



GUIDELINES

FOR SELECTING VALVES IN WATER SUPPLY SYSTEMS

Pipe Centre
Danish Technological Institute
December 2019



**DANISH
TECHNOLOGICAL
INSTITUTE**

Guidelines for selecting valves in water
supply systems

1. edition 2019

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Keywords: Valves, Pipe Centre guideline

Preface

This guideline has been prepared by Danish Technological Institute, Denmark, at the request of AVK. The guideline was implemented in collaboration with AVK, DANVA (Danish Associations of Water Services) and Aarhus Vand.

The guideline provides general guidance on the considerations to be made in connection with the selection of valves for water supply systems. The guideline covers general considerations. When it comes to the specific function of the individual types of valves, nomograms for pressure loss in bends, valves etc., as well as the installation of individual products, the manufacturer's instructions for installation and maintenance must be followed.

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1 Introduction

The purpose of this guideline is to increase the quality of the selections made regarding valves in waterworks and in water supply networks. It is very important that planners and engineers make the right decisions regarding the selection of valves to reduce the Total Cost of Ownership (TCO) - both in relation to operation and maintenance and in relation to reducing waste in the production (e.g. using less water and energy).

Total Cost of Ownership (TCO) is a calculation method designed to help decision makers to make a more detailed decision than just the costs of establishment. Rather than just looking at the purchase price of an object, TCO looks at the complete costs from purchase to disposal including expected costs to be incurred during the service life of the product, such as:

- Service
- Repair
- Loss of water and revenue
- Downtime
- Claims and insurance
- Unnecessary replacement of products

TCO is factored in the cost-benefit analysis. Today, the focus is primarily on the direct selling price which often does not promote an appropriate long-term solution.

The guideline mainly concerns valves in waterworks and in water supply networks. The main purpose of the guideline is to guide and instruct planners, engineers and contractors, so they select the correct valves in terms of service life, quality, operation etc. This applies primarily to the European, the US and the Chinese markets, but also to parts of Southeast Asia and South and Central America where the valve market is growing fast. There is a worldwide urbanisation going on, and the aim of this guideline is to introduce quality valve solutions and products with a longer service life longer than 50 years.

1.1 Total Cost of Ownership (TCO)

Total Cost of Ownership (TCO) is an estimate of the total costs of goods, services or construction works over the product's complete service life. It is the combination of the purchase price plus all other costs that will incur, less any income you receive. For instance the initial purchase price plus installation costs, operating costs and ongoing maintenance less the residual value on disposal.

1.1.1 TCO is important

The procurement principles encourage to make balanced procurement decisions. This includes getting the best value for money. It means accounting for all costs and benefits over the lifespan of the goods or services.

Part of good procurement is achieving the right price. Best value for money is the lowest total costs throughout the service life of the product. This involves identifying the initial purchase price and estimating all future costs and returns.

A procurement decision based on the initial purchase price only, rather than the total costs throughout the service life, could fail to recognize the real costs of your operations. Often a cheap product can incur high costs during the period of operation.

1.1.2 When should TCO be used?

TCO can be used at various stages of a procurement:

- In a business case to assess the costs, benefits and risks associated with the investment
- When assessing different business models, maintenance options or solutions on a comparable cost basis
- To understand the different cost drivers of the procurement
- By a supplier when bidding for a contract to demonstrate the total benefits and value being offered – especially where the initial purchase price is higher than the competitors', but the total cost of ownership (TCO) is lower
- In selecting the best supplier by assessing the comparative total cost of the competing bids
- In managing the contract to track actual expenses and income against the budget
- As part of a benefits realisation exercise

1.1.3 Identifying costs and benefits

To identify the costs and benefits you need to work through the total life of the acquisition, it must be considered when a cost or a benefit may occur and the value must be estimated. Some costs will be one-off, others will be recurring, so you need to know how many years you intend to use the product, equipment or services.

In some cases, there may be some residual value in the equipment or parts. However, there may also be costs associated with disposal. Examples of types of whole life costs for valve products:

- Purchasing costs, e.g. tender process, delivery costs, installation, cost of change
- Operating costs, e.g. regular maintenance or servicing, breakdown and repair costs, energy
- Disposal costs, e.g. fees for disposal of parts, transportation

Competitors of valve manufacturers can use TCO, because the service life for the best valves can be many years, see the figure below.

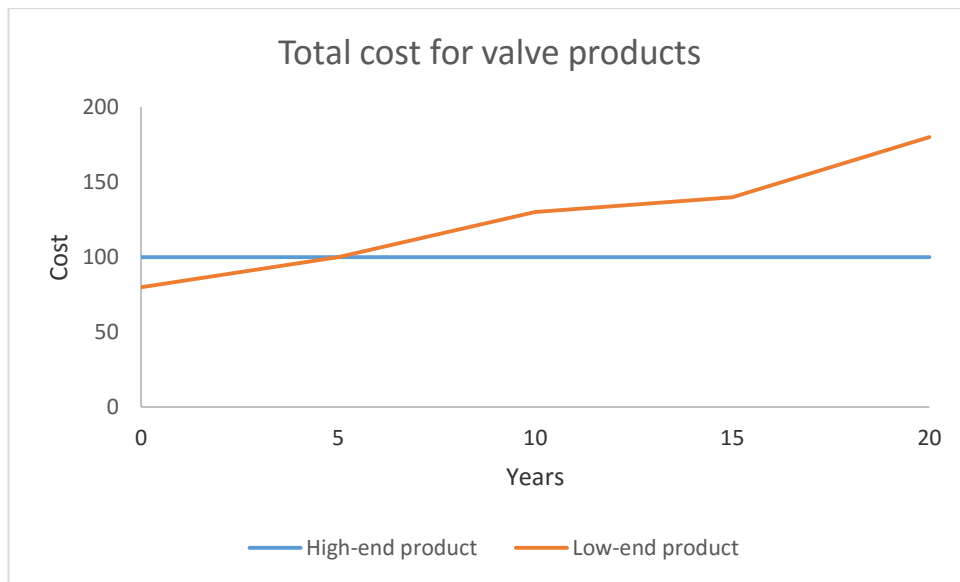


Figure 1.1. TCO can be used for selecting the valve which gives you the best value for money

TCO can be expressed in the equation:

$$TCO = T_{\text{purchase}} + T_{\text{operating}} + T_{\text{disposal}}$$

Read more about TCO in the examples in chapter 5.2.

2 Legislation

2.1 The legislation framework

2.1.1 Environmental legislation

Planners and manufacturers are obliged to ensure that all equipment designed and manufactured for use in a specific country/region shall conform to and is assessed according to the requirements of the standards of the country/region. All relevant standards must be taken into consideration. In European countries all products must comply with the relevant European standards (EN standards). In many other countries ISO standards are used.

Standards

Standards are developed according to a set of rules and procedures, providing consensus amongst many parties and countries and are published by a neutral party. Standards are mostly used as a reference for design or product criteria.

Guideline

A guideline gives or indicates construction methods meeting the requirements of standards without further documentation.

Specification

A specification is a working document developed by a single entity using content from one or more standards. This information may be altered to meet whatever is needed. Specifications are usually specific for one job and can cover multiple areas and topics, whereas a standard is typically more general. Specifications can include for example non-standard materials and can be easily revised due to having a single author.

2.1.2 The Working Environment Act

All work with valves in connection with waterworks or water supply systems, whether related to operations or construction, must meet the requirements of the Working Environment Act in the specific country.

According to this act, the utility company shall ensure that the enterprise performing the work:

- supervises, so that the work is carried out properly as regards health, safety and working conditions,
- provides the employees with the required training and instructions enabling them to perform the work in a safe way.

The builder/owner may be sentenced to fine or imprisonment if not abiding by the law, also in case of negligence by the employees.

3 Description of valves principles

This guideline covers only the most used valves such as gate valves, butterfly valves, check valves, control valves, hydrants and ball valves. These valves cover 80-90% of valves used in the market.

3.1 Typical use of valves

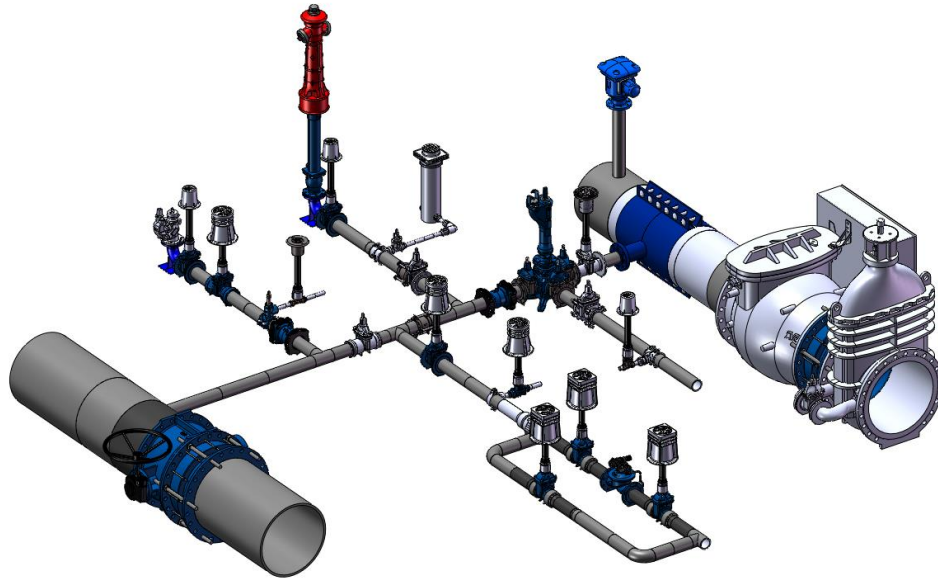


Figure 3.1. Different application areas for valves in water supply systems

Different types and designs of valves also have different application areas. The design and the materials of which the valves are made provide the properties that are essential when selecting an individual valve for a specific task.

Gate valves are typically used as shut off valves on the main and service connection lines in large supply systems buried underground. However, they are also used as shut off valves in connection with main and side lines in water supply systems in buildings.

Butterfly valves are typically used as shut off valves in connection with technical installations, e.g. in distribution centers and in waterworks.

Butterfly valves will normally not be used as shut off valves in supply lines buried underground.

Check valves are used in order to prevent contaminated or drained water from penetrating into the drinking water system. In soil, check valves can e.g. be used in connection with fire hydrants to ensure that contaminated water does not return to the drinking water system.

