WATER CORPORATION

Acquisition Group
Infrastructure Design Branch

DESIGN STANDARD DS 31-02

Valves and Appurtenances - Mechanical

VERSION 1
REVISION 3

JUNE 2014

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:

http://www.commerce.wa.gov.au/WorkSafe/Content/Industries/Construction/Further_information/National_standard_for_construction.html

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

Manager, Infrastructure Design Branch

DISCLAIMER

This Standard is intended solely for application to the acquisition of water infrastructure in Operating Areas in Western Australia where the Water Corporation has been licensed to provide water services subject to the terms and conditions of its Operating License.

This Standard is provided for use only by a suitably qualified professional design engineer who shall apply the skill, knowledge and experience necessary to understand the risks involved and undertake all infrastructure design and installation specification preparation work.

Any interpretation of anything in this Standard that deviates from the requirements specified in the project design drawings and construction specifications shall be resolved by reference to and determination by the design engineer.

The Corporation accepts no liability for any loss or damage that arises from anything in the Standard including loss or damage that may arise due to the errors and omissions of any person.

REVISION STATUS

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

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
1	1/0	18.07.05	All	Reformatted, split into Part 2	EJP	AAK
1	1/1	15.03.06	11, 12	Sections 1 & 2 amalgamated	EJP	AAK
1	1/2	01.04.07	10	Clause 1.2 amended	EJP	AAK
1	1/3	20.06.14	12	Clauses 1.1 – 1.7 amended	EJP	SE
2	1/0	18.07.05	All	Reformatted, split into Part 2	EJP	AAK
2	1/1	15.03.06	All	Renumbered, 2.7 added	EJP	AAK
2	1/3	20.06.14	14-16	Former Sections 2 and 3 amalgamated Clauses 2.1 - 2.5, 2.8, 2.10, 2.11 amended or added	EJP	SE
3	1/0	18.07.05	All	Reformatted, split into Part 2, Section 5 revised	EJP	AAK
3	1/1	15.03.06	All	Renumbered	EJP	AAK
3	1/2	01.04.07	16	Section 3 amended	EJP	AAK
3	1/3	20.06.14	20	Former Section 4 transferred into Section 3, Clause 3.4.3(i) and Table 3.2 amended	EJP	SE
4	1/0	18.07.05	All	Reformatted, split into Part 2, 6.2 revised	EJP	AAK
4	1/1	15.03.06	All	Renumbered	EJP	AAK
4	1/2	01.04.07	19, 21	4.4.1(g) added, formula, clause 4.8 amended	EJP	AAK
4	1/3	20.06.14	23 - 26	Former Section 5 transferred into Section 4	EJP	SE
5	1/0	18.07.05	All	Reformatted, split into Part 2, 7.4.3 revised	EJP	AAK
5	1/1	15.03.06	All	Renumbered	EJP	AAK
5	1/3	20.06.14	27 - 29	Former Section 6 transferred into Section 5, Heading, Clause 5.1, 5.2, 5.4.2, 5.5.2, 5.6 amended	EJP	SE
6	1/0	18.07.05	All	Reformatted, split into Part 2	EJP	AAK
6	1/1	15.03.06	All	Renumbered	EJP	AAK
6	1/3	20.06.14	31` - 47	Former Section 7 transferred into Section 6, Table 6.1, Clauses, 6.3, 6.5 - 6.10 amended	EJP	SE

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
7	1/0	18.07.05	All	Reformatted, split into Part 2, new 9.9 added, 9.10 revised	EJP	AASK
7	1/1	15.03.06	All	Renumbered	EJP	AAK
7	1/2	01.04.07	32-37,	Section clauses reformatted , Tables 7.1, 7.3, 7.12 and Clauses 7.3.2, 7.3.3, 7.3.4, 7.3.6, 7.3.5.3, 7.3.5.8, 7.3.6 amended, clauses 7.4 and 7.9.3 added	EJP	AAK
7	1/3	20.06.14	49, 60	Former Section 8 transferred into Section 7. Table 7.2, 7.3, 7.5, 7.7 Clauses 7.4.3, 7.5.1, 7.6, 7.8, 7.9 amended	EJP	SE

8	1/0	18.07.05	All	Reformatted, split into Part 2, 10.9,10.10 revised	EJP	AAK
8	1/1	15.03.06	All	Renumbered, 8.8.5 amended	EJP	AAK
8	1/3	20.06.14	62	Former Section 9 transferred into Section 8, Table 8.1 Clauses 8. 1, 8.4, 8.5, 8.8 amended and 8.7 added	EJP	SE

9	1/0	18.07.05	All	Split into Part 2, Section 11 redundant	EJP	AAK
9	1/1	15.03.06	All	Renumbered	EJP	AAK
9	1/2	01.04.07	68	Clauses 9.2.1, 9.4, 9.5 amended	EJP	AAK
9	1/3	20.06.14	69	Section changed to Appendix A	EJP	SE

10	1/1	15.03.06	All	New section	EJP	AAK
10	1/3	20.06.14	All	Section no longer exists	EJP	SE

DESIGN STANDARD DS 31-02

Valves and Appurtenances - Mechanical

CONTENTS

Section *Page*

1 SCOPE AND GENERAL

1.1 Scope

Design Standard DS 31-02 is the second part of a two part standard which provides design requirements for pipework valves and appurtenances. The first part of the Standard comprises:

DS 31-01 Pipework – Mechanical

Design Standard DS 31-02 sets out the Corporation's mechanical standards, guidelines and preferred engineering practices for design of valves and appurtenances used in water supply and sewage infrastructure.

This Standard is not intended for gas and high temperature or steam applications.

1.2 Purpose

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

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

(a) Standards and guidelines applicable in the design of Corporation assets,

(b) Explanatory or specific design information,

(c) Information relating to Corporation preferences and practices which have evolved from over a century of experience in the water industry.

1.3 Design Process

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

1.4 Standards

All materials and workmanship shall comply with latest revisions of the relevant codes and standards.

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

1.5 Referenced Documents

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

1.6 Notation

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

1.7 Nomenclature

1.7.1 Engineering Definitions and Relationships

Definitions relating to terminology used in the DS 30 Standard series are contained in section 2 ‘Engineering Definitions and Relationships’ of DS 30-01.

1.7.2 Preferred Terminology

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

1.7.3 Acronyms and Symbols

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

1.7.4 Standard Units and Relationships

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

1.7.5 Drawing Symbols

A comprehensive list of mechanical drawing symbols for pipework and valves is referenced in DS 80.

2 DESIGN CRITERIA

2.1 General

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

Consideration shall be given (but not restricted) to the following.

2.2 Confined Space Isolating Valves

Design involving confined spaces that personnel are required to access shall take into account the specific requirements detailed in the Confined Space section of DS 30-02. These cover the relevant standards and procedures applicable to operational practices. Additionally the following information relates to confined spaces within water pipelines with respect to their isolating valves and recommended design strategies.

NOTE: The following information is based on an investigation commissioned by the Corporation and subsequent report "Confined Space Entry – Single Point Isolation Devices" dated January 2000.

2.2.1 Gate Valves for Single Point Isolation

Gate valves for waterworks purposes may be considered as adequate single point isolation devices provided the following factors are taken into account:

(a) That new valves are selected correctly for the application and properly engineered in accordance with the appropriate standards.

(b) That a site assessment be conducted for potential problems that may occur with the operation of existing aged valves.

(c) A locking device shall be employed on the input shaft of gate valves to provide a lockable fixture and prevent inadvertent opening.

(d) Proper operational practices are observed in terms of:

- (i) job safety and risk analysis;
- (ii) implementation of proper operation strategies including assessment of all pressure containing valves;
- (iii) removal of all air valves (to eliminate possibility of air valve 'hang up' supporting a column of water); and
- (iv) closure and tagging of all relevant valves in the system.

2.2.2 Butterfly Valves for Single Point Isolation

Double Flanged butterfly valves for waterworks purposes may be considered as adequate single point isolation devices provided the following factors are taken into account:

(a) There exists the perception that a butterfly valve does not provide the same level of security as a gate valve and that is not supported in reality (refer Note).

(b) Contrary to the perception a butterfly disc cannot 'run open'. This is because the valve requires external assistance to overcome the sealing resistance, which is higher than the hydrostatic torque. Also the disc cannot drive the actuator gear train in order to allow it to open because of the high gearing and self-locking characteristics of the worm and quadrant.

(c) Shaft and disc pins failure is negligible risk. The shaft is designed for torque and accordingly has a large safety factor in shear (the failure scenario of most concern). Also, the disc pins also have a generous safety factor. Neither would be subject to failure once the valve was in the closed position.

(d) That new valves are selected correctly for the application and properly engineered in accordance with the appropriate standards.

(e) That a site assessment be conducted for potential problems that may occur with the operation of existing aged valves.

(f) A locking device shall be employed on the input shaft of the butterfly valve, to provide a lockable fixture and prevent inadvertent opening of the valve.

(g) Proper operational practices are observed in terms of:

(i) job safety and risk analysis;

(ii) implementation of proper operation strategies including assessment of all pressure containing valves;

(iii) removal of all air valves (to eliminate possibility of air valve 'hang up' supporting a column of water); and

(iv) closure and tagging of all relevant valves in the system.

NOTE: Ignoring the perception issue, a seal-on-body butterfly valve unlike a gate valve or seal-on-disc butterfly valve should not suffer corrosion over time because the internal wetted surfaces are corrosion resistant so that a high level of confidence in its security could be extended over an indefinite period of time, provided that periodic inspection and maintenance is undertaken.

2.2.3 Confined Space Design

Summarising, the following issues should be addressed in dealing with confined space:

(a) Compulsory locking devices on input shafts of all valves shall be incorporated into all new valves regardless of whether they are non buried or buried e.g. use of padlockable fittings on the input spindles of the valves.

(b) Ensure that the requirement to include a self-locking worm and quadrant type gearbox is included in all butterfly valve specifications.

(c) Specify ductile iron in lieu of cast iron for gate and seal-on-disc butterfly valves with polymeric coatings with corrosion mitigation strategies via sealing of threads and dissimilar metal interfaces to prevent galvanic corrosion.

(d) Where practicable seal-on-body butterfly valves of ductile iron body construction shall be the preferred selection over seal-on-disc butterfly valves and gate valves because of its simplicity, superior corrosion resistant characteristics and lower head loss.

(e) If seal-on-disc butterfly valves are required then the disc material shall either be DI coated as required by SPS 262 or of corrosion resistant material. Where the valve seat is of 'rolled-in' design, the void must be full sealed.

(f) New distribution network designs should address issues of confined space isolation wherever practicable. The key strategy in the design should always be to eliminate confined space entry by personnel where possible.

2.3 Corrosion Control

For general information on coatings and corrosion mitigation the Designer should refer to the Coating and Corrosion sections of DS 30-02. For more information on coatings refer to DS 95.

2.4 Design Information Requirements

Pipe and pipework design shall be in accordance with AS 4041 and relevant Corporation standards.

2.4.1 Information Required for Mechanical Design

Information required for mechanical design is contained in DS 30 (Clause 3.3.4) and the following (as applicable):

(a) Fluid type and characteristics e.g. temperature, corrosivity, hazard level e.g. acids or fuel oil, and water quality

(b) Pipeline size

(c) Initial and future pipeline flow rates (L/s or ML/d)

(d) Initial and future pipeline upstream and downstream heads (m)

(e) Maximum allowable shutdown hours

(f) Alternative modes of operation; e.g. local, remote, electric/manual over-ride etc

(g) Required closing time

(h) Type of actuator required e.g. lever, ungeared, geared, electric actuator, pneumatic actuator, hydraulic actuator etc

(i) Whether buried, pit (chamber) or above-ground

(j) Environment:

- (iii) corrosivity of atmosphere or soils
- (iv) sunlight effect e.g. detrimental to some plastic pipe material
- (v) effect of immersion by ground water
- (vi) potential presence of hydrocarbons or hydrocarbon based products e.g. which could taint potable water if using PE, PB or PVC pipe
- (vii) ambient temperature variation for expansion considerations
- (viii) wind effects on suspended pipe
- (ix) ground characteristics e.g. under road crossings, creek crossings, unstable soils; etc
- (x) presence of bushfires in remote locations
- (xi) contact with dissimilar pipework materials e.g. galvanic corrosion potential

2.4.2 Information to be Supplied for Electrical Design

Information to be supplied for electrical design is contained in DS 30 (Clause 3.3.4).

2.5 Labelling

All valves shall be properly identified and labeled in accordance with the Signage and Labels section of DS 30-02. This particularly includes key operated buried service by-pass gate valves and buried service butterfly valves, which shall be labeled on the top of their covers.

2.6 Materials of Construction

For general information and materials of construction requirements refer to the Materials section of DS 30-01.

2.7 Noise Levels

Valves shall comply with the noise level requirements contained in DS 30-02 for:

(a) daily noise dose for personnel, and

(b) neighbourhood noise levels e.g. environmental noise.

2.8 Occupational Safety and Health Codes

The Designer shall comply with occupational safety and health codes in accordance with the requirements set out in the Occupational Safety and Health section of DS 30-02.

2.9 Pump Station Valves

2.9.1 Water and Sewage Pump Stations

Design of water and sewage pump station manifolds, offtakes and related pipework shall comply with the requirements of the Water and Sewage Valves section contained in DS 32 and the relevant parts of this Standard.

2.9.2 Vacuum Sewage Pump Station Valves

Design of water, sewage and vacuum pipework for vacuum sewage pump stations shall comply with the requirements of Valves and Appurtenances in the Vacuum Sewage Pump Station section contained in DS 32 and the relevant parts of this Standard.

2.10 Valve Pits and Chambers

2.10.1 General

Valve pits and chambers shall comply with the relevant parts of the Pits and Chambers section contained in DS 30-02 and the following.

2.10.2 Components

The following items shall be considered:

(a) Pipework working height for maintenance of valves e.g. 900 ± 150 mm above working floor level,

(b) Provision of isolating valves either side of control valves,

(c) Bypass arrangements,

(d) Hydraulic considerations such as head losses and associated impact on sensors,

(e) Provision of valve and pipework supports,

(f) Provision of dismantling joints where required,

2.11 Valve Termination and Operator Heights

Valve operator (spindle or handwheel) termination and operating height shall comply with the following.

2.11.1 Spindle Caps for Buried Valves

Buried bypass gate valves and manually operated butterfly valves fitted with spindle cap operators, shall terminate a minimum of 125 mm ±25mm below the valve box cover underside (finished surface level). Gate valves spindle caps shall be provided with a cast iron cover set at the finished surface level. Butterfly valve spindle cap and position indicator assemblies shall be housed in a cast iron hinged metal cover and service chamber. Covers shall be rated to suit trafficable and non-trafficable paved areas as appropriate.

Where bypass gate valves and manually operated butterfly valves fitted with spindle cap operators are not intended for installation in valve boxes the extended spindle tube shall terminate a minimum of 250 mm above the finished ground level (refer note),

NOTE: This requirement is to prevent sand and water from entering and filling the enclosure tube. It also raises the butterfly valve torque limiting device (where fitted) and position indicator to minimise the potential of their immersion from local flooding

2.11.2 Handwheels

The operating height of valve actuator handwheels shall be set a standard distance above the finished ground level of 900 mm ±150 mm. Above ground valve actuator handwheels e.g. within pump stations should ideally be set at the same height however factors such as the pump pipework configuration may preclude this. Operating platforms shall be provided as required to provide the previously specified operating height. Valve handwheels should be horizontal orientation.

2.12 Vibration

Valve applications shall be designed so that vibrations that may result from operating components or generated from flow through the valve are acceptable. Valve actuator performance shall comply with the requirements contained in the Vibration section of DS 30-02.

3 AIR VALVES

Water contains some 2% dissolved air by volume in standards conditions. The dissolved air will come out of solution when exposed to lower pressures due to factors such partially open valves, velocity changes, pipe size changes and changes in grade. For proper operation of a pipeline it is essential to continually remove accumulated air and this is achieved by use of air valves. The term air valve is used to refer to a wide range of different types of air (gas) release and vacuum break valves. Combination (three function) air valves automatically remove relatively small quantities of air which accumulates in the pipeline at high points, as well as allowing the expulsion of large quantities of air during pipeline filling. They also provide air admission during pipeline emptying, or as a result of a pipe burst. The problems associated with air in pipelines and the causes are covered in the following.

