Material	Standard	Grade
Casing	Carbon steel	-	-
	Grey cast iron	AS 1830	250
Bearing housing, gearbox housing and labyrinth seals	Grey cast iron	AS 1830	250
Impeller and gearbox Shafts	Carbon steel	-	-
Impeller	Fabricated steel, aluminium or Carbon fibre	-	-
Internal coating	ARC 855, Belzona 1341 ‘Super Metal Glide’, Peerless Epigen 1311		
External coating	Preparation in accordance with AS 1627 Part 7. Coating to comply with manufacturer’s standard.		

7 COMPRESSED AIR

7.1 General

Compressed air for the purposes of this Standard refers to air delivered from a compressor and specifically covers service air (or supply air) and instrument air and as referred to in the 'Definitions' clause below.

Compressed air system designs shall be optimal in terms of performance (e.g. flow, pressure and quality) with respect to the equipment and instrumentation they are required to operate. Systems shall not be under-designed or over-designed as either has the potential for adverse outcomes in terms of energy efficiency, O & M costs and productivity.

NOTE: Compressed air operated equipment has specific advantages in terms of system control, reliability and safety however their use incurs considerably higher operating costs (e.g. 7 – 10 times greater) over electricity when used for mechanical or process related work and therefore should only be used where absolutely necessary.

7.2 Definitions

In the context of this Standard the following compressed air definitions are contained in DS 30-01:

- (a) Air compressor;
- (b) Blower;
- (c) Compressed air;
- (d) Header;
- (e) Instrument air;
- (f) Interconnecting pipework;
- (g) Outlet dropper;
- (h) Plant (process) air;
- (i) Service air.

7.3 Air Compressors

For information regarding air compressors refer to the 'Air Compressors' section of this Standard.

7.4 Air Receiver

The system shall incorporate an air receiver sized to provide 30 minutes storage or adequate compressed air to allow the safe shutdown of the facility, whichever is greater. Air receivers are further detailed in the 'Air Compressors' section of this standard.

7.5 Service and Instrument Air

- (a) The air receiver outlet shall connect to a header and then split into the required number and quality of streams in accordance with the system design requirements.
- (b) Design of systems shall take into account best engineering practices and manufacturers recommendations with respect to (but not limited to) associated ancillary moisture and oil separation and filtering, pipework grading for drainage, pressure drop, balance piping, header outlet position and location with respect to proximity to the point of application.

- (c) The nominal pressure of service air at the distribution header shall be a minimum of 7 bar(g) unless otherwise nominated by the client. The distribution header should comprise a separate distribution ring or loop as appropriate in order to reticulate service air around the facility.
- (d) Oil and water separators, regulating valves and filters shall be installed where required.
- (e) Instrument air shall be dried in duty/standby refrigerative type air dryers (as required) before being reticulated around the facility.

7.6 Pipework

7.6.1 Scope

The following clauses are intended to cover compressed air pipework for service air and instrument air relating to interconnecting piping from the compressor to air receiver and the header, the header main, and outlet droppers and branch piping. Compressed air pipework shall not be installed below ground. Plant air piping material has been included for completeness only and will not be addressed further.

7.6.2 Designation and Material

All compressor, service, instrument and plant (process) air piping and fittings shall comply with the requirements contained in the following table.

Table 7.1 – Compressed Air Piping Material

Type of Pipe or Tube	Pipe Material		Comments
	Preferred	Non-preferred ⁵	
Interconnecting pipe ¹ , header, dropper pipe, drip leg pipe	Copper ² , SS, PE 80B ³ , PE 100 ³	CS ⁴	CS may suffer corrosion depending on the level of moisture present in the air as will GMS over time. Filtered and dry air is never really dry and dryers can fail or be turned off. Also CS and GMS are not as easy to install as the preferred types
Plant (process) air ¹	GMS ⁴		
Instrument air pipe	Copper ² , SS, PE 80B ³ , PE 100 ³	CS ⁴ , GMS ⁴	
Instrument air and pneumatic tubing	Polyurethane, PE, PVC air hose		Refers to the tubing connected to the instrumentation

For information regarding surge vessel air charge and vent pipework refer to the relevant section of DS 35-01.

LEGEND:

CS – Refers to carbon steel; GMS – refers to galvanised mild steel; PE 80B – Refers to medium density polyethylene; PE 100 – Refers to high density polyethylene; SS – Refers to stainless steel.

NOTES:

1. Metallic compressed air and plant air piping and fittings ≤ DN 50 are generally screwed and >DN 50 are flanged.
2. Copper is subject to atmospheric corrosion attack in the presence of gases such as hydrogen sulphide and its use should be avoided in susceptible environments.
3. PE 80B and PE 100 refers to purpose-designed, UV stabilised Class 16 polyethylene piping for compressed air reticulation purposes e.g. not for direct connection to a compressor.
4. CS should not be used in conjunction with oil-free compressors as it will suffer corrosion from the warm moist atmosphere.
5. Used in industry but generally not preferred for Corporation applications

7.6.3 Plastic Pipework

- (a) Only purpose-designed plastic piping and fittings shall be used which are compatible with compressor lubricants and shall be UV stabilised (e.g. PE 80B and PE 100 referred to above). This would preclude the use of materials such as ABS, PVC and PB.
- (b) Plastic fittings shall be of the fusion welded type. Use of mechanical compression joints shall not be permitted.
- (c) Plastic pipework shall be derated for temperature.
- (d) The Designer shall mitigate against the characteristic of compressed air which is related to accumulation of electrostatic charge where it could produce a potential hazard in susceptible environments e.g. WWTP Hazard Zones.

7.6.4 Condensate Removal

- (a) The pipework from the compressor to the air receiver should be graded in the direction of air flow and a water separator or drain leg and drain valve fitted to facilitate condensate removal.
- (b) Headers shall be graded 1:120 in the direction of flow of the compressed air in order to facilitate condensate removal.
- (c) Branch piping and outlet droppers should be connected at the top of the header so that carry-over of condensate to the point of use is minimised.
- (d) Drain or drip legs shall be installed in conjunction with outlet droppers and at low points of the system to collect condensate and shall be fitted with drain valves preferably of the automatic type.

7.6.5 Pressure Loss

All compressed air pipework shall be sized to minimise friction losses. The system pipework shall be sized so that the overall pressure loss from compressor receiver tank outlet to the point of use does not exceed 10% of the compressor's discharge pressure at the design duty.

Outlet droppers shall be located within close proximity to the point of use to minimize pressure losses in the compressed air distribution piping.

7.6.6 Air Velocity

The pipeline velocity for interconnecting piping and the header shall not exceed 6 m/s or less, and for branch lines shall not exceed 10 m/s. These velocity limitations are designed to minimize pressure loss from friction and turbulence in the system and to prevent transportation of moisture and debris. Flow velocities in excess of 10 m/s causes moisture and debris to be transported in the air-stream and past the drop legs.

7.6.7 Thermal Expansion

Pipework installed adjacent to compressors without an integral after-cooler should be rated for the discharge temperature and allowance made for coefficient of linear expansion and associated stresses.

Consideration shall be given to thermal expansion and contraction of pipework and associated stresses, particularly for long pipe runs and mitigation by way of expansion loops shall be provided.

7.6.8 Outlet Droppers

Outlet droppers should be fitted (as appropriate) with quick connect couplings at the point of use to facilitate speedy connection of devices.

7.6.9 Ancillary Equipment

- (a) In addition to moisture removal the service and instrument air shall be appropriately filtered (e.g. surge vessels for oil carry-over) and dried as may be required.

- (b) The quality of air should be appropriate to the needs of the process, equipment or instrumentation. High quality air should only be provided if it is needed in the process as it is expensive to produce.
- (c) Service air and instrument pipework and ancillary equipment shall be isolated from vibration.

7.6.10 Valves

Isolating valves shall be inline metallic ball valves complying with SPS 252 and seal on body butterfly valves complying with SPS 260.

