VALVE HANDBOOK

REGIN

Energy-efficient systems are based on precision and accuracy of control.

Water is the most common energy carrier for heating and cooling of buildings. Its energy is transferred via radiators, heating or cooling batteries, fan-coil units, etc.

The heating and domestic hot water needs of a building are constantly changing throughout the day, while being affected by conditions in- and outside the building.

In order to maintain good heating and tap water comfort, a control system is required that constantly detects current needs and which is capable of countering fluctuations. But even using the most sofisticated control system, valve performance and control characteristics are still of vital importance. Leaking valves with unstable control qualities mean large operational costs and poor quality of comfort.

For this reason, Regin continually strives to develop new energy-efficient systems and products. Together with Osby Armatur-OAB, a part of Regin Sweden, we have extensive experience within the field of valves.

As a result of our work, we have for the past few years been able to offer control valves that are absolutely tight when closed. These offer a unique advantage, helping to conserve energy in numerous installations.

The purpose of this handbook is to shed light on precisely how valves function and which parameters are important to know in order to create an optimally functioning facility.

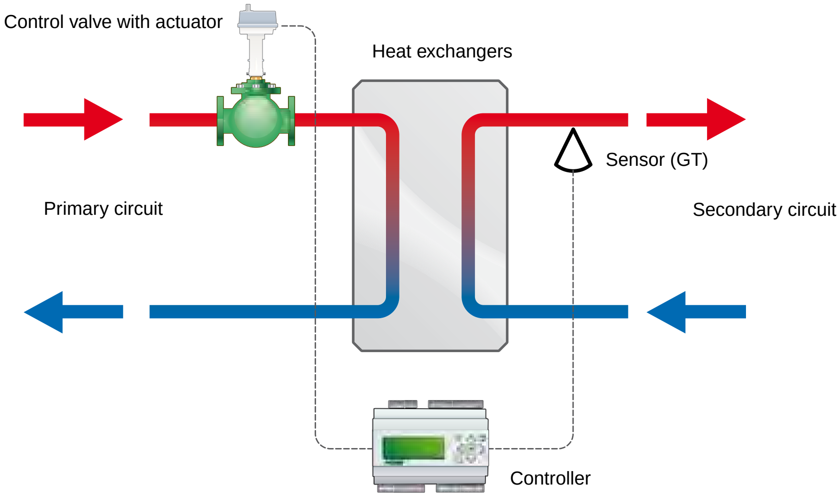
CONTENTS

Control functions in water systems

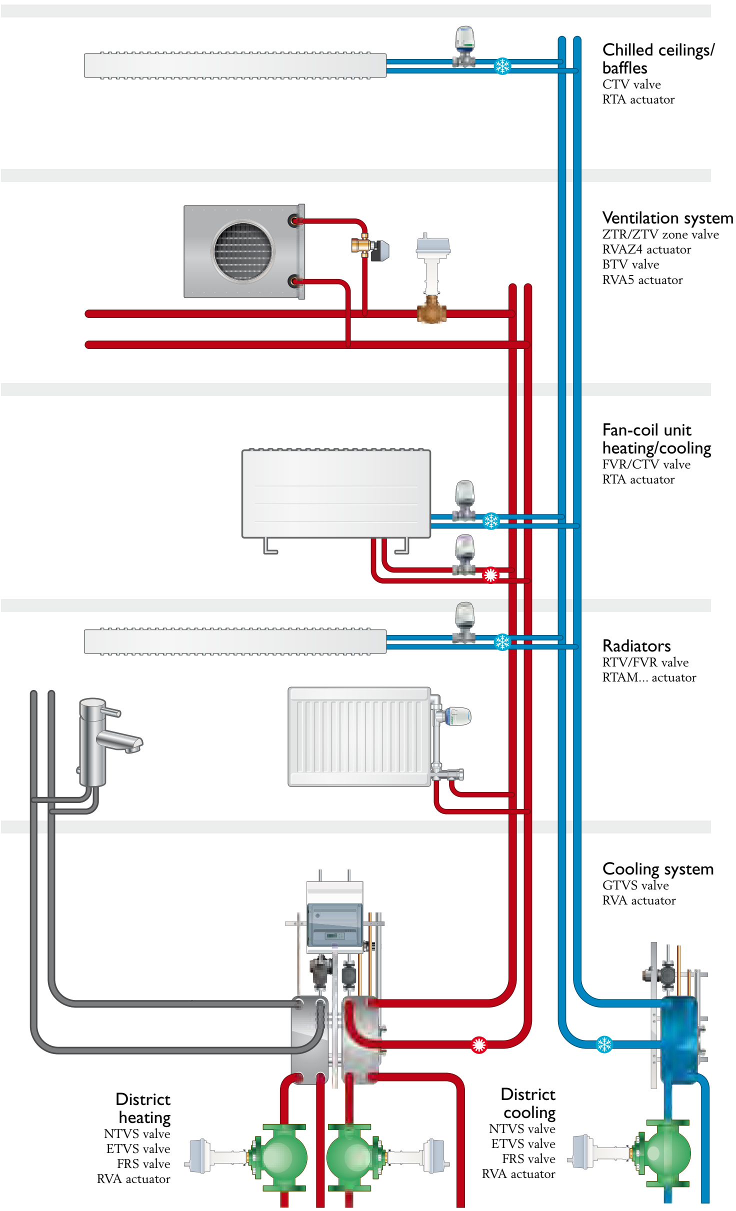
The sensor (GT) measures the water temperature of the outgoing secondary circuit – the actual value.

This signal passes to a controller that compares the actual value to the setpoint, i.e. the set temperature that the system is to maintain.

If these values do not correspond, the control unit signals the actuator to increase or decrease the amount of heated water supplied from the control valve to the heat exchanger.

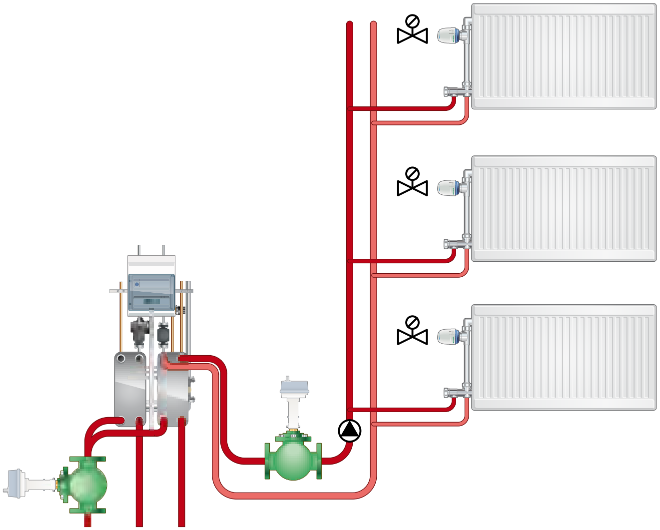


Example of the structure of a control system

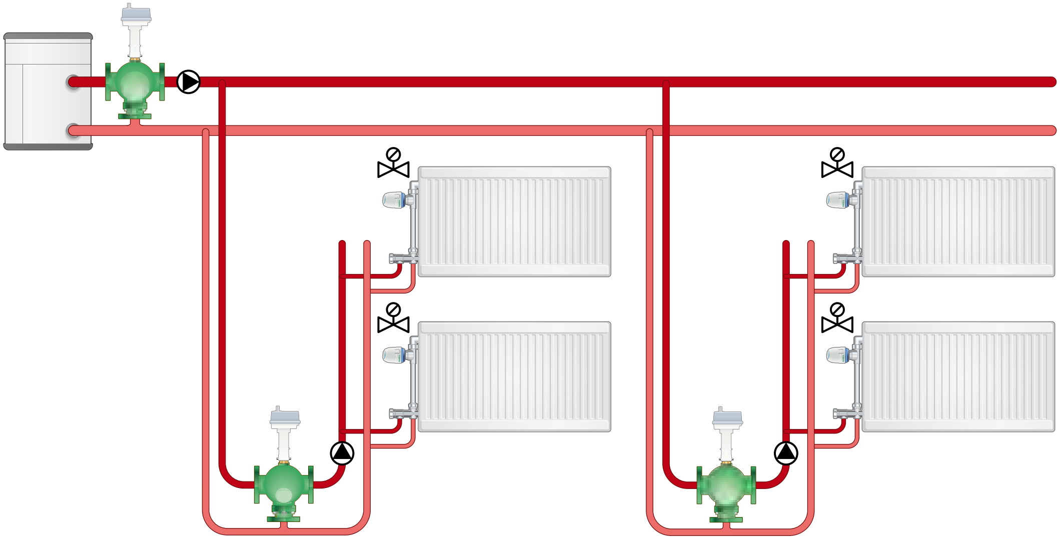


Example of a heating, cooling and domestic hot water system equipped with Regin control valves and actuators

