Solenoid Valves

EXPLANATIONS IN THE PRINCIPLE DESIGN OF SOLENOID VALVES

- Direct Acting
- Servo-Assisted

Direct-acting Valve Anatomy

Coil

The coil forms the drive system of the solenoid valve. Electrical energy is converted to a controlled magnetic force.

Plunger

The plunger is a precision turned part made of magnetic steel. It is moved by the magnetic field generated in the coil.

Closing spring

The closing spring presses the plunger onto the valve seat to close it.

Electrical connection

A broad spectrum of electrical connections is available. Many magnetic systems are designed for protection type IP 65.

Plunger guide tube

Precision machined tube made of non-magnetic steel, in which the plunger is guided.

Shading ring (AC only)

This is needed only for AC coils. The shading ring represents a coil with one winding, which during zero crossing of the AC voltage induces sufficient residual magnetism to keep the plunger from dropping.

Air gap and stopper

The stopper is part of the magnetic circuit and is firmly fastened to the plunger guide tube. The air gap is the distance between the stopper and the plunger. There should be no gap when the plunger is attracted, in order to generate an optimal magnetic force.

Encapsulation

The coil is cast in polyamide or epoxy to protect it against damage and moisture. The coil temperature and ambient influences determine the material used for encapsulation.

Diameter

The diameter refers to the inner diameter of the valve seat. It is relevant for the flow rate calculation.

Process connection

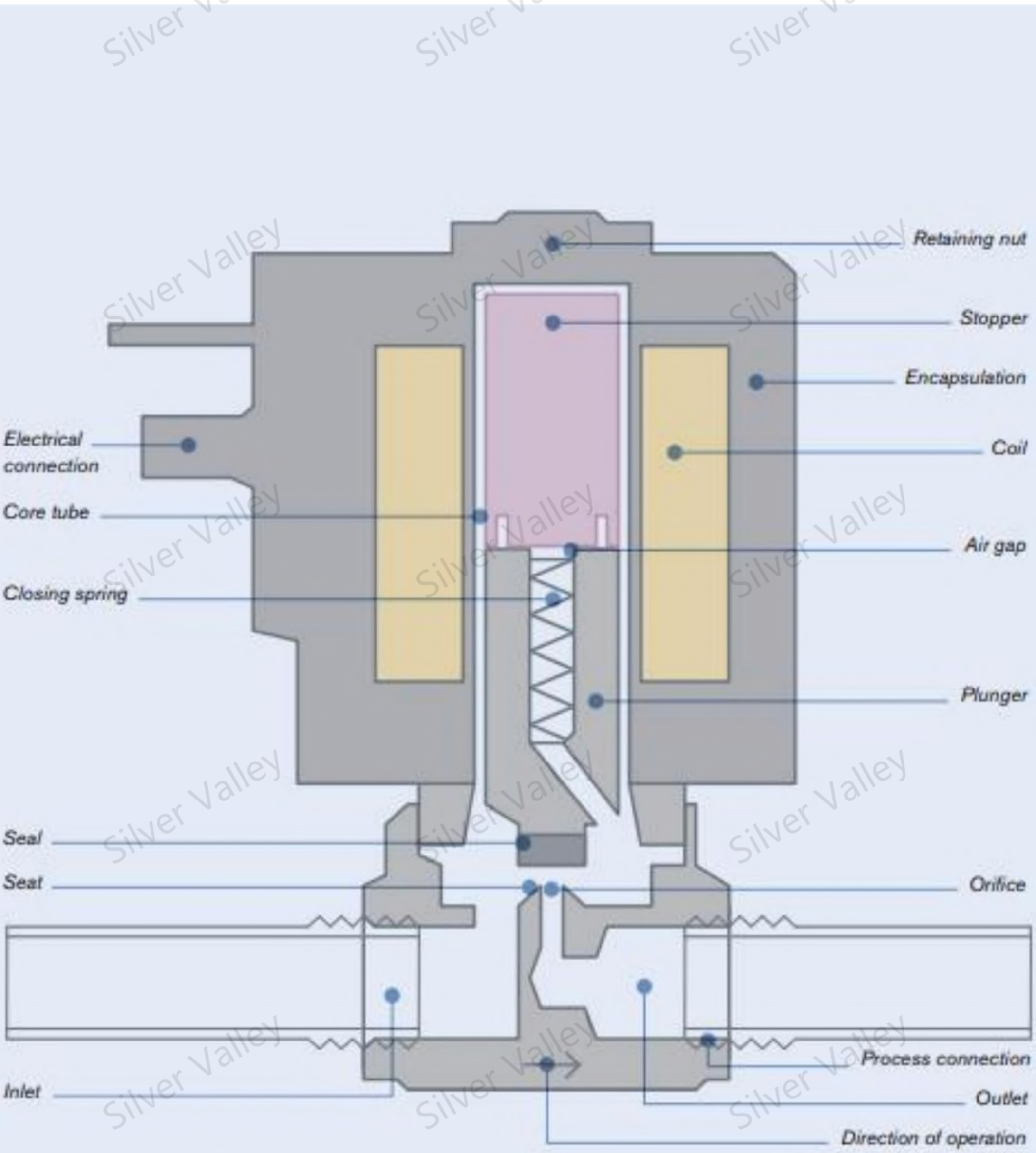
The process connection is used for the fluidic connection of the valve in the pipe system. Standard DIN and ANSI connections are available, as well as special versions.