3.1 Air or Gas Entrapment

Air or gas entrapment in the system can cause a whole range of problems including:

(a) Air locking, and cavitation in pumps

(b) Collection of air in pumps, pipework, fittings and pipeline peaks which can produce reduction of discharge capacity of pumps and the pipeline due to the throttling effect and increases operating costs

(c) Delay in filling pipelines

(d) Secondary surges that increase water hammer potential

(e) Slamming of non return valves

(f) Gas attack on internal upper pipeline surfaces in sewage applications e.g. hydrogen sulphide

(g) Surge induced vibrations in the surrounding environment leading to customer complaints

3.2 Causes of Air or Gas Entrapment

Designers should be aware of the sources of air and gas and seek to eliminate or at least minimise them. Air sources of air and gas are described in the following:

(a) As mentioned naturally occurring dissolved air at normal temperatures and pressures

(b) Dissolved air or gas in source water e.g. from an aquifer or dams

(c) Air entrainment due to vortexing at pump suctions or pumps running on the snore

(d) Improperly bled pipework and valves

(e) Suction pipework leaks

(f) Leakage through pump and valve glands

(g) Effusion of dissolved air downstream of a valve or fitting that is producing a pressure drop e.g. throttled valve or pressure reducing valve

(h) Temperature rises that cause air to come out of solution e.g. 5 cc of free air for 1 litre saturated water rising from 15ºC to 30ºC

(i) Increase of sewage gases as sewage increases in septicity

(j) Improperly adjusted oxygen dissolvers at sewage pump stations

(k) Incorrect pipeline design and incomplete air removal during filling

3.3 Air Release and Vacuum Break Valves

A simple form of air valve is a small orifice valve fitted to the top of a pipe or pump to allow the automatic venting of accumulated air or gas. Air valves on pipelines can have the additional dual function of admitting and expelling large quantities of air during draining and filling of large pipelines. Air valves are used on both water and sewage applications although their designs differ.

Air valves are available in the following forms:

(a) *Air release or admission valves* - Are small orifice valves used to automatically release or admit air in pipelines under normal working conditions. These valves are available in the following configurations: 2-way (e.g. air in and out), one-way air out or one-way air in.

(b) *Automatic air release and vacuum break valves* – Are air valves that allow the automatic release and intake of air via a large orifice (refer Note).

(c) *Combined air release and vacuum valves* – Are ‘combined’ or ‘double acting’ air valves that allow the automatic release and intake of air via a large orifice as well as bleeding of small amounts of pressurised air through a small orifice (refer Note).

(d) *Non kinetic air valves* – Are air and vacuum release valves that have a tendency to close prematurely (“dynamic closure”) at very low differential pressures (2 to 5 kPa) trapping accumulated air in the pipeline. Poorly designed air valves can also suffer reduced air inflow rates during pipeline drainage due to the “venturi effect”. This phenomenon occurs at differentials of 15 to 20 kPa vacuum and causes the control float or ball to move towards the large orifice thus restricting inflow and has the potential to cause pipe collapse (refer Note).

(e) *Kinetic air valves* – Are air valves that can discharge air at high velocities and high differential pressures e.g. 20 kPa without suffering dynamic closure and only close due to the action of water on the float. Valves may be single large orifice valves or combined with a small orifice ‘automatic’ air release valve (refer Note).

(f) *Non-slam (anti-shock) kinetic air valves* – Are air and vacuum release valves fitted with devices that automatically control the rate of air discharge. This has the effect when filling a pipeline of dissipating the energy of a surge whilst decelerating the approaching water column. In addition they allow full intake of air under vacuum conditions. Refer clause on Kinetic and Non-slam Valves for further information (refer Note).

(g) *Sewerage air valves* – Are kinetic air and vacuum release valves as defined above, configured to obviate water entering the valve mechanism. The valve body shall provide drainage outlet/s for air recharge in the case of air absorption by the waste water.

(h) *Non-slam sewerage air valves* – Are similar to non-slam (anti-shock) kinetic air valves, except they are designed for use in sewage rising mains or pump stations.

NOTE: Valves should incorporate a drain valve on the lower side of the body in order that the valve functions and static pressure can be tested.

3.4 Design Criteria

3.4.1 Kinetic and Non-slam Valves

Only ‘kinetic’ air release and vacuum valves or equivalent shall be used on Corporation assets.

Non-slam air valves are not necessarily required on locations but should be considered for the following specific applications:

(a) Where the last valve in a discharge pipe is a closed valve or where there exists the potential for a closed valve,

(b) Pipeline high points where column separation is likely to occur,

(c) At the discharge head works of deep well submersible pump rising main (column),

(d) Quick filling of mains,

(e) Where full bore kinetic air valves are to be used,

(f) For sewage valves to minimise surge induced movement of sewage into the valve mechanism during closure,

(g) Air valves shall not be able to be isolated where guaranteed surge protection is required.

3.4.2 Air Valve Performance Factors

3.4.2.1 Pipeline fill rate

The pipeline fill rate should not be less than 0.2 m/sec or greater than 0.5 m/sec velocity of water. Velocities less than 0.2 m/sec can produce air cells trapped between slugs of water, and velocities greater than 0.5 m/sec can create high pressure transients as the water reaches the control float (producing valve slamming and water hammer). Should the gradient be less than 1: 200 the fill rate velocity should be more conservative (between 0.2 – 0.4 m/s). The initial fill rate of a pipeline can be as high as 0.5 m/s as long when approaching a closed valve, the velocity is reduced to 0.2 m/s. Otherwise the use of an anti-slam air valve should be used with a fixed air outflow characteristic to minimise water hammer when the valve charges with water.

3.4.2.2 Pipeline filling differential

When selecting the differential pressure to size an air valve during filling, consideration should be given to the design of the kinetic orifice to determine a safe air outflow. There are two designs of large orifice air valve. Nominal bore is where the inlet opening of the valve body is equal to the kinetic orifice of the valve. Reduced port is where the kinetic outlet is usually around 30% smaller than the inlet body diameter. Nominal bore valves typically have a high air discharge and subsequently a modest differential should be used (0.08 – 0.1 bar). If the valve is reduced port, the differential can be as high as 0.15 bar. Care should be taken on the last valve prior to a main line isolation valve to limit the air discharge in order to reduce any effects of water hammer during valve closure. This valve should be anti-slam air valve with limited air outflows. Differential pressures in excess of this whilst claimed by some air valve manufacturers are not practicable although higher differentials may be achieved under controlled conditions e.g. in a laboratory situation. Accordingly kinetic air valves should be able to remain open against a 0.2 bar differential. The air flow will reach sonic velocity at 0.9 bar.

3.4.2.3 Pipeline emptying differential

The differential pressure developed across an air valve during pipeline emptying e.g. air intake or vacuum conditions should be limited to a partial vacuum of 0.8 to 0.2 bar (at sea level) regardless of whether the pipeline material can withstand a higher vacuum. Generally the pipe system including gaskets and valves will not support higher vacuum conditions than this. Further, the valve intake orifice will experience ‘choked flow” for vacuum conditions (sea level) in excess of 0.3 bar and therefore increased vacuum will not produce increased air flow through the valve despite some manufacturer’s claims to the contrary. The air flow will theoretically reach sonic velocity at 0.5 bar. Higher vacuums could expose the pipe to risk of collapse.

3.4.2.4 Air valve sizing

The conventional method of sizing air valves is to select the size based on pipeline diameter (refer to Table “Guidelines for Sizing of Air Valves” later in this section). As different manufacturer’s valves of the same nominal inlet connection diameter may vary in kinetic orifice design and accordingly air flow performance, the table should be used as a ‘rule of thumb’. Accordingly for critical designs the Designer should use the manufacturer’s performance data and take into account any specific requirements or limitations. There are several considerations in selecting an air valve, such as:

(a) Air outflow rate when filling at a controlled rate.

(b) Air inflow when draining the pipeline at a controlled rate via scour valves or main line valves.

(c) Air inflow during rupture of a pipeline which has taken into consideration the maximum gradient of the pipeline. Refer to Calculation of Air Flow Rate in order to Size the Valve for High Points later in this section.

3.4.2.5 Full bore or reduced bore air valves

Kinetic air valves are available in full bore or reduced bore styles. Full bore kinetic air valves can produce high instantaneous pressures during pipeline filling (because of higher air discharge capacity) as the water column initiates valve closure. Use of rapid response full bore valves should be considered to obviate this potential.

3.4.3 Conditions Requiring Air Valves

Kinetic air release and vacuum valves (combination) should be installed at:

(a) All pipeline peaks relative to the hydraulic gradient

(b) All pipelines running parallel with the hydraulic gradient, as they constitute a peak. Combined air valves should be located at each extremity with intermediate air release valves at approximately 500 m intervals when the pipeline gradient is less than 1:250 in order that entrapped air is effectively released. Distances between valves can be extended should the gradient be greater than 1:250.

(c) Downward grades that increase in grade, as they would tend to trap air at the section change

(d) An upward grade changing down, where decreasing pressure may cause liberation of air towards the upper end of the steeper section of pipe

(e) Long ascending pipelines require a combined air valve at the top end and also at 500 m intervals to ensure adequate discharge of air during filling and adequate ventilation during draining

(f) Long descending pipelines should receive the same treatment as for long ascending pipelines

(g) Long horizontal pipelines with gradients flatter than 1 in 500 should be avoided but if this is not feasible combined air valves should be located every 500 m as well as at the start and finish of the horizontal run. When sizing pipe diameters and pumps in low gradient pipelines, consideration should be given to the minimum velocity to enable air bubbles to transfer in the pipeline. The required velocity increases with pipe diameter. The formula is $V = (\sqrt{D}) \times 2$ based on flat pipeline gradients where V is the minimum velocity in m/s and D is the pipeline diameter in m.

(h) Where vacuum conditions are likely to occur such as at the summit of a steep pipe gradient; or at non-return valves, or downstream of automatic self closing valves, closing of gate valves; or opening of scour valves or drain valves

(i) Submersible borehole pump headworks.

Generally air valves should be closer together in the first portion of a pipeline than towards the downstream end e.g. the upstream section might have air valves at 600 m intervals whereas at the downstream section 1000 m intervals may be appropriate.

The design should endeavour to expel as much air as possible from high-pressure zones to minimise the amount of soluble air likely to come out of solution in the low-pressure zones.

Air valves should not be used as a primary method of water hammer control and should be used as a secondary strategy only.

Air valves shall not incorporate a built-in isolating valve.

3.4.4 Air Valve Sizing

Kinetic air valves should be sized such that for any section of pipeline it should be possible to drain it in 8 hours and refill it in 4 hours. In any event air valve sizes shall not be less than the air valve sizes listed in the following table for the pipeline diameters shown. The pipeline gradient is based on 1:100 for sizing.

Table 3.1 Guidelines for Sizing of Air Valves (refer Notes)

Nominal Pipeline Diameter	Air Valve Branch Size	Air Valve Size - Full Bore Kinetic Orifice	Air Valve Size - Reduced Bore Kinetic Orifice
Up to and including DN 250	DN 80	DN 50	DN 50
Above DN 250 to DN 375	DN 80	DN 50	(DN 80)
DN 400 to DN 600	DN 100	(DN 80)	DN 100
DN 600 to DN 700	DN 150	DN 100	DN 150
DN 750 to DN 1600	DN 200	DN 150	(DN 200)

NOTES:

1. The above table should be used as a guide only. For critical applications the Designer should refer to the published air inflow and discharge performance data for the specific air valve brand, type and size.
2. For sewage air release and vacuum break valves the Designer should also refer to the Pipeline Design section of DS 51.
3. Air valve sizes shown in brackets are non-preferred

Calculation of Air Flow Rate in order to Size the Valve for High Points

The following formula is used to determine the air inflow requirement of a pipeline apex in order to protect it in the event of a full diameter pipe rupture at the bottom of the descent. A factor of safety should be included to provide a safety margin.

$$\mathbf{Q = \sqrt{SD^5/ß}}$$

Q is expressed in m^3/s

S = slope expressed in mm/m

D = diameter expressed in m

ß = dimensional resistance coefficient of pipeline

Air valves for use on Corporation pipelines should not be smaller than DN 50 or greater than DN 150. For larger pipe sizes than DN 1600 the DN 150 air valves should be positioned close together or arranged in multiple configurations.

Air valves smaller than DN 50 may be used for other venting purposes e.g. pumps and small pipework.

DN 50 air valves fitted to mild steel pipelines should be installed onto a DN 100 flanged spigot in lieu of a tapping plate. This is to restrict any galvanic corrosion to the blank plate and to facilitate upgrading to DN 100 if required in the future. This will also reduce the effect of local induced water hammer caused by air valve closure.

3.5 Summary of Air Valve Data

A summary of technical data for air valves is shown in the following table. Details shown in the table should be taken as a general guide only as a manufacturer's specific product may vary.

Table 3.2 – Air Valve Data

Valve	**Water**		**Sewage**
Description	Single Automatic	Combined	Combined
Size range	DN 15 – 25	DN 50 – 200	DN 50 – 200
Pressure range	PN 16, 21, 35		PN 10, 16
Connection: Screwed/flanged	Screwed	≤ DN 50 – Screwed or flanged ≥ DN 50 Flanged	Flanged
Body material	GR Nylon, bronze, DI	DI, cast steel	Ductile iron, carbon steel, stainless steel, polyethylene
Coating	As required polymeric coating to AS/NZS 4158/Coating Specification G2		
Configuration	2-way, air in, air out	Combined with integral or optional rapid response mechanism	Combined with integral or optional rapid response mechanism
Application	Pumps and pipework	Pipelines	Pipelines
Strategic Product Specifications	SPS 200	SPS 200	SPS 201

3.6 Water Applications

3.6.1 Water Type Air Valves

Air valves for water applications are designed to allow immersion of the valve sealing mechanism.

3.6.2 Isolating Valves

(a) Air valves on pipelines shall be provided with a separate isolating valve immediately upstream of the valve to enable removal of the valve for servicing without having to shut down and drain the pipeline.

(b) For screwed air valves the isolating valve shall be a gate valve or ball valve. Dissimilar valve materials to the pipeline shall be electrically insulated to avoid galvanic corrosion.

(c) For flanged air valves isolating valves shall be double flanged gate valves or butterfly valves conforming to SPS 271 or SPS 272 (depending on working pressure) and SPS 261 respectively. Butterfly valves should not be used if the manufacturers air valve incorporate kinetic floats with guide stems that protrude below the free passage of the flange connection. Gate valves should be used if space requirements are not relevant, as they are much cheaper in these sizes.

NOTE: Wafer or lugged butterfly valves should not be used as the former is not a termination valve and the latter requires setscrews to be fitted from either side, which is considered potentially unsafe because the depth of engagement cannot be guaranteed. Long setscrews fitted through each lug in lieu of setscrews are also not acceptable. Where space is limited (e.g. in a pit) butterfly valves should be used in combination with Corporation authorised squat style combined kinetic air valves.

3.7 Sewage Applications

3.7.1 Sewage Air Valves

Purpose designed sewage air valves should be used in sewage and dirty water applications. Sewage air valves are designed to provide separation of the fluid from the orifice sealing mechanism to minimise fouling. It is important that sewage air valves selected be designed so that they maintain the air gap for a sustained period after priming of the pipeline. The inherent separation height of sewage air valves means that the valves are relatively tall and for pit type service and therefore consideration of the overall valve height should be taken into account with respect to pipeline depth. The design of the sewage air valve should incorporate a manual ball valve located at the lower portion of the valve body to enable pressure release, back washing and testing of the valve operation. An anti-slam function should be available as an option.

3.7.2 Water Type Air Valves in Sewage Applications

Water type air valves should not normally be used in sewage or dirty water applications without the approval of the Corporation. Use of water type air valves in sewage applications could produce fouling of the sealing mechanism and valve malfunction resulting in leakage. Small water air release valves have been used on sewage pressure mains up to size DN 250 where manual air bleed is not considered practicable and risk associated with malfunction is low.

3.7.3 Manual Release and Air Valves

For information relating to provision of manual release points and air valves for sewage pressure mains refer to the Pipeline Design Section of DS 51.

3.7.4 Air Valve Isolating Valves

Sewage air valves shall be provided with a separate isolating valve immediately upstream of the valve to enable removal of the valve for servicing without having to shut down and drain the pipeline.

For screwed air valves the isolating valve should be a gate valve or ball valve. Dissimilar valve materials to the pipeline shall be electrically insulated to avoid galvanic corrosion. For flanged air valves isolating valves should be double flanged gate valves conforming to SPS 271 or SPS 272 depending on pressure rating. Butterfly valves shall not be used as they could be subject to fouling of the disc.

3.8 Location of Air Valves

3.8.1 Air Valve Pits

Air valve pits should not be located in roadways or where they will be subject to flooding by groundwater or surface water.

Air valves in buried pipelines in urban areas should be installed in pits.

Where it is necessary for air valve pits to have covers it is essential that ventilation be provided that will handle the entry and exit air volumes required by the air valve. The venting should have a free orifice which is twice that of the kinetic orifice in the air valve to ensure correct performance.

3.8.2 Above Ground Air Valves

In rural areas, air valves required for buried pipelines may be mounted above ground on a branch pipe providing the obstruction poses no risk to others or is at no risk in terms of damage to the valve. Above ground air valves should be of metal construction, and protected from potential damage e.g. via steel bollards when fitted to buried pipelines. Air valves shall be installed in accordance with the Drawing Series: EG20-5.

4 BACKFLOW PREVENTION DEVICES

4.1 General

The design shall comply with the requirements of AS 3500 for the protection of drinking water from backflow through a cross connection to the drinking supply.