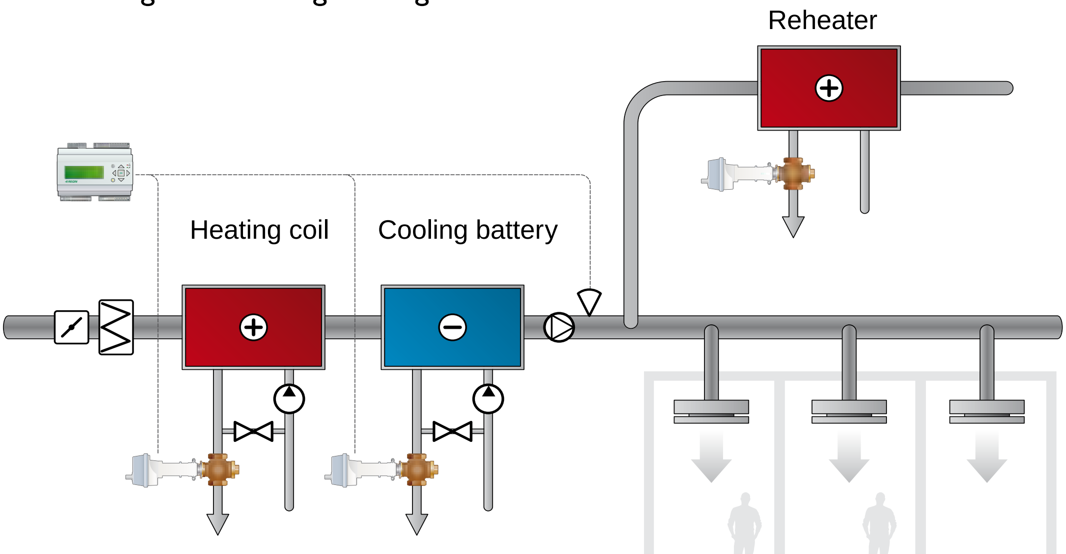
District heating system



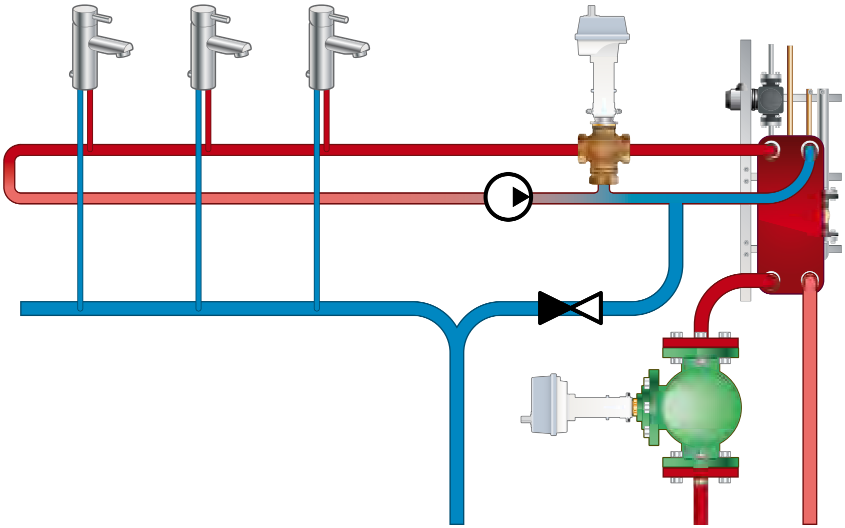
Heating system with boiler



Air handling units heating/cooling



Domestic hot water system



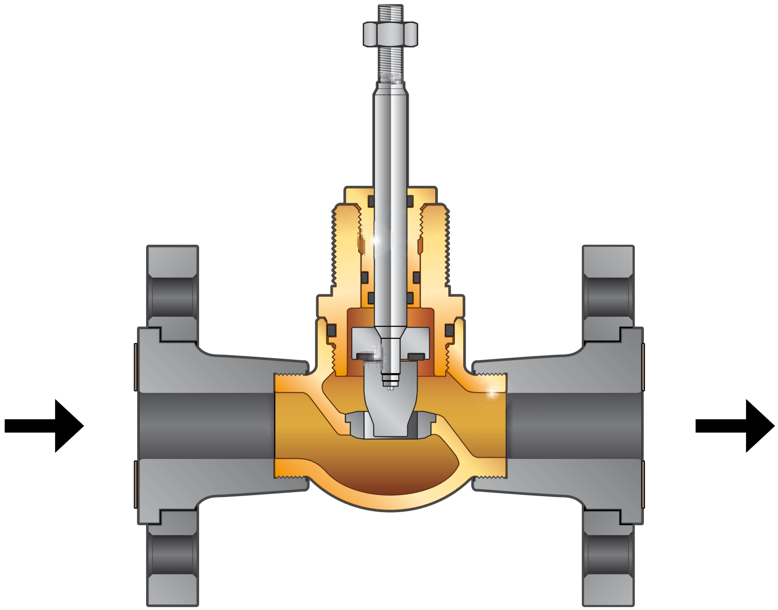
Types of valves

The types of valves most commonly occuring in HVAC control are seat valves (plug valves), ball valves and butterfly valves. Other types of valves are knife gate valves, diaphragm valves and gate valves.

Regin valves are of the seat valve variety

Regin flow control valves are of the seat or plug valve variety. This valve type fulfills several very rigid demands for control accuracy, and the valve is capable of both controlling and closing flows.

The flow through the valve should flow against the plug (as marked on the valve). During reverse flow, vibrations and noise may occur inside the valve.



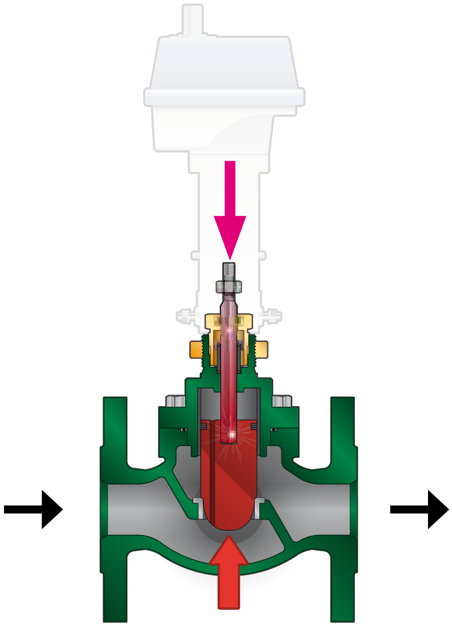
Regin's FRS plug valve series

Pressure balancing in valves

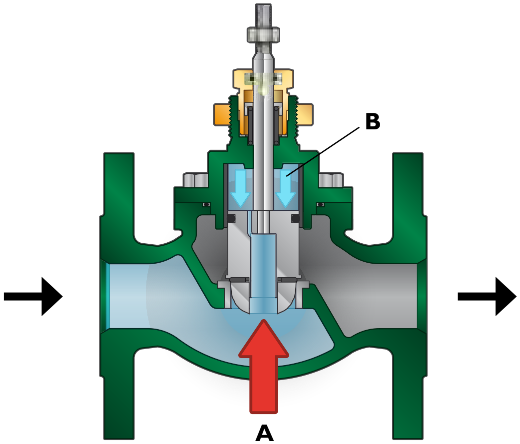
Large valves require powerful actuators

2-way valves of large sizes are difficult to manoeuvre and require actuators capable of generating a high positioning force. In order to reduce the force required, the valves are pressure balanced. The principle is to minimise the force on the valve plug which is caused by the pressure drop across the valve.

In Regin's pressure balanced valves, water is fed through a hole to a chamber above the top of the plug. The water's pressure against the plug (A) is balanced by the counterpressure against the top of the plug (B). Using this solution less power is required to manoeuvre the valve, enabling the use of smaller actuators.

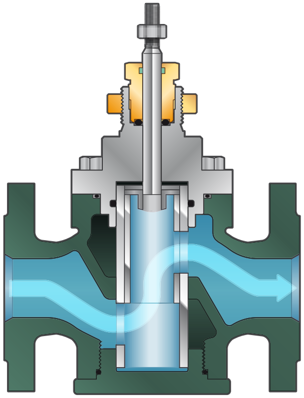


In large valves a powerful actuator is needed, capable of withstanding high pressures against the valve plug.

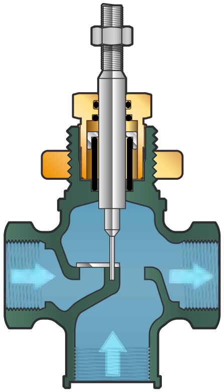


In Regin's pressure balanced valves, water is fed through a hole to a chamber above the top of the plug.

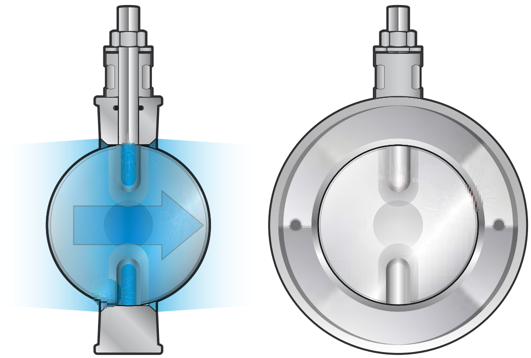
Other types of valves



Piston valve
Primarily used in district heating facilities with high pressure drops.



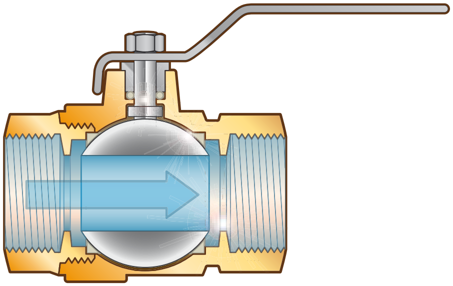
Rotary valve
Relatively inexpensive but difficult to prevent leakage. This 3-way valve is used as a distribution and mixing valve (shunt valve).



Butterfly valve

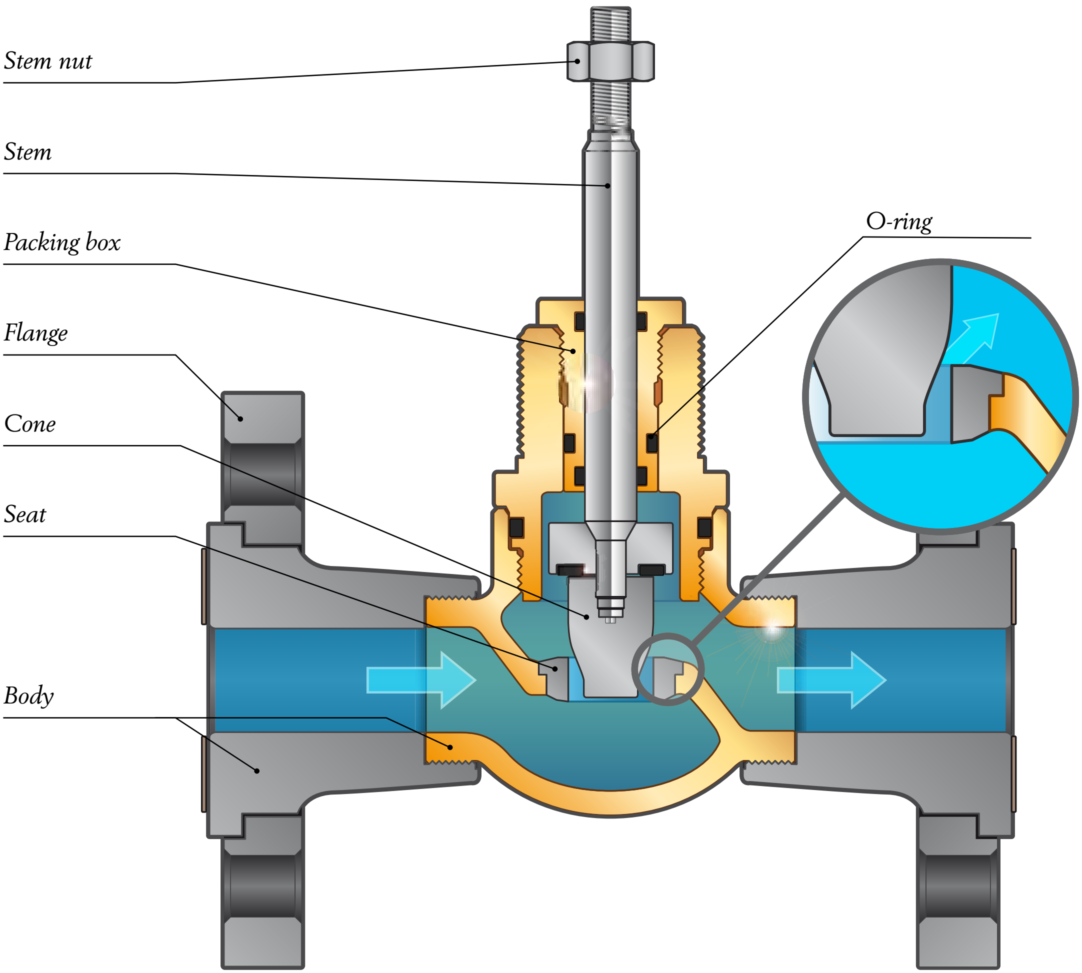
Open (side view)

Closed



Ball valve
Used primarily for shutting down flows.