Check valves are most often used in drinking water installations in buildings, either to ensure that contaminated water from machines and components does not return to the

internal drinking water installation, or at the water meter to ensure that the public water supply is not contaminated.

Control valves are used e.g. in ring connected water supply lines. Control valves ensure a uniform pressure in the piping system. When control valves are used here, they are often placed in a well, so it is possible to maintain them.

Control valves are also used for control of the supply pressure in pressure zones in order to protect the distribution network from unnecessary high pressure.

Fire hydrants are typically placed in the public water supply system for the fire service to use them in connection with fire. In large areas with private buildings, fire hydrants are also placed in the internal private water supply on the site.

House connection valves/ball valves are normally used as shut off valves in front of buildings and private properties. The valves are primarily placed as shut off valves on the service connection pipe from the mainline pipe to the consumer (e.g. as a shut off for an apartment or as a shut off in front of a sanitary component). When using larger valves in the water pipeline network, e.g. on main water pipes, ball valves should be avoided. However, if used, they should have a gearbox as an operating device in order to avoid water hammer.



Figure 3.2. Different valves for use in water supply systems

3.2 Gate valves

Gate valves can be used for all types of applications and are suitable for installations both above and below ground. For underground applications, it is crucial to select the correct type of valve to avoid high replacement costs.

Gate valves are designed for fully open or fully closed operation. They are installed in pipelines as shut off valves and should not be used as control or throttling valves. A gate valve is operated by rotating the spindle either clockwise to close (CTC) or clockwise to open

(CTO). When the valve stem is operated, the wedge moves up or down on the threaded portion of the spindle.

Gate valves are often used when minimal pressure loss and full flow are required. When it is fully open, a typical gate valve has no narrowing in the passage meaning that the pressure loss is very low. Since the cross section of the pipe is not narrowed, it is possible to use a cleaning pig for maintenance. A gate valve is a multi-turn valve meaning that the valve is operated by a threaded spindle. The valve spindle must be rotated several times to move from open to closed position, and this slow operation prevents water hammer.

Gate valves can be used for many different types of applications. Gate valves are suitable under the following conditions:

- Drinking water, waste water and neutral liquids
- Temperatures between -20 and +70 °C
- Max. 5 m/s flow rate
- Up to 16 bar differential pressure

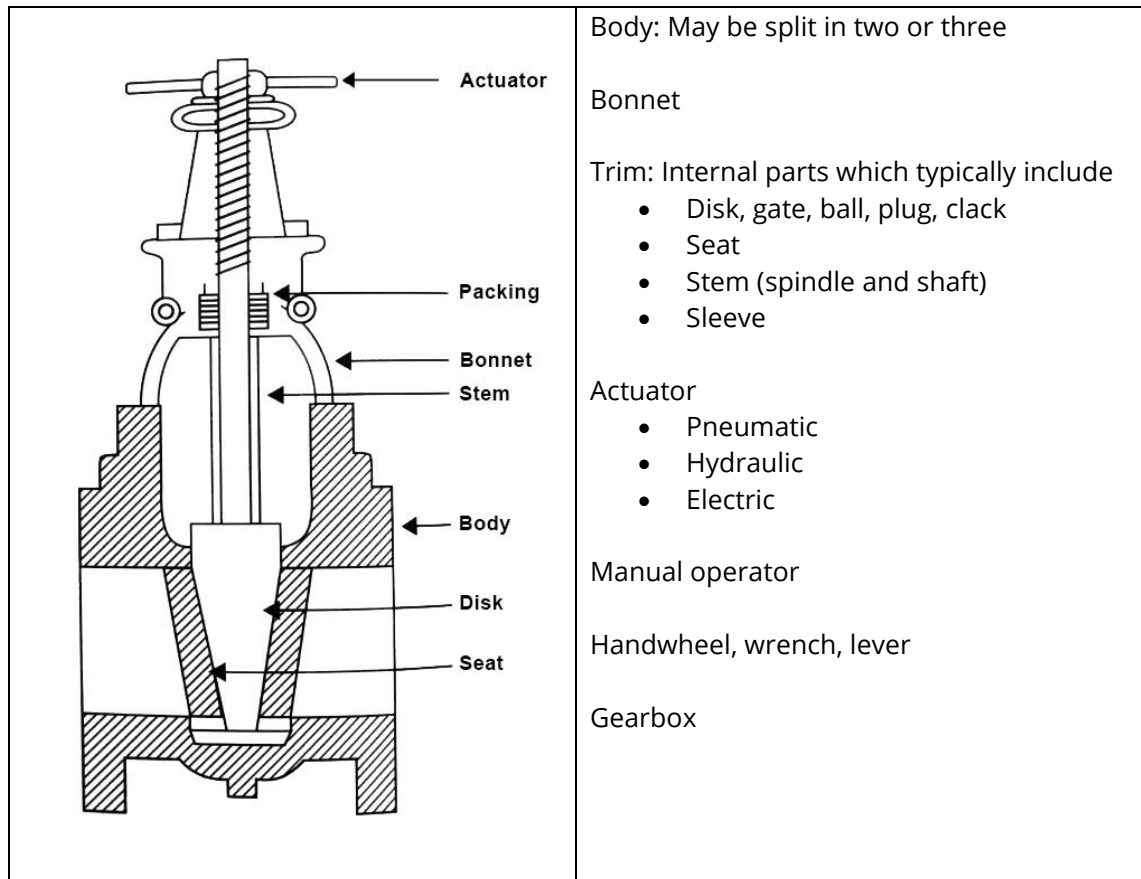


Figure 3.3. Basic parts of a gate valve (resilient seated/metal seated)

Select the right gate valve

Selecting the right gate valve with a robust and durable construction can save many costs of maintenance and repair and prevent high replacement costs.

Five overall selection criteria can help you make the right decision:

1) Design

Wedge: The wedge is the sealing part of the gate valve and therefore very important.

Be aware of the following:

- Wedge nut
- Wedge guide rails
- Wedge shoes

2) Quality (inside materials)

Solidified vulcanized rubber lines must be approved for use in drinking water systems.

Rubber: The rubber quality is important for the durability and function of the valve. The rubber must withstand continuous impact from impurities and chemicals without being damaged. In order to close, the rubber must be able to absorb small impurities.

3) Corrosion protection (inside and outside)

Fully corrosion resistant construction with epoxy coating.

4) Tight construction (under pressure)

5) General function

The valve must be easy to operate.



Figure 3.4. Installation with knife gate valve, ball check valve, swing check valve and gate valves

3.3 Butterfly valves

Butterfly valves can function as shut off valves or as regulatory valves. They can fully shut off the flow or be kept partially open limiting the flow. Controlling flow can be extremely helpful if it is necessary to decrease the pressure in a system. Fluid passing through a small opening will be restricted, making the pressure further down the pipeline lower, depending on how far open the valve is. A butterfly valve can also be used as a typical 90-degree turn valve, just switching between the positions "on" and "off".

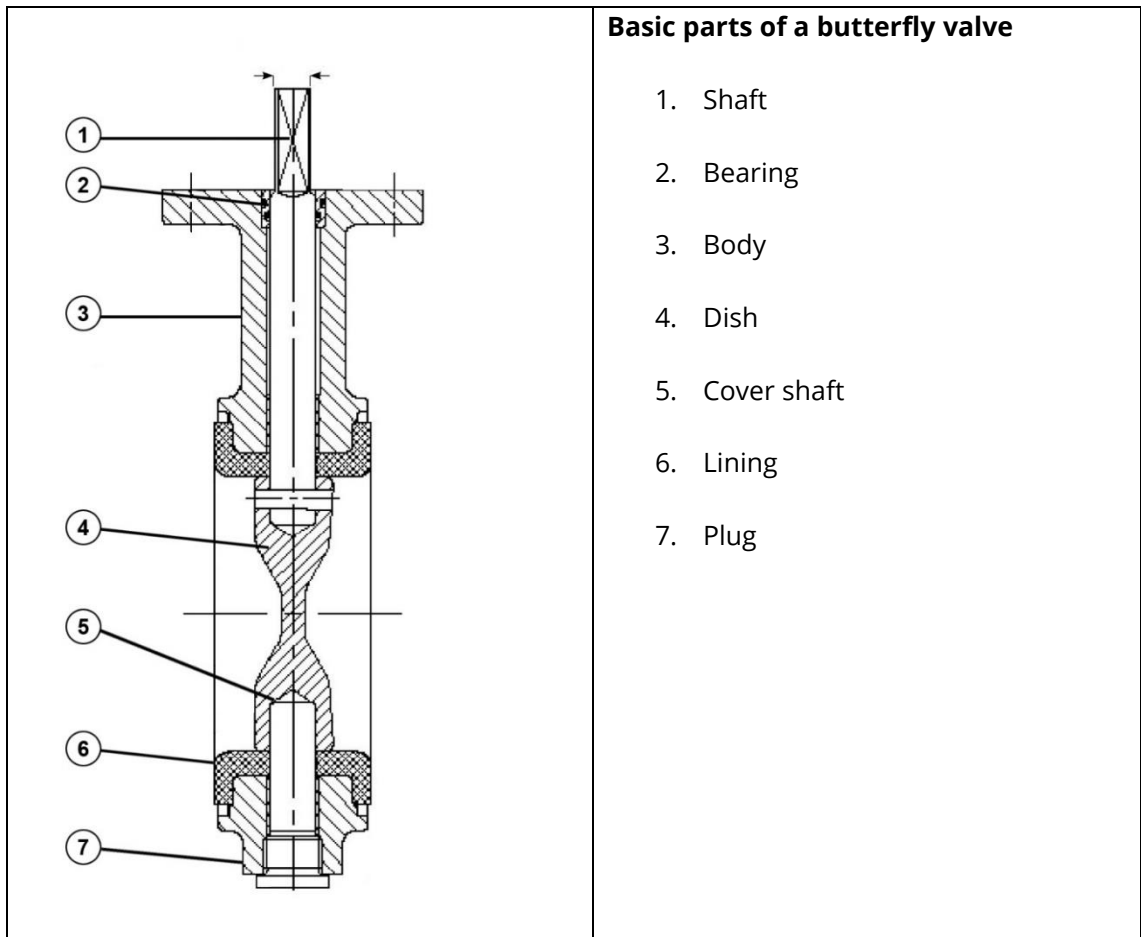


Figure 3.5. Rubber lined butterfly valves

Selecting the right butterfly valve

Selecting the right butterfly valve with a robust and durable construction can save many costs of maintenance and repair and prevent expensive replacement costs.