Designers shall consider the following factors when designing backflow prevention requirements:

(a) Hazard rating of the facility or process e.g. high, medium or low

(b) Types of protection required e.g. individual, zone or containment

(c) Types of backflow risks involved e.g. back-siphonage or back pressure or both

(d) The future potential for cross connections to be made within a facility e.g. due to the number and complexity of process pipes or as described above

(e) The type of backflow prevention device (or devices) required to address the above factors

4.2 Cross Connection

Backflow may result from an intentional or inadvertent cross connection or may be assessed as having the potential to occur. For example a high hazard process tank may incorporate a correct air gap at the water supply outlet but it has the potential for an operator to unwittingly attach a hose in order to reduce splashing, which may trail into the process fluid negating the air gap. Accordingly a low pressure in the water supply main could cause backflow of the process fluid into the drinking supply. (These types of cross connections have been detected by Corporation inspectors).

Refer to DS 30-01 Glossary for further specific information on backflow definitions and terminology.

4.3 Hazard Ratings

In accordance with AS 3500 the following hazard ratings apply and these shall be used in order to identify the type of backflow prevention device required for a particular application:

4.3.1 High Hazard

Any condition, device or practice within the water supply system and its operation that has the potential to cause death.

4.3.2 Medium Hazard

Any condition, device or practice within the water supply system and its operation, which could endanger health.

4.3.3 Low Hazard

Is any condition, device or practice within the water supply system and its operation, which would constitute a nuisance but not endanger health.

4.4 Levels of Backflow Protection

There are three levels of protection that a Designer should consider when designing water supply systems in a facility or plant and they are outlined in the following.

4.4.1 Individual

Is the provision of a backflow prevention device at an individual fixture in order to protect the water supply system upstream of the device from contamination e.g. a hose connection vacuum breaker fitted at a tap.

Service water downstream of a backflow prevention device that provides individual protection shall be deemed non potable. Accordingly all potable water fixtures shall be supplied from upstream of the back flow prevention device.

4.4.2 Zone

Is the provision of a backflow prevention device at a section or zone in order to protect the water supply system upstream of the device from contamination e.g. a reduced pressure zone device fitted where the drinking supply enters a high hazard building or high hazard section of plant.

Service water downstream of a backflow prevention device that provides zone protection shall be deemed non potable. Accordingly all potable water fixtures shall be supplied from upstream of the back flow prevention device.

4.4.3 Containment

Is the provision of a backflow prevention device at a property boundary in order to protect the Corporation's water supply system upstream of the device from contamination e.g. a double checkvalve device fitted at the property boundary for an industrial process identified as having a medium hazard.

Service water downstream of a backflow prevention device that provides containment protection shall be deemed potable up to the zone or if there is no zone device then the individual backflow prevention device.

4.5 Backflow Prevention Devices

4.5.1 General

There are four basic devices that may be used for backflow prevention as follows:

(a) Air gaps or break tanks which are non mechanical devices used for high hazard protection

(b) Reduced pressure zone devices (RPZD)

(c) Vacuum breakers of the atmospheric and pressure types

(d) Double check valve assemblies (DCV)

4.5.2 Standards

Mechanical backflow prevention devices selected shall conform to the requirements of AS/NZS 2845.1.

Air gaps or break tanks shall conform to the requirements of AS 2845.2.

The devices for high and medium hazards are testable in accordance with AS/NZS 2845.1 and shall be tested during commissioning, and field tested and maintained thereafter in accordance with the requirements of AS 2845.3.

4.5.3 Field Testing and Maintainability

DCVs and RPZDs shall be maintainable in the field without removal from the line.

4.5.4 Devices Overview

The following table provides an overview of the backflow prevention devices that may be required to be fitted to the Corporation's assets depending on the hazard and application required:

Table 4.1 – Summary of Backflow Prevention Devices and Hazard Ratings

Device	Size Range/ Functionality	Hazard Rating	Description
Reduced pressure zone device (RPZD)	DN 6 – DN 400 BP and BS (Note 1)	High (5)	Two independent check valves with an intermediate vent
Reduced pressure Detector assembly (RPDA) – fire service	DN 6 – DN 400 BP and BS	High	An RPZD incorporating a DN 20 bypass fitted with a secondary RPZD and water meter
Pressure vacuum breaker (PVB)	DN 15 – DN 250 BS	High/ Medium	Spring loaded disc with independent 1st check
Anti- spill pressure vacuum breaker (APVB)	DN 6 – DN 50 BS	High	A PVB incorporating a ventilation valve, air port entry seal and non return valve
Double check valve (DCV)	DN 15 – DN 400 BP and BS	Medium (5)	Two independent check valves
Double check valve detector assembly (DCV) – fire service	DN 15 – DN 400 BP and BS	Medium	A DCV incorporating a DN 20 bypass fitted with a secondary DCV and water meter
Dual check valve (Dual CV)	DN 5 – DN 50 BP and BS	Low	Two independent check valves – non testable device
Dual check valve with atmospheric port (DCAP)	DN 15, DN 20 BP and BS	Low	Two independent check valves with an atmospheric port – non testable device
Dual check valve with intermediate vent (DuCV)	DN 10 BP and BS (Note 2)	Low	Two independent check valves with an intermediate vacuum breaker and relief valve – non testable device
Atmospheric vacuum breaker (AVB)	DN 15 – DN 80 BS (Note 2)	Low	Single float and disc with large atmospheric port valve – non testable device
Hose connection vacuum breaker (HCVB)	DN 15 and DN 20 hose taps (BP and BS (Notes 2, 3)	Low	Single check with atmospheric vacuum breaker vent valve – non testable device
Vacuum breaker check valve (VBCV)	DN 15 to DN 40 BP and BS (Note 4)	Low	Hose tap with integral ventilation valve and non return valve
Beverage dispenser dual checkvalve with atmospheric port (BDDC)	DN 6 and DN 10 BP	Low	Two independently acting non return valves with intermediate ventilation valve and air port

NOTES:

1. BP and BS are abbreviations of back pressure and backsiphonage respectively
2. These devices not designed for use under continuous pressure
3. HCVB with limited backpressure capability e.g. 30 kPa
4. VBCV is rated for limited backpressure capability e.g. 300 kPa
5. High and medium hazard devices are testable

5 FLOW REGULATING VALVES

5.1 General

Valves used for flow, pressure or level control shall be selected based upon the minimum, normal and maximum flow rates and any other relevant condition. Control valve types shall be selected so that the process variables being controlled are controlled accurately over the full range of flow rates and conditions. Control valve logic shall be in accordance with Drawing FQ-11 Valve Control contained in DS 40-7.

Globe and vee-ball control valves should be sized so that the valve opening is between 5% and 90% for equal percentage trim, or for linear trim selection, the valve opening should be between 10% and 80%.

Butterfly, diaphragm and pinch control valves shall be sized based on valve openings of 15% to 70%.

5.2 Valve Pits and Chambers

Where feasible control valves shall be installed above ground e.g. below ground valve pits and chambers shall be avoided.

Where a below ground pit or chamber is unavoidable it shall comply with the requirements contained in the general Pits and Chambers section of DS 30-02 and the specific Valve Pits and Chambers section of this Standard.

5.3 Automatic Control Valves

In the context of this standard an automatic control valve refers to a control valve with a cast ductile iron globe style body and cover chamber incorporating a diaphragm, spring and disc assembly. The cover chamber incorporates ports that can be configured and with valving or pilot controls to provide modulating and non-modulating operation. The configuration of pilot controls determines modulating and non- modulating valve functionality e.g. on-off, pressure reducing, pressure sustaining etc. whilst the pilot settings determines operating control parameters.

5.4 Pressure Reducing Valves

5.4.1 General

A pressure-reducing valve (PRV) automatically reduces a higher inlet pressure to a steady preset lower downstream pressure regardless of changing flow rate and/or inlet pressure fluctuations. The automatic control valve style PRV, which is hydraulic pilot operated is accurate and provides repeatable and predictive pilot settings.

The PRV is configured with an adjustable pressure reducing control valve, which causes the main valve to hold a steady outlet pressure. Should the downstream pressure exceed the preset pressure, the main valve and pilot control valve will close drip tight.

5.4.2 Design Requirements

Designers should ensure the turn down does not exceed the manufacturer's recommendations where large flow variations will be present. Large flow variations should be handled by incorporating parallel pressure reducing valves of different sizes with the large valve handling the peak flows and the small valve the low flows.

The valve supplier using a sizing program generally does selection of the appropriate valve. Accordingly the Designer should provide the following information for valve sizing to be undertaken:

(a) Pipeline upstream and downstream pressures

(b) Maximum and minimum flow rates required in the system.

The valve selection generally requires a valve of one size smaller than the pipeline nominal diameter.

Generally these control valves are not sensitive to turbulence so providing straight pipe lengths upstream and downstream is not critical for valve performance.

Valves in series may be required for large pressure drop requirements. This is in order that the pressure drop is staged to keep each valve within the manufacturers recommendations to avoid cavitation. An upstream orifice plate may be an alternative to assist with high-pressure reduction.

Valves shall be fitted with a position indicator as a standard requirement.

5.4.3 Pipework Layout and Ancillaries

Pressure reducing valve installations should incorporate upstream and downstream isolating valves to allow the valves to be removed for servicing. The downstream isolating valves should be located sufficiently far downstream so that turbulent flow will not cause damage. The recommended minimum distance is 5 - 7 pipe diameters. This is particularly important for butterfly valves, which could be subject to disc flutter and eventual disc retaining pin failure and are accordingly not recommended for this service. A gate valve would be less susceptible to turbulence than a butterfly valve and is preferred where turbulence is likely to be a factor.

Pressure gauge tapping points should be provided upstream and downstream of the pressure-reducing valve to facilitate setting of the pilot controls.

5.5 Pressure Sustaining Valves

5.5.1 General

A pressure-sustaining valve (PSV) automatically holds a steady preset inlet pressure within close limits. The automatic control valve style PSV, which is pilot operated is accurate and provides repeatable and predictive pilot settings.

The PSV is configured with an adjustable pressure control valve, which causes the main valve to hold a steady inlet pressure. The pilot control system has fast opening characteristics to maintain a steady pipeline pressure and slow closing characteristics to minimise surges.

5.5.2 Design Requirements

The valve supplier using a sizing program generally does selection of the appropriate valve. Accordingly the Designer should provide the following information for valve sizing to be undertaken:

(a) Pipeline upstream and downstream pressures (downstream pressure is particularly important for pressure sustaining valves to ensure cavitation does not present as a problem due to lack of backpressure).

(b) Maximum and minimum flow rates in the system.

The valve selection generally requires a valve of one size smaller than the pipeline nominal diameter.

Generally these control valves are not sensitive to turbulence so providing straight pipe lengths upstream and downstream is not critical for valve performance.

Valves shall be fitted with a position indicator as a standard requirement.

5.5.3 Pipework Layout and Ancillaries

PSV installations should incorporate upstream and downstream isolating valves to allow the valves to be removed for servicing. The downstream isolating valves should be located sufficiently far downstream so that turbulent flow will not cause damage. The recommended minimum distance is 5 - 7 pipe diameters. As mentioned previously this is particularly important for butterfly valves that could be subject to disc flutter and eventual disc retaining pin failure and accordingly are not recommended for this service. A gate valve would be less susceptible to turbulence than a butterfly valve and may be necessary if turbulence is likely to be a factor.

Pressure gauge tapping points should be provided upstream and downstream of the pressure-reducing valve to facilitate setting of the pilot controls.

5.6 Pressure Reducing and Sustaining Valve Data

Valve body and cover components are available in various materials e.g. cast steel, bronze, stainless steel and aluminium if necessary. SPS 240 specifies ductile iron only, which is the Corporation's normal requirement.

Details shown in the following table should be taken as a general guide only as manufacturer's specific products may vary:

Table 5.1 – Control Valve Data

Item	Pressure Reducing	Pressure Sustaining
Size range	DN 40 to DN 600	DN 40 to DN 600
Pressure range	PN 16 and 35	PN 16 and 35
Type	Pressure reducing	Pressure sustaining
Applications	Control of pipeline downstream pressures	Control of pipeline upstream pressures
Service	Water	Water
Configuration	Non buried	Non buried
Strategic Product Specifications	SPS 240	SPS 240

5.7 Inline Regulating Valves

Inline regulating valves are used in trunk mains downstream of dams for flow control purposes. Valves used by the Corporation are either a multiple jet and regulating sleeve type or the fixed cone and regulating sleeve type.

5.7.1 Inline Regulating Valves (IRV) Design Issues

Pipework should be configured as follows in the direction of flow order:

(a) The IRV should be above ground and not in a below ground pit

(b) A pipework manhole upstream of the isolating butterfly valve

(c) A pipework scour valve

(d) An isolating butterfly valve with triple gate valve by-pass

(e) A pipework manhole downstream of the butterfly valve

(f) A pipework scour valve

(g) 45° flanged bends and connecting pipework

(h) An upstream pipework banded closing joint

(i) Double air valve and flanged isolating butterfly on adjacent upstream isolating pipework

(j) An upstream pipework support

(k) An upstream pipework restrained dismantling joint adjacent to the IRV

(l) The IRV.

(m) A downstream reducer incorporating a manhole on the side with access steps

(n) Support of the downstream reducer at each flange (flanges act as stiffeners in lieu of flexible pipe body)

(o) 45° flanged bends downstream of the reducer

(p) Downstream closing joint

(q) Thrust blocks upstream and downstream

(r) Sound attenuation building with removable roof in noise sensitive areas

NOTES:

1. Care is required to ensure that the valve connections are not subjected to lateral forces or couples. The tie-bolt design of the fixed cone style of IRV produces flexibility in the valve, which can cause misalignment when subjected to external forces particularly for large valves e.g. DN 1200

2. Valves should be installed into position then pipework attached at both ends with closure of the pipework via banded joints to ensure alignment without applying unnecessary forces. Pipework should be supported so loads are not transferred to the valve inlet and outlet flanges.

5.8 Discharge Regulating Valve

Discharge regulating valves are either the horizontal or vertical are used as scour valves or water release valves to regulate flow and dissipate the energy due to the potential head in a dam or pipeline. The Corporation uses cone dispersal valves mainly for this purpose. However for small dams where low cost infrequently operated scour valves are proposed a plug valve may be suitable. Cone dispersal valves currently used by the Corporation are generally of the fixed cone sliding regulating sleeve style. Valves may be manual or electrically operated.

6 ISOLATING VALVES

6.1 Application and Suitability of Isolating Valves

The following table summarises the suitability of the various types of isolating valves used by the Corporation to perform particular functions. Designers should refer to the Corporation if they propose to use valves in applications not in strict accordance with the following table.

Table 6.1 – Isolating Valve Functionality

Isolating Valve Type	Application, Suitability and Resistance Coefficient					
	On-Off Control	Throttling Capability	Flow Control	Solids Handling	Multi-port Option	Resistance Coeff – *K*
Ball	S	LS	NA	LS	S	0.05
Butterfly	S	NS	LS	NS	NA	0.65
Diaphragm	S	LS	NA	S	NA	0.27
Gate	S	NS	NS	S	NA	0.13
Globe	S	S	S	NS	NA	5.10
Plug	S	LS	S	LS	S	0.27
SD Hydrant	S	S	NS	NS	NA	2.25

NOTES:

1. K factors are indicative only for comparison purposes and based on size DN 150
2. SD hydrant means screw-down hydrant

LEGEND:

S = Suitable

NS = Not suitable

LS = Limited suitability

NA = Not applicable

Isolating valves shall be supported and shall not support the pipework.

6.2 Ball Valves

6.2.1 General

A ball valve is a spherical plug valve in which the plug is in the form of a ball that incorporates circular hole through it. The hole is either full or reduced bore and aligns with the valve inlet and outlet ports in the open position and is fully shut when rotated 90º to the port. They are used for isolating and some control functions.

Material selection for ball valves can be very important from an operability perspective as plastic valves can be inclined to seize when used for some chemical handling applications. In these applications a SS ball valve (or other compatible material) should be specified.

6.2.2 Design Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer's specific products may vary.

Table 6.2 – Ball Valve Data

Ball valve	Data
Size range	DN 8 to DN 150
Pressure range	PN 14, 21 and 35 depending on valve
Applications	Treatment plants and general purposes
Service	Water, oil, gas, chemical solutions
Configuration	2 and 3 way porting in metal bodied, straight through and right angle
Strategic Product Specifications	SPS 251 – Mains tapping SPS 252 – General purpose SPS 254 – Meter ball valves

6.3 Butterfly Valves

6.3.1 General

A butterfly valve is an isolating valve in which the sealing disc rotates on a shaft through 90^{o} from the fully open to fully closed positions. Butterfly valves are available in metal sealing or resilient sealing, the latter being effected by a resilient seal fitted to either the body or disc. Resilient seated butterfly valves are used almost exclusively by the Corporation and these will be the subject of this Standard.

Valve termination and operator heights shall comply with the relevant parts of Clause 2.10 of this Standard.

6.3.2 Types

Butterfly valves are available as seal-on-body, seal-in-body and seal-on-disc depending on location of the resilient seal within the valve. Butterfly valves are also available in wafer, tapped-lugged or flanged body styles.