Valve seat

The valve seat is the essential fluidic element. It is manufactured with high precision and formed according to the sealing principle.

Seal

The seat seal is the heart of the fluidic system. It is always adapted to the valve pressure, media temperature and chemical resistance.



Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids (liquids and gases). They are confronted with many different requirements in a plethora of application environments and must offer:

- *fast and safe switching*
- *high reliability*
- *long service life*
- *good medium compatibility of the materials used*
- *low control power*
- *compact design*

Direct-acting 2-way plunger valve

Function:

The main components of this valve type are a coil, a closing spring, a valve body cover and the valve body with the seat. Without current the path to the outlet is blocked (normally closed), since the closing spring, supported by the pressure of the medium, presses the plunger onto the valve seat. If current flows through the coil, the latter generates a starting force, which pulls the plunger and the seal against the spring force and draws the medium upward. The channel is opened for the medium.

Application:

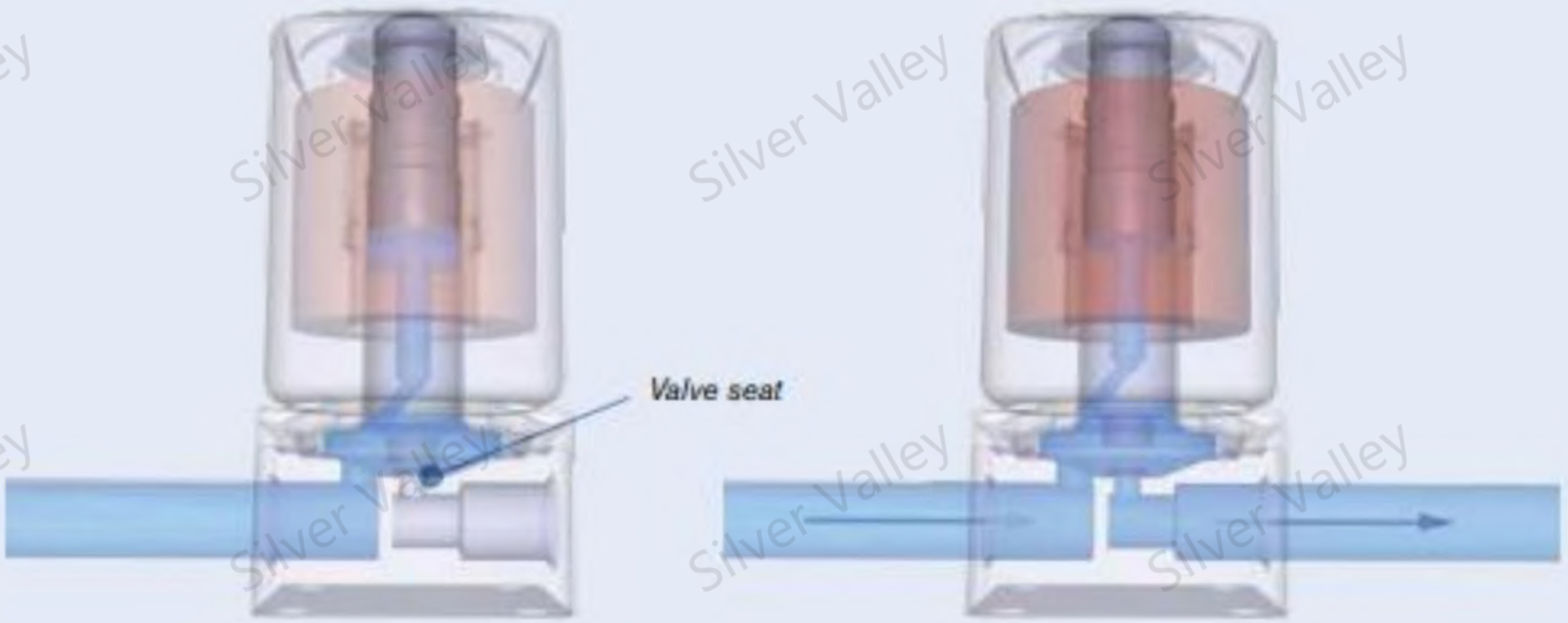
This cost-effective valve type is used in universal applications for neutral and clean liquids, gases and vapours. Versions with special high-quality materials also allow their use in mildly acidic and alkaline solutions. The direct-acting 2-way plunger valves therefore can be used for diverse applications, such as shut-off, dosing, filling and ventilation.