Five overall selection criteria can help you make the right decision:

1) Design

Seat design

Rubber parts: The rubber quality is important for the durability and the function of the valve. The rubber must withstand continuous impact from impurities and chemicals without being damaged, and in order to close, it must be able to absorb small impurities. Cast iron must be epoxy coated.

2) Quality

Stainless steel: The quality should be at least as EN 1.4404, (316L).

3) Corrosion protection (inside and outside)

Fully corrosion resistant construction with epoxy coating or stainless steel.

4) Tight construction (under pressure)

5) General function

The butterfly valve must be easy to operate.



Figure 3.6. Installation with butterfly valves

3.4 Check valves

Check valves or one-way valves normally allow fluid (liquid or gas) to flow through in only one direction.

Check valves come in many forms. The primary function of a check valve is to prevent backflow. This makes them regulatory valves, as they control the flow direction. Check valves are controlled by the fluid in the pipeline instead of an operator which makes them different from the valves previously described. The two most common types are *swing check valves* and *ball check valves*.

Check valves are two-port valves meaning they have two openings in the body, one for fluid to enter and one for fluid to leave. There are various types of check valves used in a variety of applications. Check valves are also used as backflow protection in consumer installations. They are available in a wide range of sizes and costs. Check valves work automatically, and most valves are not controlled by a person or any external control. Consequently, most check valves are not equipped with a valve handle or a stem. Body material for check valves are most often ductile iron or brass.

An important concept for check valves is the opening pressure which is the minimum upstream pressure at which the valve will operate. Typically, the check valve is designed for - and can therefore be specified for - a specific opening pressure.

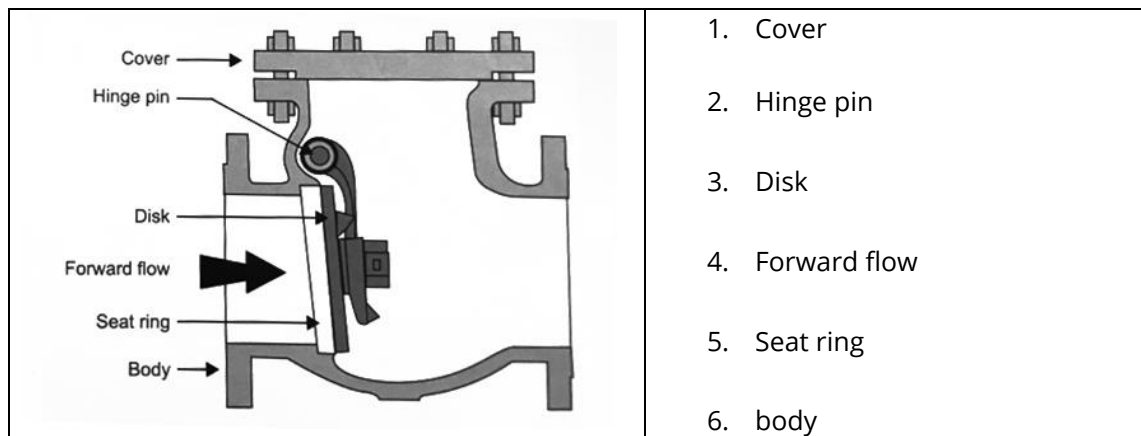


Figure 3.7. Basic parts of a swing check valve

Select the right check valve

Selecting the right check valve with a robust and durable construction can save many of the costs of maintenance and repair and prevent expensive replacement costs.

Five overall selection criteria can help you make the right decision:

1) Design

Protection against backflow, flap, EPDM with steel insert.

2) Quality (inside material)

Select a valve made from an internal material that is resistant to corrosion, has a robust construction and is easy to repair and replace parts.

3) Corrosion protection (inside and outside)

Valve body and top in ductile iron with epoxy coating.

4) Tight construction (under pressure)

5) General function

The valve must have a stable function and a long service life.

3.5 Control valves

A control valve is a valve used to control fluid flow by varying the size of the flow passage directed by a signal from a controller. This enables the direct control of flow rate and the consequential control of process quantities such as pressure, temperature and liquid level. Pilot-operated control valves for pressure reducing applications (PRV) automatically reduce high inlet pressures to lower outlet pressure. The outlet pressure is kept constant even if changes in flow or inlet pressure occur. The control valve is pilot-operated and can be adjusted very accurately with easy adjustment of outlet pressure.

Select the right control valve

Selecting the right control valve with a robust and durable construction can save many costs of maintenance and repair and prevent expensive replacement costs.

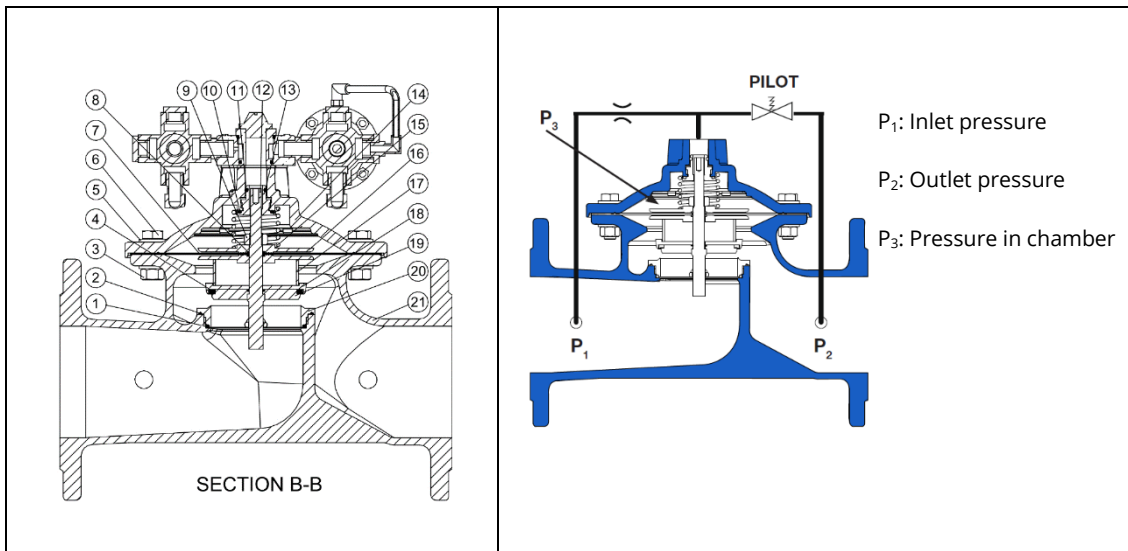


Figure 3.8. Basic parts of a control valve

Five overall selection criteria can help you make the right decision:

1) Design

2) Quality (inside materials)

Select a valve made from an internal material that is resistant to corrosion, has a robust construction and is easy to repair and replace parts.

3) Corrosion protection (inside and outside)

4) Tight construction (under pressure)

5) General function

The valve must have a stable function and a long service life.



Figure 3.9. Hydrant installation with an insulated gate valve

3.6 Hydrants

A hydrant is an outlet from a water supply pipe often consisting of an upright pipe with a valve attached from which fluid (e.g. water) can be tapped.

A fire hydrant is a connection point by which water can be tapped from a water supply system. A top-mounted fire hydrant can be turned 360 degrees and is height adjustable, ensuring easy access and installation. Hydrants which manually drain the water are manually emptied by means of a screw in the bottom flange, which is loosened after use. On the automatically draining hydrant, the water is emptied by opening a drain hole in the bottom part. The hole is automatically opened when the main valve closes the hydrant.

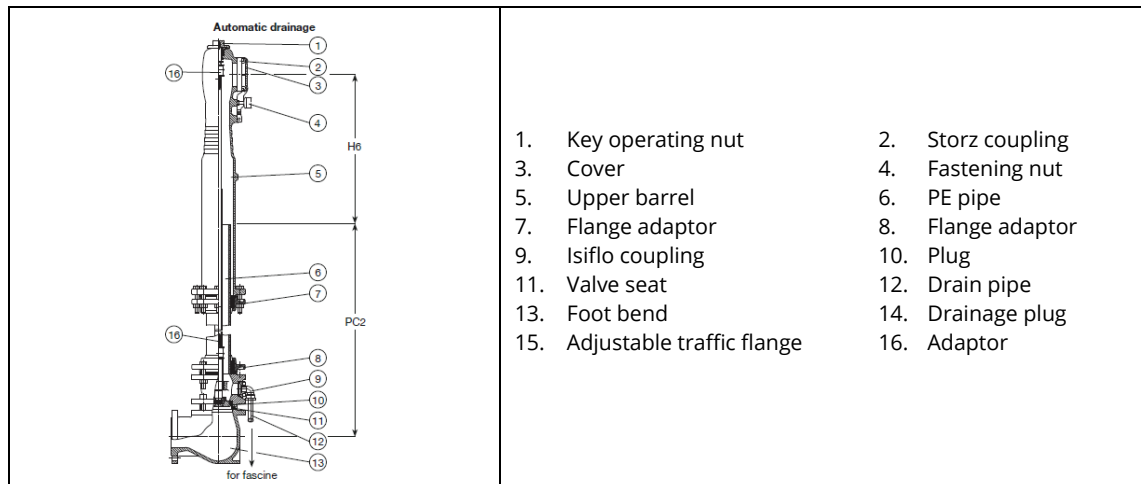


Figure 3.10. Basic parts of a hydrant

Selecting the right hydrant

Selecting the right hydrant with a robust and durable construction can save many costs of maintenance and repair and prevent expensive replacement costs.

Five overall selection criteria can help you make the right decision:

1) Design

Must be designed to protect against leakage in case of traffic damage.

Must be manually or automatically drained and have a protection against unauthorized use.

2) Quality (inside materials)

Telescopic tube of hot galvanized steel.

3) Corrosion protection (inside and outside)

Epoxy coating.

4) Tight construction (under pressure)

5) General function



Figure 3.11. Ball valve

3.7 House connection valves/ball valves

A ball valve is an example of a shut off valve. Ball valves use a spherical seating to stop or allow flow. The ball has a hole through the center, so fluid can pass through when the handle is turned to the "open" position. When the handle is turned 90 degrees to the "close" position, fluid hits the solid side of the ball and is stopped. On some markets, ball valves are also used as house connection valves.