The Corporation uses the following types of butterfly valves:

(a) Wafer and lugged butterfly valves (seal-on-body).

(b) Double flanged butterfly valves (seal-on-body)

(c) High performance butterfly valves (seal-on-disc).

(d) Dam guard butterfly valves (seal on disc)

For information related to the following butterfly valve terminology refer to DS 30-01:

- Lenticular blade butterfly valves,
- Lattice blade butterfly valves,
- Wafer and lugged butterfly valves,
- Concentric butterfly valves,
- Eccentric (offset) butterfly valve,
- Double eccentric (double-offset) butterfly valve,
- Triple eccentric (triple-offset) butterfly valves.

Details of valves are summarized in the following table which should be taken as a general guide only as manufacturers specific products may vary.

Table 6.3 – Summary of Butterfly Valve Data

Valve type / Item	Wafer and Lugged (Note 1)	Double Flanged SOB (Note 2)	High Performance (Notes 2, 3, 6, 7)	Guard (Notes 2, 4, 5, 6, 7)
Strategic Product Specifications	SPS 260	SPS 261	SPS 262	SPS 263
Size range	DN 50 to DN 600	DN 100 to DN 2000	DN 300 to DN 2000	DN 300 to DN 2000
Pressure range	PN 10, PN 16	PN 16, 21 and 35	PN 16, PN21, PN 25, PN35, PN 40	PN 16, PN21, PN 25
Disc type	Lenticular concentric	Lenticular concentric	Lenticular double eccentric	Lenticular double eccentric
			Lattice double eccentric	Lattice double eccentric
Seal type	Seal-on-body	Seal-on-body	Seal-on-disc	Seal-on-disc
End connections	Wafer or lugged	Double flanged	Double flanged	Double flanged
Service	Non-buried	Non-buried, and buried	Non-buried and buried	Non-buried
Actuators	Manual handle, handwheel, spindle cap,	Manual handle, handwheel, spindle cap,	Handwheel, spindle cap,	Manual handwheel, spindle cap
	Electric, hydraulic pneumatic,	Electric, hydraulic pneumatic,	Electric	Electric, double acting hydraulic cylinder, single acting hydraulic cylinder with fail-safe counterweight
Input stops (Manual operation)	No	For buried service gearboxes end stops rated <250 Nm	For buried service gearboxes end stops rated <250 Nm	No
Torque limiting Devices	No	Manually operated valves ≥DN 700	Manually operated valves ≥DN 700	Manually operated valves ≥DN 700
Applications	Small pump stations, treatment plants, small bore headworks	Pump stations, trunk mains, distribution mains, valve complexes	Distribution and trunk mains	Dams guard valves
Maximum rated velocity	5 m/s	5 m/s	Lenticular: 6 m/s	Lenticular: 6 m/s
			Lattice: 7.5 m/s	Lattice: 7.5 m/s
Maximum emergency velocity	7.5 m/s	7.5 m/s	Lenticular: 9 m/s	Lenticular: ~ 20 m/s
			Lattice: 12 m/s	Lattice: ~ 20 m/s

NOTES:

1. SPS 260 references AS 4795.1
2. SPS 261, SPS 262 and SPS 263 reference AS 4795.2
3. Butterfly valves conforming to SPS 262 would normally be used for trunk mains
4. Valves are required to close safely into the maximum emergency flow velocity

5. The hydro-dynamic torque for emergency velocity closure (e.g. 20 m/s) is relatively high. Accordingly the drive train and valve shaft assembly must be rated to safely withstand closure into emergency flow velocity without structural damage. Some damage of the seal may be expected after emergency flow closure which would be a rare event.

6. Double eccentric valves may be uni-directional or bi-directional. If bi-directional sealing is required it would need to be specified.

7. The maximum rated and emergency velocities shown for high performance and guard valves are a guide only and the valve manufacturer should be consulted for specific ratings where high velocity is anticipated.

6.3.3 Design Features

(a) Butterfly valves tend to be cheaper than gate valves for sizes above DN 500.

(b) Butterfly valves are externally smaller than gate valves which provides for simpler, cheaper and more compact installations where appropriate. This particularly applies to double flanged seal-on-body butterfly valves which are suitable for buried service requiring no costly pipework pits.

(c) Seal-on-body waterworks butterfly valves are essentially manufactured from corrosion resistant waterway materials whereas traditionally waterworks gate valves and seal-on-disc butterfly valves have been prone to failure by corrosion long term e.g. after 30 years.

(d) Butterfly valves may be suitable for some control applications e.g. between 20º and 60º disc angle depending on the flow and pressure drop requirements.

(e) Resilient seated butterfly valves provide for drop tight sealing.

6.3.4 Butterfly Valve Design Constraints

(a) Butterfly valves should be used for on-off and limited control valve service. They shall not be used for throttling service because of the likelihood of cavitation damage (refer Appendix A).

(b) Butterfly valves shall not be located close to other pipe appurtenances that can induce disturbed streamlines likely to produce disc flutter and consequently premature wear or failure of components e.g. bends or immediately downstream of a control valve or pump.

(c) To obviate disc flutter, a straight length of pipe of 3 - 5 pipe diameters shall be provided upstream of the butterfly valve. Refer to Flow Regulating Valves Design Criteria relating to pressure reducing valve pipework layout and ancillaries for further specific information.

(d) Butterfly valves shall not be used in raw sewage as they will be subject to fouling and malfunction. Butterfly valves may be used for effluent or screened sewage providing it is clear (no solid or fibrous material).

6.3.5 Wafer and Lugged Butterfly Valves

(a) Wafer and lugged butterfly valves are relatively cheap valves designed for above ground (non buried) service and should only be used for medium duty isolation applications.

(b) General purpose butterfly valves are commonly available in sizes from DN 50 to DN 600 and for pressures from PN 10 to PN 16. End connections are wafer style for fitting between an AS 4087 flange bolt circle, tapped lugged to AS 2129 Table E. Valves are of the seal-on-body type with components in the wetted area being of non corrosive materials. The resilient seal-on-body feature includes integral flange gaskets so that separate flange gaskets are not required.

(c) For manual operation, valves may be fitted with a lever and notch plate for sizes up to and including DN 200 (refer Note). For valve sizes above DN 200 a gearbox should be fitted. In addition to manual operation valves may be electrically, hydraulically or pneumatically actuated. Wafer and Lugged butterfly valves shall not be used on pipework for major pump stations. However they may be used for non-critical ancillary plant such as minor pump stations, borefield headworks and treatment plant applications.

NOTE: A gearbox is recommended for DN 200 valves where PN >400kPa.

(d) Wafer and lugged butterfly valves should only be used for pipe velocities up to 5 m/s or short term (e.g. 30 minutes) emergency velocities to 7.5 m/s.

(e) Large wafer and lugged butterfly valves should generally not be opened against full differential head such as would occur when opening a valve exposed to an upstream head and an empty pipe downstream. Under these circumstances the head should be balanced before opening the valve. This can be achieved by providing a bypass around the valve (refer to Bypass Valves in this Standard). Under certain hydraulic conditions opening against full differential can be tolerated subject to approval of the manufacturer.

(f) Wafer and lugged butterfly valves shall not be used as termination valves (refer Note for air valves).

6.3.6 Double Flanged Seal-on-Body (SOB) Butterfly Valves

(a) Double flanged SOB butterfly valves are relatively expensive valves designed for above and buried service for medium to heavy duty isolation and control applications.

(b) Double flanged SOB butterfly valves are available in sizes from DN 100 to DN 2000 and for pressures from PN 10 to PN 35. End connections are double flanged or tapped ring style. Valves are of the seal-on-body type with components in the wetted area being of non corrosive materials. The SOB feature includes integral flange gaskets so that separate flange gaskets are not required.

(c) For manual operation a gearbox should be fitted (refer Note below). In addition to manual operation valves may be electrically, hydraulically or pneumatically actuated.

NOTE: Valves are normally fitted with a gearbox for manual operation. Valve sizes and pressure classes up to DN 150 PN 21 could be fitted with a lever in lieu of a gearbox however the Corporation only uses this arrangement for DN 150 PN 21 valves for fitting immediately under air valves to provide quick on-off operation.

(d) Butterfly valves should be used for pump suction and delivery pipework in lieu of large gate valves because they are more compact and cheaper in sizes above DN 500. This is providing the extra head loss they incur over a gate valve does not impact adversely on the design e.g. head loss on the suction side could be important for critical NPSHa situations.

(e) Double flanged SOB butterfly valves should only be used for pipe velocities to 5 m/s or short term (e.g. 30 minutes) emergency velocities to 7.5 m/s.

(f) Double flanged SOB butterfly valves shall be installed with the shaft in the horizontal position so that the lower half of the disc opens in the direction of the flow. Refer also DS 38-01 for further information

(g) The gearbox orientation for double flanged SOB butterfly valves, where possible shall be specified as being located on the left hand side of the valve when looking in the direction of the flow. Refer also DS 38-01 for further information.

(h) Large double flanged SOB butterfly valves should generally not be opened against full differential head such as would occur when opening a valve exposed to an upstream head and an empty pipe downstream. Under these circumstances the head should be balanced before opening the valve. This can be achieved by providing a bypass around the valve (refer to Bypass Valves in this Standard). Under certain hydraulic conditions opening against full differential can be tolerated subject to approval of the manufacturer.

(i) Double flanged SOB butterfly valves incorporate an enclosed gearbox and accordingly may be installed in the following applications:

- Non-buried;
- Non-buried with extended spindle; or
- Buried service with extended spindle.

Extended spindle valves shall be fitted with a position indicator.

6.3.7 High Performance Butterfly Valves

(a) High performance butterfly valves are used for high velocity applications, such as would be required for large distribution mains.

(b) High performance butterfly valves are seal-on-disc type. In order to minimise dissimilar metal corrosion, valves shall incorporate an all-stainless steel disc, and disc seal ring and fasteners. A ductile iron body is acceptable however all wetted surfaces and interfaces shall be fully and effectively coated and the coating or a suitable sealant isolates the stainless steel body ring fastener threads from moisture. Ingress of water into interfaces can promote growth of iron tubercles which can interfere with and damage the disc seal. Similarly ingress of moisture into the fastener thread area could likely produce graphitic corrosion causing dislodgement of the body ring during valve operation.

(c) Seal-on-disc butterfly valves require separate flange gaskets.

6.3.8 Guard Valves

6.3.8.1 General

Butterfly guard valves are isolating valves, generally located immediately downstream of a dam wall. Guard valves shall be designed to operate in either the fully open or fully closed positions and close safely under the maximum emergency flow velocity in the event of catastrophic downstream pipework failure. Guard valves are structurally more robust than standard butterfly valves and are normally fitted with higher rated actuators (refer Note 1).

Guard valve actuators are available in standard or fail-safe types as follows:

- The standard guard valve can be actuated via a manual or an electric actuator, or an electro-hydraulic double-acting cylinder (refer Note 2). The standard actuator can be closed manually via the electric actuator handwheel or via a manual hand pump in the case of the electro-hydraulic actuator in the event of a power failure.
- The fail-safe guard valve actuator comprises an electro-hydraulic power pack, and a single-acting hydraulic cylinder and counterweight assembly. The valve actuator is configured to open hydraulically and close under the action of the counterweight.

NOTES:

1. Whilst guard valves are designed to be structurally capable of closing into the maximum emergency flow velocity some damage to the resilient seal may occur.
2. Rotary hydraulic actuators are not favoured due to higher cost and complexity.

6.3.8.2 Risk Potential

The key issue in considering the type of butterfly valve used as a guard valve depends upon the degree of importance of the water body in the dam. Therefore it is necessary to determine the risk potential and the consequence if the water body was lost or seriously depleted e.g. whether the risk is strategic or non strategic.

NOTE: The decision as to the integrity of the valves required ultimately rests with the Dams and Dams Safety Section and they should adjudicate on this (normally would be as a design or specification requirement).

6.3.8.3 Valve Types

If the guard valve is likely to be exposed to sustained flow velocities greater than 5.0 m/s then this is generally outside the maximum performance capability of standard seal on body butterfly valves. In this event there are two options available. One option is to utilise seal-on-body butterfly valves and the others are the use of high performance seal-on-disc butterfly valve or a purpose designed guard valve as further discussed.

NOTE: Use of ring follower valves as guard valves was common decades ago but is probably not feasible now due to their lack of availability, undoubtedly due to considerably cheaper and more compact butterfly valves.

6.3.8.4 Seal-On-Body Butterfly Valves

Use of seal-on-body butterfly valves are preferred over seal-on-disc butterfly valves for general waterworks applications because of their simple construction, corrosion resistant characteristics and lower cost. However seal-on-body butterfly valves are generally limited to 5 m/s continuous velocity and not normally suitable for high emergency flow velocities because of damaging downstream cavitation which can cause rubber failure whereby the rubber can tear away in chunks. However a case for their use may be made under the following circumstance:

(a) For non critical and low risk applications it may be acceptable to use seal-on-body butterfly valves in conjunction with an actuator designed to close against maximum differential head. This would be in the full knowledge that the maximum performance capability of the valve may be exceeded under emergency flow conditions and that liner failure could occur (perhaps catastrophic).

(b) A valve actuator rated to close under maximum differential should theoretically be able to be close the valve against emergency flow conditions. However this assumes that any seat damage would not cause an obstruction which could act to prevent full closure. Hopefully any resulting leakage through the damaged seat would be tolerable and sufficiently manageable to enable a bulkhead gate to be fitted upstream in order to rectify the downstream failure. The valve would then have to be removed for repair if there was damage to the liner.

NOTE: The use of seal-on-body butterfly valves would obviously not be a preferred option for protecting strategic water bodies and should only be used where there was low risk of failure and minimal strategic implications.

6.3.8.5 Seal-On-Disc Butterfly Valves

For critical applications guard valves should be of the high performance butterfly valve type rated for closure against maximum differential head and suitable for continuous operation under emergency flow conditions e.g. without seal failure. Guard valves would normally be seal-on-disc type butterfly valves fitted with a lenticular or lattice blade and designed for continuous flow velocities up to 20 m/s. The seal-on-disc valve rubber seal fitted to the disc is not subject to damaging cavitation.

However seal-on-disc butterfly valves have been prone to premature failure in the past due to corrosion of the disc and body fastener threads and other areas of the ductile iron or carbon steel valve body exposed to immersion.

The Corporation has addressed corrosion of seal-on-disc butterfly valves over recent years by requiring high performance butterfly valve and guard valve components subject to immersion be manufactured in accordance with the following :

(a) Disc, disc and body seat rings and fasteners to be manufactured from corrosion resistant material.

(b) Ductile iron body seat ring mating face and tapped holes to be sealed against moisture ingress.

(c) All immersed ductile iron or carbon steel surfaces and interfaces to be fully coated and sealed respectively to eliminate contact with moisture.

6.3.9 Direction of Rotation for Closure

Butterfly valve operators (e.g. key or handwheel) shall rotate anti-clockwise for closure of the valve.

6.4 Diaphragm Valves

6.4.1 General

The diaphragm valve is an isolating valve that utilises an actuator driven diaphragm to seal against the valve body in either a weir or straight-through flow way body type. The diaphragm serves not only as the sealing mechanism for the process fluid but also prevents fluid contact with the bonnet internal components.

The weir type diaphragm valve produces less flexing of the diaphragm because of the shorter travel required and also presents a seal face that requires a lower closing force than the straight-through flow type.

The straight-through flow type has a clear flow way and this makes it more suitable for solids handling however the longer travel of the diaphragm limits the availability of suitable diaphragm elastomers.

6.4.2 Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer's specific products may vary.

Table 6.4 – Diaphragm Valve Data

Item	Straight Through	Weir
Size range	Screwed – DN 25 to DN 50 Flanged – DN 25 – DN 350	Screwed – DN 8 to DN 80 Flanged – DN 15 – DN 350
Pressure range	1000 kPa for DN 25 – DN 50 600 kPa for DN 65 – DN 150 300 kPa for DN 200 – DN 250 170 kPa for DN 300	1600 kPa for DN 8 – DN 50 1000 kPa for DN 65 – DN 150 800 kPa for DN 200 500 kPa, 400 kPa, 350 kPa for DN 250, DN 300 and DN 350 resp.
Type	Straight-through	Weir
Applications	General purposes, WTP's	General purposes, treatment plants
Service	Water, solids, corrosive and abrasive fluids	Water, corrosive and abrasive fluids
Configuration	Non buried	Non buried
Strategic Product Specifications	N/A	N/A

6.5 Gate Valves for General Purposes

6.5.1 General

In the context of this Standard this section refers to a copper alloy or stainless steel isolating valve with non rising stem that employs a guided metal wedge onto metal seats to effect a seal.

6.5.2 Design Requirements

Gate valves should be used for general purposes for unrestricted fluid flow, lowest pressure drop, and for infrequent operation. They are available in sizes from DN 15 to DN 100 in screwed or flanged end connections.