The design and function of control valves



The plug controls the flow throughout the control valve together with the seat. Movement up and down is generated by an actuator. The valve is closed when the plug is flush against the seat. When the actuator is activated, the plug is lifted by the stem and water begins to flow through the valve. The difference between the highest and lowest possible position of the stem and plug is what equates the valve's stroke or lift. The total amount of water let through by the valve depends on the current height of the plug and the flow characteristics for the valve.

The valve plug and seat are often made out of stainless steel in order to handle large pressure drops (800 - 1000 kPa). If the pressure drop across the valve is low, plugs cast from gun metal are used.

Larger dimensioned valves often utilise some form of control method to keep the plug from vibrating. Vibrations decrease overall control accuracy and give rise to noise and wear.

Valve sizes DN

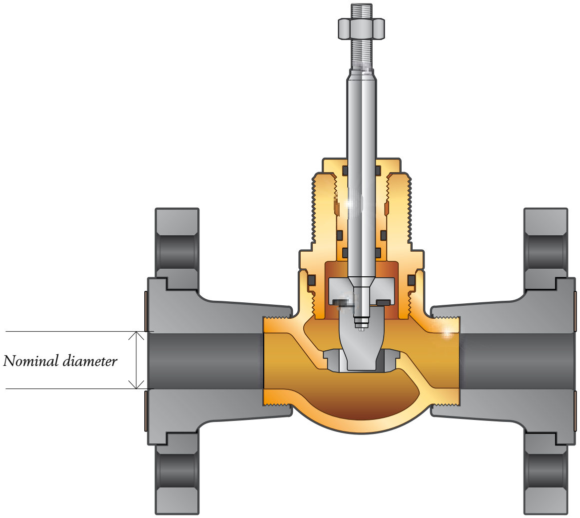
Valve connections are measured in DN (Diameter Nominal), a measurement of nominal internal diameter. This designation largely corresponds to that of millimetres, but values are rounded into even numbers.

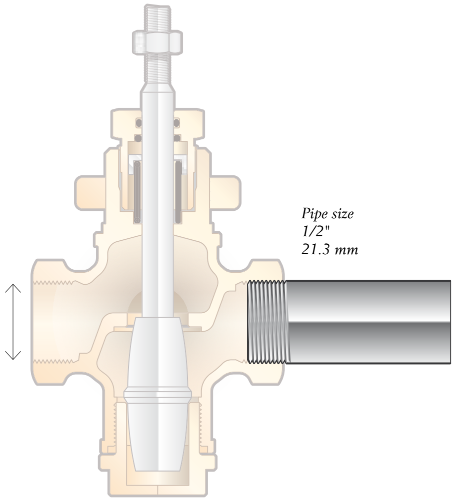
The table displays pipe/valve size in DN.

Components such as valves and pipes with the same DN are therefore dimensionally compatible with one another.

Valve	Pipe size	
DN	Exterior dimensions in mm	Interior dimensions in inches
8	13.5	1/4
10	17.2	3/8
15	21.3	1/2
20	26.9	3/4
25	33.7	1
32	42.4	1 1/4

Valve	Pipe size	
DN	Exterior dimensions in mm	Interior dimensions in inches
40	48.3	1 1/2
50	60.3	2
65	76.1	2 1/2
80	88.9	3
100	114.3	4
125	139.7	5
150	168.3	6





Nominal pressure and pressure rating PN

Pressure rating, PN (Pressure Nominal), is a designation of the interior pressure (measured in bar) which forms the basis for calculating a valve's durability at a temperature of 20°C.

PN is followed by a number representing pressure. PN16, for instance, means the maximum permitted interior pressure for the valve is 16 bar (=1.6 MPa).

PN is available in the following series of numbers: 2.5 / 6 / 10 / 16 / 25 / 40 / 64 / 100 / 160 / 250 / 320 / 400.

Connection methods

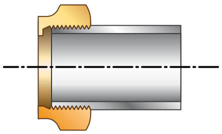
Valves may be connected to pipe routes in the following ways:

- Threaded connection
- Flanged connection
- Welded connection

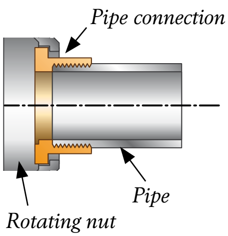
Regin valves are available in threaded connection or flanged connection.

Threaded connection

Valves of up to DN 50 are available featuring threaded connection. Threading may be either female or male.
In valves with female threading, pipes may be screwed directly into the body. When male threading is used, the use of rotating couplings can make replacing the valve easier.



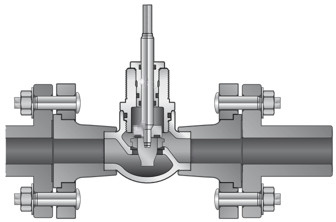
Female thread

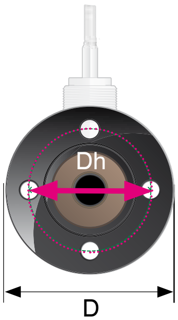


Flanged connection

In the case of large valves, installation and replacement are simplified if the valves are flanged. The flanges of the valve are bolted flush against the flanges of the pipe system. Flanges are sealed by placing a gasket in between them.
Flange dimensions are certified in accordance with DIN-standards based on the pressure class and material of the valve.

Regin flanged valves are constructed in accordance with pressure class **PN 16** (see table).





PN16

DN	D = flange dimensions	Dh = hole diameter	Bolts	
			Dim	Number
6	75	50	M10	4
8	80	55	M10	4
10	90	60	M12	4
15	95	65	M12	4
20	105	75	M12	4
25	115	85	M12	4
32	140	100	M16	4
40	150	110	M16	4
50	165	125	M16	4
65	185	145	M16	4
80	200	160	M16	8
100	220	180	M16	8
125	250	210	M16	8
150	285	240	M20	8

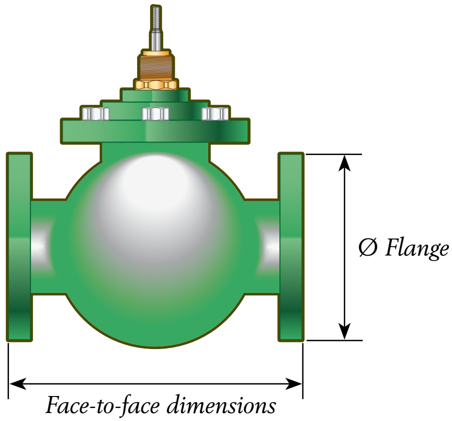
Face-to-face dimensions for flanged valves

Face-to-face dimensions as per DIN

Flanged valves with face-to-face dimensions as per DIN have a standardised distance between the flanges. Gaskets are not included in face-to-face dimensions. As shown in the table, face-to-face dimensions are related to connection size DN.

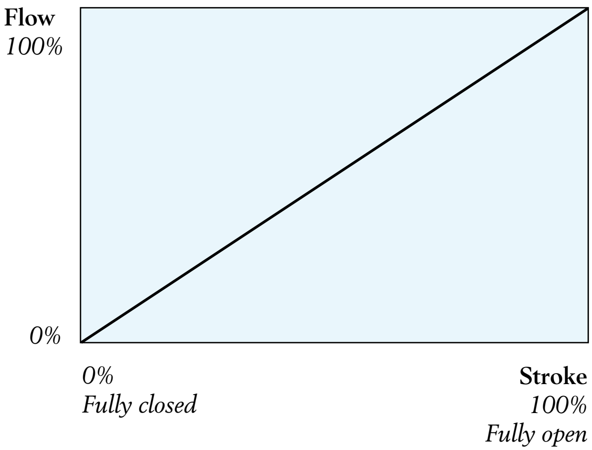
Connection	Face-to-face dimensions in mm	Ø Flange
DN 15	130	95
DN 20	150	105
DN 25	160	115
DN 32	180	140
DN 40	200	150
DN 50	230	165
DN 65	290	185
DN 80	310	200
DN 100	350	220
DN 125	400	250
DN 150	480	285

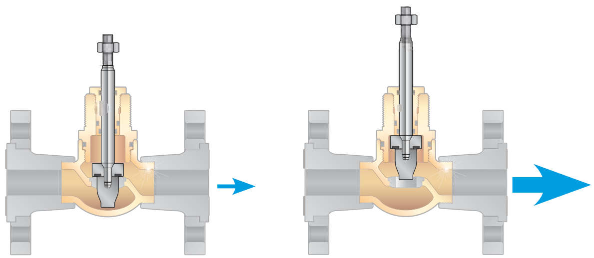
Regin NTVS valves utilise face-to-face dimensions as per DIN



Flow characteristics

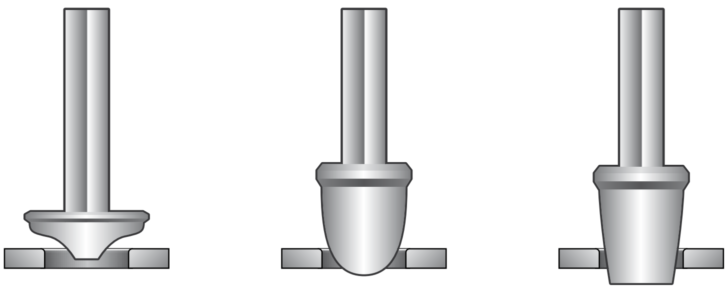
The plug controls flow throughout the control valve together with the seat. The valve is closed when the plug is flush against the seat. When the actuator is activated, the plug is lifted by the stem and water begins to flow through the valve.
The amount of water let through by the valve correlates to the position of the valve plug. This relation is referred to as the flow characteristics of the valve, measured during constant pressure drop across the valve (normally 1 bar).