Ball valves are durable as they perform well after many cycles, and reliable as they close securely even after long periods of disuse. These qualities make them an excellent choice for shut off applications where they are often preferred to valves, but they lack their fine control in throttling applications.

Ball valves are easy to operate and repair which leads to extensive industrial use, but they should be avoided in water distribution installations. Valve bodies are made of metal, plastic or metal with a ceramic coating. Floating balls are often chrome plated for durability.

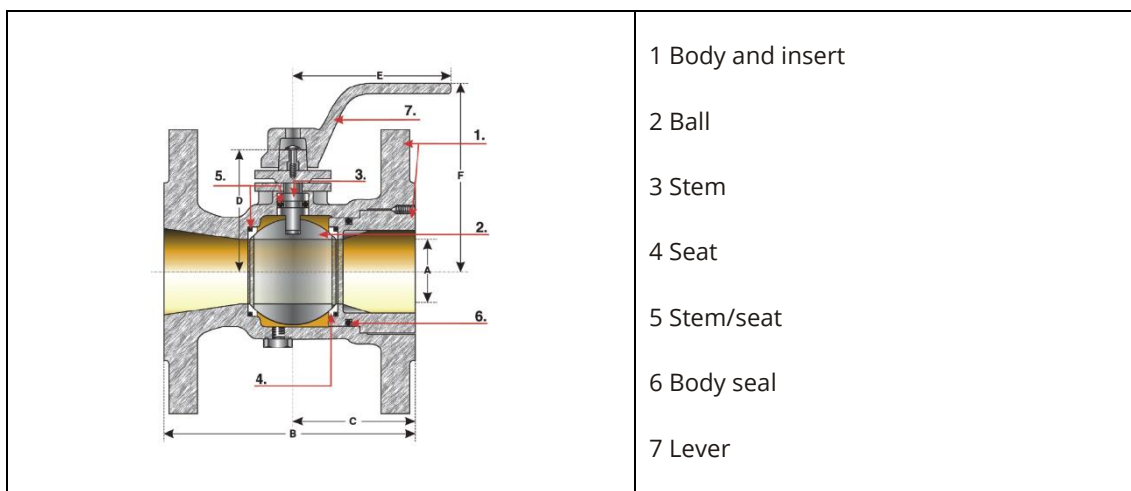


Figure 3.12. Basic parts of a ball valve

Select the right ball valve

Selecting the right ball valve with a robust and durable construction can save many costs of maintenance and repair and prevent expensive replacement costs

Five overall selection criteria can help you make the right decision:

1) Design

- Low pressure loss
- Easy operation

2) Quality (inside materials)

Select a valve made of an internal material resistant to corrosion, has a robust construction and is easy to repair and replace parts.

3) Corrosion protection (inside and outside).

House: epoxy coated; ball: stainless steel (at least as EN 1.4404) and gasket: teflon

4) Tight construction (under pressure)

5) General function

The valve must have a stable function and a long service life.

4 Characteristics of valves

4.1 Materials

The most important parameters for the service life of a valve are the wedge, the coating of the surface and the stem.

4.1.1 Corrosion in general

Corrosion is the gradual deterioration of materials (usually metals) by chemical reaction with the environment. It comes in many different forms and can be classified by the cause of the chemical deterioration of a metal. Corrosion degrades the useful properties of materials and structures including strength, appearance and permeability to liquids and gases. It can be concentrated locally to form a pit or crack (localized corrosion), or it can extend across a wide area more or less uniformly corroding the surface (uniform attack corrosion).

Impurities give rise to increased risk of corrosion of pipe materials and valves. Consequently, drinking water pipes should be thoroughly flushed prior to commissioning at new plants and after major repairs. Materials such as hot-dip galvanized steel, galvanized steel and copper are not applicable in areas where the drinking water has a high content of hydrogen carbonate, because there is a large amount of migration to the drinking water. Migration is also a form of corrosion.

All possible forms of corrosion can take place, all leading to valve failure. These include crevice corrosion at the shaft primary sealing point due to oxygen depletion (stagnant media) which subsequently deteriorates the metals further. This can damage the seals and progressing to secondary shaft seal failure. Finally, media can enter the shaft area where conditions for galvanic corrosion prevail.

If corrosion problems are isolated to the valve only, it is necessary to replace the corroded valve with a valve more resistant to corrosion. This may be expensive, as it may be necessary to close the plant or the production during the replacement.

4.1.2 Materials for valves

4.1.2.1 Ductile iron

A ductile iron valve is a valve that is primarily manufactured using ductile iron, which is iron containing spheroidized free carbon, known as graphite. The high percentage of graphite nodules present in ductile iron provides it with better mechanical properties than other varieties of cast iron.

A good quality valve manufacturer will use qualified foundries to ensure that the base material is correct. Using lower-end foundries may result in defective products due to material failures like porosities or similar fault mechanisms.

4.1.2.2 Brass

Brass is primarily a mixture of copper and zinc, although other metals may be added to give it different properties, including corrosion resistance (more on that later). Brass is considered one of the softer metals used for industrial valves. Brass responds better to higher temperatures than plastics because of the ability to absorb more heat. Brass must be of a corrosion resistant quality, e.g. zinc resistant brass.

4.1.2.3 Rubber

No matter in which industry the valves are used, it is essential that the rubber components inside the valves and couplings are of the highest quality to ensure a safe, watertight seal and trouble-free operation, even after many years without use.

No single type of rubber is universally suitable for all areas of use. Rubber compounds are far more complex than plastic and metal alloys. They are not standardised but are subject to individual formulation. This makes it impossible for users to specify by ingredients, so focus should be on the properties and of course approvals required for the actual application.

In water supply systems the rubber must be resistant to all types of chemicals used in the system. This can be documented by testing according to national and international standards. In water supply systems rubber compound must minimise the build-up of bio-film. This prevents the biofilm from acting as a breeding ground for bacteria. It is also important to ensure that the rubber is odour free, colour free and taste free, even after many years of use.

4.1.2.4 Stainless steel

Because of its excellent corrosion resistance and durability, stainless steel is commonly used in a wide spectrum of applications, ranging from the petrochemical industry to general plant systems. For valves and parts of valves the quality should be at least as EN 1.4404.

4.1.2.5 Plastic (POM)

Polyoxymethylene (POM), also known as acetal, polyacetal and polyformaldehyde, is an engineering thermoplastic used in precision parts requiring high stiffness, low friction and excellent dimensional stability. Typical applications for injection moulded POM include high-performance engineering components such as different kinds of valves.

4.1.2.6 Coating

The purpose behind coating a valve is to extend the service life and reduce friction. The coating can be on the outside of the valve, on the inside or on both sides as in resilient seated gate valves. Coating is primarily applied in order to protect against corrosion.

All cast iron components should be shot blasted before coating. The process ensures an optimum bonding of the coating which is essential for corrosion resistance.

Epoxy coating

The valve bodies and bonnets and other components should be epoxy coated according to standards.

After the valve components have been shot blasted, the clean and preheated components are submerged into epoxy powder. The powder melts when in contact with the preheated components and cures when the components enter the cooling tunnel shortly after the coating process.

Test procedure which should be followed

The mentioned test methods are standardised test methods. Hence, there may be reference to the relevant standards.

Coating thickness and corrosion protection: The coating layer thickness shall be no less than 250 µm. (ASTM E376 – 17).

Coating units used to produce heavy duty corrosion protection of valves and fittings with coatings (GSK-online).

Pore free coating: The coating must be completely free of penetrating pores to avoid subsequent corrosion of the material underneath. (NACE TM0177).

Impact resistance: The impact resistance test is carried out at room temperature right after the coating process. (ASTM D 2794).

Cross linkage: One drop of methyl isobutyl ketone is put on a horizontal epoxy resin coated surface of the test piece at room temperature.

Adhesion: The adhesion of the powder coating is tested on one side of a test plate four times a year for each coating. (ASTM D3359 – 17).

Cathodic disbanding: Cathodic disbonding tests are carried out on one of each type of component at least twice a year.

Approvals: The coating should be approved for use in drinking water systems, meeting all specified toxicological conditions e.g. contamination (WRAS).

4.1.3 Influence on water (health, contamination of odour, taste and smell)

Migration of substances from various materials can adversely affect the drinking water quality.

Harmful migration can occur from heavy metals such as lead, cadmium and nickel. These metals often form part of the alloy in e.g. brass.

Migration of harmful substances may even occur from different types of rubber and plastic materials.

The limit value for the presence of harmful substances in drinking water varies greatly, so it is always imperative to seek information from local authorities regarding the specific limit values.

Types of natural rubber and synthetic rubber can increase the risk of contamination with bacteria, more specifically legionella. Especially in installations where the temperature can rise above 20 °C, and maybe even higher. This should be taken into account when selecting valves. This problem is mostly concentrated in installations in buildings.

It is essential that products in contact with drinking water are tested for migration of harmful substances to the drinking water.

4.2 Flow

4.2.1 Flow in pipelines

Fluid flow in circular and non-circular pipes is commonly encountered in practice. The hot and cold water used in homes is pumped through pipes. Water in a city is distributed by extensive piping networks.

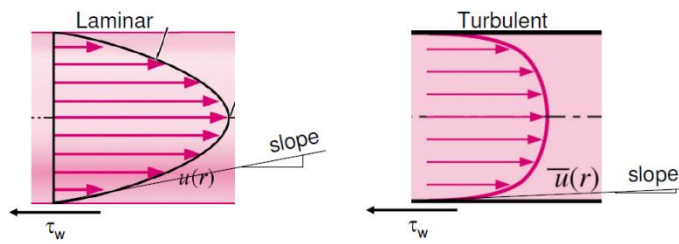


Figure 4.1. Flow patterns in pipes

In the first case the flow profile is said to be laminar, characterized by smooth streamlines and highly ordered motion. In the second case it is turbulent, characterized by velocity fluctuations and highly disordered motion. The transition from laminar to turbulent flow does not occur suddenly; rather, it occurs over some area in which the flow fluctuates between laminar and turbulent flows before it becomes fully turbulent. Most flows encountered in practice are turbulent. Laminar flow is encountered when highly viscous fluids such as oils flow in small pipes or narrow passages.

The flow form is important for the energy consumption of water transport in a water supply system. More energy is needed for transport, if the flow is turbulent. This will apply throughout the service life of the water supply system and must therefore be included in the TCO. Consequently, it is important to have dimensioned pipes and valves, so that the flow is as far as possible laminar.