Gate valves should not be used for modulating or throttling purposes. Velocity of flow through a partially closed wedge is likely to cause vibration and chattering that can damage the sealing faces and produce erosion of the wedge.

Gate valves should normally be used in conjunction with swing check non-return valves, not lift type non-return valves, on low to medium pipeline velocities.

6.5.3 Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer's specific products may vary.

Table 6.5 – Gate Valve Data

Item	Copper Alloy		Stainless Steel
	Screwed	Flanged	
Size range	DN 8 to DN 50	DN 10 to DN 100	DN 6 to DN 100
Pressure range	PN 35	PN 21	2000 kPa
Type	Screwed	Flanged	Screwed
Applications	General purposes, treatment plants	General purposes, treatment plants	Treatment plants
Service	Water, oil, gas	Water, oil, gas	Chemical solutions
Strategic Product Specifications	SPS 255	SPS 255	-

6.6 Gate Valves for Waterworks Purposes

6.6.1 General

In the context of this Standard the term gate valve refers to a ductile iron waterworks isolating valve with non rising stem that employs either a guided resilient or metal gate onto the body or metal seats respectively to effect a seal.

NOTE: The term gate valve has been adopted as the preferred terminology since the inclusion of 'gate valves ' into AS 2638.2 in 2002. Formerly they were known as "sluice valves".

Gate valves should not be used for modulating or throttling because of their inherent difficulty in precisely regulating flow. This is due to their relatively high discharge capacity variation for relatively small gate movement in the controllable range, which is approximately the last one third from the closed position. Further, the velocity of flow through a partially closed gate is likely to cause turbulence with associated gate vibration and chattering due to the relatively short gate guide length. Chattering can damage the seating faces and the flow velocity can produce erosion.

Valve termination and operator heights shall comply with the relevant parts of Clause 2.10 of this Standard.

6.6.2 Valve Orientation

Ideally both metal and resilient seated gate valves should be installed in horizontal pipelines i.e. with the stem vertical, particularly if grit and solids are present as is the case for sewage applications. There is a risk of the bonnet area becoming clogged with solids for sewage applications if the stem is not oriented vertically. This is not so critical for clean water.

Installation in horizontal pipelines is also an advantage in terms of inspection and servicing of large valves where direct lift can be used. Lifting of the bonnet and internal components for large valves could present difficulties for vertical pipelines. This is because of lifting constraints that would otherwise present themselves in trying to remove heavy components horizontally. Further, large valves installed with the stem horizontally may need specially designed body liners and wedge shoes.

6.6.3 Buried Gate Valves

Gate valves without gearboxes may be installed below ground e.g. reticulation valves. Below ground valves shall be fitted extended spindles.

Large gate valves on pipelines may be partially buried to eliminate costly valve pits e.g. distribution mains. Valves should not be buried above the body to bonnet lower flange. Exposed adjustable glands shall not be buried and may need gland covers depending on the valve design. A platform, handrailing and steps shall be provided where necessary to allow safe access to the valve operator.

6.6.4 Metal Seated Gate Valves

Metal seated gate valves used for water and sewage pump stations shall comply with SPS 271 for sizes above DN 750 and for pressure classes above PN 25 unless authorized by the Corporation..

NOTE:Resilient seated gate valves are preferred over metal seated for sizes ≤DN 750 and for pressure classes ≤PN 25

Gate valves shall be fitted with a bypass in accordance with the Bypass Valves clause in this section if they are likely to be subject to unbalanced head conditions.

Gate valves with gearboxes (generally above DN 500) are normally installed above ground (non buried) in a valve pit. However subject to approval by the Corporation they may be partially buried in order to save valve pit costs e.g. up to the body-to-bonnet flange for pipelines outside the pump station. For gate valves in sizes larger than those authorised for resilient seated gate valves and for all PN 35 valves, metal seated gate valves are required.

Metal seated gate valves:

(a) Incorporate a pocket to accept the wedge in the closed position, which can collect debris making them difficult to close and therefore seal,

(b) Are not suitable for drop tight sealing, as they will always pass a small amount of fluid.

6.6.5 Resilient Seated Gate Valves

Resilient seated gate valves for water and sewage shall conform to the requirements of SPS 272 and are suitable for use in sizes up to and including DN 750 and pressure classes to PN 25.

Resilient seated gate valves are generally preferred over metal seated gate valves because they offer a number of advantages:

(a) The construction of the resilient seated valves allow a continuous coating to be applied to the body, encapsulating the ductile cast iron and protecting it from corrosion. The gate is also fully encapsulated with rubber and is therefore protected from corrosion. A metal seated gate valve has gunmetal seating rings set into the ductile cast iron and in practice it may be difficult to obtain a fully effective coating at this dissimilar metal interface.

(b) Resilient seated valves are suitable for drop tight sealing and can accommodate grit and small solids and still provide an effective seal, but metal seated valves may pass a small amount of fluid.

(c) Resilient seated gate valves have a resilient coated wedge, which allows them to seal effectively against a smooth bore i.e. no pocket and therefore no debris collection..

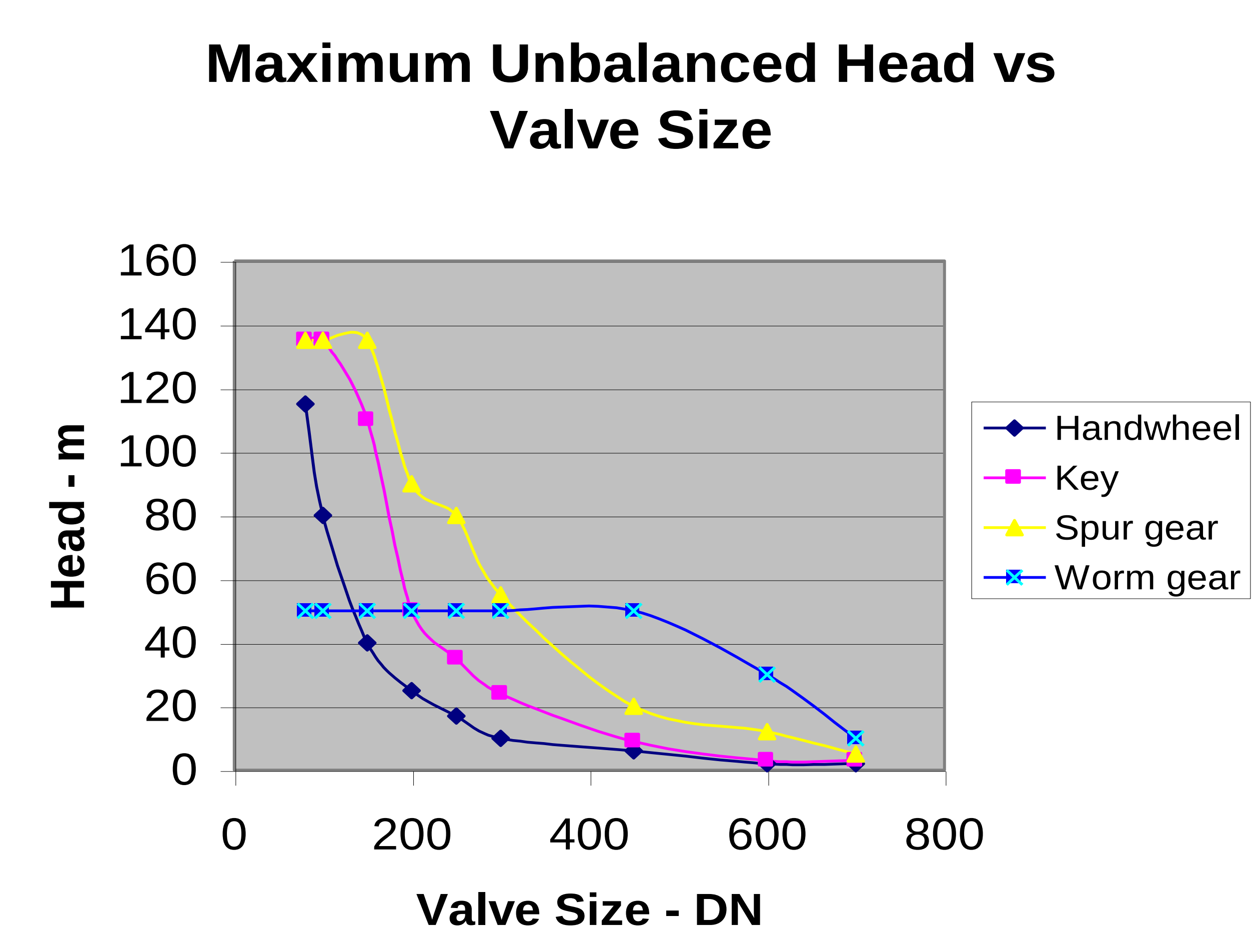
6.6.6 Direction of Rotation for Closure

Gate valve operators (e.g. key or handwheel) shall rotate anti-clockwise for closure of the valve.

6.6.7 Unbalanced Head Limits

The manual operation of valves is limited by the unbalanced head across the valve and the type of actuation. The following figure represents a guide to the maximum unbalanced head that a gate valve should be operated against. For actual values the valve manufacturer should be consulted.

Fig 6.1 Maximum Unbalanced Head versus Valve Size



6.6.8 Gate Valve Gearing

Gate valves shall be geared in accordance with the requirements shown the following table.

Table 6.6 – Gate Valve Gearing

PN	Geared Gate Valve Size
PN 16	DN 600 for > 60 m head
	DN 700 and larger
PN 21 and 35	DN 400 and larger

NOTE: DN 600 valves being used under balanced head conditions do not necessarily require a gearbox e.g. in pump stations.

Gearbox ratios relating to specific valves sizes and pressures are contained in SPS 271 and SPS 272.

6.6.9 Data and Specification

Details shown in the following table should be taken as a general guide only as manufacturers specific products may vary particularly with respect to sizes.

Table 6.7 – Gate Valve Data

Item	Metal Seated	Resilient Seated
Size range	DN 80 to DN 900 (Note 1)	DN 80 to DN 750
Pressure range	PN 16 and 35	PN 16, PN 25 (Note 2)
Type	Metal seated gate	Resilient seated gate
End connections	Double flanged	Double flanged
Service	Water and sewage	Water and sewage
Configuration	Non buried, or buried service for non-geared valves	Non buried or buried service
Gearbox	Available	Available
Strategic Product Specifications	SPS 271	SPS 272

NOTES:

1. Larger sizes are available
2. Available with integral by pass for sizes > DN 300 but not Corporation authorised

6.7 Globe Valves

6.7.1 General

A globe valve is an isolating or stop valve that is configured so that two halves of the valve are separated by a partition with a central section accommodating the disc or plug. The axis of the stem is normally a right angles to the seat faces. The stem and disc or plug assembly has a relatively short movement from open to closed and produce a very positive seating action. This allows accurate regulation and throttling service. Immediately the disk or plug lifts away from the seat all contact between components is eliminated so that mechanical wear is minimised.

Disc type globe valves are not as effective as plugs for throttling and require resilient seating for drip tight closure. Plugs are shaped to provide specific throttling characteristics e.g. equal percentage plugs and linear plugs. Needle plugs (referred to as needle valves) provide the most accurate and controllable flow but for small sizes only (DN 25 max.).

The more tortuous flow characteristics of a globe valve results in higher K factors than for other valves. The globe style body construction is used for automatic cast iron control valves.

6.7.2 Design Requirements

Globe valves should only be used where operation will be frequent, or for throttling or control and where a high pressure drop can be tolerated. Globe valves should normally be used in conjunction with lift type non-return valves, not swing type non-return valves, on high pipeline velocities.

6.7.3 Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer's specific products may vary.

Table 6.8 – Globe Valve Data

Item	Copper Alloy		Stainless Steel
	Screwed	**Flanged**	**Flanged**
Size range	DN 8 to DN 50	DN 10 to DN 100	DN 20 to DN 150
Pressure range	PN 21	To DN 80 – PN 21 DN 100 – 1700 kPa	1000 kPa
Purpose	High cycling, regulation and throttling	High cycling, regulation and throttling	High cycling, regulation and throttling
Applications	General purposes, treatment plants	General purposes, treatment plants	Treatment plants
Service	Water, oil, steam	Water, oil, steam	Chemicals
Strategic Product Specifications	N/A	N/A	N/A

NOTE: Globe valves are available in larger sizes e.g. up to DN 300 for cast iron and steel, and for pressures up to PN 35 rating but are not commonly used on Corporation assets.

6.8 Knife Gate Valves

6.8.1 General

A knife gate valve is an isolating valve used on relatively low head applications where the fluid contains solids e.g. sewage. The valve comprises a sliding plate with a bevelled semi-circular leading edge that can cut through any solids that may be fouling the seat during closing. The plate slides in a cast iron, ductile iron, or stainless steel body and is generally operated by a handwheel for Corporation applications.

Knife gate valves are available in wafer, lugged or flanged end connections; resilient or metal seat combinations for bi-directional or uni-directional flow with rising or non-rising spindles. They are available in ductile and stainless steel with gland box or bonneted bodies.

6.8.2 Design Requirements

Knife gate valves should only be used for relatively low head applications (e.g. <1000 kPa), where stringy and fibrous material is likely to be present.

Knife gate valves tend to be subject to leakage through the closed valve and packing gland however particular brands have addressed this with the use of elastomeric resilient seatings and packing.

Knife gate valves are generally used on the inlet sewer to submersible sewage pump stations and in treatment plant applications for Corporation assets.

Submersible sewage pump station inlet sewer knife gate valves shall be of all stainless steel construction with a Viton resilient seat. Viton seats allow drop tight sealing at low heads e.g. 10 m.

6.8.3 Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer's specific product may vary.

Table 6.9 – Knife Gate Valve Data

Item	Uni-directional	Bi-directional
Size range	Wafer – DN 50 to DN 300 (DN 600 for stainless steel) Lugged – DN 350 - DN 1200	Wafer – DN 50 to DN 300 Lugged – DN 350 – DN 1200
Pressure range	PN 10	Up to PN 10 depending on valve size
Type	Unidirectional resilient or metal seat	Bi-directional resilient liner
Applications	Water, sewage	Water, sewage, abrasive service
Configuration	Rising and non-rising stem depending on size and trim	Rising and non-rising stem depending on size and trim
Strategic Product Specifications	SPS 259	SPS 259

Corporation specific options and requirements are contained in SPS 259.

6.9 Plug Valves

6.9.1 General

The plug valve is a derivation of the simple cock that incorporates a cylindrical, tapered or eccentric plug that can be rotated relative to the body inlet and outlet ports to control or isolate flow. The plug rotates a quarter turn (90º) from fully open to fully closed. The construction is simple with a straight through flow way and relatively low *K* factors. Plug valves are also available in multi-port construction for flow diversion. Plug valves are primarily used for open-close isolation purposes but they can be used for coarse throttling on low flow services. Drip tight performance depends on the plug material e.g. hard rubber and metal may not be drip tight

6.9.2 Data and Specification

Details shown in the following table should be taken as a general guide only as a manufacturer’s specific product may vary.

Table 6.10 – Plug Valve Data

Item	**Eccentric Plug**	**Concentric Plug**
Size range	DN 15 to DN 1800	DN 15 to DN 150
Pressure range	1200 kPa for DN 15 – DN300 1000 kPa for DN 350 – DN 1800 Higher pressures available in steel and stainless steel	Ductile iron – 1700 kPa and 4400 kPa. Other pressures available in different materials.
Type	Inlet and outlet ports	2 and 3-way porting available
Applications	General purposes, treatment plants, throttling	General purposes, treatment plants
Service	Water, solids, corrosive and abrasive fluids	Water, corrosive and abrasive fluids
Configuration	Non buried or buried service	Non buried
Strategic Product Specifications	N/A	N/A

6.10 Pump Station Isolating Valves

For pump stations isolating valves refer to DS 32.

7 NON-RETURN VALVES

7.1 Non-Return Valve Applications and Suitability

7.1.1 General

The following table summarises the functionality and suitability of non-return valves for various applications. Designers proposing to deviate significantly from the applications shown in the table should refer to the Corporation.

Table 7.1 – Non-return Valve Applications and Functionality

Non Return Valve Type	**Functionality**			
	Control Functionality	**Slam Characteristics**	**Head Loss**	**Use in Sewage**
Cone and Diaphragm	No	Low	High	No
Dual plate	No	Low	Medium	No
Lift type	No	Medium	High	No
Rapid response	No	Very low	Low	No
Single Spring Flap	Yes	Low – medium	Low	No
Swing Check	Yes	High	Low	Yes
Tilting Disc	Yes	Low	Low	No

7.1.2 Slamming of Non-Return Valves

Non-return valves are often selected without consideration being given to their response under transient flow conditions. Installing valves that are not matched to the system causes non-return valve slam. Systems at most risk are those where a high-energy source continues to exist downstream after pump shutdown e.g. high head systems are particularly susceptible. Other typical examples are:

(a) When two pumps are running in parallel and one shuts down, and

(b) Where a pump shuts down on a system incorporating a surge vessel at the pump station.