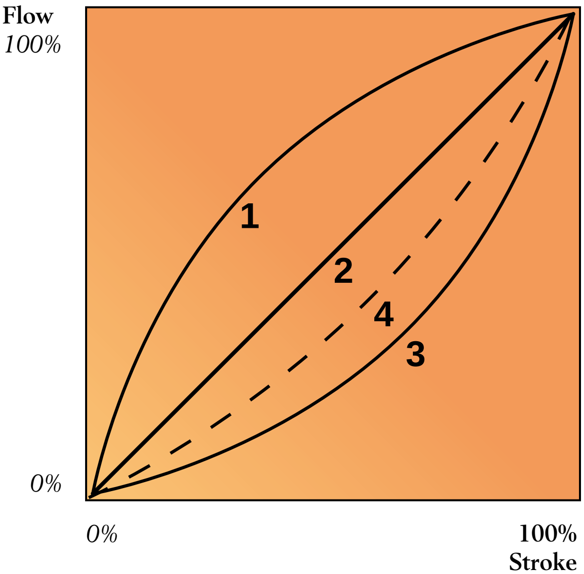
Small stroke = small flow *Large stroke = large flow*

By designing the plug and seat in different ways, valves can be given different flow characteristics.



Quick opening *Linear* *Equal percentage*

Flow characteristics can be illustrated by way of a diagram:



1. Quick opening flow characteristics
Valves using quick opening flow characteristics are characterised by a large flow already when the valve stem is raised only slightly from its closed position. As the stem reaches its end-position, the flow decreases only relatively little.
This characteristic is typical for shut-off valves and is not used in control valves.

2. Linear flow characteristics
Valves using linear flow characteristics are designed so that the flow is directly proportional to the height to which the stem is raised.

3. Equal percentage (logarithmic) flow characteristics
Valves using equal percentage flow characteristics provide a low flow during the opening phase, which then increases in an accelererating fashion as the stem approaches its open position. Equal percentage flow characteristics provide good flow control during the opening phase, as pressure drop across the valve is great while the valve simultaneously receives the same capacity sought in a fully open valve.

4. Square flow characteristics
Square flow characteristics represent a compromise between linear and equal percentage (logarithmic) flow characteristics. This means flow changes squarely depending on the stem's current height.

What is the practical use of flow characteristics?

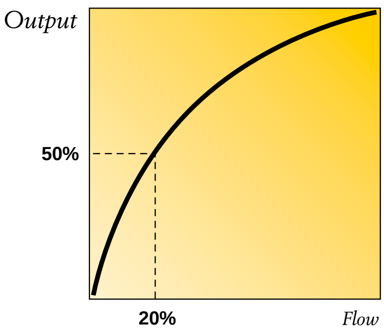
Flow characteristics do not normally have to be taken into consideration during valve sizing. For reasons discussed below, however, the flow characteristics of a valve does have practical implications in installations comprising heat exchangers and heating appliances.

In order to obtain a good level of comfort, heat exchangers are constructed so as to provide a high output already when supply flows from the district heating network (the primary side) are low. This is referred to as the transfer characteristics.

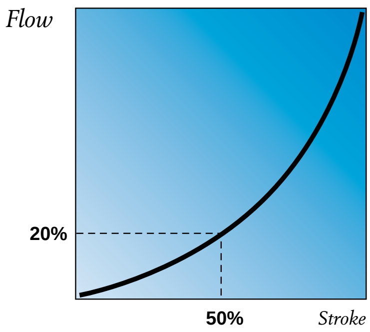
At, for instance, 20% flow, the output of the heat exchanger is approx. 50%. As primary side flow increases, the output then gradually decreases. If flow increases from, for instance, 80% to 100%, the output of the heat exchanger will increase by only a few percent. In order to obtain an even, stable temperature from the heat exchanger during all loads, a control valve using **equal percentage flow characteristics** is used.

The heat exchanger's transfer characteristics thereby combines with the flow characteristics of the valve, providing outgoing water with a temperature that constitutes a smooth, linear function based on the current lift (stroke) of the stem. This provides the control unit with very accurate possibilities for control.

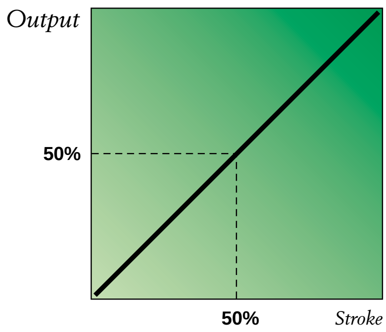
Heat exchanger



Control valve with equal percentage flow characteristics



Heat exchanger + control valve



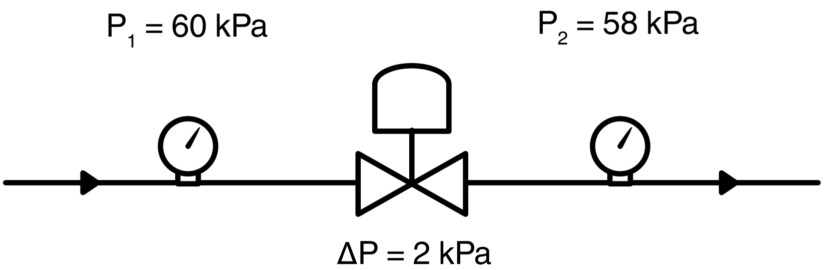
Pressure drop

Pressure drop is a decisive factor when sizing and choosing valves for a system. Pressure drop occurs as flow in a pipe system is slowed down by the valve.

Pressure drop ΔP is the difference in pressure between two measuring points (P_1 and P_2), e.g. meaning before and after the valve.

Pressure drop and flow are directly related. If flow through the valve increases, so will the drop in pressure. Conversely: if flow is reduced, the drop in pressure decreases.

The relationship between pressure drop/flow is not linear, but rather quadratic. In practice, this means even small changes in flow will result in large pressure drop changes. If flow is doubled, pressure drop is quadrupled. If flow is tripled, pressure drop is increased ninefold, etc.



Pressure drop ΔP across a valve is calculated as the difference between input pressure (P_1) and output pressure (P_2).

When the differential pressure is too great, there is a risk for so-called cavitations occurring in the control valves of district heating substations. When flow of water through a valve is throttled back, the water's speed is increased while water pressure goes down. This may lead to the water boiling, bringing with it the formation of small steam pockets. These pockets collapsing may then lead to small jets of water so powerful that they can damage the surface of the material of which the valve consists. This may in time lead to pitting and to the valve beginning to leak when closed. See also the section Cavitation.

Valve sizing (kv and kvs value)

The capacity of a valve is indicated by its kvs value.

When sizing a valve, its kv value is first calculated using the formula on the right. The kv value represents maximum flow measured in m³/h when the valve is entirely open (stroke = 100%) at a pressure drop* of 1 bar (=100 kPa). Based on the calculated kv value, a valve is chosen with a kvs value closest to that immediately above the projected kv value. Valves are usually constructed so that the kvs value follows the so-called Renard series in terms of size:

1.0 1.6 2.5 4 6.3 10 16 and so on.

*) *A valve in a pipe system provides a flow resistance, pressure drop, that is proportional to the flow squared. If flow is doubled, pressure drop is quadrupled. If flow is tripled, pressure drop is increased ninefold.*

Formula for calculating the kv value:

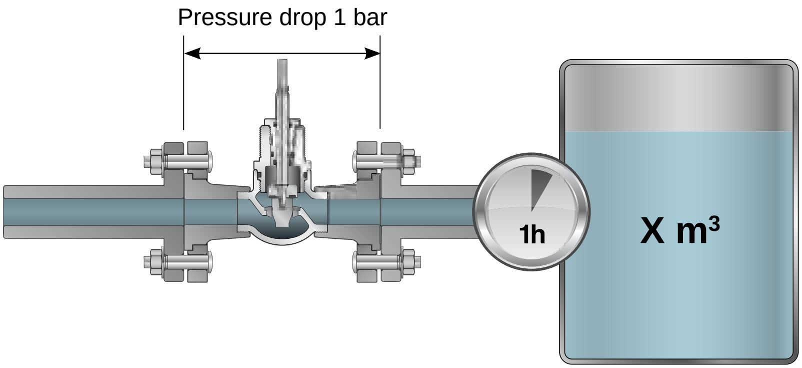
$$\frac{Q \times \sqrt{\rho}}{\sqrt{\Delta P}}$$

Kv = valve capacity
Q = flow in m³/h
ΔP = pressure drop across the valve measured in bar (P_1-P_2)
ρ = media density in kg/dm³ (= 1 for water)

EXAMPLE:
Calculate kv value at a flow of 2.9 m³/h and a pressure drop of 1.5 bar across the valve

$$Kv = \frac{2.9}{\sqrt{1.5}} = \text{approx. } 2.37$$

I.e. choose a valve with a kvs of 2.5.



The kvs value is defined as the maximum flow in m³/h that can pass through an entirely open valve at a pressure drop of 1 bar m³/h = number of cubic metres during one hour

In American literature, the term cv is used instead of kv.

Cv = Flow per US gallons (3.785 l/min) at a pressure drop of I psi (7 kPa) across a fully open valve.