4.2.2 Flow characteristics for different valves

Pressure loss in general for valves

The pressure loss across a valve can be expressed as a correlation between the water flow and the valve's K_{vs} value. The valve coefficient indicates the amount of water measured in $m^3/hour$ flowing through the fully open valve when there is a pressure drop (differential pressure) across the valve of 1 bar. The coefficient is used for determining the size that will best allow the valve to pass the desired flow rate, while providing stable control of the process fluid. It can be used for comparing flow capacities of valves of different sizes, types, and manufacturers. The flow coefficient is different for gases, liquids and steam and is also dependent on the pressure drop across the valve. The K can apply to either the opening or closing action depending on the function.

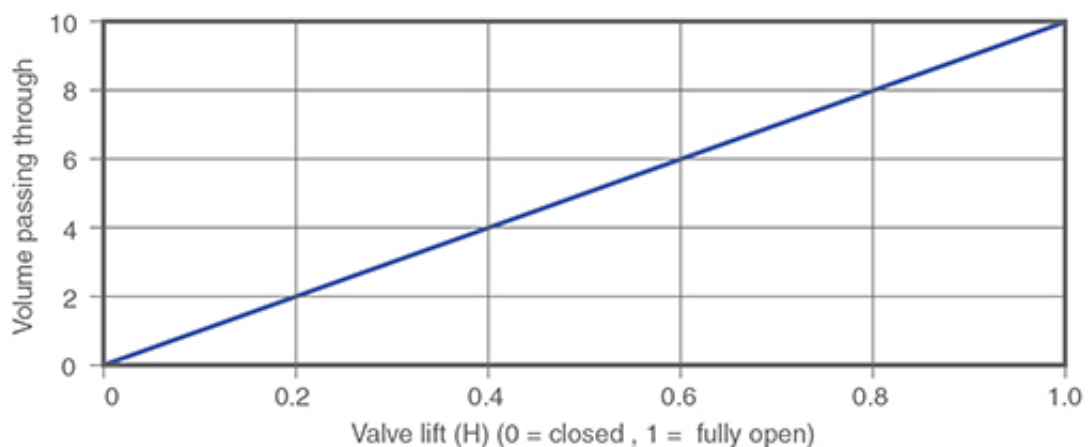


Figure 4.2. Example of linear characteristics of a valve

Selecting a valve with the correct flow characteristic (the ratio between valve opening and flow capacity) can be as important as the selection of the valve size. Actually, a control valve has two characteristics: an inherent characteristic and an installed characteristic.

The inherent characteristic of a valve is the characteristic published by the manufacturer, based on tests performed in a system where great care is taken to ensure that the pressure drop across the test valve is held constant at all valve openings and flow rates. The inherent characteristic, therefore, represents the ratio between valve flow capacity and valve opening when there are no system effects involved. Figure 1 shows the ideal linear and equal percentage characteristics. The source of the name of the linear characteristic is self-evident from the graph.

The name of the equal percentage characteristic comes from the definition: "Equal changes in valve position cause equal percentage changes in flow." The result, as shown in the graph of Figure 4.3, is a characteristic where a small increment of the valve position at small openings results in a small increase in flow capacity, while the same increment of the valve position at large openings results in a larger increase in flow capacity.

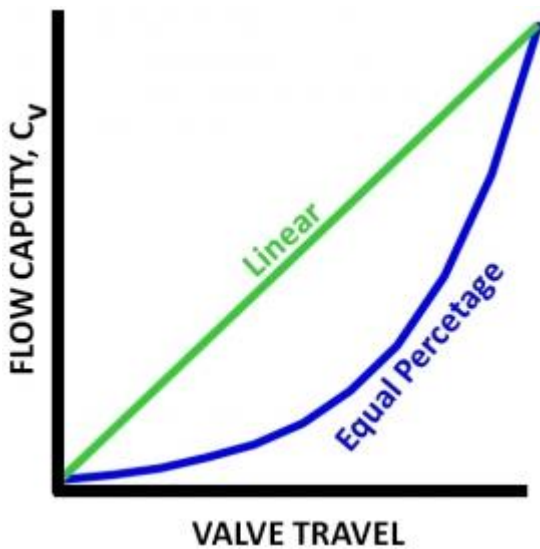


Figure 4.3. Linear and equal percentage inherent characteristics

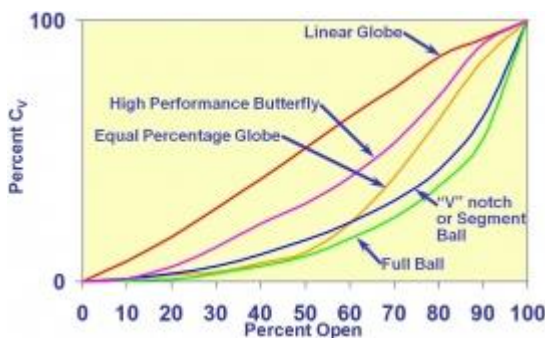


Figure 4.4. Typical actual inherent characteristics of common control valve types

Globe valves are available with either linear or equal percentage inherent characteristics, giving them versatility not generally available with the rotary valves. In fact, most globe control valve designs can be changed from linear to equal percentage (and vice versa) by changing the trim. The ball valves (both full ball and segmented ball) exhibit a nearly perfect (more so than most equal percentage globe valves) equal percentage inherent characteristic. High performance butterfly valves exhibit an inherent characteristic that is approximately midway between equal percentage and linear.

Most control systems provide the best performance when they behave in a linear manner. In the light of this fact, the question might be asked: why use the equal percentage valve? which is not at all linear. The answer is because of the installed characteristic. The installed characteristic is the ratio between the valve position and the water flow in the specific system, taking into account any changes in the pressure differential there is available to the control valve due to the approximately flow squared ratio between flow and piping pressure losses and/or a centrifugal pump head curve.

A large percentage of process systems include a significant amount of pipe and a number of fittings (elbows, Tee's, isolation valves etc.) resulting in a ratio between the flow in the system and the pressure loss available to the control valve similar to Figure 4.5.

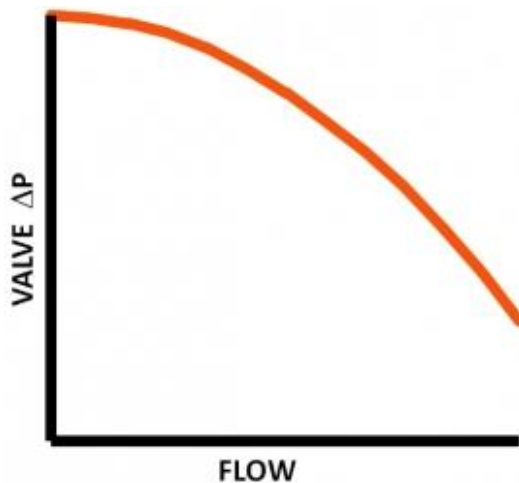


Figure 4.5. Valve pressure loss vs. flow in a typical system with a significant amount of pipe

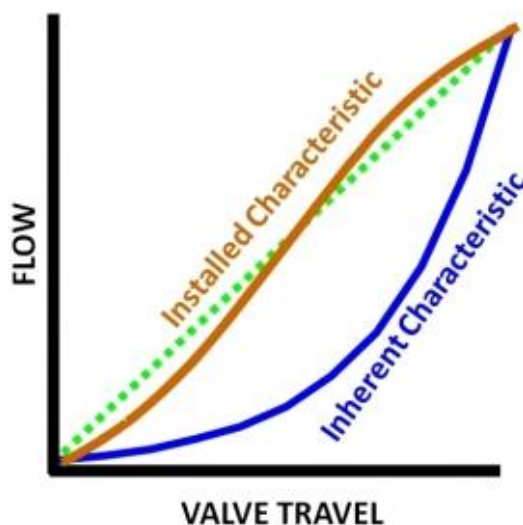


Figure 4.6. Installed characteristic of an equal percentage valve in the system of Figure 4.5

Refer to Figure 4.6 and imagine a control valve with an inherent equal percentage characteristic installed in a system that has a characteristic like that of Figure 4.5. When the control valve is wide open, the flow will be at its maximum value. Moving the control valve in the closing direction of course causes the flow to decrease. As soon as the flow starts to decrease, it can be seen from Figure 4.5 that the pressure drop across the valve tends to increase, resisting the decrease in flow through the valve. The result of this interaction between control valve and system produces a nearly linear installed characteristic.

As a general rule, systems with a significant amount of pipe and fittings (the most common case) are best suited to equal percentage inherent characteristic valves. Systems with very little pipe (where the pressure drop available to the control valve remains nearly constant and as a result the inherent characteristic of the valve is also the installed characteristic) are better suited to linear inherent characteristic valves.

4.2.3 Pressure loss for different types of valves

When selecting valves for water supply systems, it is important to select valves with either no pressure loss or a pressure loss as low as possible.

Valves with full drilling (throughput) will normally not cause any pressure loss. Valves where a reduction in the throughput occurs, will cause a pressure loss.

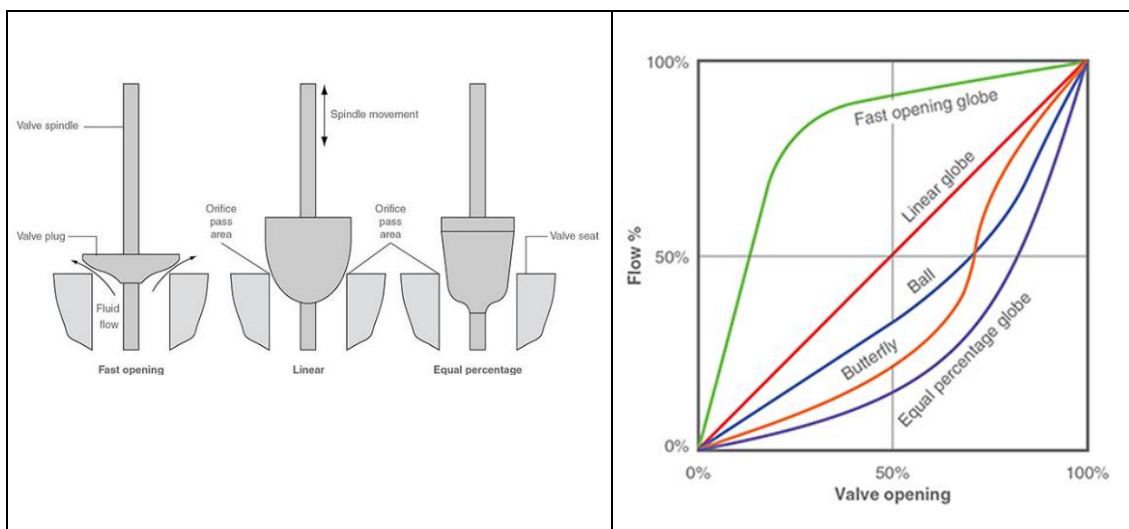


Figure 4.7. Example of valve characteristics

Gate valves: Gate valves without a reduction in the flow will normally not have a pressure loss that will affect the installation.