To avoid non-return valves slamming under the above conditions or where a water hammer analysis dictates the Designer should select a valve that has rapid response. Rapid response valves are characterised by:

(a) Their moving components will be of low mass

(b) Their dynamic components will have a short travel from the fully open to closed position

(c) Their closing motion will be spring assisted

Non-slam valves (often referred to as nozzle checkvalves) are purpose designed for rapid response and are further detailed in the section on Rapid Response Non-return Valves.

7.2 Cone and Diaphragm Non-Return Valve

7.2.1 General

The cone and diaphragm non-return valve is a flangeless wafer type non-return valve that comprises a conical perforated stainless steel body containing a thin rubber diaphragm fixed at the apex of the cone. Flow direction is from the apex end passing through the perforated body causing collapse of the diaphragm and relatively free flow. Reverse flow flattens the diaphragm against the body closing the valve and stopping the flow.

7.2.2 Application

Cone and diaphragm non-return valves are suitable for clean water applications only. It is a general-purpose valve used on small pipelines.

7.2.3 Features

Physical features of the cone and diaphragm type non-return valves are detailed in the following table.

Table 7.2 Features of Cone and Diaphragm Non-return Valves

Specification	Cone and Diaphragm Non-Return Valve
Size range	DN 80 – DN 150
Pressure/PN	PN 14/16
End connections	Wafer
Body style	Compact
Head loss	High
Orientation	Horizontal or vertical (Refer Note)
Flow control functionality	Not available
Termination style	No
Complexity	Simple
Ease of maintenance	Simple
Low head sealing	Good
Drip tight sealing	Yes
Direct burial	Yes but not normally buried
Water hammer susceptibility	Low
Maintenance	Low
Noise	Low

NOTE: This valve can be installed with the flow vertically downwards.

7.2.4 Design Criteria

These valves should not be used where blockage is likely because of the strainer effect of the body e.g. should not be used on sewage.

Excessive turbulence should be avoided as it could cause premature failure of the membrane to fastener joint.

7.3 Damped Swing Check Non-Return Valves

Damped or cushioned swing check non-return valves are purpose-built to provide controlled closing via an air or oil type damper system to eliminate slamming. The valves are heavy duty to resist shock and the damper system is field adjustable to vary the rate of closure. The valve flow characteristics are the same as for a swing check valve.

The air damper is designed to provide rapid response for general applications whereas the oil damped system is for more severe rapid response applications such as would occur with rapid flow reversal at pump shut off e.g. effect of a nearby surge vessel.

Damped swing check non-return valves are suitable for water and sewage applications and available in sizes from DN 200 to DN 1600. For further details refer to relevant manufacturers published information

7.4 Dual Plate (Flap) Non-Return Valve

7.4.1 General

The dual plate non-return valve comprises two spring loaded semi-circular plates hinged from a centrally mounted post in a wafer or double flanged spool type body. The plates seal against a resilient seal in the body. The characteristics of this valve are compactness and rapid response to reverse flow so they tend to be low slam. They are not suitable for flow control monitoring or control.

7.4.2 Specification

Dual plate non-return valves shall comply with SPS 226.

7.4.3 Applications

Dual plate non-return valves should be used for general purpose clean water applications only. They shall not be used for sewage applications.

Dual plate non return valves should not be used where extended shafts are required. If an extended shaft is required then a swing check valve should be used providing slamming is not an issue.

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

7.4.4 Features

Features of dual plate non-return valves are detailed in the following table.

Table 7.3 Features of Dual Plate Non-return Valves

Features	Wafer	Flanged
Size range	DN 50 – DN 250	DN 300 – DN 600
Pressure/PN	PN 16	PN 16, 21, 35
End connections	Flangeless wafer and lugged wafer	Double flanged
Body style	Compact	
Head loss	Medium	
Orientation	Horizontal or vertical up-flow	
Flow control functionality	No	
Termination style	Flangeless – No; lugged - Yes	Yes
Complexity	Simple	
Ease of maintenance	Simple	
Low head sealing	Good	
Drip tight sealing	Yes	
Direct burial	Yes	
Water hammer	Low	
Noise	Low	

7.4.5 Materials

Cast or ductile iron bodies shall only be used where:

(a) Hinge and stop posts do not penetrate the body (e.g. posts are fitted to slippers) and,

(b) The body is coated in accordance with AS/NZS 4158. Intrusive posts allow graphitic corrosion of the body and over time the posts can become loose and ultimately fall out.

Otherwise the body and plates should be a corrosion resistant material e.g. aluminium bronze to AS 1565.

7.4.6 Design Criteria

(a) For vertical pipelines the valve shall always be oriented with the plates opening upwards i.e. pressure is below the seat.

(b) Flanged dual plate non-return valves shall not be used to carry the weight of the pipeline.

(c) Dual plate non-return valves should be sized to enable the plates to attain the fully open position to ensure stability and reduce wear. It may be necessary to size the valve below the pipeline size to achieve this. Oversizing should be avoided as the plates will not be resting against the stop pins, which may result in turbulence induced oscillations producing severe and premature wear in the linkages, bearings and spindles.

(d) Dual plate non-return valves are particularly sensitive to flutter caused by turbulence generated from upstream conditions or high velocity or both producing accelerated hinge wear and premature spring failure. To optimize valve life valves should be installed a minimum of 5 – 8 pipe diameters of straight pipe away from a pump discharge or turbulence causing device and should not be exposed to velocities greater than 3.5 m/s (maximum flow should normally not exceed 2.5 m/s).

(e) For normal dynamic response applications standard springs should be used. However where high system decelerations exist valves require fast dynamic response and therefore maximum torque springs should be used. Valve sizes above DN 100 shall incorporate 2 or more independent springs to operate the plates. On the larger valves a single spring can cause excessive diverse velocities through the plates' waterways causing uneven closure of the plates.

(f) For backpressures <10 m the valve should be fitted with low torque springs, hand lapping of seat faces and low head hydrostatic performance testing (which entails filling the valve body with water whilst it is in the vertical up-flow position and checking for leakage).

7.5 Lift Type Non-Return Valve

7.5.1 General

In the context of this Standard lift type non return valve refers to a copper alloy non-return valve in which the disc and body seat is configured similar to a globe valve except that the disc, which is guided, is free to move axially. Flow lifts the disc from its seat whilst no flow or reverse flow causes it to return to the seat thus preventing backflow. Like the globe valve the flow path is tortuous and correspondingly the K factors are higher than other valves.

The lift type non-return valve allows a tighter more positive seal than a swing type. Horizontal lift non-return valves should be installed in horizontal pipelines with the disc axis vertical however specific vertical or angle type valves are available.

Lift non-return valves should be used in conjunction with globe valves in high velocity pipeline applications.

7.5.2 Specification

The lift type non-return valve shall comply with SPS 220, which references AS 1628.

7.5.3 Application

Lift type non-return valves are suitable for water only.

7.5.4 Features

Physical features of lift type non-return valves are detailed in the following table.

Table 7.4 Features of Lift Type Non-Return Valves

Specification	**Lift Type Non-Return Valve**
Size range	DN 15 – DN 50
Pressure/PN	Up to PN 21
End connections	Screwed and flanged
Body style (Bulky or compact)	Bulky
Head loss	High
Orientation	Horizontal or vertical (Refer Note)
Flow control functionality	Not available
Termination style	Yes
Complexity	Simple
Ease of maintenance	Simple
Low head sealing	Good
Drip tight sealing	Yes
Direct burial	No
Water hammer susceptibility	Moderate
Maintenance	Low
Noise	Medium-low

NOTE: For vertical or angled pipelines specific lift type non-return valves are available.

7.5.5 Design Criteria

(a) Lift type non-return valves should be sized to enable the disc to attain the fully open position to ensure stability and reduce wear. It may be necessary to size the valve below the pipeline size to achieve this. Oversizing should be avoided.

(b) Lift type non-return valves should be used in conjunction with globe valves not gate valves.

(c) For vertical pipelines the valve should always be oriented with the disc moving away from the seat i.e. pressure below the seat.

(d) The non-return valves shall not be used to carry the weight of the pipeline.

7.6 Rapid Response Non-Return Valve

7.6.1 General

Rapid response non-return valves comprise a spool type body with an internal streamlined waterway (venturi principle), hub and guide, which accommodate a spring assisted disc ring. The disc ring incorporates an integral spindle or guide which slides axially in the hub guide. The valve has a rapid response to flow changes with spring assisted closure just as normal flow through the valve ceases.

The rapid response valve disc ring is light weight and operates on a short stroke to provide rapid dynamic response. The disc ring should seal on one diameter only. Disc seating may be resilient or metal-to-metal (with minimal leakage) and accordingly drip tight performance should be expected. Head loss through the valve is low and the maintenance requirements are minimal.

7.6.2 Specification

Rapid response non-return valves shall comply with SPS 230.

7.6.3 Application

Rapid response non-return valves are:

(a) Suitable for clear water applications e.g. drinking, raw and recycled water only. They shall not be used for sewage.

(b) Used where system decelerations is 5 m/s^2 or higher.

(c) Used for environmental reasons where it is desirable to minimize noise during normal flow conditions or upon closure of the valve.

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

7.6.4 Features

Physical features of rapid response valves non-return valves are detailed in the following table.

Table 7.5 Features of Rapid Response Non-return Valves

Specification	Rapid Response Non-Return Valve
Size range	DN 400 – DN 1200
Pressure/PN	PN 16, 21, 35
End connections	Double flanged
Body style	Compact or long body styles
Head loss	Low
Orientation	Horizontal, vertical or inclined
Flow control functionality	Not available
Termination style	Yes
Complexity	Simple
Ease of maintenance	Simple
Low head sealing	Good
Drip tight sealing	Yes (bubble tight)
Direct burial	Yes
Water hammer susceptibility	Very low
Maintenance	Very low
Noise	Low

7.6.5 Design Criteria

(a) Rapid response valves are normally used in horizontal pipelines however for vertical pipelines valves shall be oriented with the disc opening upwards i.e. pressure below the seat.

(b) The valves shall not be used to carry the weight of the pipeline or to resist couples as a result of lack of pipework restraint. Rapid response valves can be installed a minimum of 2 pipe diameters downstream of a turbulence generator e.g. pump, bend etc.

(c) A water hammer analysis shall be conducted to identify the need for a rapid response non-return valve. Rapid response valves are relatively expensive and if a swing check or dual plate (flap) valve is identified as suitable then they should be used.

(d) Deceleration values shall be obtained during the water hammer analysis in order to select the proper spring rating for optimal closure and water hammer mitigation. Manufacturers shall be provided with accurate data for correct spring selection by the Designer. In addition to deceleration values data shall include minimum flow rate, maximum flow rate and most importantly normal flow rate. Normal flow rate is extremely important in that given minimum and maximum flow rates only a manufacturer may be tempted to the take an average to determine normal flow rate. However if the actual normal flow rate is nearer to either the low or high end of the flow range, spring related operational problems may occur,

(e) The Designer should ensure the stem guide and stem are manufactured from materials that will not produce galling due to the combination of mutual contact and relative motion. The Corporation has experienced this problem. Refer to Stainless Steel in the Materials section of DS 30-02 for further information regarding galling.

(f) These valves should require minimal maintenance therefore effective coating of the cast iron body is critical to ensure long life by minimising graphitic corrosion.

7.6.6 Valve Selection

7.6.6.1 Flow Velocities

The valve shall be selected to operate within the following velocity boundaries:

(a) The minimum steady state velocity shall be determined on the basis of the critical velocity, V_0 required to fully open valve, based on the valve inlet diameter, D_i.

V_0 shall not exceed 0.8 times the minimum steady state velocity of the pipe. Preferred values of V_0 are between 0.7 and 0.8. Lower values of V_0 are to be avoided.

(b) The maximum steady state velocity in the valve shall not exceed 5.0 m/s

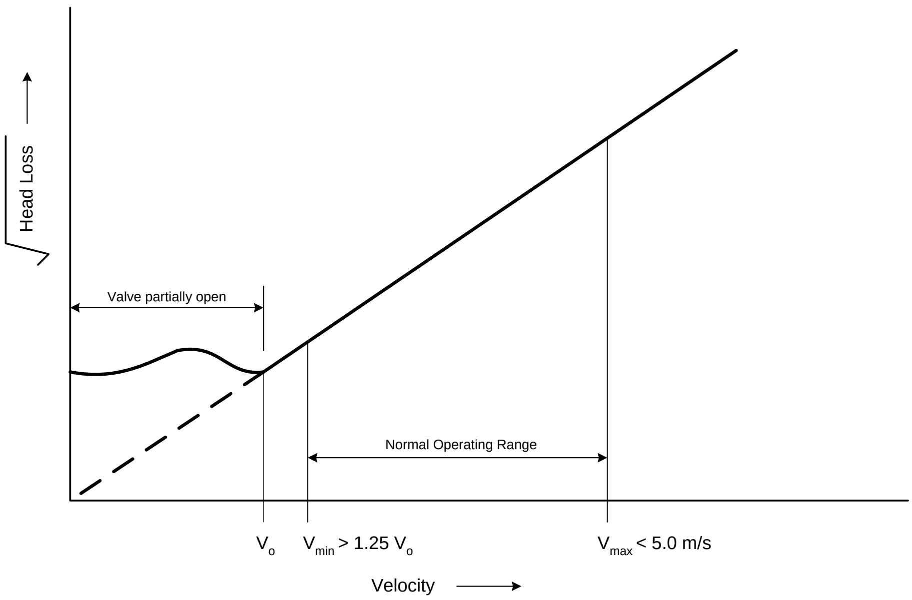


Fig 7.1 – Flow Velocities

NOTES:

1. It is expected that the flow velocities in the system may vary depending on the system design (refer Purchasing Schedule – Table 11.1). Valve size selection will be greatly influenced by the flow velocities through the valve, and it expected that the valve size will be less than the pipeline nominal diameter.

2. In applications where the system deceleration is high, the valve configuration is likely to include high strength springs to increase the valves dynamic response to system deceleration. Care must be taken to not oversize the valve and thus cause the valve to operate in a partially open condition.

7.6.6.2 Dynamic Response

The valve shall be selected to produce a dynamic response to rapid flow reversal that:

(a) Is sufficient to limit any reverse flow to a value which will keep the transient pressure rise to an acceptable level (see below); and,

(b) Will limit slamming of the valve moving element on its seat so that the seats have a long, maintenance-free life under the specified service conditions.

The dynamic response of the valve to various system decelerations shall be described in the form of a tabulation and a graph (for the particular valve to be supplied) of the resulting reverse velocity, V_R through the valve caused by the system deceleration,

The tabulated values shall be verified results of type tests carried out by an accredited hydraulics laboratory and shall be provided by the Supplier.

7.6.6.3 Acceptable Reverse Velocities

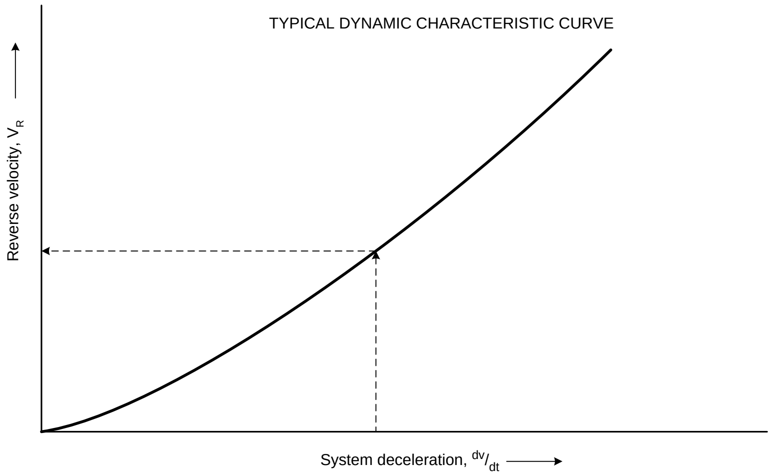


Fig 7.2 – Acceptable Reverse Velocities

The acceptable *reverse velocity*, V_R shall be determined as follows:

1. The transient pressure rise that is caused at valve closure added to the system pressure at the time of valve closure shall not exceed the allowable operating pressure of the valve.

2. The *reverse velocity*, V_R shall not exceed the following values:

Table 7.6 - Operation versus Reverse Velocity Relationship

Operation	Environmentally sensitive locations	Remote locations
Normal steady state operation	0.15 m/s	0.20 m/s
Less frequent operation (<10% of time)	0.20 m/s	0.25 m/s
Infrequent operation (≤ 1% of time)	0.25 m/s	0.30 m/s

NOTES:

V_0 = Critical water velocity based on D_i required to fully open valve – m/s

V_R = Reverse water velocity based on D_i at the point of valve closure – m/s

Di = Valve inlet diameter or throat diameter (if tapered) – m/s

7.7 Single-Spring Flap Type Non-Return Valve

7.7.1 General

The single-spring flap type non-return valve is a compact valve that employs a spring loaded disc that is hinged at the top of the valve allowing it to swing away or towards a vertical body seat. The disc can swing out of the flow in the fully open position providing a clear waterway and minimal pressure drop. Swing check valves have a relatively low-pressure drop compared with some other valves with correspondingly low K values. The body waterway is not full-way being reduced at hinge area. Valves are available in metal or resilient seat.