This equates to cv = 1.7* kv, alt. kv = 0.86* cv

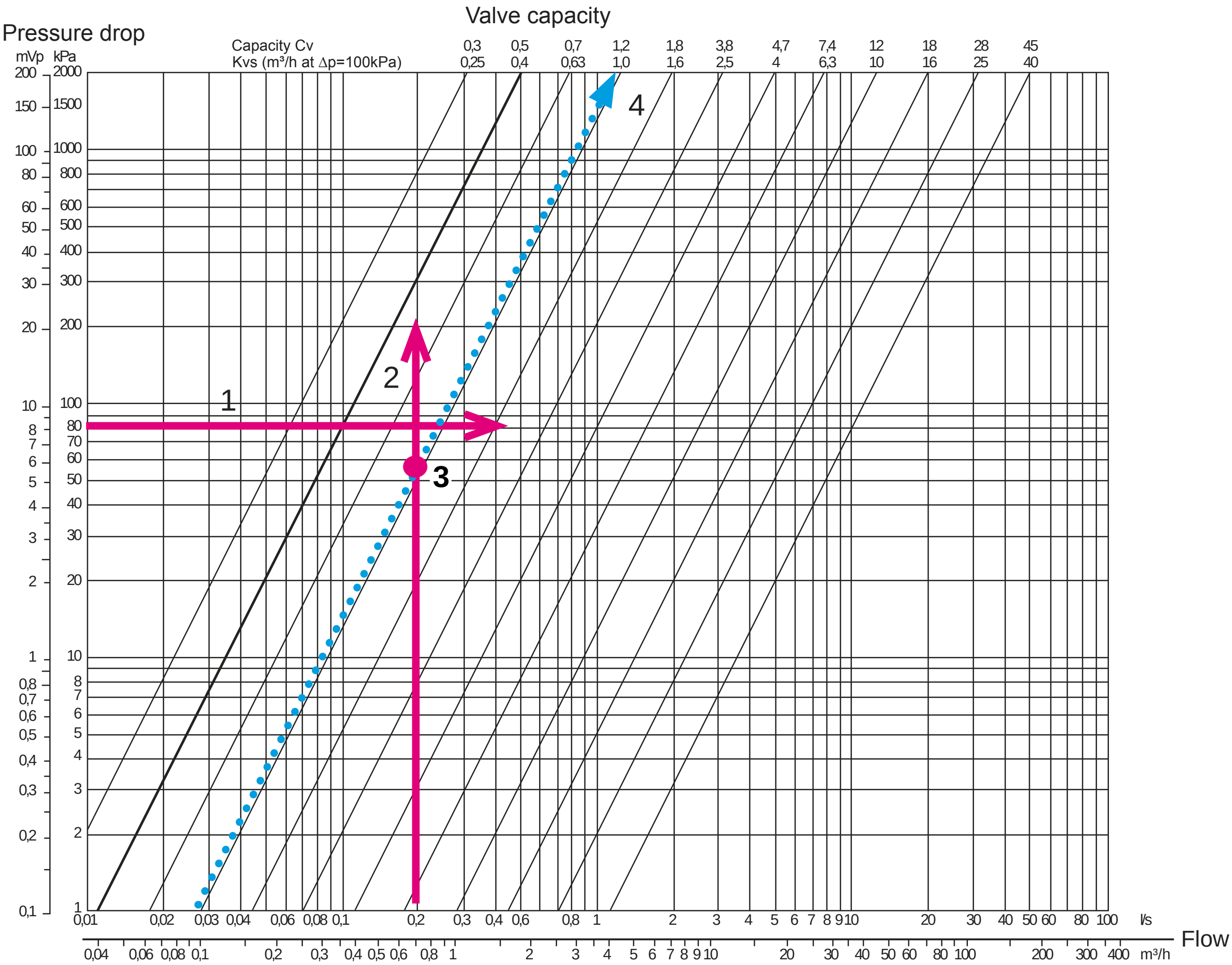
Pressure drop diagrams simplify calculations

In order to simplify choosing the correct kvs value for a control valve, a pressure drop diagram may be used. The diagram illustrates the connection between flow and pressure drop.
(The axes use logarithmic graduation, permitting each kvs value to be displayed by a straight line.)

Here's how one would choose kvs value for a valve with a pressure drop of 80 kPa across and a flow of = 0.2 l/s.

1. Draw a horizontal line through the dimensioned pressure drop across the valve (Δp = 80 kPa)
2. Draw a vertical line through the dimensioned flow through the valve (0.2 l/s).
3. Proceed in a straight, upwards direction from the intersection to the nearest kvs line. Read the kvs value.
4. Results: Kvs = 1.0
   I.e. choose a valve with a kvs of 1.0.

By using this method, one would usually choose the nearest higher kvs value for the valve, which may lead to unnecessary oversizing. During precise calculations, it is therefore important to always use the kv formula for verification purposes.


Valve capacity
Pressure drop
mVp kPa
Capacity Cv
Kvs (m³/h at Δp=100kPa)
0,3 0,5 0,7 1,2 1,8 3,8 4,7 7,4 12 18 28 45
0,25 0,4 0,63 1,0 1,6 2,5 4 6,3 10 16 25 40
200 150 100 80 60 50 40 30 20 10 8 7 6 5 4 3 2 1 0,8 0,7 0,6 0,5 0,4 0,3 0,2 0,1
2000 1500 1000 800 600 500 400 300 200 100 80 70 60 50 40 30 20 10 8 7 6 5 4 3 2 1
1
2
3
4
0,01 0,02 0,03 0,04 0,06 0,08 0,1 0,2 0,3 0,4 0,6 0,8 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 80 100 l/s
0,04 0,06 0,08 0,1 0,2 0,3 0,4 0,5 0,6 0,8 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 80 100 200 300 400 m³/h
Flow

Regin's valve sizing calculator

Regin's web-based tool for valve sizing makes it considerably easier to calculate the kv value and valve authority as well as select the right valve for the application. It can also help you find a suitable actuator for the calculated valve.

The valve sizing calculator is available on Regin's website **www.regin.se.**

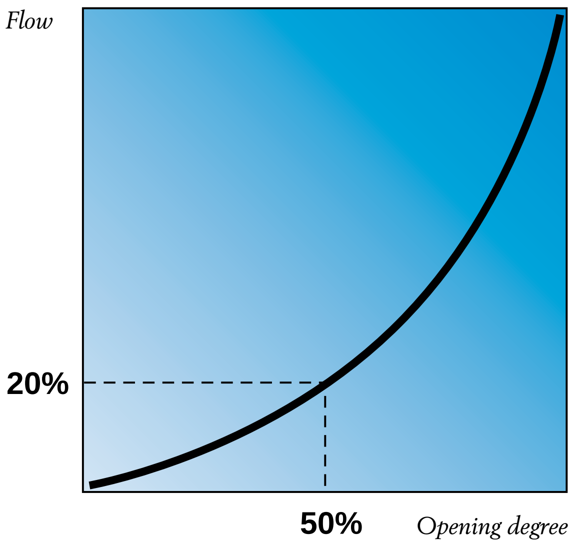
Control range and accuracy

The control range, or rangeability, of a valve constitutes the relationship between the maximum flow (kvs) and smallest possible controllable flow (kvr) through the control valve. The valve should then follow its flow characteristic across the entire control range. A valve capable of controlling flow when increased a by a hundred from the smallest controllable amount is said to have a control range of 1:100.
The control range of HVAC control valves normally lies in the interval between 1:50 and 1:100.

Control accuracy is greatly dependant on how the valve is manufactured and processed. The higher the control accuracy, the more demanding the processing and the more expensive the valve will become.
Since the valve is affected by impurities in water and the like, a control range of 1:75 for smaller valves and 1:50 for larger ones is in practice more realistic.
Valves do exist with a control range of up to 1:500. However, sediment, debris and particles present in the system usually ensure this control accuracy can seldom be maintained in practice.

$$R = \frac{Kvs}{Kvr}$$

Control range = R
Maximum flow (Kvs)
Minimum controllable flow (Kvr)



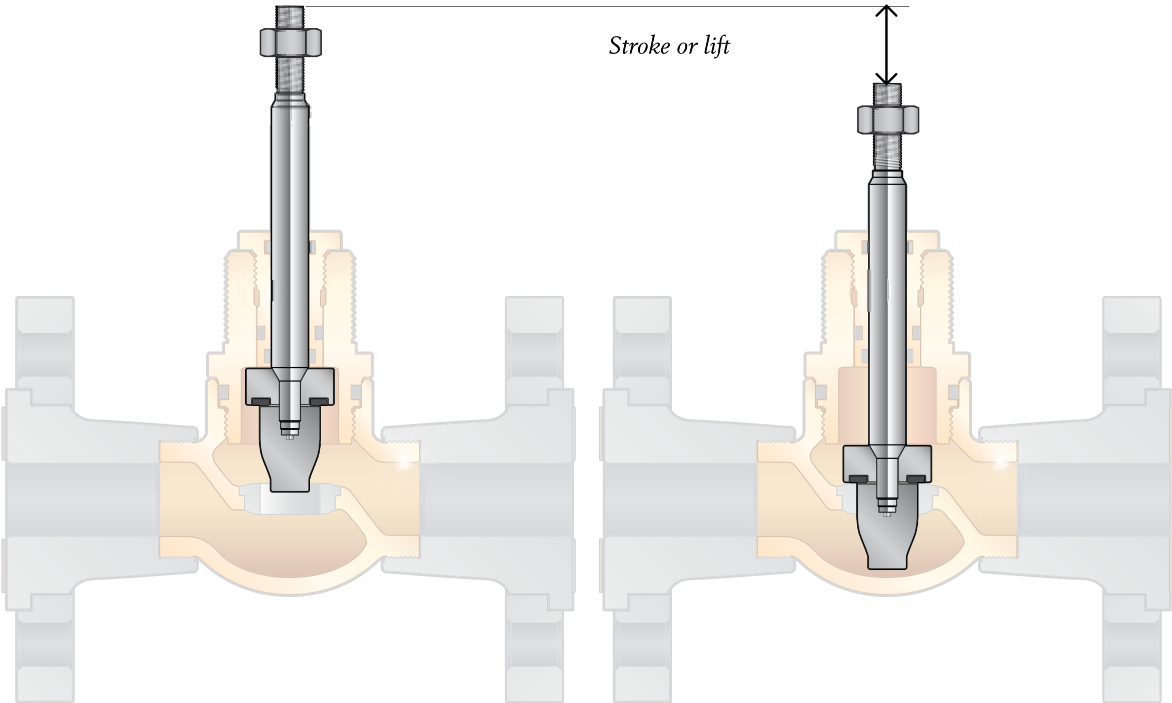
Stroke

Stroke length or lift is the distance which the plug and stem must move in order to go from an entirely closed to an entirely open position.
Generally speaking, the larger the valve, the greater its stroke.

The stroke of Regin control valves ranges from 5 to 40 mm, depending on valve size.

Too short a stroke may make fine adjustments difficult, especially at low flows.
Too long a stroke may generate control instabilities, including oscillations.

Since stroke is dependent on valve size, in practice one would not select a valve based on stroke but rather on its capacity. If the valve has the required capacity (without being oversized), it helps to safeguard optimal control both as far as comfort and economy are concerned.