7.6.11 Supports

Pipework shall be appropriately supported and secured by galvanized or corrosion resistant hangers, clamps and clips. Supports should comply with the relevant parts of the 'Pipework Supports' section of DS 31-01.

7.6.12 Standards

Pipes and fittings shall comply with the relevant parts of DS 31-01.

8 CRANES – BRIDGE AND MONORAIL

8.1 General

This section covers the design of overhead cranes (referred to as crane in the following) used for materials handling in pump stations, vacuum sewage stations, and treatment plant and stores buildings. A crane shall be provided within a building where periodic lifting of consumables and or removal of equipment for servicing is required.

Cranes used by the Corporation would normally be electrically operated bridge, jib or monorail types however manually operated cranes may be appropriate for relatively small loads and infrequent usage. This section essentially refers to electrically operated cranes.

For electric cranes all crane motions shall be electrically motorised where the rated capacity exceeds 1000 kg.

Cranes shall comply with ‘Stairways, Walkways and Ladders’ section of DS 30-02.

8.2 Types of Overhead Cranes

8.2.1 Bridge Crane

A crane comprising a bridge beam mounted at each end to an end carriage which is capable of travelling along elevated runways and having one or more hoisting mechanisms arranged to traverse across the bridge.

Bridge cranes referred to in this Standard would normally be for indoor service and of the single-girder type constructed from a rolled section or a welded box incorporating double carriages at each end for rail mounting. The girder would accommodate a motorised trolley and lifting hoist, and a single hook fitted with a safety catch.

8.2.2 Gantry Crane

A crane comprising a bridge beam, supported at each end by legs mounted on end carriages, capable of travelling on supporting surfaces or deck levels, whether fixed or not and which has a trolley with one or more hoisting units arranged to travel across the bridge. This crane type is not commonly used by the Corporation.

8.2.3 Jib Crane

A crane comprising a baseplate-mounted free standing column fitted with a slewing jib and trolley incorporating a lifting hoist and a single hook fitted with a safety catch. This crane type is used by the Corporation for dam applications for lifting deadplates. The jib crane is the subject of a later section in this Standard.

8.2.4 Equipment Lifting Davit Crane

A crane comprising a baseplate-mounted free standing column fitted with a boom, winch, lifting cable and pulley. This crane type is used by the Corporation primarily for raising or lowering equipment. The davit crane is the subject of a later section in this Standard.

8.2.5 Monorail

A crane which comprises a single girder suspended from a supporting structure and incorporates a trolley and hoist and constructed from a rolled section in straight or curved longitudinal configuration. This crane type is used by the Corporation for vacuum sewage stations and dam intake towers for lifting deadplates.

Monorail cranes referred to in this Standard should be a single girder type for indoor service. The girder should accommodate a motorised trolley and lifting hoist, and a single hook fitted with a safety catch. The girder shall be positioned directly over the equipment to be serviced. The Designer should consider whether a monorail crane is really appropriate for the application or whether an electric or manual bridge type gantry crane may be more suitable e.g. for small installations such as vacuum sewage stations.

8.3 Structural and Mechanical Design

8.3.1 General Requirements

The Designer shall address the following requirements:

- (a) The crane shall be designed in accordance with AS 1418.1, AS 1418.18 and AS 1418.3;
- (b) Design shall relate to either an electric bridge crane incorporating dual speed hoisting with wire drum, trolley travel and bridge travel or a monorail crane;
- (c) The height of lift shall be sufficient to lift equipment over any other equipment installed in the path of the crane travel to the loading area based on safe and practicable rigging requirements in accordance with WorkSafe WA. The minimum height shall also accommodate lifting the equipment onto a truck tray;
- (d) Incorporate a maintenance platform and ladders in accordance with AS 1418.1 with the maintenance platform located in accordance with the Crane Access clause in this section;
- (e) Supply of a control pendant able to be operated from the ground or floor level (or dry well floor level for sewage pump stations). Hard wired pendants shall be freely movable along the rail i.e. independent from the hoist. Remote pendant handsets may be used where specified by the client;
- (f) Designed to accommodate the weight of either the complete unit or the individual components as dictated by cost and client requirements;
- (g) Designed to accommodate the runway beam lateral differential and vertical deflection specified below.

8.3.2 Crane Capacity

The crane rated capacity shall be able to handle the heaviest item of plant within a building. The crane shall traverse all equipment to be lifted. Subject to client approval cost savings may be affected by rating the crane to lift individual items of equipment rather than as a set e.g. blower, motor and bedplate lifted individually rather than as a whole. Once a set or unit has been installed generally only individual items are removed for servicing thereafter. It should be noted that the crane is not normally required to lift pump station transformers or switchboards.

The crane shall be sized to take into account larger equipment that may be installed during future upgrading.

8.3.3 Structural Design

The steel structure for the bridge and the trolley shall be in accordance with crane code AS 1418 and steel structure code AS 4100.

Where the requirements specified in the codes are considered for any reason to be inadequate to maintain safety or to meet the intended working condition, appropriate increase of such requirements shall be made with the prior agreement of the client.

The structure shall be designed within the permissible stresses and fatigue conditions specified in the crane code. All welding shall comply with AS 1554 and Corporation Technical Specification WS-1.

8.3.4 Design Parameters

The Designers Specification should include but not be restricted to the following parameters:

Hoist

Rated capacity	kg
Lifting speed	m/min
Height of lift	m
Classification of hoist	per AS 1418

Common Duty

Classification of crane	per AS 1418
Rail span	m
Speed of trolley cross travel	m/min
Speed of crane down shop travel	m/min
Distance down-shop travel (approx)	m

8.3.5 Crane Access

- (a) The crane service platform shall provide convenient access to all mechanical and electrical equipment located on the bridge and trolley. The service platform shall be accessible from a crane access ladder;
- (b) Access shall also be provided to the down shop power collectors;
- (c) The platforms, walkways and access ladder from ground floor to the crane shall be constructed with safety features etc, as generally specified in AS 1657 and the relevant parts of 'Stairways, Walkways and Ladders' of DS 30-02.

8.3.6 Crane Coverage

The crane shall be designed and arranged in such a manner that it will be capable of lifting loads within 1000 mm from the inside edge of the runway beam.

8.3.7 Runway Beams and Rails

- (a) The crane runway rails billets to the runway beams shall comply with AS 1418. Runway beam lateral differential and vertical deflection shall not exceed 10mm.
- (b) The erection tolerance on crane rails shall be in accordance with AS 1418.1. The height and position of crane runway beams shall be adjusted using shims and packers in accordance with the Shims and Packers section of Alignment in DS 30-02.

8.3.8 Drive Mechanism

The drive mechanism shall comprise reduction gearboxes in accordance with the relevant section of 'Transmissions' contained in DS 30-02.

The drives to be supplied for long travel and cross travel purposes shall be designed such that any crabbing effect during travel will be eliminated.

The crane hoisting and travelling mechanisms shall be positively driven and incorporate a fail-safe system designed to come into operation in the event of power failure or malfunction.

8.3.9 Lubrication

Gears shall be lubricated by an oil bath and shall be contained in a sealed enclosure to prevent contamination caused by ingress of dust, moisture and foreign material.

Other lubrication points requiring grease shall be connected by high pressure tubing to individual lubrication points centrally located local to the equipment to facilitate easy maintenance and to ensure that all points are greased during the maintenance period.

8.3.10 Brakes

Service brakes and brakes necessary for holding load and emergency stops shall be automatic, fail-safe, electromagnetic type suitable for continuous duty.

8.3.11 Guards

Exposed rotating machinery shall be fitted with guards complying with the 'Guards' section of DS 30-02.

8.4 Electrical

The electrical design, material, wiring, equipment and installation shall comply with AS/NZS 3000 except as varied by AS 1418.1 section 8.

8.4.1 Power Supply

The crane shall be suitable for operation with a 415V +/-10%, 50Hz +/- 2.5% power supply.