Butterfly valves: Butterfly valves without a reduction in the flow will normally not have a pressure loss that will affect the installation.

Ball valves: Ball valves without a reduction in the flow will normally not have a pressure loss that will affect the installation. The size of the pressure loss depends on the size and the design of the reduction in the area.

Check valves: The pressure drop in a check valve depends on its design. The pressure drop across flap check valves is usually less than across spring loaded check valves.

Control valves: The pressure drop and the characteristic of a control valve depend on the design of the seat.

4.2.4 Pressure loss is energy

The pressure loss across a valve and the pressure loss in the pipe system have a significant impact on the amount of energy to be used to pump the water through the system. If valves with a large pressure loss are chosen, it will lead to a strong increase in the energy consumption in the system's lifespan. This should be taken into account when calculating TCO.

4.3 Temperature

4.3.1 Normal operating temperatures in Water systems

For cold water the normal temperature in drinking water systems is between 5 and 20 °C. For hot water it may vary between 50 and 65 °C. The temperature to which valves and other components may be exposed in an installation may vary considerably more than within these bounds.

4.3.2 Rating temperature – Temperature rating

Rating temperature is the temperature of the pressure containing the shell of the valve (body). It is assumed to be the same as the system fluid temperature.

Temperature rating is the maximum and minimum temperature at which the valve can be used.

4.3.3 Maximum and minimum temperatures for different types of valves

The maximum temperatures that different types of valves can withstand depend, among other things, on the materials involved in the design of the valves. However, the valves are designed so that they can always charge the normally occurring temperatures in a normal water supply system.

Temperature limits for valves in general

Temperature: Max. 70 °C

For valves with PE ends max. 40 °C

Rubber parts (EPDM) in valves

Minimum temperature -40 °C

Maximum temperature 120 °C

Valves must not be exposed to temperatures that may cause the medium to freeze. Water will expand when it freezes and this may cause damage.

4.4 Pressure

4.4.1 Pressure conditions in water supply systems

The pressure in water supply systems depends on the local conditions. In areas with high variations in height difference, the pressure may vary widely, and it may be necessary to divide the area into different pressure zones.

Normally, the water supplier will try to keep as low a supply pressure as possible to minimise leaks in the pipe network. The water pressure will normally be between 2.5 and 5 bar.

When selecting components and valves, it is expected that the water pressure locally may reach 10 bar and that the components should be able to handle this pressure as an operating pressure.

4.4.2 Working pressure for different types of valves

The operating pressure for different types of valves depends on the water pressure in the local system. Consequently, when selecting a valve, it is necessary to ensure that the valve can at least handle this pressure. During tests, it is tested whether a valve can handle a test pressure 1.5 times the maximum pressure that may occur in the supply grid.

4.4.3 Maximum test and working pressure for different types of valves

Pressure test of valve body:

Valves PN 10 should be pressure tested at 15 bar.

Valves PN 16 should be pressure tested at 24 bar.

Maximum working pressure:

Valves PN 10: the maximum working pressure is 10 bar.

Valves PN 16: the maximum working pressure is 16 bar.

Pressure test of closing function: Valve PN x 1.1

4.4.4 Water hammer in valve installations

Water hammer in pipelines occurs when pumps are started and stopped or when valves are opened and closed. Water hammer gives both overpressure and negative pressure. Overpressure has usually the strongest impact and is the most frequent cause of damage.

Water hammer (or more generally, fluid hammer, also called hydraulic shock) is a surge or wave caused when usually a liquid, but sometimes also a gas, in motion is forced to stop or change direction suddenly, a so-called momentum change. Water hammer commonly occurs when a valve suddenly closes at an end of a pipeline system causing a pressure wave to propagate in the pipe.

Water hammer associated with installations frequently occurs due to the use of quick closing valves. Quick closing valves are typically:

- Ball valves
- Solenoid valves

Water hammer in the installation may cause damage to the pipe system or damage to components. Particularly water hammer from the closure of large valves, typically larger than DN 32 mm, will cause serious damages to the installation.

4.5 Security, health and safety

The workplace should, as far as possible, be adjusted so that inappropriate working positions and heavy lifting are avoided. Appropriate work clothes and relevant protective equipment should be used such as gloves, glasses, safety shoes and helmets.

4.5.1 Equipment and materials

All equipment and components must be kept clean during work performance. All new equipment and components that come in contact with water, must - as far as possible - be packaged and be unpacked just prior to use.

4.5.2 Excavation

Excavations must be carried out in accordance with local safety regulations regarding excavation, support of the excavation etc. The work must be carried out in accordance with national regulations and instructions of the supplier.

5 Planning considerations

5.1 Planning and selection of valves

Many factors are involved in selecting the correct valve for an application, and valve sizing and selection can be a complex process. An engineer can start the valve selection process by understanding the application requirements and finding suitable valve specifications to meet the needs. The first step in this process is to consider the most important valve attributes.

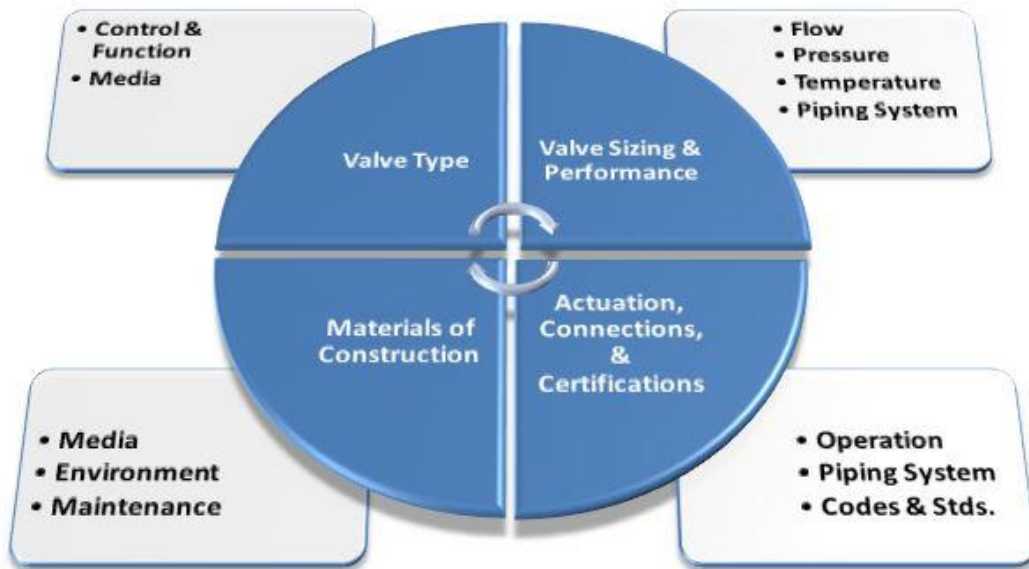


Figure 5.1. Considerations when selecting valves

5.1.1 Valve type

First of all, what is the purpose of the valve - preventing backflow, control, open/close, water/air?

The type of valve required for the application will depend on the flow control, the function and the valve operation. If the application only requires flow control, then a valve type with good throttling performance is required. Ideally, valve size and type should be selected to provide flow control over the range of opening of the valve plug. Inherent in the design of certain valves is a change in flow rate during opening. Valves with characterised plugs can be selected to alter the flow or gain of the valve. For on/off or shut off applications, ball, plug and butterfly valves provide good performance.

If the application requires prevention of backflow, a check valve would be the best option. Applications requiring pressure control would need a pressure regulator or pressure regulating valve. A mixing valve might be the appropriate choice for tempering of water stream or blending two process streams. In comparison, if the processes are feeding chemicals or additives into a formulation or compounding process, then a metering valve can often provide the control capabilities needed.

5.1.2 Materials and construction

See chapter 4.

5.1.3 Valve sizing and performance

The selection of the proper valve size or the correct valve sizing is the most important step in selecting the right valve for an application.

Pressure: It depends on a time variable: it can be a “slow” or a “fast” process. An equal percentage is used, if variation between the pressure loss at maximum flow and at minimum flow is less than 20%. For fast processes under any pressure loss, an equal percentage is also recommended.

Flow: The flow is controlled by the setpoint. It should also be taken into account that transmitters are not always linear. They can be proportional to flow or to the square of the flow rate. The selection of the valve characteristic will depend on what type of signal is sent to the controller. It will also differ if the valve is used in series or as bypass.

Temperature: When temperature control loops occur, time constants are large, and the frequency of the system changes as the load varies. This is very common in chemical plants and refineries. The best inherent characteristic for a valve is equal percentage.

5.1.4 Actuation, connection and certifications

Operation: Another consideration is how the valve will be operated within the product or the plant. If the valve is to be manually operated, a manual valve with a hand wheel or a handle for opening and closing the valve is required.

Connections: Another selection factor is the valve end connection - typically defined by the existing connections in the process or piping system. Valve connections are not considered primary selection criteria for engineers, because suppliers often offer the same valve product with multiple connection options. Besides, adapter fittings can be purchased if the desired connection type is not available.

Codes and standards: It must be checked that the valves meet the standards used in the country concerned and whether certificates are available.

5.2 Examples - Cases related to TCO and longer service life of products

5.2.1 Case from Anhui Province in China

In 2014, a large waterworks in China installed new valves. The tender and procurement process was based only on the lowest price. By 2016, half of the valves were in such a poor condition that it was necessary to replace them. Parts of the waterworks had to be shut down during the period of valve replacement. In the end, the total price of the valves was significantly higher than if valves of a better quality (and with a service life of more than 20 years) had been chosen from the start. In addition to the increased price, there were also indirect costs because the waterworks had to close while the valve replacement took place.