Fully open valve *Closed valve*

Over- and undersized valves

The right valve offers great benefits

In domestic hot water control, particularly in large residential buildings, large variations in flow occur throughout the day. Overall hot water usage reaches a maximum during a few hours every morning and evening. Similarly, great variations occur in the system between winter and summer, respectively. In decades past, when energy costs were not a limiting factor, control valves with a capacity for the most extreme conditions were often selected as a safeguard. These valves, in other words, were oversized.

In reality, however, it has been shown that reductions of up to 30% can be made to installed output while still maintaining the same level of comfort. By thereby replacing older, oversized valves with newer ones featuring lower kv values and a higher control accuracy, a more stable level of control is achieved. Simultaneously, operations become far more economic for both building owners and district heating plants.

Marginals in district heating systems FOU 2003:85 and Consequences of smaller control valves in distribution networks FOU 2004:105

Oversized valves

In an oversized valve, even the smallest change in stroke will result in large flow variations.
When water requirements are slight, the plug moves only very little from the valve seat. As the valve opens or closes, large flow speeds and a powerful turbulence are created between the plug and seat. This both erodes the valve and causes noise.

During normal operating conditions, the valve operates using only a small part of its combined stroke (=lift).
As operating conditions change and the control system attempts to locate the setting that currently provides the proper amount of heat, the valve will begin oscillating back and forth between its minimum and maximum positions; the flow becoming simply too large to handle. These oscillations wear on the packing box, which may begin to leak prematurely. The servomotor and gearbox, too, will wear out in advance.

Undersized valves

Undersized valves are rarely completely closed. The valve seat and plug will wear less on each other, making the valve retain its given valve characteristics. If on the other hand the valve is too small, i.e. has an insufficient capacity, it must be open for full flow constantly.
Undersizing, however, will frequently cause the valve to not provide an adequate flow. If the valve is undersized it will remain fully open when needs are at a maximum without providing an adequate flow of fluid.

Valve tightness

A valve that leaks internally allows water to pass through even when closed. This is wasteful and makes poor economic sense. In order for the valve to be completely sealed in its closed position, the plug must fit closely against the seat. During manufacturing, this is achieved through processing valve details with a high degree of precision and by using soft sealing.

Regin valves provide a leakage of 0 %

Normally, control valves on the market have a leakage of 0.02 - 0.05 % of their kv value (full flow). Regin offers valve series that are absolutely tight when closed. This is achieved through a combination of carefully processed valve plugs and seats (made from stainless steel) as well as teflon seals on the plug, enforced with carbon fibers.

Tight valves conserve energy

In the long term, even a small valve leakage may lead to great losses. Leakages are particularly noticeable during summer months, when control valves are supposed to be entirely closed.

Old control valves in heating stations are frequently oversized. The plug then operates near a closed position where the risk of erosion corrosion is greatest, further increasing valve leakage. The leakage originally stated by the manufacturer may therefore gradually come to increase during the lifetime of the valve.

A completely tight valve offers substantial savings in a district heating system.

An example

Many manufacturers specify leakage in a brand new valve as being up to 0.02 % of the kv value. After a few years of operation, leakage may have climbed as high as to between 0.08 and 0.1% of the kv value.

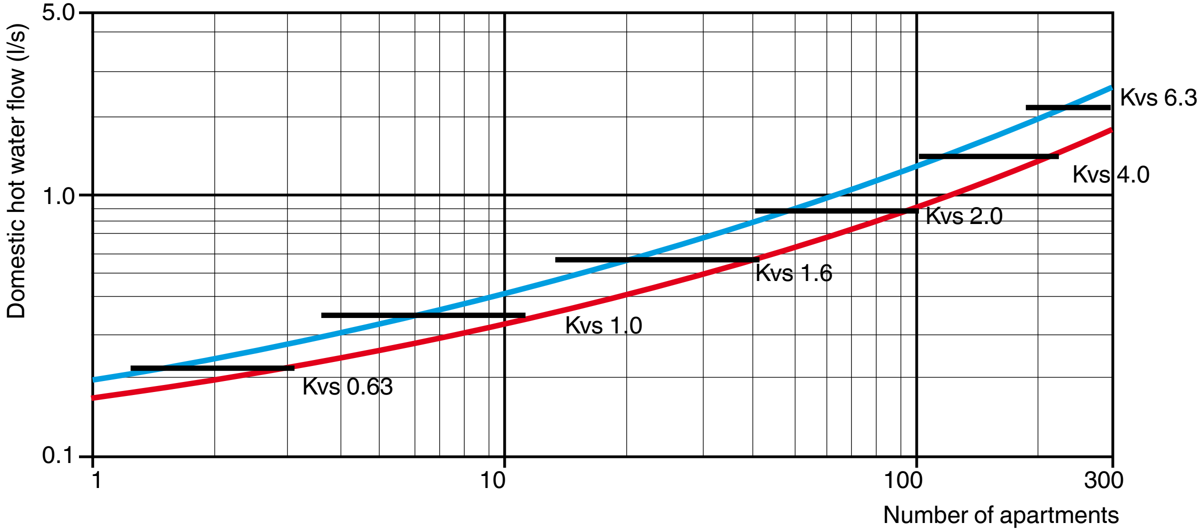
For a valve with DN 65 and a kv value of 20, a leakage of 0.1% of the kv value corresponds to 20 l/h for a constantly closed valve. During operations where the valve is closed during 30% of the running time, leakage will therefore amount to approx. 6 l/h.

Costs of leakage, as these relate to district heating bills, may seem negligable in each individual case but will prove massive in cases where property holdings are larger or in an area that may contain hundreds of leaky valves.
Using a completely tight valve may therefore mean making significant savings.

Leakage at closed position % of kv	0.1 %
Leakage at kv 20	0.02 m^3/h or 20 l/h
Leakage at 30% closed position of total run time	6 l/h
Leakage at total annual run time of 8760 hours	52 560 litres

Sizing of domestic hot water control valves

Recommendations from the Swedish District Heating Association.
Technical regulations F:101, 2004.



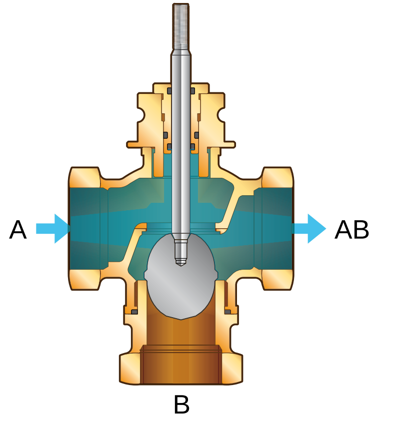
The Swedish District Heating Association: Old houses with special needs.
For instance, a residential building with large hot water requirements.

The Swedish District Heating Association: New building using energy-saving technology

Recommended kvs for control valves, primary side

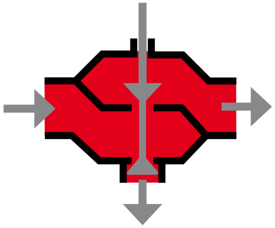
3-way valves

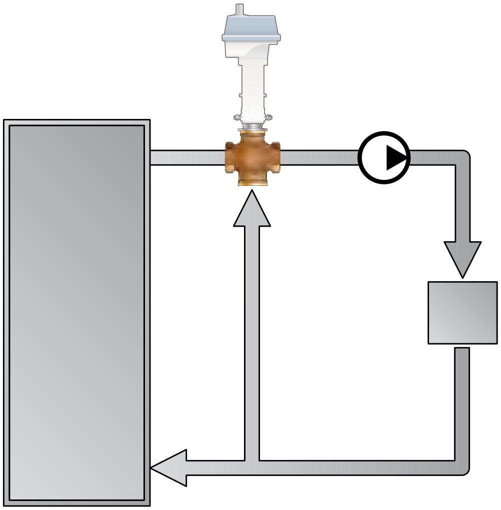
The primary application for 3-way valves is to mix flows from two circuits, e.g. hot and cold water, into a flow of desired temperature.
The valves are used in domestic hot water, heating and underfloor heating systems. Other applications are in cooling, ventilation and air conditioning systems.



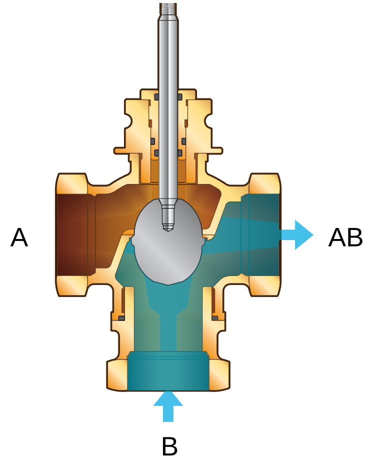
As the stem is at its lower position, flow-through between ports A and AB is entirely open.

There are also 3-way valves that can be used as distribution valves. A constant primary flow is distributed into two circuits with a variable flow and constant temperature.



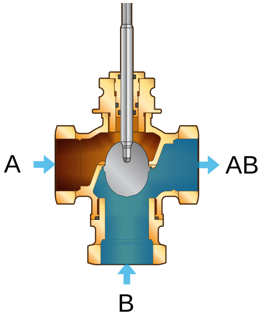


3-way valve connected as a mixing valve

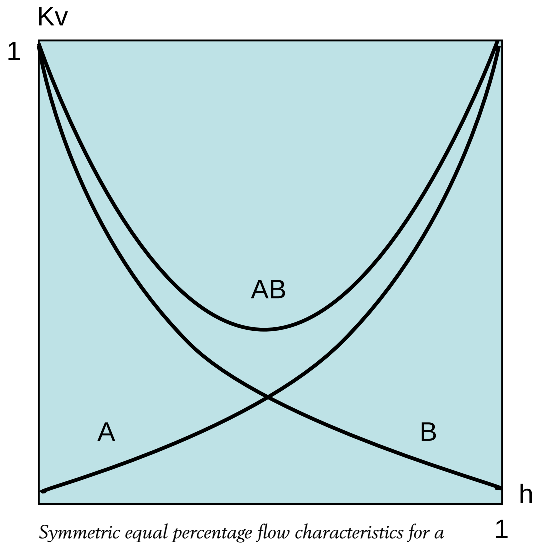


As the stem moves upwards, the flow between ports B and AB gradually opens while the flow from port A simultaneously closes to a corresponding degree. When the stem is in its highest position, port A is entirely closed and the flow between ports B and AB is maximised.