The crane shall be supplied with a down shop power conductor and collectors including safety guards around the conductors. Crane power shall be supplied with either catenary power cables or energy chain arrangements or equivalent as specified by the client.

8.4.2 Electric Motors

The electric motor and motor starter shall comply with DS 22.

8.4.3 Lighting

Lighting levels should comply with the Pump Station Lighting section of DS 22. Where lighting under the crane requires enhancement lighting shall be provided under the trolley to illuminate the working area of hook and it shall be switched via the control pendent. Such light fittings shall not restrict the operational movements of the crane and shall be accessible for maintenance from the crane service platform.

8.4.4 Socket Outlets

The crane shall be provided with an RCD protected 240 AC, 10 Amp single-phase socket outlet at a convenient location on the crane service platform for maintenance purposes.

8.4.5 Switchboard

Switchboards shall be manufactured in accordance with DS 26.09.

8.5 Controls and Monitoring

8.5.1 Crane Controls

The crane shall be supplied with a push button type roving control pendent as follows:

- (a) It shall enable the crane operator to operate the crane at any point under the bridge and safe distance/location from the left;
- (b) The pendent shall be suspended in such a manner that it will be capable of supporting the weight of a 90 kg person;
- (c) The pendent shall enable the crane operator to operate the controls whilst standing next to the work at ground level;

- (d) Each function button shall be engraved, on the pendant casing adjacent to the button nominating the correct duty;
- (e) The control pendant shall be of manageable hand held size and shall be provided with the necessary controls as detailed in the Control Pendant clause of this section of the Standard. Where specified by the client cranes supplied with radio controlled handsets shall also be provided with a pendant control handset as a back up.

8.5.2 Control Pendant

The control pendant shall be a weatherproof totally enclosed type and shall operate on an extra low voltage. The push buttons shall be of such shape and arrangement as to enable ready and convenient operation and designed to automatically return to the off position. In addition to direction buttons, the following controls shall be available:

- (a) ON-OFF Switch;
- (b) STOP (Emergency Stop) – Lockable;
- (c) Light Switch (As required).

8.5.3 Condition Monitoring

The Safe Working Period should be monitored by a condition monitoring unit compliant with AS 2550.1.

8.6 Motion and Load Protection

8.6.1 Motion Protection

- (a) The crane shall be provided with fail-safe, self-resetting, automatic and positive motion travel limiting devices to obviate physical damage of the crane and fixed structure.
- (b) The travel limit devices shall be easily accessible from the crane service platform.

8.6.2 Load Protection

- (a) For intake tower gantry cranes, a load limiting device shall be provided to protect the crane in the event that the crane rated capacity is exceeded e.g. there is this potential when lifting dead-plates and bulkhead gates (at dams) due to possible pressure differential across them, and also for stop logs which can jam.
- (b) The load limiting device shall be of the load cell type, which shall be set to trip out the hoist motor if the crane rated capacity is exceeded by no more than 10%. The crane control pendant shall incorporate two indicator lights, a green light set to illuminate once 10% of crane rated capacity is taken up by the operator through to the trip limit, and a red light to indicate when an overload has occurred.

8.7 Coatings and Inscriptions

8.7.1 Coatings

Crane components shall be coated in accordance with Coating Specifications B2. The finish colour should comply with AS 2700 (Y14) Golden Yellow.

8.7.2 Compass Point Inscriptions

- (a) Compass directions (i.e. North, South, East and West) shall be inscribed on the underside and in the centre of the crane bridge or trolley;
- (b) The lettering shall be black on a white background and the whole inscription shall be at least 600 mm x 600 mm.

8.7.3 Rated Capacity Inscriptions

- (a) The rated capacity and WorkSafe registration number (if required) shall be inscribed on both sides of the bridge at a prominent location;
- (b) The inscriptions shall be in black paint on a white background;
- (c) The inscription shall be of sufficient size to enable the crane operator standing at ground level to take note of the crane capacity.

8.8 Installation and Testing

8.8.1 Installation

The Designer shall require the crane installation to comply with the requirements of WorkSafe WA.

8.8.2 Testing and Certification

The Designer shall require the crane to be load tested and certified for the nominated rated capacity in accordance with the requirements of WorkSafe WA.

8.9 Registration

Registration of cranes shall comply with WorkSafe requirements as detailed on their 'Plant – Term Definitions' web page from which the following requirements have been extracted:

8.9.1 Bridge Cranes

Bridge cranes with a safe working load greater than 10 tonnes, or which are designed to handle molten metal or dangerous goods require registration of the plant design

8.9.2 Gantry Cranes

Gantry cranes with a safe working load greater than 5 tonnes, or which are designed to handle molten metal or dangerous goods require registration of the plant design e.g. Diversion Dam 20 t Gantry crane and 15 t Gantry crane (stop log).

8.9.3 Hoists

Hoists, other than elevating work platforms, that have a platform movement in excess of 2.4 metres and which are designed to lift people require registration of the plant design e.g. Diversion Dam 20 t gantry crane auxiliary 1250 kg hoist.

9 CRANES - JIB

9.1 Scope

This section specifically relates to column mounted jib cranes for water supply dam intake towers designed for operating in conditions equivalent to a marine environment.

9.2 General

The crane shall comprise a free standing column with base plate mount slewing jib crane complying with the requirements of AS 1418.1 and AS 1418.3 and the additional requirements detailed in the following. The crane shall be suitable for installation on the crest of a dam to allow removal of intake screens and dead-plates. The crane shall be suitable for a location with very high humidity producing condensation and highly corrosive conditions to susceptible materials.

9.3 Mechanical Design

9.3.1 General Requirements

The crane shall comply with the following specific mechanical requirements:

- (a) Fabricated steel items shall be hot dip galvanised to AS/NZS 4680. Pre-painted proprietary items shall be solvent cleaned and top coated with a two coat epoxy system applied in accordance with the paint manufacturer's instructions;
- (b) Clearance under the hook shall be determined e.g. shall take into account lifting of intake screens onto a tray truck. The hook minimum and maximum horizontal travel radius from the column centre-line along the jib shall be determined;
- (c) The slewing angle required shall be determined by the Designer. The slewing action shall be chain operated (hot dip galvanised to AS/NZS 4680 or stainless steel) and pad lockable with gearing system located at the top of the column. The column shall incorporate a park-position padlockable device;
- (d) Anchor bolts and positioning templates shall be supplied with the crane.

9.3.2 Hoist

The hoist shall incorporate:

- (a) A trolley hoist with motorised extend/retract, and a hoist raise/lower functionality operated via a stainless steel chain;
- (b) An overload slipping clutch to provide protection in the event of the lifting load jamming during lifting or an electric load limiting device as specified in the Electrical Design clause below;
- (c) A wire rope or chain which shall maintain its horizontal position during lowering or raising to assist with screen location into/out off the screen guides;
- (d) A safety catch which is an integral part of the lifting hook;
- (e) A stainless steel brake assembly, which shall provide extend/retract and raise/lower braking functionality;
- (f) A hoist lifting speed of nominally 1m/min and with a hoist lifting height as previously determined.

9.4 Electrical Design

9.4.1 General

The crane shall comply with the following electrical requirements:

- (a) It shall be suitable for a three phase, 415V +/- 10%, 50 Hz +/-2.5% power supply;
- (b) It shall be fitted with a 2 x 36 W vandal proof, weatherproof (rated IP65 in accordance with AS 60529) and corrosion resistant lights mounted on the jib.

9.4.2 Electric Motors

- (a) The Electric motors shall be in accordance with DS 22.3, DS 22.4 and DS 22.6;
- (b) Motor starting shall be in accordance with DS 22.7.

9.4.3 Electrical Cabinets

All cabinets and switchboards shall be vandal proof and weatherproof rated IP 66 in accordance with AS 60529 and as follows:

- (a) A column mounted stainless steel switchbox shall be provided for the main crane isolator, an RCD protected 10 Amp socket outlet and a light switch;
- (b) The motors switchboard shall be constructed in accordance with DS 26.9;
- (c) The hoist and switchboards shall incorporate anti condensation heaters;
- (d) The crane shall be provided with a vandal proof stainless steel lockable cabinet which shall house a removable pendant or remote controller, and associated charger.