Swing check non-return valves are available in the following types:

(a) Wafer style cast iron body with lever and counterweight option.

(b) Flange style cast iron body with lever and counterweight option.

7.7.2 Applications

Single-spring flap type non-return valves should be used for general purpose, clean water applications only. Features of single-spring flap type check non-return valves are detailed in the following table.

Table 7.7 Features of Single-Spring flap Type Non-return Valves

Features	**Wafer**	**Flanged**
Size range	DN 100 – DN 1000	
Pressure/PN	PN 16	PN 16, 21, 35
End connections	Wafer – installed between flanges	Flanged
Body style (Bulky or compact)	Compact	
Head loss	Low	
Orientation	Horizontal or vertical	
Flow control functionality	Yes	
Termination style	No	Yes
Complexity	Simple	
Ease of maintenance	Simple	
Low head sealing	Good	
Drip tight sealing	Yes	
Direct burial	No	
Water hammer susceptibility	Spring assistance provides low – moderate susceptibility	
Maintenance	Refer Note	
Noise	Low – moderate	

NOTE: Hinge wear, corrosion of cast iron, severe tuberculation of cast iron wetted surfaces may occur if not properly coated, and resilient seats can dislodge.

7.7.3 Materials

Cast iron bodies should not be used unless they are provided with a good quality coating to prevent tuberculation.

7.7.4 Design Criteria

(a) For vertical pipelines the valve shall always be oriented with the disc opening upwards i.e. pressure is below the seat.

(b) Flanged non-return valves shall not be used to carry the weight of the pipeline.

(c) Single flap swing check valves should sized to enable the disc to attain the fully open position to ensure stability and reduce wear. It may be necessary to size the valve below the pipeline size to achieve this. Oversizing should be avoided as the valve will drop into the flow, which may produce turbulence induced oscillations producing severe and premature wear of the spindle and bushes.

(d) Single-spring flap type non-return valves are sensitive to flutter with associated hinge wear and spring failure and therefore should be installed a minimum of 4 – 5 pipe diameters of straight pipe away from a pump discharge or turbulence causing device.

7.8 Swing Check Non-Return Valve

7.8.1 General

Is a non-return valve that employs a disc that is hinged at the top of the valve allowing it to swing away or towards an angled body seat. The disc can swing out of the flow in the fully open position providing a clear waterway and minimal pressure drop. Swing check valves have a lower pressure drop than other valves with correspondingly lower *K* values.

Swing check non-return valves are available in the following types:

(a) Copper alloy

(b) Cast iron body type with metal disc

(c) Cast iron body type with resilient disc

7.8.2 Specification

The copper alloy type non-return valve shall comply with SPS 220. The cast iron body type non-return valve, comprising either metal or resilient disc and hinge assembly, shall comply with SPS 223.

7.8.3 Application

Swing check non-return valves are suitable for water and sewage (Note - copper alloy non-return valves shall not be used in sewage).

For very large sewage pump stations alternative non-return valves may have to be considered in lieu of the swing check type. Alternatives such as relatively quick closing electrically or hydraulically operated gate valves or plug valves, with pneumatic back up in the event of power failure may be required. Piston damped swing check non-return valves are also available but are relatively expensive in large sizes.

7.8.4 Features

Physical features of swing check non-return valves are detailed in the following table.

Table 7.8 Features of Swing Check Non-return Valves

Specification	Copper Alloy	Cast iron Body Metal disc	Cast iron Body Resilient disc
Size range	DN 15 – DN 50	DN 80 – DN 900 (Refer Note)	DN 80 – DN 250
Pressure/PN	PN 14, 21	PN 16, 35	PN 16
End connections	Screwed and flanged	Flanged	Flanged
Body style	Bulky		
Head Loss	Low		
Orientation	Horizontal or vertical		
Flow control functionality	Not available	Yes Counterweight	Yes Position sensor
Termination style	Yes		
Complexity	Simple		
Ease of maintenance	Simple		
Low head sealing	Poor	Poor	Good
Drip tight sealing	No	No	Yes
Direct burial	No	No	Yes
Water hammer susceptibility	High		
Maintenance	Hinge wear	Hinge wear	Low maintenance
Noise	High	High	Medium - low

NOTE: Larger sizes are available but would be specials and alternative solutions may be better in terms of reduced slamming and cost e.g. motorised gate or plug valve.

7.8.5 Design Criteria

(a) Swing check non-return valves should be sized to enable the disc to attain the fully open position to ensure stability and reduce wear. It may be necessary to size the valve below the pipeline size to achieve this. Oversizing should be avoided as the valve will drop into the flow, which may produce turbulence induced oscillations producing severe and premature wear in the linkages, bearings and spindles.

(b) Copper alloy swing check non-return valves should be used in conjunction with gate valves not globe valves.

(c) For vertical pipelines the valve should always be oriented with the disc opening upwards i.e. pressure below the seat.

(d) Vertical orientation should not be used for sewage application, as debris is likely to settle on the disc causing fouling of the seat and leakage.

(e) Fluid velocities should be low and non-pulsating otherwise hinge wear will be excessive.

(f) Swing check non-return valves should not be used where water hammer is likely.

(g) The non-return valves shall not be used to carry the weight of the pipeline.

(h) Swing check non-return valves are particularly sensitive to flutter with associated hinge wear and therefore should be installed a minimum of 4 – 5 pipe diameters of straight pipe away from a pump discharge or turbulence causing device.

7.9 Tilting Disc Non-Return Valve

7.9.1 General

Is a type of swing check non-return valve that has its disc pivoted in front of the centre of pressure and is counterweighted on the shaft to close. The disc pivots in the valve waterway and incorporates an aerofoil shape that lifts or floats it thus providing minimum resistance to flow. The disc is balanced such that it will close just before flow has ceased and reverse flow commences. The disc swing geometry and seat angle provides conical seat lift valve type closure.

Characteristics of this valve are low-pressure drop at low flows and rapid response to flow reversal producing a smooth and silent operation under all conditions. They are not suitable for sewage and tend to resist opening when operating at low heads or with age, probably associated with wear. The Corporation has opted to use alternative non-return valves to the tilting disc.

7.9.2 Specification

The tilting disc non-return valves are detailed AS 4794.

7.9.3 Application

Tilting disc non-return valve are only used in clear water applications and are not suitable for sewage.

7.9.4 Features

Physical features of tilting disc non-return valves are detailed in the following table.

Table 7.9 Features of Tilting Disc Non-return Valves

Specification	Tilting Disc Non-Return Valve
Size range	DN 300 – DN 900
Pressure/PN	PN 16, 35
End connections	Flanged
Body style (Bulky or compact)	Compact
Head loss	Low
Orientation	Horizontal
Flow control functionality	Yes – Counterweight
Termination style	Yes
Complexity	Simple
Ease of maintenance	Simple
Low head sealing	Not suitable
Drip tight sealing	Yes
Direct burial	No
Water hammer susceptibility	Low
Maintenance	Hinge wear
Noise	Medium-low

7.9.5 Design Criteria

(a) Fluid velocities should be low and non-pulsating otherwise hinge wear will be excessive.

(b) Tilting disc non-return valves should not be used where high water hammer is likely.

(c) The non-return valve shall not be used to carry the weight of the pipeline.

(d) Tilting disc non-return valves are sensitive to flutter with associated hinge wear and therefore should be installed a minimum of 4 – 5 pipe diameters of straight pipe away from a pump discharge or turbulence causing device.

8 MISCELLANEOUS VALVES AND APPURTENANCES

8.1 Air Vent

Manual air vent valves should be provided on pumps that don't naturally vent. This is in order to release accumulated air particularly during initial priming during commissioning or after servicing.

Automatic air vent valves should be provided if accumulation of air is an ongoing problem or on borehole pump headworks immediately downstream of the discharge bend to allow backflow of water in the column to the rest water level and expulsion of air during start-up. The valve should be a rapid response (anti-shock) kinetic type as described in the Air Valves section of this Standard.

8.2 Bypass Valves

8.2.1 External Bypass

Bypass valves shall be fitted around isolating valves such as gate and butterfly valves where unbalanced head conditions are likely to occur e.g. during filling of pipelines and manifolds etc.

Bypasses are not normally fitted on isolating valves for pump suction and discharge pipework as the valves can normally be operated under balanced flow conditions e.g. by shutting down the pump. They are also not fitted around dam guard valves.

Bypass valves for pressure class PN 16 service should be resilient seated gate valves in accordance with SPS 272.

Two bypass valves shall be fitted, one either side of the main isolating valve on flanged pipework stubs with a connecting bypass pipe between them. This allows the bypass to be readily dismantled for servicing. Use of two valves allows the upstream valve to act as an isolating valve and the downstream valve as sacrificial. On heads above 100 m a third valve shall be used on bypasses to act as a sacrificial valve which results from cavitation damage. The third valve would be fitted on the bypass between the other two bypass valves. This allows the third valve to be replaced by closing the valves on the stubs and without shutting down the main.

Bypass requirements are summarised in the following table.

Table 8.1 - Bypass Requirements for Pipelines

Size/Number	**Bypass Requirements**	
	PN 16	**PN 21 and 35**
For all pipeline sizes	≥ DN 400	≥ DN 300
Bypass valve size	• DN 100 for DN 600 pipeline and smaller • DN 150 for DN 700 pipeline and larger	
Number of bypass valves required	• Heads < 100 m – 2 bypass valves shall be required • Heads > 100 m – 3 bypass valves shall be required (centre valve sacrificial)	

A pressure tapping should be provided for all bypasses installed in a valve pit.

8.2.2 Integral Bypass Valves

Gate valves (≥DN 450) are available configured with an integral bypass utilising a single bypass valve however they would have limited use in Corporation applications because:

(a) On water supply applications the use of waterworks butterfly valves are favoured over gate valves because of lower capital and installation costs.

(b) Use of a single bypass valve (generally DN 80) does not meet the Corporation standards as shown in the above table.

(c) For wastewater applications there may be the odd occasion where an integral bypass gate valve would be suitable. For pump isolation purposes however a bypass is not normally required because the pumps can be taken off line so that operation of the isolating gate valve is under balanced head conditions.

8.3 Fire Hydrants

8.3.1 General

Hydrants are required on Corporation reticulation mains in accordance with the requirements shown in the “Water Supply Reticulation Manual”.

Hydrants are installed on Corporation reticulation mains for use by the WA Fire Brigade. The Corporation also utilises the hydrants for its own operational purposes e.g. scouring and flushing of mains etc and maintains them. The Corporation also allows approved contractors to access water from its mains via the hydrants and metered hire standpipes.

8.3.2 Screw Down Versus Spring Hydrants

The Corporation has specific requirements with respect to fire hydrants. Only the Corporation style screw down type fire hydrant shall be used on its assets. Spring type hydrants shall not be used. The screw down hydrant incorporates the following desirable features:

(a) A positive valve closure that only allows the valve to be opened when the spindle is operated. This means the valve is positively closed for most of its life e.g. 99.9%.

(b) A large jumper valve that provides backflow protection in the event of low upstream pressure in the main.

The above features represent an advantage over the standard spring hydrant as follows:

(a) A spring hydrant relies totally on the spring force to keep the valve closed. Spring hydrants tend to suffer leakage for various reasons often producing a puddle in the immediate vicinity.

(b) Tests by the Corporation have demonstrated that a spring hydrant will open under a negative head of 5.5 m that would potentially allow backflow of contaminants into the main, particularly if the hydrant had been leaking.

(c) During operation the hydrant mushroom valve is held in the open position by the standpipe screw so that in the event of low upstream pressure backflow into the mains would possible.

8.3.3 Specification

Screw down hydrants shall comply with SPS 292.

8.3.4 Applications

Fire hydrants are used on water supply or clear water applications.

8.4 Magnetic Flowmeters

For design and installation of magnetic flowmeters refer to DS 25-01.

8.5 Mechanical Flowmeters

Definitions of volumetric and helical vane water meters are contained in the Glossary in DS 30-01.

8.5.1 General

The Corporation uses the following two types of mechanical water meters namely:

(a) Volumetric (or semi-positive),

(b) Helical vane (also referred to as turbine or inferential).

Both types of water meters shall comply with AS 3565.1

Meters are water lubricated and should not be run dry for long periods (as can occur when pressurized pipe contains large pockets of air).

Meters are available for remote reading but the Corporation has not taken advantage of this feature at this stage however the matter may be considered for large commercial customers.

DN 40 and DN 50 volumetric chamber meters are relatively expensive compared to helical vane meters which now tend to be favoured, however volumetric chamber meters still predominate in terms of numbers in the field for Corporation water services.

Meters greater than DN 40 should incorporate a:

(a) Dismantling joint;

(b) Downstream isolating valve to allow removal of the meter for servicing;

(c) Temporary bypass to maintain supply for critical industrial and commercial processes.

8.5.2 Volumetric Chamber Meters

Volumetric chamber water meters are available in sizes DN 20, DN 25, 40 and 50 and are used for consumption measurement for revenue purposes. The Corporation uses DN 20 meters for measuring domestic water consumption and the larger sizes for commercial water consumption. Master meters are also used on Corporation facilities for potable water usage measurement e.g. sewage pump stations.

Volumetric meters have screwed connections for sizes DN 20 and 25 and flanged connections for larger sizes.

Volumetric chamber meters shall have a stop tap or a meter ball valve fitted upstream of the meter.

Domestic water meters are fitted with dual check valves to provide a measure of backflow prevention.

8.5.3 Helical Vane Meters

Helical vane water meters used by the Corporation are cast iron bodied available in sizes DN 40 to DN 150 although sizes up to DN 500 are available. They are used for consumption measurement for revenue collection purposes and Corporation data acquisition e.g. on bore headworks for abstraction measurement.

Helical vane meters may be installed in the horizontal, inclined or vertical positions without loss of accuracy. Sizing with respect to the flow range may allow installation of a smaller meter diameter than the pipeline than the adjacent pipeline.

To ensure optimum accuracy, particularly when flows approach the maximum continuous meter flow rating, a straight length of pipe equal to 10 times the nominal meter size shall be fitted to the meter upstream and 5 times the nominal meter size downstream.

8.6 Level Control Ball Float Valves

Process pipework incorporating level control ball float valves shall be provided with the following end connection:

(a) DN 50 and smaller shall be threaded to ISO 7.1 for sealing threads

(b) DN 65 and larger shall be flanged to AS 2129 Table E.

For tank feed lines larger than DN 150 a remote control ball float valve should be used which incorporates a small diameter ball float which acts a pilot valve.

8.7 Bourdon Tube Pressure Gauges for Water Service

8.7.1 General

In order to optimise the life of bourdon tube pressure gauges (gauges) for water services the following requirements are recommended:

(a) Gauges should not be exposed to continuous vibration and pressure fluctuations, or extreme temperatures;

(b) Permanently mounted gauges should be installed remotely from vibrating machinery via flexible tubing;

(c) Maximum steady pressures (MSP) should not exceed 75% of the maximum scale rating (MSR);

(d) Gauges should not be exposed to pressures in excess of the MSR;

(e) Preferably gauges should only be fitted when monitoring or testing is to be conducted;

(f) If permanently installed the gauge isolating valve should be closed until a reading is required;

(g) If gauges are required for continuous monitoring they should be glycerine filled to provide vibration and pressure damping;

(h) Gauges should be installed in the upright position.

8.7.2 Technical requirements

Pressure gauges shall comply with the relevant requirements contained in AS 1349 relating to industrial pressure gauges for water service and following:

Accuracy:	Per clause 4.1.2 of AS 1349 e.g. 100 mm dial ±1.0% of MSR in the working range >10% to<90% of MSR	
Bourdon tube:	Grade 316 stainless steel	
Case and bezel:	Minimum grade 304 stainless steel	
Connection:	External taper thread in accordance with AS/ISO 7.1 as follows:	
	ISO 7 – R 1/4 for 63 mm dial; ISO 7 – R 3/8 for 100 mm dial	
Dial size:	63 mm (Note 1); 100 mm, 150 mm	
Dial marking:	270º black marking on a matt white background	
Immersion rating:	IP 65	
Scale ranges:	0 – 1600 kPa (for MSP of 1200 kPa)	- PN 10
	0 – 2500 kPa (for MSP of 1900 kPa)	- PN 16
	0 – 4000 kPa (for MSP of 3000 kPa)	- PN 21, PN 25
	0 – 6000 kPa (for MSP of 4500 kPa)	- PN 35, PN 40

Scale graduation: Directly in kilopascals

Medium: Water

Mounting: Direct mount bottom entry (refer Note 2)

Movement: Grade 304 stainless steel

Type: Industrial

Vibration and pulsation protection: Glycerine filled case

Window: Laminated safety glass for 100 mm or larger dial

NOTES:

1. 63 mm is less preferred because it is not as accurate as larger dial sizes e.g. ±3% of MSR
2. Direct mounting is the normal mounting arrangement but surface mounting or flush mounting type pressure gauges can be used as required.