Symmetric and asymmetric valves



A 3-way valve has two controlled flows, A-AB and B-AB. In a ***symmetric*** valve, characteristics are the same for both. Valve sizing and calculating the kv value can therefore be performed in the same manner as for a 2-way valve.
When ports A and B have differing characteristics, the valve is ***asymmetric***. This requires use of special accuracy. If the ports are confused with one another, it may bring about a significant decrease in valve controllability.



Symmetric equal percentage flow characteristics for a 3-way valve

Radiator systems and radiator valves

Single-pipe radiator system

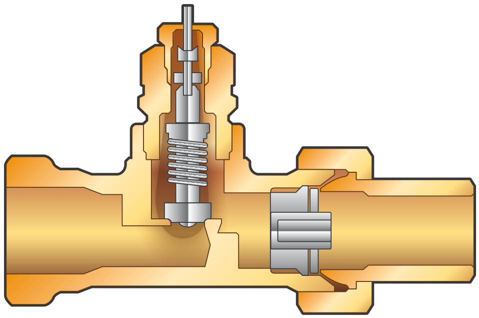
In a single-pipe system, radiators are connected in a loop (a circulation system) in series with one another. As water passes through the radiators/heaters, the temperature gradually decreases. This temperature loss is compensated for by installing larger radiators further away from the heat source. At most, a single-pipe system should comprise 6-7 radiators/heaters in sequence. So as to not interrupt circulation in a single-pipe system when a radiator valve is shut off, a bypass pipe is mounted near each radiator.

Dual-pipe radiator system

This system consists of a supply pipe, leading water to each respective radiator/heater, as well as a return pipe leading back to the heat source. Each radiator/heater is connected in parallel to the heating system, and individual radiator size needs therefore not be compensated for.

Control valves/radiator valves

In order to control the supply of hot water to the radiators/heaters, a control valve is mounted on the intake to the radiators/heaters.
To provide the right amount of heat in relation to where in the system they are placed, each radiator valve is adjusted according to a kv value calculated using water pressure and pressure drop across the radiator.
At the same time, it is desirable to generate as great a temperature difference as possible between supply and return. This holds especially true for district heating systems.



Cross section of a radiator valve

Thermostatic valves

A thermostatic valve is an automatic valve controlled by an expanding thermostatic head. Inside the head is a wax element that expands as the temperature rises. This enables the stem of the radiator valve to be controlled according to room temperature and a setpoint. Thermostatic valves thereby provide a desired temperature in each room while also compensating for possible oversizing of the radiator/heater. They also reduce the supplied heat when other heat sources increase the room temperature. Thermostatic valves are generally used together with a central controller that regulates the supply temperature.

Thermal actuators for radiator valves

These are mainly used when a electronic controller is installed in the room. Should cooling be installed in the room, it is necessary to control the supplied heat via the radiator by using a thermal actuator connected to an electronic controller for the radiator valve. The controller controls heating and cooling in sequence, so as not to risk the two being active at the same time.

High differential pressure across thermostatic valves may cause noise

As a thermostatic valve closes, the differential pressure across the valve increases, which simultaneously increases the risk of noise. Noise often occurs when heating requirements are low, as radiator thermostats – due to additional heat – decrease flow throughout the system. The risk of noise is at its greatest when the valve plug is near its closed position.
The noise will increase as the flow does, which can be eliminated through adjusting the radiators so as to avoid overflows. Noise can also be reduced by decreasing the pump pressure to a lower setting (thereby reducing differential pressure and flow).

Valve material

Regin's valves are made of the following materials:

Body

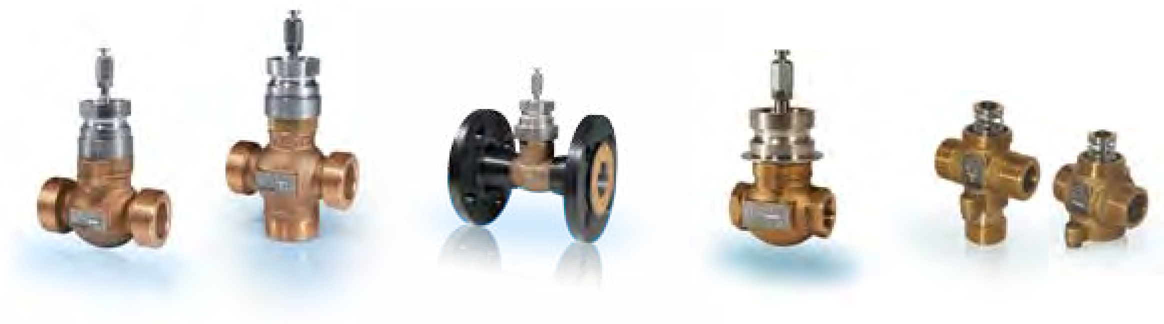
- Gunmetal 1400 LG2
- Brass CZ 121
- Chromed brass CZ 121
- Grey iron Grade 260
- Nodular cast iron Grade 500/7

Plug/seat

- Gunmetal 1400 LG2
- Stainless steel X3CrNiMoN27-5-2 / 304S15 / 303S31
- Brass CZ 121

Stem

- Stainless steel 303S31



Copper alloys

Gunmetal (bronze)

Gunmetal or bronze contains 85 % copper, 5 % tin, 5 % lead, 5 % zinc.

Brass

Brass contains approx. 58% copper and 42% zinc.

Domestic water systems create special demands

Dezincification

Dezincification, primarily occurring in domestic water systems, is the most difficult form of corrosion to prevent. It is a gradual process in which the zinc inherent in the brass is dissolved, leaving behind only a brittle, porous coppery mass. The advantages of using gunmetal instead of brass is that dezincification will not occur due to low levels of zinc that are chemically "locked in place".
Brass alloys, containing a high (42%) level of zinc, are therefore inferior to copper alloys as far as resistance to dezincification is concerned.

Corrosion properties

In domestic water systems that place great demands on corrosion properties (resistance to dezincification), valves with a body of bronze (gunmetal), or sometimes brass, are primarily used.

Brass resists neutral solutions well, but in acidic solutions it is possible for brass to dezincify. Brass valves should therefore not be installed in domestic hot water systems. Heating systems often use additives in water, venting, etc. that reduce the risks of dezincification occuring.

Cast iron

Cast iron contains approx. 2.1–4 % carbon and is available in different variations. Regin's cast iron valves consist of grey iron or nodular iron.

Grey iron

Grey iron is an alloy from iron/carbon containing 2-4% carbon (graphite). Grey iron is cast in qualities ranging from Grade 100 (GJL-100) to Grade 350 (GJL-350), where the numbers indicate tensile strength. The carbon occurs as graphite flakes, interpersed in the iron matrix. The carbon mixture provides grey iron with a graphite layer that protects against corrosion. The level of protection increases with the carbon content, but with the downside that durability simultaneously decreases (due to the graphite flakes). From a corrosion point of view, grey iron is far superior to ordinary steel. In water or water-based solutions with pH values ranging between ~6 and 10, grey iron can be used with no significant risks of corrosion damage occurring. Grey iron can still be used in more acidic fluids. However, one should pay attention to exactly what substances give rise to the lower pH value.

Grey iron should be avoided in systems subjected to internal and/or external pressure shocks. These may occur in a pressurised pipe as a valve opens or closes, a pipe ruptures or when a pump starts or stops, etc.
In Sweden, the upper limit permitted for pressurised systems using grey iron components is 120°C. For higher temperatures, nodular iron or cast steel must be used. This is especially important in hot water systems.

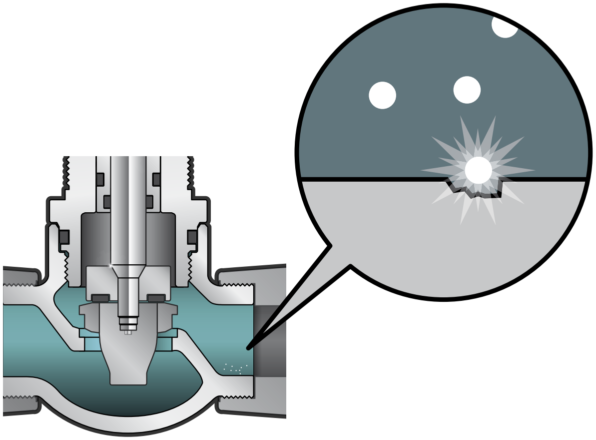
Nodular iron

Nodular iron is very similar to ordinary grey iron in regard to carbon and silicon content. As opposed to the graphite structure of grey iron, whose structure is squamous (scale-like), the graphite content in nodular iron takes the form of small, round spheres. This is achieved by adding small measures of magnesium to the batch before casting. Through the spherical shape of its graphite, nodular iron is made significantly stronger and more impact resistant than grey iron. Nodular iron is very useful in components subject to internal overpressure. Its upper limit of use is approximately PN 25 with a temperature limit of 300°C for fluids. The corrosion resistance of nodular iron is quite similar to that of grey iron. This also applies to its use in chemical liquids.

Damages

Cavitation

Cavitation is an erosion process that may occur at high flow temperatures in conjunction with a high pressure drop across the valve. This occurs in the following way: As water passes the valve plug and seat, its flow speed increases while the static pressure drops – leading to a massive loss in pressure. If the static pressure drops below the vapour pressure of the water, the water will boil; giving rise to pockets of steam.



Once the water has passed the seat, its flow speed will decrease and the static pressure increase – leading to the pockets of steam rapidly collapsing (imploding). The imploding steam pockets form very thin jets, whose great momentum cause massive damage to the surfaces inside the valve. These damages resemble tiny craters. The pressure blasts also give rise to vibrations and noise resembling the sound of sand or gravel inside the valve.
In order to prevent cavitation damages to the valve plug and seat, the pressure drop across the valve should not exceed certain maximum values.

Max. pressure drop kPa	
Cast iron	approx. 150
Bronze	approx. 350
Stainless steel	800 – 1000

It is also possible to eliminate cavitation by mounting a pressure reduction valve before the control valve.

Cavitation damages to an impeller

Corrosion

Corrosion usually takes place through chemical or electrochemical (galvanic corrosion) wear on metal. Damages resemble those of cavitation damages, featuring pits of varying size with a reticulate, sponge-like pattern.

Dezincification, which may pose a problem in HVAC installations, is a form of galvanic corrosion in brass alloys in which zinc is dissolved, leaving behind a brittle coppery mass. Dezincification occurs only in oxygenated water and normally in systems with soft water or water with a high chloride content. Dezincification is more common in domestic water systems than in heating systems. In systems placing great demands on corrosion resistance, valves constructed from bronze (so-called gunmetal) are commonly used.