9.4.4 Controls and Load Protection

The controls and load protection shall comply with the following:

- (a) The crane shall be controllable by either a remote hand held controller or a removable plug-in type pendant controller;
- (b) The crane shall incorporate a load limiting device comprising a current transformer with motor current monitoring relay set to trip at no more than 5% greater than the crane rated capacity.

10 CRANES – EQUIPMENT LIFTING DAVIT

10.1 Scope

This section specifically relates to column mounted equipment lifting davit cranes (hereafter termed davits).

The requirements for prevention of falls davits are not covered in this standard but can be found in Corporation Standard S151 Prevention of Falls.

10.2 General

Davits shall comply with the requirements of AS 1418.

Where davits are not power operated they shall comply with either the requirements of AS1418 or an equivalent international standard.

NOTE: The general duties of *OSH Regulations 1996-Part 4-Plant* do not apply to davits that are non-powered. However the requirements of *OSH Act 1984-Section 23* are still applicable. For this reason it is recommended that non-powered davits used in Corporation infrastructure are operated and maintained as cranes with the same regular inspection intervals.

10.3 Rated Capacity

Davits must be rated for the maximum load conditions expected during their service life. This maximum load shall allow for possible increases in equipment or load weight during operation, for example the build-up of rags on pumps and mixers in wastewater applications.

10.4 Marking

Marking of davit equipment shall comply with the requirements of AS1418.1

10.5 Lifting Cable

Lifting cables on davits shall nominally be grade 316 stainless steel.

NOTE: Due to the possible effects of corrosion and other factors that may weaken the stainless steel lifting cables over time, the lifting cables should be replaced every 12 months or sooner, subject to documented observations during 3 monthly maintenance visits.

11 DIESEL ENGINES

11.1 General

Engines used by the Corporation as prime movers for mobile and fixed plant are almost exclusively air or liquid cooled-cooled diesel engines.

The Corporation uses diesel engines in lieu of electric motors as prime movers mainly for either remote locations where electric power supplies are not available, or as standby plant, for the following applications:

- (a) Small diesel engine driven borehole pumpsets in remote locations where electric power is not available;
- (b) Small diesel engine driven transfer pump stations in remote locations where electric power is not available;
- (c) Standby diesel engine driven generators for small to medium applications;
- (d) Standby diesel engine driven pumpsets;
- (e) Diesel engine driven mobile plant such as dewatering pumps, sewage blowers, lighting plants and air compressors.

The direction of rotation of the engine shall be anticlockwise looking at the flywheel.

11.2 Engine Sizing and Selection

Engines should be sized taking into account of the following de-rating, transmission loss and duty cycle factors:

11.2.1 Ambient Conditions

Engines shall be de-rated for the extreme site ambient conditions in terms of atmospheric pressure (altitude), ambient temperature and relative humidity. As a guide there may be a 1% power reduction for every 100 metre increase in altitude above 500 metres above seal level and 1% for every 2°C above 20°C ambient temperature.

Engines shall be de-rated for altitude, ambient temperature and relative humidity in accordance with the requirements of AS 4594.1 for the relevant site conditions.

11.2.2 Transmission Losses

Allowance for additional loads caused by transmission such as:

- (a) Transmission belt drives;
- (b) Gearbox drives;
- (c) Borehole line-shaft transmission and drives.

11.2.3 Continuous Rating

Engines used on applications for continuous duty cycle should have appropriate conservative service factors applied.

11.2.4 Intermittent Rating

Engines used on applications for intermittent duty should have appropriate service factors applied, which are less conservative than for continuous duty.

11.2.5 Engine Reserve Power

Diesel engines should not be selected with an excessively high reserve power e.g. site power rating (derated for site conditions) compared to duty power requirement (including transmission losses). A reserve power greater than 10% may cause the engine to run too lightly loaded. This can cause insufficient bedding of the piston rings on the cylinder, which produces glazing of the cylinder walls, piston blow-by and a consequent loss of power.

11.3 Engine Type and Performance

Diesel engines should comply with the following requirements:

- (a) Solid injection, cold starting, 4-stroke compression ignition type, naturally aspirated or turbo charged with vee or inline multi-cylinders;
- (b) The engine net power and torque shall be measured in accordance with AS 4594;

11.4 Engine Ancillaries

11.4.1 Cooling System

The engine cooling system shall be either air-cooled or liquid-cooled to suit the client's requirements in accordance with the following. Refer also clause 11.8.1 'Air-Cooled versus Liquid-Cooled Diesel Engines' of this Standard.

11.4.1.1 Air-Cooled Diesel Engines

Air-cooled diesel engines use forced air from either an integral flywheel fan for small engines or via an auxiliary fan driven from the crankshaft for larger engines.

Auxiliary cooling fan driven engines shall have automatic belt tensioning and the fan bearings shall be sealed against ingress of dust and moisture where they are to be located in dusty environments exposed to the weather.

11.4.1.2 Water-Cooled Diesel Engines

Water-cooled diesel engines of the sizes used by the Corporation should have an integral cooling system comprising a radiator, cooling fan and water jacketed engine. External coolant heat exchanger systems are not preferred.

The cooling system shall incorporate the following requirements:

- (a) A closed circuit radiator and water jacket cooling system;
- (b) The water jacket temperature shall be monitored at the common outlet on the engine;
- (c) A gear or belt driven circulating coolant pump shall be fitted in the closed circuit;
- (d) An expansion tank of adequate capacity with a water level indicator;
- (e) A single down-flow radiator with a short reach filler neck and the cap shall be readily accessible;
- (f) The coolant should be treated with an inhibitor approved by the engine manufacturer. Treatment shall be in accordance with the manufacturer recommendations. An Inhibitor Treatment label shall be placed adjacent to the radiator filler point.

11.4.1.3 Oil-Cooled Diesel Engines

Oil-cooled diesel engines utilize oil or a combination of oil and airflow as the cooling system, however they are limited to small engine sizes. Engines utilizing this type of cooling system tend to embody the advantages of both air-cooled and water-cooled diesel engines (refer Table 11.1).

11.4.1.4 Cooling Air Supply

The engine shall be provided with an adequate quantity of fresh combustion and cooling air.

The air quantity required to cool the engine should be in accordance with the engine manufacturer's recommendations.

In addition to engine combustion and cooling air requirements allowance shall be made for the extra cooling air required for generator cooling in the case of generator plants.

The building or enclosure shall have ventilation openings to facilitate admission of fresh ambient air into the room. The number and sizes of the ventilation openings shall be in accordance with the manufacturer's requirements.

Inlet louvres and openings shall be fitted with security features and acoustic damping as required.

11.4.1.5 Hot Air Ducting

Engines located inside a building or enclosure shall be fitted with a hot air adaptor and associated ductwork in order to direct reject cooling air either horizontally or vertically outside the building or enclosure.

Ductwork sizes shall be in accordance with the engine manufacturer's requirements. Where ductwork exceeds 2 metres in length the ductwork sizes should be increased and room air exhaust fans or blowers provided. The fan or blower capacity should be selected as a function of temperature drop in the room.

Ductwork shall be manufactured from plain galvanized steel sheet and connected to the engine by a flexible membrane that is resistant to the effects of heat from the engine and hydrocarbons.

11.4.2 Lubrication System

The engine shall incorporate a forced oil lubricating system and be fitted with a full flow replaceable cartridge type lubricating oil filter.

The capacity of the lubricating oil sump shall be such that topping up of the lubricating oil level shall not be necessary at intervals less than the maximum attendance interval specified by the client when the engine is running continuously at full load.

Turbocharger lubrication shall be maintained during shutdown.

11.4.3 Fuel System

The engine shall be suitable for operation on automotive diesel fuel as specified in AS 3570.