Figure 5.2. Control valve installation with new valves for pressure management

5.2.2 Case from Denmark

Supplying power to wells in an underground water supply network is not an easy task. This turned out to be the reality for Strømmen Vandværk in Randers, Denmark. After much planning and consideration, the first well is now in place at Strømmen Vandværk (water-works) and the ideal power solution has been chosen.

Obtaining a valuable overview

Prior to this, a comprehensive task was carried out dividing the entire supply network into separate pressure zones. The network was split into four zones, each of them was to have an inlet chamber established. The chamber would have an intelligent control valve mounted alongside an ultrasonic water meter, which would then measure the volume entering the pressure zone. This is very valuable information, as the network gets a full overview of how much water enters a specific zone compared to how much water is actually consumed by the network customers - all relative to the specific time of day. This way, Strømmen Vandværk was able to start establishing parameters for the pressure adjustments within the zone based on the collected network data. In other words, the pressure will follow the water demand, reducing the pressure when possible to the minimum service pressure promised the network customers.

This way of regulating the pressure can also be used actively for controlling pressure elsewhere in the pressure zone. There might be areas with large pressure losses when the consumption is high, which could happen with old, internally overgrown pipes reducing the flow, or if the piping is too narrow for the actual water demand. By logging data on flow and pressure in this critical area, the control valve can be programmed to regulate the pressure and keep it at a constant level within the area.

Having the control valve adjusting the pressure constantly is not only saving water and energy, but it also stabilises the overall pressure which has a direct positive impact on the service life of the pipeline system.

5.2.3 Case from Bulgaria

Sofia Water supplies water for the inhabitants of the Bulgarian capital and a number of villages surrounding it; a total number of 1.4 million people. The served area has a size of 1,348 m², the length of the water networks is 4,075 km, and the length of the wastewater networks is 1,600 km. Sofia Water has around 1,200 employees. Sofia Water invests approx. EUR 20 million every year in the rehabilitation and maintenance of its drinking and wastewater networks.

As a result of the city's investments in and systematic work with different types of valves for regulating water flows, the regulation of the drinking water networks in Sofia has become much more stable, flexible and comfortable for the customers. In case of repair or rehabilitation works in the networks, smaller areas can now be closed and isolated from the rest of the networks thus affecting much fewer households. Besides, water losses caused by emptying and refilling the water networks before and after, the repair works have been reduced significantly as well.

The overall reduction of water losses from 62% (1997) to 45% (2016) is a result of complex measures (new water pipes, pressure reduction in the whole network etc.).

5.2.4. Case from Malaysia

The price of water in Malaysia is very low and does not cover the actual costs. The huge amount of unidentified water loss calls for the government to support the water utilities with major funding each year.

There are many factors to be considered when trying to identify water loss. Leaking pipes, valves or tapping saddles as well as more difficult factors to identify such as malfunctioning domestic household meters, water theft and lacking management skills of the water utilities should all be checked.

Non-revenue water within a utility's network is a huge source of wastage. It adds greatly to operating costs, and leaks can add big complications and expenses to the sustainable management of water services. Hence, the Malaysian government and the Kelantan State decided to initiate the reduction of non-revenue water by focusing on repairing the pipelines. A contract with a company was set up supplying tapping saddles, repair clamps and valves to improve the pipelines of Kelantan State in Malaysia. Kelantan has approximately 1.5 million inhabitants and is an agrarian state with lush paddy fields and rustic fishing villages resulting in quite a huge amount of water consumption.

The project included 60,000 tapping saddles, 60,000 repair clamps, 5,600 gate valves and 600 air valves. Quality was a very important issue. Another important issue was a 10-year product warranty and a halal certificate for the grease used for the assembly of the valves. Besides, the company worked closely with the contractor to avoid mistakes.

Before the launch of the project, the water loss in the state of Kelantan was measured to 45%. Now, a year after the project ended in Kelantan, the non-revenue water is measured to 30%. The pipelines were repaired, and they work well. Some of the issues now to be addressed are the more difficult ones to identify. In Malaysia there are huge problems with people tapping water directly from the pipelines trying to get around the household meters, and with household meters that are malfunctioning or tampered with and - as a consequence - not measure correctly. This causes a continuous huge amount of water loss.



Figure 5.3. Installation with gate valves and control valve

5.2.5 Case from Georgia

A water loss of around 70% in the Tbilisi region has previously given rise to leakage reduction initiatives. Now, the water utility has decided to go all the way to obtain an efficient water supply management, and 150 pressure reducing valves have already been installed as part of the initiative. More are to be replaced in addition to more than 350 new installations. The expected savings on the water production is more than six million USD every year.

Less water losses and million dollar savings

Pressure management has proven to efficiently reduce leakages and thereby also lower the non-revenue water level. This improves energy efficiency as well as operation and maintenance costs. Pressure management using pressure reducing valves can really make a difference, and besides savings on produced and pumped water it can also improve e.g. consumer satisfaction by minimised disruptions. A major benefit of pressure management in the Tbilisi region is specifically the allowance for control of the excess pressure that arises as the water flows from the highly situated areas.

The benefits of pressure management are many – most of them having the overall theme of minimising the water loss. There are benefits for consumers and water utilities as well as for sustainability.

After installation of 235 of the total 500 pressure reducing valves, significant results are already seen. The overall water distribution in the supply area has been reduced by 7% compared with the past year. The risks of water hammer and pipe bursts are minimised, and the electricity consumption and the amount of pumped water is reduced.

Results after installation of 235 pressure reducing valves:

- Electricity consumption is reduced by approx. 10%
- Less risk of water hammer, and pipe bursts are reduced by 25%
- Pumped water is reduced by 27,740,000 m³/year

Expected results after installation of 500 pressure reducing valves:

- Pumped water is reduced by 58,000,000 m³/year
- Saved production costs are 6,380,000 USD/year*

*The cost of producing 1 m³ water in Tbilisi being 0.11 USD

6 Installation



Figure 6.1. Installation of valves in cold climate

6.1 Installation instructions – different types of valves

The manufacturer will always provide guidelines for installing a product. The following are general instructions for the individual products.

General instruction

Valves must be protected from damage during transportation, loading and handling. Lifting by means of a crane or any other lifting device should only be done using the flange holes, lifting eyes or appropriate straps. Never suspend the valve in a hand wheel, gearbox or actuator.

Before the installation, a visual check must be performed. Special attention should be paid to checking the stem, the valve seat area, the flanges and the coating. Look for defects, bend, dents, scratches and other damages. Actions should be taken to repair or replace the valves, if any defects are detected.

Different kinds of valves are supplied with a number of different connections to the pipeline. The use of flanges, sockets or spigot pipes depend on the customers' specifications. For all connection types correct craftsmanship must be applied.

Valves with flanges must be installed using suitable gaskets, bolts, washers and nuts. Maiden flanges must be designed to adapt standard flange drillings appropriate to the specific flange drilling on the valve.

Bolts must be tightening in a criss-cross pattern, and bolt torques must be applied according to the recommendations of the flange gasket manufacturer. Actions should be taken to ensure that the valve flanges are aligned to ensure an even pressure on the gasket surface.

During installation in pipeline systems, care must be taken to ensure that the connecting flanges of the pipeline getting into contact with the gate valve are arranged parallel to each other and are exactly aligned to avoid any tension loads acting upon the valve body. For the same reason, and to achieve a regular mounting of the flange sealings, it is also necessary to tighten the connecting bolts regularly in a cross pattern.

Valves with sockets must be installed according to the recommendations of the pipe manufacturer. Check that the outside diameter of the pipe corresponds to the inside diameter of the valve socket before installation. If gaskets are mounted in the valve, ensure that the gasket is placed correctly and is adequately lubricated.

Valves with spigot pipe ends are to be installed either by means of appropriate welding or the use of a suitable coupling. For welding procedures please refer to the specifications of the pipe manufacturer.

6.2 Good installation practice

6.2.1 General

Valves are sensible to dust and dirt on the upper parts where the piston slides in the cylinder. If installed outdoors or in a dusty or otherwise dirty environment, the valve must be protected in a suitable valve chamber with sufficient cover from objects and debris falling from above.

Do not install closer than six times the pipe diameter downstream of tees, elbows or other irregularities, as this could cause violent turbulence and cavitation inside the valve and reduce its performance and durability.

When the pipeline has been charged, inspect for leaks and adjust, if necessary, in accordance with the maintenance instructions. Operate the valve over a full stroke and check for free movement.

6.2.2 Pressure testing

After installation, perform a pressure test before the trench is closed or the system is being put into operation. Secure the pipe and valve against movements. If the pipeline and valve are tested with water prior to gas/air tests, ensure that the pipeline and valve are drained to prevent frost damage. In general, valves are designed to withstand a test pressure of 1.5 X PN.

6.2.3 Instructions for installing gate valves

Installation of gate valves follows the general instruction. The bolts must be tightened in a diagonal pattern, and the torque of the bolts must be applied according to the recommendations of the flange packing manufacturer. Make sure that the valve flanges flush to ensure uniform pressure on the entire package.

During installation in the pipeline it is important that the pipeline connection flanges to be assembled with the gate valve are located parallel to each other and flush accurately in order to avoid any stress on the valve body. For the same reason and in order to achieve

even flange sealing, it is also necessary to tighten the bolts diagonally (see figure 1). Bolt tightening moments are stated by the packaging supplier.

Gate valves with sleeves must be fitted according to the recommendations of the manufacturer. Check that the outside diameter of the pipe corresponds to the inner diameter of the valve sleeve before assembly. If the gaskets are fitted in the valve, ensure that the gasket is positioned correctly and is sufficiently lubricated.

6.2.4 Instructions for installing butterfly valves

Installation of butterfly valves follows the general instruction. In horizontal pipelines, butterfly valves must be installed with their shaft in a horizontal position. The valve should never be mounted directly in pipes where the actual bore dimension is smaller than the nominal bore dimension of the valve. Due to the risk of turbulence, it is recommended to install the valve minimum 6xDN after pipe fittings. Never use gaskets or grease during installation.

It is recommended to make a functional test before use. That is why the valve must be opened and closed at least once in order to check that the disc does not touch the flange and the valve is tight through the passage.

If a pressure test of the complete piping system is carried out, it is very important that the test pressure is not higher than the nominal pressure of the valve. An overpressure may damage the valve.