Erosion corrosion

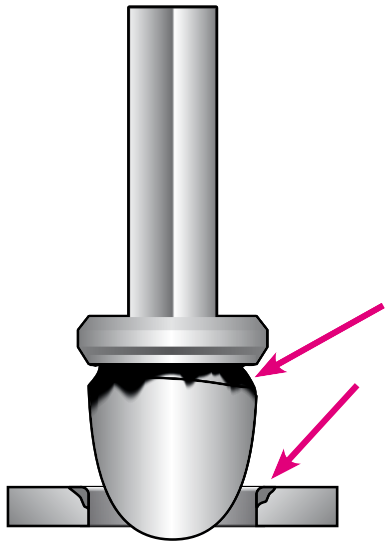
Erosion damages are caused by the mechanical impact of fluid flowing at great speed. Erosion corrosion is sped by pockets of gas or solid particles caught up in the fluid. These damages appear as pits and grooves surrounding the seat and plug (since the flow speed is highest when the valve is almost closed). No noise occurs, making it difficult to track the erosion.

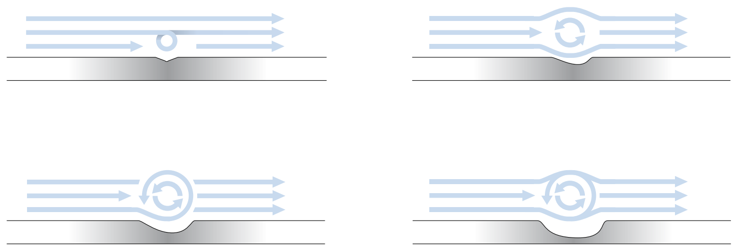
Damages resulting from erosion corrosion

Mechanical wear

Shock waves propagating through the water may give rise to vibrations and generate motion between the seat, plug and seals. This may also happen during low pressure drops and flows.

Damages are frequently asymmetrical. The resulting noise sounds like rattling in the valve.





The process of erosion corrosion

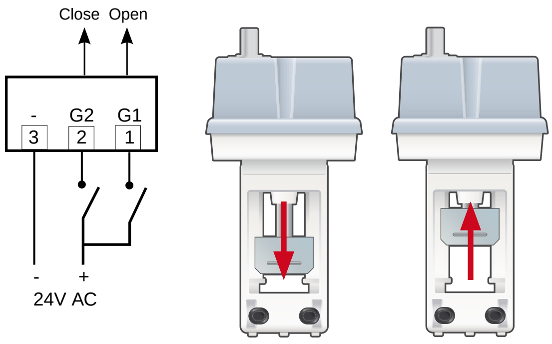
Electromechanical actuators

The purpose of the actuator is to close/open and control flow through the valve. Electromechanical actuators are usually controlled via either an increase/decrease signal, a so-called 3-position signal, or a proportional (modulating) signal such as 0...10 V DC.

Increase/decrease signal (3-position control)

The actuator receives either a signal to increase or to decrease via closing contacts. When given a signal to increase, the actuator stem is pushed towards a closed position (= valve closes). When given a signal to decrease, the actuator stem is pulled towards an open position (= valve opens). Once balance has been attained and the requested water flow passes through the valve, this is sensed by the controller which issues neither a signal to open or to close. The actuator does not move. Three positions therefore exist; increase, decrease, halt. This type of actuator uses a simple and secure construction and is often used in simpler applications. A downside may be that the actual position of the valve is not known by the control system.

3-position control



G2 closed/close

G1 closed/open

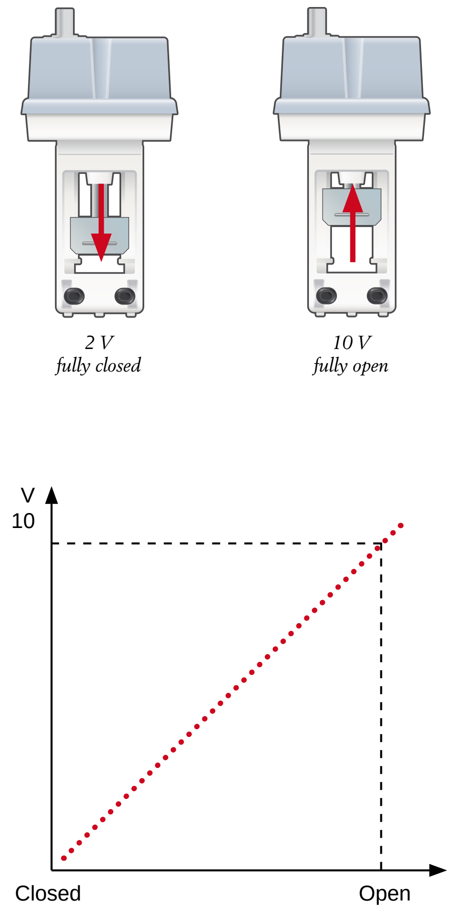
NB: Whether open or close = up or down depends on the valve construction

Proportional (modulating) signal (0)2-10 V, 0-20 mA , 4-20 mA)

The control signal is variable, most commonly between 0-10 V (or 2-10 V to avoid problems with interferences within the 0-2 V range). The actuator positions the motor according to the given signal. At a 2-10 V control signal, 2 V usually means a fully closed valve and 10 V a fully open valve.
Whether or not the valve closes in an up- or downward direction depends on the valve and the chosen setting.

The advantage of using this type of actuator is that the valve position is always proportional to the current control signal. This is a useful function in integrated solutions for building automation, in which valve position can be displayed using a graphic interface.

Proportional signal control

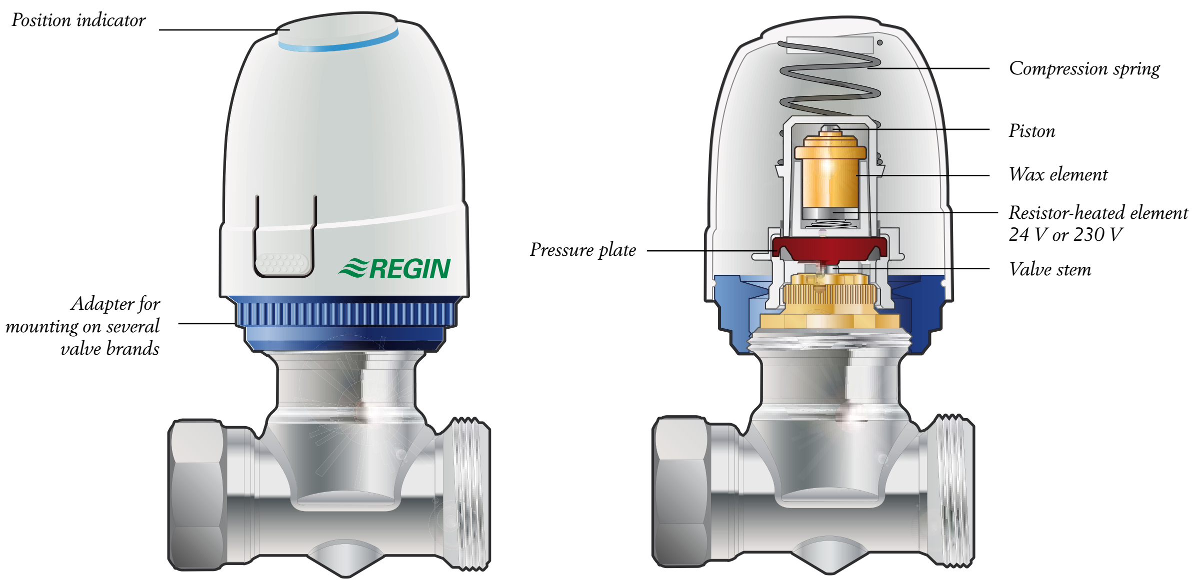


Thermal actuators

Thermal actuators are used for control of radiators, solar heating systems, chilled beams, floor heating systems, etc.

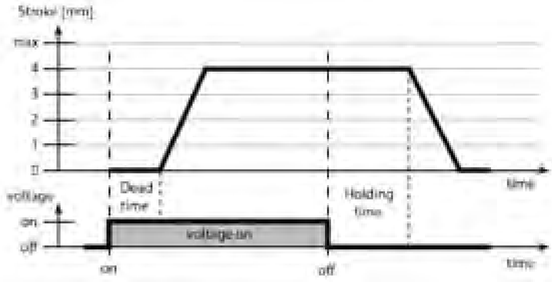
The central component of a thermal actuator is the so-called thermal body, a wax element and a thermistor.

When a current (24 V AC/DC or 230 V AC) is applied to the thermistor, the wax element is heated. The wax expands and a piston increases pressure on the valve stem. The control signal from the controller can either be on/off (increase/decrease) or proportional (0...10 V). Pulse width modulation of the output provides stepless valve opening using an on/off actuator. This output function is available in Regin's Regio series of room controllers. Thermal actuators may be of the type normally closed (NC) or normally open (NO).



Normally closed (NC)

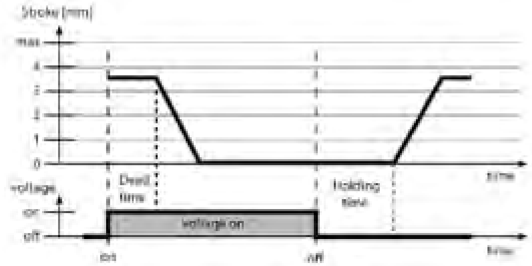
After the supply voltage has been switched on and the dead time has elapsed, the movement of the piston opens the valve. When power is cut and the hold time has elapsed, the wax element cools off and the compression spring closes the valve.
The compression spring keeps the valve normally closed (NC).



Normally open (NO)

For normally open (NO) actuators, the movement of the piston is adjusted on the actuator mechanically so that its function is opposite to that of normally closed (NC) models. I.e. once power is cut and the hold time has elapsed, the valve will open. The running time for opening and closing is 3-5 minutes.

This applies to all valves constructed in such a fashion that they are closed when the stem is depressed.



Regin's Valve Centre

Regin's research and manufacturing facility for valves is located in the town of Osby. Valves have been manufactured here since the early 1920s, resulting in an extensive expertise in the field. Today, Osby houses a modern facility for development, mounting and testing.

The components of our valves are manufactured by those suppliers that are able to meet our high demands on quality. As a result of our development in the field, Regin can now offer valve series featuring a unique sealing technology that makes them absolutely tight when closed.

All valves are tested according to established ISO routines and provided with the CE mark and an ID number.

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THE CHALLENGER IN BUILDING AUTOMATION

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