The engine shall be fitted with an injection pump and injector system protected from contamination by a replaceable cartridge type fuel filter.

The engine fuel tank shall comply with the 'Fuel Tanks' clauses contained in the 'Diesel Engine Driven Plant' section of this Standard.

11.4.4 Induction System

The inlet to the air cleaner should ideally be piped from the external ambient air. The air intake shall be fitted outside the engine compartment for enclosure type applications and should be fitted outside engine rooms as mentioned.

The intake vacuum from the air cleaner outlet to the engine intake manifold should not exceed 300 mm water column.

The engine air cleaner shall incorporate a dry double life element with a bowl type pre-cleaner e.g. Donaldson "Cyclopac" or equivalent.

All components forming the air intake system shall resist the entry of dust and shall be sufficiently rigid to avoid collapse during operation.

The system shall be fitted with an air cleaner service-warning device, which should be mounted on the instrument panel for enclosure type applications.

11.4.5 Exhaust System

The engine exhaust system should comply with following requirements:

- (a) For engines located in a building the exhaust pipe should be located inside the hot air ducting and connected to an externally mounted muffler;
- (b) The exhaust system shall be fitted with a spark arrester or a combination spark arrester/muffler in accordance with AS 1019;
- (c) The exhaust pipe shall terminate in such a way as to minimise the entry of rainwater. A rain hat or hinged flap is not preferred;
- (d) The exhaust fumes shall not be induced into the engine air cleaner pre-cleaner or cooling fan intake;
- (e) The muffler shall be of the heavy-duty residential type constructed from aluminised steel and terminating in a horizontal outlet;
- (f) The exhaust pipework shall be steel with dimensions in accordance with the engine manufacturer requirements;
- (g) The maximum exhaust backpressure downstream of the last engine cylinder or the turbocharger (if fitted) and before the muffler should not exceed 700 mm water column for both turbocharged and naturally aspirated engines;
- (h) Exposed exhaust pipework shall be fitted with a guard or lagged to protect personnel from burns if accidentally touched.

11.4.6 Governing System

Diesel engines use two types of governing systems to maintain engine speed control namely:

- (a) Isochronous governing which provides a constant speed regardless of the load;
- (b) Droop governing which allows slight speed variation in response to load changes. The amount of droop is expressed as a percentage.

Isochronous governors are essential for generators used in parallel where it is essential to achieve accurate load sharing and regulation.

Drooping governors are satisfactory for single standby generators and pumpsets.

The engine governing shall be in accordance with the appropriate class as specified in AS 4594.4.

11.5 Electrical System

The engine shall incorporate a local electric starting system. The electrical system shall be 12V or 24V as dictated by the design requirements.

The diesel engine shall be fitted with the following electrical equipment:

- (a) A generator incorporating voltage regulation and sized to provide sufficient output to charge the battery(s) and power all ancillary equipment and accessories within the engine's operating speed range;
- (b) A 12V or 24V DC starter motor;
- (c) A 12V or 24V DC fuel rack solenoid, which shall operate in a 'fail-safe' manner, i.e. the engine shall shut down when the solenoid is de-energised. The solenoid shall have separately connected 'pull-in' and 'hold' windings. The 'pull-in' windings shall be internally disconnected when the solenoid has completed its 'pull-in' operation;

- (d) A low oil pressure switch to initiate engine shutdown in the event of low oil pressure and an audible alarm to alert the operator;
- (e) Temperature sensor to cause the engine shut down in the event of high coolant temperature;
- (f) An engine over-speed switch and associated circuitry;
- (g) For water-cooled engines a radiator water level switch to cause engine shut down in the event of low water level;
- (h) Cooling fan belt failure detector;
- (i) A fuel tank level switch and circuitry set to indicate in the event of low fuel level.

11.5.1 Controls

11.5.1.1 General

The engine control cubicle shall incorporate timer equipment that will provide three repeat engine cranking attempts, with an appropriate delay between each attempt that shall be initiated once the start signal has been received.

11.5.1.2 Control Selector Switch

Engines shall be supplied with a key lockable three position control selector switch with Manual, Off and Auto function located in the control cubicle mounted integral with the diesel unit for standby plant, or alternatively in a separate starter cubicle e.g. diesel-driven pumpsets.

The control selector switch functions shall be:

- (a) Manual - In this position the engine can be initiated by a separate “engine start” pushbutton in the control cubicle;
- (b) Off - In this position the engine cannot be started manually or by automatic control;
- (c) Auto - In this position the initiation of the engine shall be determined by the operation of a voltage free contact in the Plant Switchboard.

11.5.1.3 Start/Stop Push Buttons

The following Start/Stop push buttons shall be fitted in the control cubicle:

- (a) One engine Start push button;
- (b) One engine Stop push button;
- (c) One engine latched emergency Stop push button;
- (d) Remote run relay;
- (e) Main circuit breaker or On, Off and Reset controller;
- (f) Battery charger circuit breaker or On, Off and Reset controller;
- (g) Battery charger booster switch.

11.5.1.4 Hand Throttle

Where required a micro-adjustable hand throttle shall be provided.

11.5.2 Instrumentation

The engine shall be fitted with instrumentation as follows:

- (a) An engine battery charge/discharge ammeter;
- (b) A battery voltmeter;
- (c) An engine oil pressure gauge scaled in kPa;
- (d) An engine tachometer in revolutions per minute;

- (e) An engine hour-meter;
- (f) A high coolant or high cylinder head temperature indicator lamp (water/air-cooled) and alarm;
- (g) A low coolant level indicator lamp (water-cooled engines);
- (h) A low lubrication oil pressure alarm;
- (i) A high lubrication oil temperature indicator lamp;
- (j) An engine over-speed indicator lamp (where required);
- (k) A low fuel indicator lamp;
- (l) A battery charger fault indicator alarm;
- (m) A lamp test/reset button.

A relay shall be provided for remote alarm indication when any of the above alarms trip or the engine fails to start after 3 attempts.

Warning lights and colour coded gauges shall conform to SAE J209 "Instrument Face Design and Location for Construction and Industrial Equipment" and SAE J298 "Universal Symbols for Operator Controls on Industrial Equipment".

11.5.3 Protection

The diesel engine shall be provided with the following automatic shut down protection equipment:

- (a) High coolant or high cylinder head temperature;
- (b) Low coolant level;
- (c) Low lubrication oil pressure;
- (d) High lubrication oil temperature;
- (e) Engine over-speed;
- (f) Emergency stop pushbutton;
- (g) Low fuel;
- (h) Cooling fan belt breakage.

Turbocharged engines shall be fitted with turbo-lube protection for engine shutdown.

11.5.4 Batteries and Charging System

11.5.4.1 Batteries

- (a) The batteries shall be of the lead-acid type and rated at 12 V or 24 V DC;
- (b) The batteries shall have sufficient capacity to provide at least 6 sets of starting sequence without assistance from either the mains battery charger, or engine generator;
- (c) The batteries shall be capable of providing power for all control equipment and indicator lamps;
- (d) The batteries shall be located so that they are readily accessible for servicing and removal. The battery carrier shall be an integral part of the baseplate and located clear of cooling air intakes;
- (e) The battery carrier shall be constructed of corrosion resistant material;
- (f) The battery cables shall be as short as possible to reduce the voltage drop on starting;
- (g) The battery bank terminals shall be fitted with insulating shrouds;
- (h) A battery isolator shall be provided in a convenient location within the kiosk.

11.5.4.2 Battery Charger

Where required a battery charger shall be supplied which shall include a 240V AC powered fully automatic controlled constant potential 12V or 24V D.C. battery charger to maintain a controlled trickle charge to the battery set during periods when the diesel engine is non-operative.

The battery charger shall be capable of replacing the battery charge run-down within a period of 8 hours from the engine starts

The battery charger shall include:

- (a) A manually selectable boost charge facility;
- (b) Automatic isolation during engine start and run.