8.8 Penstocks

8.8.1 General

A penstock is a single faced valve comprising a sliding rectangular or circular gate or door that moves vertically or horizontally between guides attached to a frame. The frame is fixed to a wall or bulkhead.

Penstocks are usually fitted to channels or within tank structures. They are designed to operate against pressure or against off-seating pressure or a combination of both.

Penstocks are generally used for controlling large volumes of water or sewage at low head. Modulating penstocks are used for controlling flow rates and levels.

8.8.2 Penstock Types

Penstocks with parallel guides provide uni-directional sealing that is dependent on resultant fluid pressure.

Tapered guides provide a wedge effect between the frame and guide to produce bi-directional sealing for off-seating pressures.

The penstock frame is fitted with a resilient seal against which the gate or door sealing face is forced via either upstream pressure or under the action of the tapered guides. Pressure actuated sealing is generally more effective than off-seating sealing.

Wall mounted frames are either flush-invert or chased-invert types.

Penstocks are either rising or non-rising spindle types. The rising spindle type has the bottom of the spindle attached to the top of the gate or door. Rising spindle types are not subject to immersion and are easier accessed for lubrication. Non-rising spindles operate through a nut fitted to the top of the gate or door and are generally subject to immersion. Actuation is normally manual, electric or pneumatic

Materials available are cast iron, laminated plastic and stainless steel. Problems have been encountered by the Corporation with severe corrosion of cast iron penstocks in sewage pump stations subject to sulphides and also from delamination of plastic types. Accordingly all 316 stainless steel penstocks should be used for wastewater applications.

8.8.3 Design Criteria

Penstocks in wastewater treatment plants should:

(a) Be able to be serviced live so that process flow should be stopped either by stop logs upstream or other means,

(b) Incorporate in-situ replaceable seals,

(c) Have minimal leakage

(d) Incorporate high quality limit switches that can withstand corrosive conditions or proximity switches in lieu of limit switches

(e) Where powered actuation is required it should be electric with pneumatic backup in the event of power failure.

The preferred width to depth ratio is 2:3 for vertical type and 4:3 for the horizontal type. A partially open penstock is equivalent to an obstruction in an open channel through which fluid accelerates with a free liquid surface, which is equivalent to a weir. Accordingly the flow rate is proportional to the penstock width and the velocity head and can be represented by the following relationship:

$Q = 0.7A\sqrt{2gH}$

Where: Q = Flow rate in m^3/s

A = Area in m^2

H = Head in m

G = Gravitational constant

8.8.4 Reference Standards

Penstocks shall be manufactured and tested in accordance with SPS 295.

8.9 Scour Valves

8.9.1 General

Scour valves are fitted at low points on pipework in order to drain the pipelines for maintenance and other purposes. Scour or drain valves are fitted to suction and discharge pipework in large drywell sewage pump stations in order to drain the pipework prior to dismantling for maintenance purposes, usually associated with removal of pumps and non return valves.

Where possible the scour valve fitted to the discharge pipework should discharge back into the wet well or suction side to avoid large volume spillage into the pump station dry well.

Scour valves for water supply applications shall be configured in order to prevent the possibility of it presenting a backflow hazard by allowing contaminants to enter the pipeline.

8.9.2 Valve Sizing and Specification

The following table details the normal scour valve size with respect to pipeline sizes and relevant product specification:

Table 8.2 – Scour Valve Sizing and Specification

Main Size – DN	Scour Valve Size	PN	Valve Specification
≤ DN 600	DN 100	16, 25 35	SPS 272 SPS 271
≥ DN 700	DN 150	16, 25 35	SPS 272 SPS 271

NOTES:

1. PN 16 and 25 valves shown are resilient seated gate valves.
2. PN 35 valves shown are metal seated gate valves
3. High-pressure scour valve applications may require a special design to minimise damage to the valve and environment due to high-energy release.

8.10 Vacuum Interface Valve

8.10.1 General

The vacuum interface valve (valve) is an automatic isolating valve that operates using vacuum and interfaces between a sewage collection chamber and a vacuum sewage collection system. The sewage collection chamber receives sewage from the households. The valve incorporates a sensor that detects the sewage levels and at a preset level fires the valve via a controller. The valve opens and allows the vacuum from the system downstream to empty the collection chamber. The resulting low level in the chamber initiates valve closure.

8.10.2 Features

The design features for vacuum sewage valves are particularly important because the Corporation has experienced orders of magnitude increases in whole-of-life costs using valves with inferior design.

The valve should incorporate the following basic features:

(a) Piston type with straight-through lower housing and coincident inlet and outlet centrelines;

(b) Non-clog design;

(c) DN 80 size;

(d) Incorporate a sensor and controller to initiate and control valve operation;

(e) Suitable for a normal vacuum operating range between 50 kPa and 80 kPa;

(f) Constructed from corrosion resistant materials;

(g) Designed for access to the valve seats and waterway by removal of the piston housing using a quick decoupling method, by an operator without tools;

(h) Incorporate an in-sump breather;

(i) Have a throughlet of 100% of the valve nominal diameter for passage of solids;

(j) Connections readily demountable with reusable ‘No-hub’ couplings and fittings;

(k) A controller that incorporates:

  (i) a quick-release no tools mechanism for removal from the body,

  (ii) has a clear plastic body, and

  (iii) self-purging characteristics.

8.10.3 Specification

The valve shall comply with SPS 245 which is based on AS 4310.

9 APPENDIX A: BUTTERFLY CAVITATION

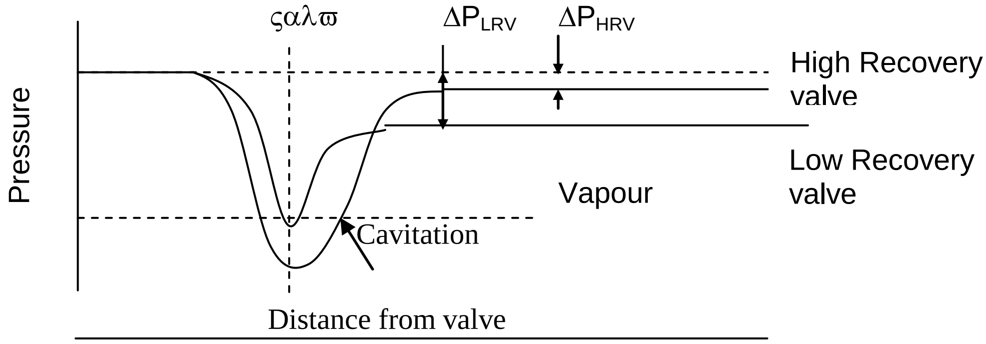
9.1 Butterfly Valve Cavitation (Informative)

9.1.1 General

The following information is provided as a guide for circumstances where butterfly applications are likely to be subject to cavitation.

Butterfly valves are particularly susceptible to cavitation compared with other control valves because they have high recovery characteristics. High recovery valves tend to be more efficient than low recovery valves with a relatively small pressure differential ΔP across the valve. However, the low frictional losses produce increased velocities and larger pressure drops at the valve opening. Hence for a given inlet pressure, the pressure is more likely to decrease below the vapour pressure and cause cavitation, as indicated in the following figure.

Fig 9.1 – Cavitation in Butterfly Valves



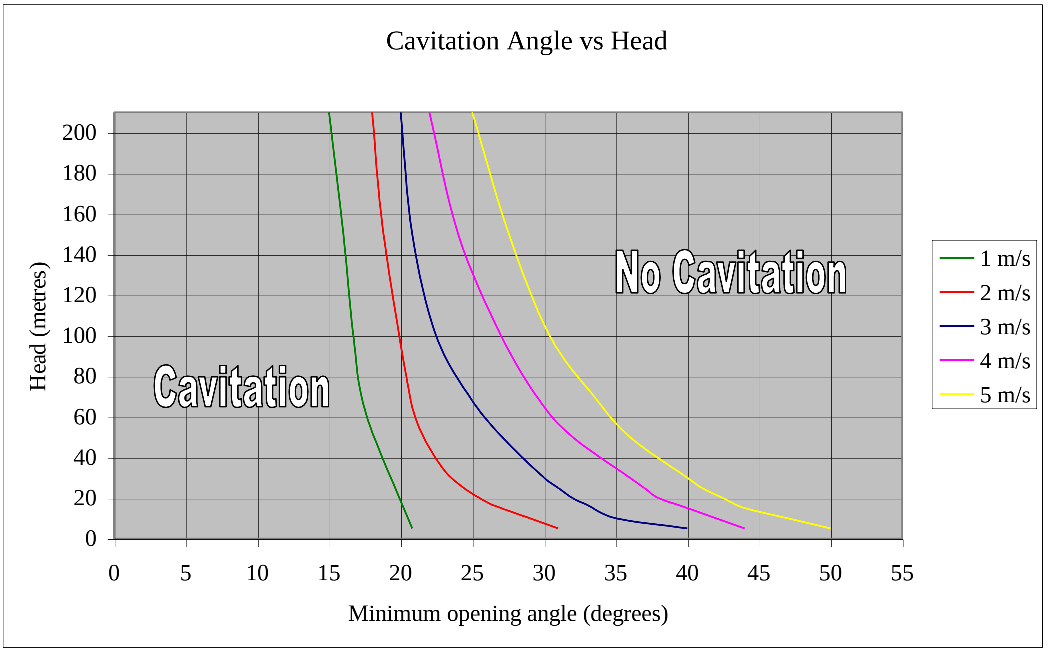
Other examples of high recovery valves are the plug and ball valves. Globe type valves are typical low recovery valves. While globe valves have low efficiency due to high frictional losses, they are less likely to be damaged due to cavitation.

Butterfly valves are often used as control valves to regulate flow. Regulating the flow involves increasing the valve opening to increase the flow or reducing the valve opening to lessen the flow. Cavitation is more likely to occur while throttling the flow at low disc angles because the obstruction of flow causes a rapid decrease in pressure. When the valve angle is reduced, the pressure at the valve will decrease until vapour pressure is reached, and at this angle cavitation will occur.

9.1.2 Valve Diameter Equal to Pipe Diameter

Cavitation occurs on the left side of the curve for various inlet velocities. The following graph indicates that cavitation is more likely to occur when the valve is operating at small opening angles, low pressures and high velocities. This seems reasonable because a large drop in pressure will result from small disc angles, high velocities and low inlet pressures and will be more likely to drop below the vapour pressure of water.

Fig 9.2 – Cavitation Angle for Control Valves



9.1.3 Valve Diameter Equal to 75% Pipe Diameter

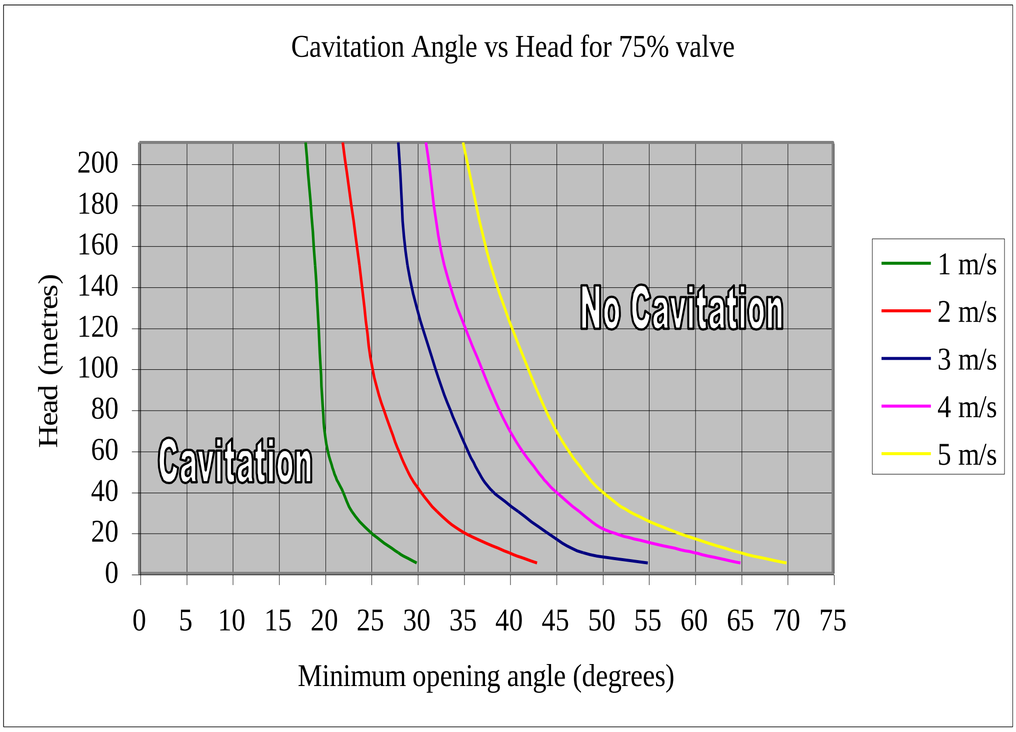
If two valves of equal size have the same inlet flow rate, the valve with the larger pipeline will be slightly more likely to cavitate because the reduction in diameter will increase the velocity at the valve. However, if the velocity is the same for both inlet pipes, the larger inlet pipe will have the higher flow rate.

Hence the larger inlet pipe with its larger flow rate will have a higher-pressure drop and will cavitate more readily. The following graph can be used if the diameter of the valve is 75% of the pipeline and demonstrates the pressure-angle relationship for fixed velocity. The graph assumes that the inlet and outlet pipe diameters are equal.

Note that the velocity given is the velocity of the inlet pipe, so the flow rate will vary with different inlet pipe sizes. Therefore for valves of the same size but different inlet pipe sizes, it is not appropriate to compare angle for cavitation.

When a butterfly valve used for on/off purposes is fully closed there is often a large unbalanced pressure across the disc that can cause cavitation when the valve is opened. Initially, the valve will not cavitate because there is little flow through it. However, as the valve is opened further the flow will increase and cavitation is likely to occur.

Figure 9.3 – Cavitation Angle for 75% Control Valves



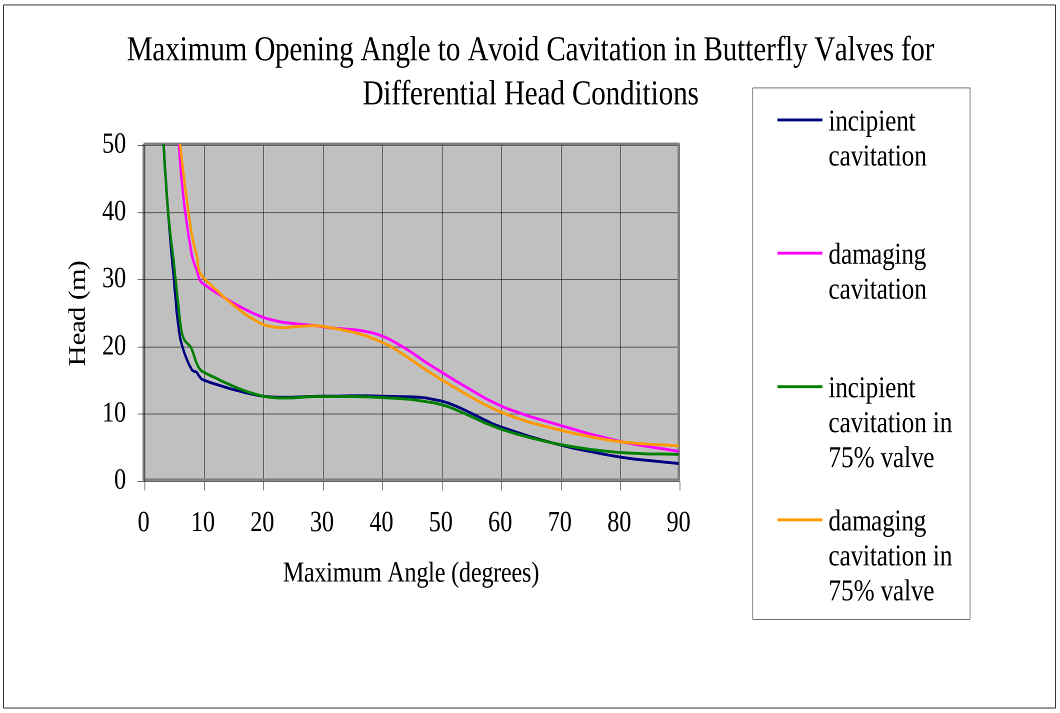
9.1.4 Maximum Opening Angle and Differential Head Relationship

The graph below indicates that there is little difference between a valve that is 75% of the pipe size compared with a valve that is the same size as the pipe.

As they are so similar it would be sufficient to use one graph to describe both situations. Thus when choosing valve sizes slightly smaller valves should be chosen because they are less expensive and do not change the flow significantly.

The graphs can be used in practice to estimate the valve angle that will prevent cavitation. However it is recommended that the curve for incipient cavitation is used, allowing for a further 2 or 3 degrees opening before damaging cavitation occurs.

Figure 9.4 – Maximum Opening Angle versus Differential Head for Butterfly Valves



END OF DOCUMENT