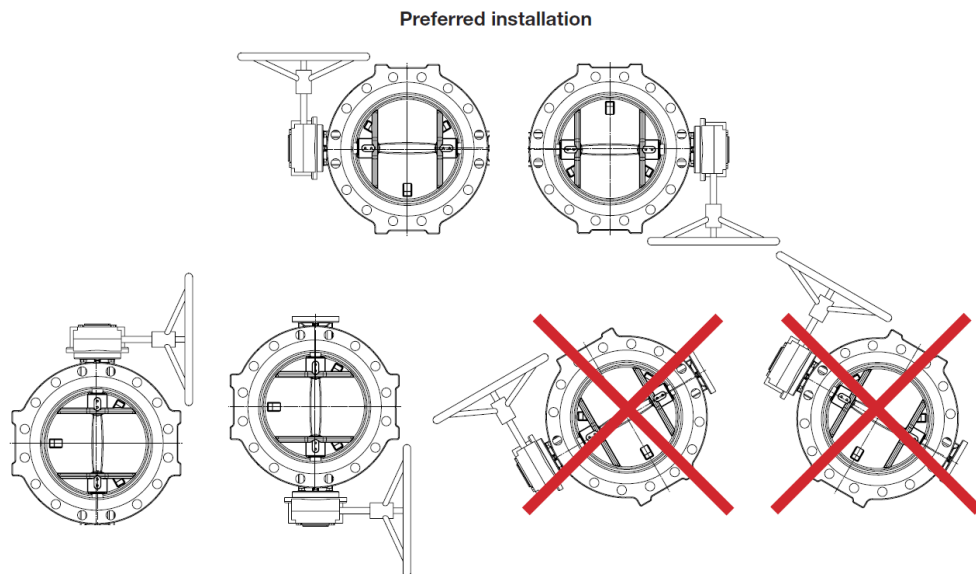


Figure 6.2. Preferred installation for valves

6.2.4 Instructions for installing check valves

Installation of check valves follows the general instruction. Correct installation is important for a proper operation. The valve can be installed in either a horizontal or a vertical flow-up application. If installed in the vertical flow-up position, a lever and weight or lever assembly must be used to ensure proper valve operation. In all installations the flow arrow cast on the valve body must be pointed in the direction of flow during normal system operation.

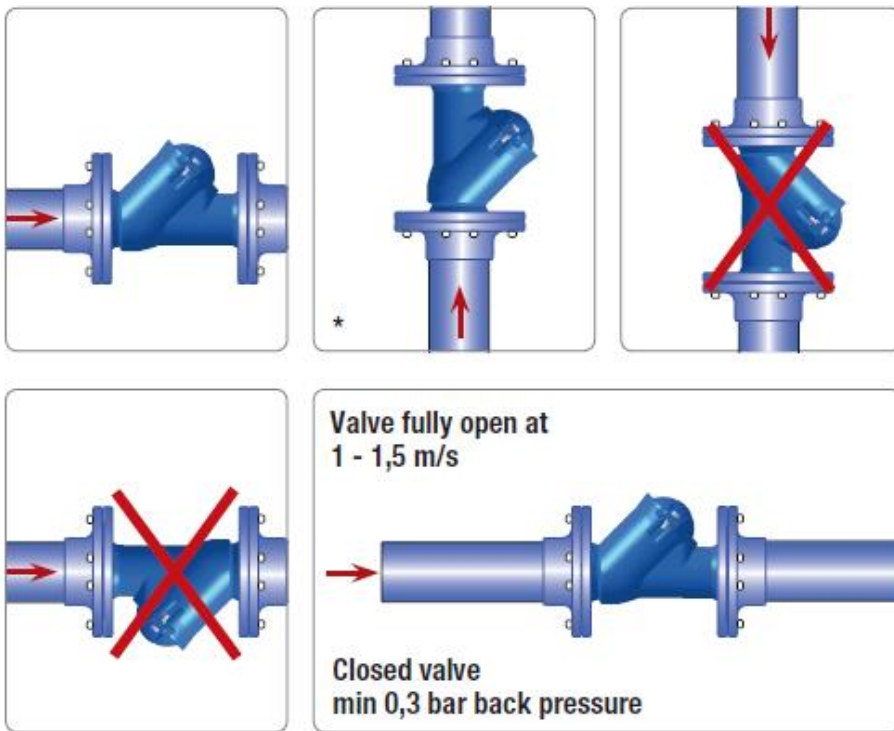


Figure 6.3. Instruction for installing check valves

6.2.6 Instructions for installing control valves

Installation of control valves follows the general instruction. It is recommended to install a protection strainer on the inlet side to filter out impurities that could damage the control valve. Isolation valves on each side of the control valve facilitate the commissioning and maintenance.

In many cases, it is recommended to install an air valve at the inlet of the control valve in order to avoid trapped air pockets in the system. Air pockets may cause an increased energy consumption, operational costs and pressure loss and may increase the risk of water hammer which will again increase TCO.

6.2.7 Instructions for installing ground fire hydrant

Installation of hydrants follows the general instruction.

A. Connect the inlet flange with the water main. To prevent pipe joint separation, restrain the hydrant's movement with appropriate thrust blocking or with restraining joints. If the soil is too sandy and does not support the loads, the barrel can be supported by pouring a concrete pad or at least 6 inches in thickness and 24 inches in diameter around the barrel at or near the bury line.

To provide drainage, place clean coarse gravel or crushed stone from the bottom of the trench to at least 6 inches above the drain opening in the hydrant and to a distance of 1 foot around the elbow. For clay or other impervious soil types, excavate a drainage sump 2 feet in diameter and 3 feet deep below each hydrant. Fill the sump with clean coarse gravel or crushed stone to a level of 6 inches above the drain opening. Place a plastic sheet over the gravel to prevent dirt from clogging the drains.

B. The traffic flange can be placed above ground level since the hydrant is height adjustable, and the outlet can be placed in any requested position due to the 360° rotatable upper barrel. It is very important to cross-tighten the bolts. The assembly is complete when the visible rubber seal gasket between the flanges is slightly compressed.

C. Hydrant with automatic drain: Connect the Ø20 mm PEL pipe with the drain nipple in the lower barrel. Place it in the gravel as described above (A).

Hydrant with manual drain: Connect the Ø20 mm PEL pipe with the two drain nipples - one in the lower barrel and the other in the traffic flange.

D. When the hydrant is installed, it must be operated from fully closed to fully open position and back to make sure no obstructions are present.

6.2.8 Instructions for installing ball valves

Installation of ball valves follows the general instruction. Water hammer may occur in large dimensions, e.g. larger than size 32 mm.

7 Operation and maintenance



Figure 7.1. Operation and maintenance are very important to ensure a longer lifespan of installations and valves

It is important that each valve and each plant with valves are provided with an installation, operation and maintenance manual including:

- Principle of operation
- Health and safety at work
- Receiving and storage
- Installation and commissioning

This manual should contain the overall principle for how the different valves work and should also show drawings or images of the different valves.

The manual must contain a drawing showing the location of the components that require maintenance and control. Maintenance and control must be described.

All components requiring operation and maintenance must be easily accessible and must be placed in such a way that the maintenance can take place in an appropriate and safe manner.

For special installations requiring supervision and maintenance, there must be sufficient space for maintenance work. The area of the installations should be arranged, so that it is possible to replace or repair the components.

It is the responsibility of the manufacturer to ensure that all product surfaces can be mechanically cleaned, sterilised or easily dismantled for manual cleaning.

7.1 Health and safety at work

This section should contain the most important descriptions in relation to health and safety at work etc.

Make sure that all relevant health and safety issues and regulations are adhered prior to and during installation or maintenance work carried out on this product. It is the end user's responsibility to ensure that safe working practices are followed at all times.

Whenever the manufacturer's products are installed, operated or maintained, the inherent dangers of pressurised liquids and gasses must be addressed. Before work on a valve or other piping component is undertaken, that may involve the release of internal pressure, the valve or line must be fully isolated, depressurised and drained prior to commencing the work. All workers handling the product must be aware of the weight of the components or assemblies to be handled and manipulated during installation and maintenance.

It is essential that staff undertaking these operations are adequately trained and it is the responsibility of the end user that only trained and competent staff undertake these duties.

This manual is designed to assist, but it cannot replace quality training in the workplace.

7.2 Receiving and storage

This section should contain the most important descriptions in relation to receiving and storage of the valves etc.

- *Unloading must be carried out carefully. The load must be put gently to the ground without dropping. Lift only by means of shackles in the flange bolt holes or slings around the body casting.*
- *Do not lift the assembled valve in fulcrum pins, fulcrum bracket or float lever.*
- *If a forklift is used, it shall have sufficient capacity to lift the required weight and have a valid inspection certificate.*
- *All workers involved in the unloading shall be able to perform their functions. They shall wear safety boots, safety vest, safety goggles and hard hat.*
- *All slings used for the lifting shall be of sufficient strength. A record shall document that they have been stored under cool, dry conditions away from sunlight and chemical atmosphere, and that they still perform according to their marked strength.*
- *Immediately after unloading, the item should be inspected for compliance with specifications and damage during shipment.*
- *Compliance with specification check shall as a minimum comprise: size, pressure class, flange type and float material.*
- *Damage during shipment check shall as a minimum comprise: coating, seating surfaces, bent levers or shafts, cracked parts, loose bolts, missing parts or accessories or any other evidence of mishandling during shipment.*
- *Each item should be operated through one complete open-close cycle in the position in which it is to be installed*
- *Storage shall be under dry, cool conditions, away from direct sunlight and corrosive or otherwise chemically active atmosphere.*
- *Make sure that the main seal rubber ring was not compressed during storage.*

7.3 Installation and commissioning

This section should contain the most important descriptions in relation to the installation and commissioning of the valves etc.

If there are any risks of application hazards, they should also be addressed in this section.

7.4 Operation and maintenance

This section should contain the most important descriptions in relation to the operation and maintenance of the valves:

- *Operation:* The complete assembly must be able to move freely and easily up and down between fully open and fully closed. Make sure all pin joints and linkages are lubricated and have sufficient space to move. By adding water into the float through the filler cap, it is possible to finely adjust the regulated height of the water surface level.
- *Maintenance:* Once every month the valve must be operated a few times all the way between fully open and fully closed. Check that the valve shuts completely and is drip tight when closed. Once every 6 months clean and lubricate cylinder, pin joints and linkages. Check for wear or damage and for sufficient space for operation and movement.
- *Troubleshooting:* In case the valve does not work easily, there should be a troubleshooting instruction including 1) symptom, 2) cause and 3) problem solving.