11.6 Service Pipework

Service pipework used for fuel, water, oil and exhaust shall be compatible for the application and shall be provided with flexible connections where they connect to the engine to minimise vibration transfer. The service pipework shall be rigidly clamped immediately downstream of the flexible connection.

Fuel transfer pipework shall not be galvanized or zinc coated.

11.7 Special Operational Requirements

The engine manufacturer should be consulted for the following special operational requirements:

- (a) Degree of engine longitudinal and transverse tilt;
- (b) Permissible continuous or intermittent end thrust on engine crankshaft;
- (c) Maximum permissible side load on the front and rear crankshaft pulleys and stub shafts e.g. for belt transmission drives;
- (d) Power takeoffs from other than the main crankshaft e.g. front pulley and auxiliary front-mounted PTO adaptors.

11.8 Engine Type Comparisons

11.8.1 Air-Cooled versus Liquid-Cooled Diesel Engines

The Corporation uses both air and liquid-cooled (water) diesel engines as prime movers on its assets. Generally air-cooled diesel engines are used on remote pumping and generator plant applications (where noise is less of a consideration) in lieu of water-cooled diesel engines because they tend to have a lesser operation and maintenance requirement. Water-cooled diesel engines have more favourable noise levels thus reducing the sound attenuation requirements, which is important for standby pumping and generator plant located in residential areas. The higher servicing requirement of water-cooled engines could pose a problem remote locations. For more detailed information regarding advantages and disadvantages of each system refer to the following table.

Table 11.1 – Engine Cooling System Comparisons

Pros and Cons	Air-Cooled	Water-Cooled	Oil-Cooled
Advantages	<ul style="list-style-type: none"> • Simple • Low maintenance • Reliable • Compact size • Extreme operating temperatures 	<ul style="list-style-type: none"> • Low noise • Low emissions 	<ul style="list-style-type: none"> • Low noise • Low emissions • Simple • Low maintenance • Reliability

Pros and Cons	Air-Cooled	Water-Cooled	Oil-Cooled
	<ul style="list-style-type: none"> • Remote locations 		<ul style="list-style-type: none"> • Compact size • Extreme operating temperature
Disadvantages	<ul style="list-style-type: none"> • Noisier than water-cooled • Higher emissions • Size limitations e.g. ≤ 500 kW 	<ul style="list-style-type: none"> • Higher complexity • Higher maintenance • Less compact • Operating temperature limitations 	<ul style="list-style-type: none"> • Size limitations e.g. ≤ 70 kW

11.8.2 Two-Stroke Cycle versus Four-Stroke Cycle

Diesel engines are available in either two-stroke or four-stroke cycle types.

Two-stroke cycle engines in comparison with four-stroke cycle engines are generally:

- (a) Less efficient;
- (b) More complex;
- (c) Noisier;
- (d) Lighter weight;
- (e) Not as expensive.

Two-stroke engines may be considered for standby or intermittent duty engines depending upon client preference but should not be used for continuous duty applications.

11.8.3 In-line Cylinders versus Vee Cylinders

Diesel engines are manufactured in in-line or vee cylinder configuration. In comparison with in-line engines for the same power rating vee cylinder engines are:

- (a) More complex;
- (b) More expensive to maintain;
- (c) Operate with less vibration;
- (d) Are more compact and therefore require less floor space.

11.9 Testing

The diesel engine design shall have been type tested in accordance with AS 4594.1 and related certification shall be made available if requested.

The diesel engine shall be acceptance tested at the manufacturer's works in accordance with AS 4594.1 and AS 4594.3 and a test certificate from the manufacturer shall be supplied.

12 DIESEL ENGINE DRIVEN PLANT

Diesel engine plant (e.g. generating units, pump units, sewage blowers etc.) ancillary items shall comply with the following requirements where applicable:

12.1 Diesel Engines

For requirements relating to diesel engines refer to the Diesel Engines section of this Standard.

12.2 Baseplate and Skidbase

Diesel engine plant shall be mounted on a common baseplate. The construction of the baseplate and skid-base shall comply with the relevant parts of the 'Baseplate' section contained in DS 30-02.

For generating sets the diesel engine and generator shall be mounted on a common baseplate, which shall be mounted on a skid-base, using anti-vibration mounts.

The baseplate or skid-base (whichever is relevant) shall be fitted with single or multi-point lifting eyes which provide a balanced, horizontal lift with a full fuel tank. The lifting point/s shall be tested and certified by the manufacturer.

12.3 Guards

The guards shall comply with the Guards section contained in DS 30-02.

12.4 Fuel Tanks

12.4.1 Fuel Tank and Integral Bund for Standby Diesel Plant

Standby plant should generally incorporate a fabricated steel fuel tank mounted on the skid-base.

The standby fuel tank should have sufficient capacity to allow a minimum of 24 hours continuous running at full load or as specified by the client.

The fuel tank shall comply with the relevant parts of AS 1692 and the following:

- (a) Baffle plates suitable for transporting;
- (b) An extended filler pipe;
- (c) A readily accessible drain valve and sealing plug located in the lowest section of the tank and shall maintain the integrity of the fuel bund;
- (d) Where relevant a low fuel level alarm switch set at approximately 25% of the full capacity and a visual fuel indicator.

The skid-base shall incorporate a fuel bund designed to contain fuel from the fuel tank and engine components in the event of a leak e.g. the fuel tank shall be self-bunding. The bund shall also contain any major lubricating oil or coolant leakage from the engine. The bund capacity shall be at least 110% that of the fuel tank. The fuel tank shall not be of the double-skinned type. An easily accessible drain valve fitted with a plug shall be provided for the bund.

12.4.2 Fuel Tank and Bund for Fixed Diesel Plant

Diesel driven plant required for continuous operation such as a borefield pumping units or transfer pumps should have a separate elevated fuel storage tank in conjunction with a daily service tank. Storage of diesel fuel and the requirements for fuel storage tanks shall comply with the relevant parts of AS 1940 and AS 1692 respectively.

Diesel engines should either draw fuel using a fuel transfer pump (e.g. from the tank in a skid base) or via gravity from a daily service tank. Pumped supplies to the engine shall not be used, as diesel injection systems are not designed to cope with them.

Large quantities of fuel shall be stored external to a building in order to reduce the fire risk. All fuel tanks shall be provided with a bund to contain fuel spillage from the tank and containment system for the pipework (refer Notes). The bund capacity shall be at least 150% that of the fuel tank.

A readily accessible drain valve with sealing plug shall be fitted at the lowest section of the fuel tank. The drain valve shall be located at the fuel tank and the sealing plug shall be accessible outside of the bund, whilst maintaining the integrity of the fuel bund.

The fuel tank shall be coated externally in accordance with Coating Specification B2. The fuel tank shall not be coated internally.

Allowance shall be made for piping the excess fuel from the injectors back into the fuel system.

NOTES:

1. Regular maintenance of external bunds is required to ensure accumulated rainwater is drained off, and blown-in sand and debris is removed.
2. Barrier hydro-carbon flow filters can be fitted to prevent accumulation of rainwater in the bund e.g. C.I Agent® barrier hydro-carbon flow filter or equivalent..

12.5 Enclosure

12.5.1 General

The diesel engine plant enclosure shall be sound attenuated and weatherproof and comply with the following requirements.

12.5.2 Construction

The enclosure shall comply with the following:

- (a) Heavy duty construction with a galvanized steel frame;
- (b) Enclosure cladding shall be galvanized steel sheet;
- (c) All doors shall be fitted with stainless steel locks and hinges;
- (d) Fasteners shall comply with the requirements detailed DS 30-02 and shall be either hot dip galvanized or stainless steel;
- (e) The enclosure shall not adversely restrict the cooling of the engine or generator;
- (f) The enclosure shall not adversely affect the generator set's performance rating at the site operating conditions;
- (g) The enclosure shall be weatherproof to the equivalent of IP23 as defined in AS 60529 and shall be provided with gutters at each opening;
- (h) The enclosure shall be provided with a weatherproof shield for the fuel tank bund;
- (i) Where hot air ducts, or heated components pass through sound proofed panels they shall be isolated from soundproofing so as to protect it from heat damage.

12.5.3 Noise attenuation

The noise attenuation treatment of the enclosure shall limit acoustic emissions to 85 dB(A) maximum sound pressure level measured 1 m from the enclosure in accordance with AS 1055.1.

Noise attenuation materials shall be compatible with diesel fuel, engine oil and the engine operating temperature.

Noise measurements shall comply with the section on Noise contained in DS 30-02.

12.5.4 Accessibility for Service and Maintenance

The enclosure, which shall be removable from the baseplate, shall incorporate the following design requirements:

- (a) Access to the engine and driven unit (as applicable) components shall be via large access doors on each side;
- (b) Ready accessibility and convenience to perform routine servicing on the engine and driven units, i.e. air, oil and fuel filters and the battery(s);
- (c) A system to allow easy draining of the engine oil, coolant (where applicable), the fuel tank and the integral bund to the outside of the engine enclosure shall be provided i.e. an isolating valve at the sump or tank and a connecting flexible hose with plug;
- (d) Where doors are hinged to open vertically, then gas struts shall be fitted to hold them in the open position. Horizontal hinged doors shall be fitted with restraining devices to hold them in the open position against the effect of wind and other external forces.

12.5.5 Lock-up Provision

Access doors provided to the engine, instruments and control compartments, radiator cap, battery storage, fuel tank filler cap and other exposed fill points shall incorporate lockable security features including the following:

- (a) All doors and covers shall be lockable to prevent unauthorised access. Lockwood Night Latches or Lockwood 8474 handles with EM1 Key Cylinders (or Bi-lock to suit client's requirement) shall be used on all doors and covers except to AC powered switchboards which shall be fitted with an EL2 Key Cylinder;
- (b) All doors shall have security switches. The doors switches shall be wired to provide a voltage free contact (normally closed when the door is closed);
- (c) Viewing windows shall be clear vandal-proof polycarbonate.

12.6 Coatings

All components subject to the weather shall comply with the requirements detailed in the Corrosion section of DS 30-02.

Additionally the baseplate, skid base, enclosure, fuel bund and any other steel components used in the assembly of the generator set shall comply with the following:

- (a) Hot dip galvanising shall comply with the relevant part of DS 95;
- (b) The enclosure shall be coated externally in accordance with Coating Specifications B1 and M7 and with the relevant parts contained in DS 95.

12.7 Trailers

Where trailer mounted diesel driven plant is required it should comply with the relevant parts of AS 4177 Parts 1 to 5 for trailers of up to 3500 kg ATM and the following:

12.7.1 Trailer Chassis

The trailer chassis and drawbar shall be:

- (a) Of robust construction designed to accommodate the required Gross Trailer Mass (GTM);
- (b) Welded in accordance with the relevant parts of the Welding section contained in DS 30-02;
- (c) Designed to be used in conjunction with a towbar complying with AS 4717.1.
- (d) Coated in accordance with the 'Coatings' clause above.

12.7.2 Suspension

The springs shall be double eye and the shackles shall be fitted with grease nipples. Slipper type springs are not acceptable.

12.7.3 Brake System

The trailer shall be fitted with a braking system appropriate to the GTM and vehicle licensing requirements.

12.7.4 Coupling Body and Safety Chains

A 50 mm ball type coupling body and safety chains shall be fitted to the drawbar. The coupling body shall comply with AS 4177.3 and safety chains shall comply with AS 4177.4. Two hot-dip galvanized safety chains shall be provided including hot-dip galvanized D shackles to suit the trailer ATM rating.

12.7.5 Electrical Connector and Trailer Lights

The electrical connector plug shall be a 7 pin metal trailer type (Utilux H 409071/1 or equivalent) complying with AS 4177.5. The trailer lights shall be combination type LED rear lights protected with crash bars to minimise physical damage during operation.

12.7.6 Tyres and Rims

Where appropriate, standard cross-ply tyres should be fitted to all wheels. The complete wheel assemblies shall comply with the requirements of the current Standards Manual of the Tyre and Rim Association of Australia.

12.7.7 Mudguards and Flaps

The trailer shall be fitted with steel mudguards and rubber mud flaps. The mud flaps shall be secured utilising steel backing plates and bolts. All steel components and fasteners shall be hot dip galvanized in accordance with the relevant part in the Coating section of DS 30-02.

12.7.8 Jockey Wheel

The trailer shall be fitted with a drawbar mounted Artwell "Power Wheel Series 2" jockey wheel or equivalent, complete with double clamp and swing up arrangement for transportation.

12.7.9 Licensing

The trailer unit, attachments and accessories shall comply in every respect with the Vehicle Standards Regulations of the Road Traffic Act 1974/1981 and all subsequent amendments.

13 FANS

13.1 General

Fans generally available are propeller, axial and centrifugal types. Specific performance characteristics will in many cases determine the type of fan that should be selected for a particular application.

For further information regarding propeller, axial and centrifugal fans refer to the ‘Glossary’ contained in DS 30-01.

Designers should take into account the characteristics of a particular fan type being considered in order to optimise performance. Fan characteristics are outlined in the following table.

The design shall incorporate all necessary fans required for supply or extraction of ventilation air, process air or odours as required.

13.2 Selection Guide

The typical operating range of the various blower types is shown in the following table:

Table 13.1 – Typical Fan Ratings

Fan Type	Typical Pressure Range – bar (g)	Typical FAD Range – L/s
Propeller	0.03 (3kPa)	Very high
Axial: - Tube axial	25 kPa	250 – 1,000,000
- Vane axial	25 kPa	250 – 1,000,000
Centrifugal: - Backward curved blade	1.5 (150 kPa)	250 – 600,000
- Forward curved blade	1.5 (150 kPa)	Medium flow
- Radial blade	1.5 (150 kPa)	High flow
- In-line flow (mixed)	Medium pressure	Medium flow

13.3 Propeller and Axial Fans

Propeller fans are limited to low pressure applications restricted to mainly wall or ceiling mounted extraction fans.

Axial fans are more widely used than propeller fans but less so than centrifugal fans because of their higher noise levels and lower developed pressures. They are available as tube axial fan or vane axial fan types (refer ‘Glossary’ DS 30-01).

The following table summarises the characteristics of axial fans:

Table 13.2 – Axial Fan Characteristics

Fan Type	Advantages	Disadvantages
Propeller	Very high capacity	Operating noise is relatively high
	Low initial cost	Sensitive to increased downstream resistance particularly shut-off
	Low operating cost per volume flow rate	Not tolerant of corrosive or abrasive conditions
	Minimum space and weight per volume flow rate	Direct-coupled type not suitable for flammable or explosive gases, vapours or dust
	Available for bi-directional flow	Not suitable for process temperatures much greater than ambient
Axial – Tube and vane types	Very high capacity	Operating noise is relatively high compared with centrifugal types
	Low initial cost	Can be noisy and unstable when subjected to increased downstream resistance
	Relatively high efficiency, approaching that of backward curved centrifugal type	Not tolerant of corrosive or abrasive conditions
	Can be staged for higher pressures	Direct-coupled type not suitable for flammable or explosive gases, vapours or dust
	Relatively small space and weight per volume flow rate	Not suitable for process temperatures much greater than ambient
	Available for bi-directional flow	

13.4 Centrifugal Fans

Centrifugal fans are available in backward curved blade, backward inclined blade, forward curved blade, straight or radial blade and tubular in-line flow types.

- (a) Backward curved and backward inclined blade centrifugal fan blades either curve or incline away from the direction of rotation respectively. They provide optimal efficiency and the lowest sound levels of all fan types, particularly when symmetrical aerofoil blades are used. Used for clean industrial applications;
- (b) Forward curved blade centrifugal fan blades curve towards the direction of rotation. The fan drum incorporates a relatively high number of shallow depth blades with a high aspect ratio. The inlet is relatively large compared to the drum diameter. This type is a general-purpose fan suitable for medium pressure systems and is relatively quiet due to the relatively low tip speed. Used widely for domestic and commercial heating and ventilation requirements;
- (c) Straight or radial blade centrifugal fan blades are generally flat, straight radial blades although slight curvature is often used to marginally increase efficiency. Used widely for industrial exhaust fans particularly for contaminated or high temperature air applications;
- (d) In-line flow centrifugal fan blades are mixed flow and operate in a tubular housing that incorporates curved straightening vanes to provide axial flow. In-line flow centrifugal fans are used widely for supply and exhaust ventilation applications.

The following table summarises the characteristics of the different types of centrifugal fans:

Table 13.3 – Centrifugal Fan Characteristics

Fan Type	Advantages	Disadvantages
Backward curved blade	High volumes with static pressures to 150 kPa	Not suitable for contaminated air which can adhere to blades causing imbalance and difficult cleaning
	Highest efficiency of all fan types – up to 85% (aerofoil blades)	Large physical size and weight
	Lowest noise of all fan types	
	Non-overloading load characteristics	
Forward curved blade	Medium volume	Not suitable for contaminated air which can adhere to blades causing imbalance and difficult cleaning
	Low speed	Large physical size and weight
	Low noise	Not as efficient as backward curved blade centrifugal fans
	Reasonable efficiency e.g. 50% - 60%	Power steadily increases with volume flow rate e.g. not non-overloading power characteristic
Radial blade	Suitable for clean or heavily contaminated air e.g. dust	Lowest efficiency of the centrifugal fans $\leq 50\%$
	Suitable for corrosive or abrasive materials handling	Highest noise levels of centrifugal fans
	Suitable for high temperature applications	Power steadily increases with volume flow rate
	Blades are easily cleaned, and repaired in situ	
In-line flow	Medium volume flow rate performance	Clean air applications only
	Medium pressure applications	Not suitable for contaminated air which can adhere to blades causing imbalance and difficult cleaning
	Performance characteristics are similar to the backward curved blade centrifugal fan	Not as efficient as backward curved blade centrifugal fans
	Relatively low space and weight	Not tolerant of corrosive or abrasive conditions
		Direct-coupled type not suitable for flammable or explosive gases, vapours or dust
		Not suitable for process temperatures much greater than ambient

13.5 Requirements

Fan sets shall comply with the following:

- (a) Fans and fan drives and all materials shall be specifically designed to suit the site ambient and process air or gas conditions;

- (b) Vee belt drives shall comply with the relevant part of the Transmission Drives section of DS 30-02;
- (c) Fan sets shall be supplied as integrated units on fabricated base frames including provision for drive alignment adjustment and safety guarding;
- (d) Fan drive motors shall be installed outside of the airstream;
- (e) Fans shall be mounted using anti vibration foot mounts or hangers and shall have flexible joints isolating from the ductwork and scrubbers;
- (f) Fans shall have their impeller rotating elements dynamically balanced in accordance with ISO 1940/1;
- (g) Fan installation shall make due provision for safe access for maintenance requirements;
- (h) Fans shall have a local supplier for continuity of spares and service.

14 GENERATING SETS (STAND-ALONE)

Stand-alone generating sets shall comply with the requirements detailed in the Type Specification contained in DS 26-05. Further information relating to fixed installations or mobile (trailer) applications is contained in the 'Diesel Engines' and 'Diesel Engine Driven Plant' sections of this Standard.

15 PITS AND CHAMBERS

Wherever operationally practicable, use of below ground pits to house valves and equipment should be avoided because of confined space issues. Where provision of a below ground pit is an essential operational requirement it shall comply with the requirements of 'Pits and Chambers' section of DS 30-02 and, where valve related, the 'Valve Pit and Chamber' section of DS 31-02.

16 SURGE VESSELS, ONE-WAY DISCHARGE TANKS AND AIR CUSHIONS

16.1 Surge Vessels

Surge vessels shall comply with DS 35-01.

16.2 One-way Discharge Tanks

For general information regarding one-way discharge tanks refer to the 'One-way Discharge Tanks' section of DS 60. Requirements for the tank will not be covered in this Standard. Pipework shall comply with the 'Pipework' clause below.

16.3 Air Cushion

16.3.1 General

For general information regarding air cushions refer to the 'Air Cushions' section of DS 60. Air cushions shall incorporate access ladder, platform, pipework and surge protection equipment including valves, supports, fittings, and all materials required to complete the installation.

Air cushions shall be of vertical orientation, connected to the pipeline via a horizontal tee and isolating valve. The isolating valve shall be a manually operated double flanged butterfly valve.

The air cushion tower shall comprise a MSCL flanged pipe section for the shell with a DN 100 drain and lockable ball valve. The top of the tower shall incorporate a flange and flange cover assembly to which is fitted an isolating valve and air valves. An internal FRP perforated pipe in accordance with Corporation Technical Specification FRP shall be fitted under the air valve nozzle.

Pipework shall comply with the 'Pipework' clause below.

16.3.2 Contamination of Water

All materials in contact with the drinking water in the surge vessels and air cushion towers shall be in accordance with AS/NZS 4020.

16.3.3 Welding

All welding shall be carried out under the supervision of a person who has had suitable training or experience in the form of construction and the process of welding used on the vessels. Such person shall hold a supervisor's certificate in accordance with AS 1796 or have other qualifications or experience acceptable to the Superintendent and the Inspecting Authority.

Vessel welding shall be conducted in accordance with AS 4458 and Corporation Technical Specification WS-01.

All materials which are to be welded, procedures for preparation of surfaces for welding, assembly of plates and components for welding, arrangement of welding joints as well as other applicable welding techniques during manufacture of pressure parts of surge vessels shall comply with requirements of relevant sections from AS 1210.

All welding of attachments to the vessel shall be carried out prior to coating.

16.3.4 Ladders Platform and Handrails

An access platform, ladder, hand-railing and spring loaded gate shall be provided for maintenance of the air valve. External ladders for the air cushion sites shall be fitted with double-sided full length hinged lockable covers to prevent unauthorised access to the platforms.

Metal ladders, platforms and handrails shall comply with the Stairways, Landings, Walkways and Ladders section of DS 30-02.

16.3.5 Lifting Lugs

All necessary lifting and handling devices including lifting eyes shall be fitted to all equipment to facilitate in-transit lifting and handling and on site installation. The lifting eyes shall be located in a position sufficiently braced to avoid any distortion during lifting.

16.3.6 Corrosion Protection

The top flange shall be hot-dip galvanized after fabrication.

All external surfaces of the air cushion towers tower with the exception of the platform, handrail and ladder shall be coated to Coating Specifications B2. The final coating shall be white to AS 2700 - N14, with a 300mm band to be coloured Jade to AS 2700 - G21.

All above ground pipework between the air cushions and the main pipeline shall be coated externally to Coating Specifications C2. The final coating shall be coloured white to AS 2700 - N14.

16.4 Pipework

16.4.1 MSCL Pipework and Fittings

MSCL pipework and fittings shall comply with the MSCL Pipe section of DS 31-01.

16.4.2 Valves

Valves shall comply with the following:

- (a) Air release and vacuum break valves shall comply with SPS 200;
- (b) Ductile iron swing check non-return valves shall comply with SPS 223;
- (c) Hydraulically operated automatic control valves shall comply with SPS 240;
- (d) Ball valves shall comply with SPS 252;
- (e) Double flanged butterfly valves shall comply with SPS 261.

16.4.3 Flanges

Flanges shall comply with DS 38-02.

16.4.4 Fasteners

Structural Fasteners shall comply with the Fasteners for Structural Applications section of DS 31-02.

Flange fasteners shall comply with the requirements of DS 38-02.

16.4.5 Gaskets

Gaskets shall comply with Flange Gaskets section of DS 38-02.

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