Special features:

Due to a spring-damped seat seal, these valve types have a long service life. Especially noteworthy are the increased switching cycles and service life due to sliding ring bearings. These products are also suitable for high pressure and temperature ranges.

Type	6011	6013	6027
			
Process connections			
Diameter [DN in mm]	1.2 … 2.4	2.0 … 6.0	1.0 … 12.0
Pressure range [bar]	0 … 21	0 … 25	0 … 250
Temperature [°C]	-10 … +100	-40 … +180	-40 … +180

2/2-way plunger valve type 6013



De-energised **Energised**

Direct-acting 3-way plunger valve

Function:

The functioning principle of the direct-acting 3-way plunger valve depends on how the fittings are connected to the fluid system. As opposed to the 2-way plunger valve it has two valve seats and one return flow. If no electric voltage is present, a normally closed 3/2-way valve allows no passage from the pressure connection P to connection A (outlet), since a conical spring presses the plunger onto valve seat 1. At the same time A is directly connected to R (return flow) and valve seat 2 is opened. If the coil is energised the plunger is pulled in and seals valve seat 2. The path between A and R is therefore blocked. At the same time valve seat 1 is opened and the channel between P and A is opened for the medium.

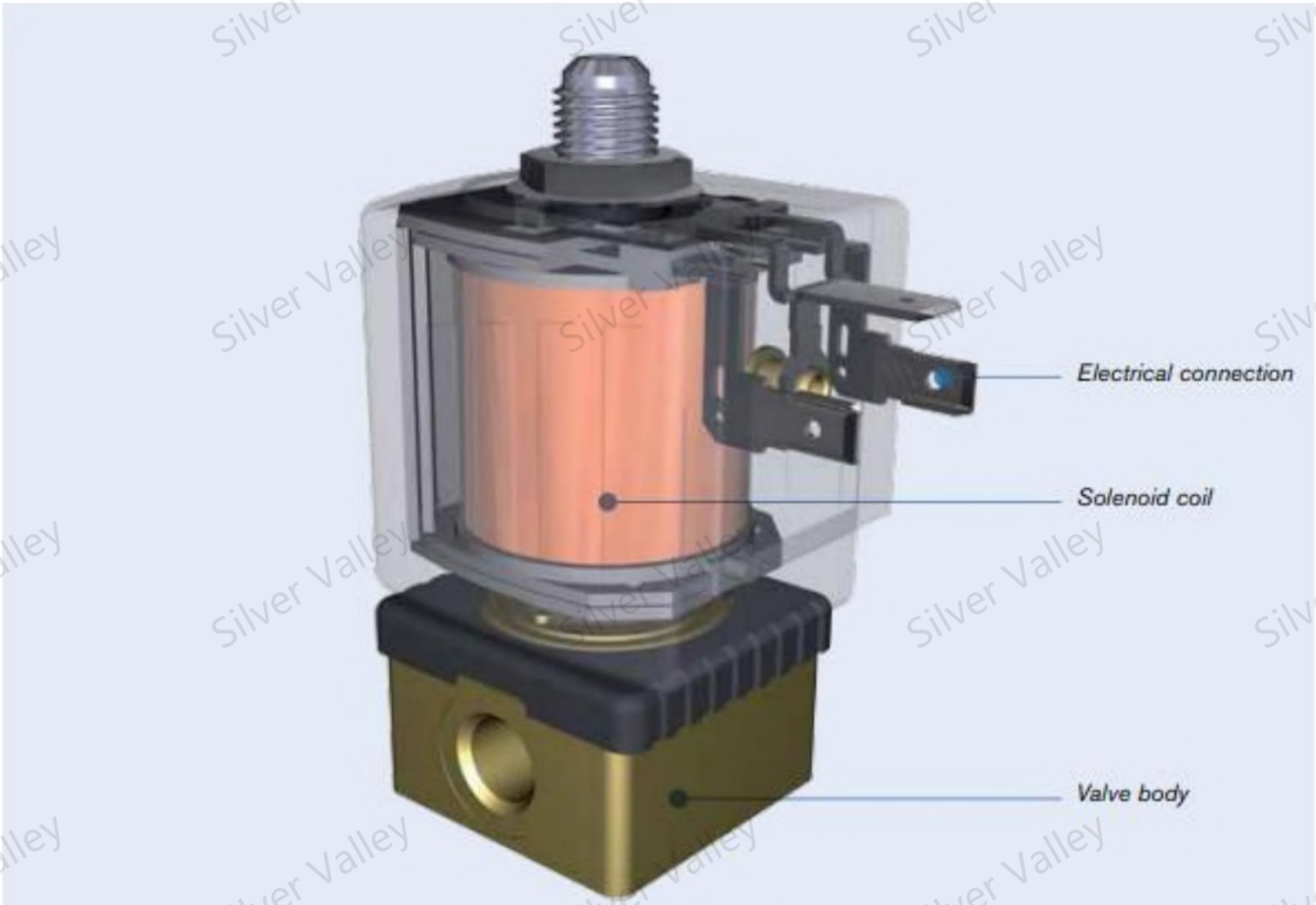
Application:

These valves can be used in diverse applications, such as mixing, distribution, ventilation, dosing, etc. of neutral gaseous and liquid media. This type is frequently used as a pilot valve for larger pneumatically actuated valves.

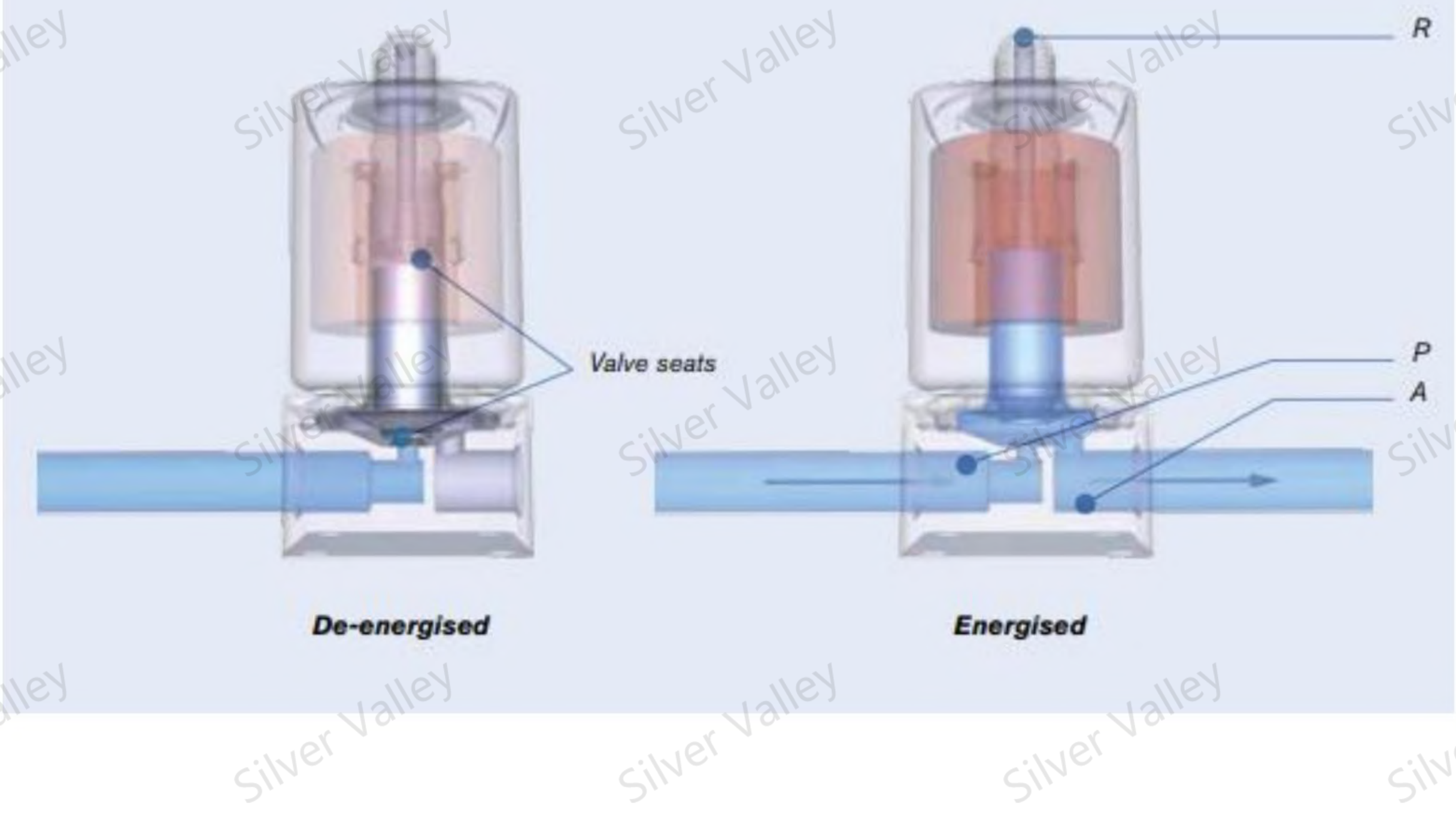
Special features:

Special features of this valve type are the convenient, service-friendly manual override, the energy-saving pulse design and its suitability for use in explosive areas. In addition there are versions that are suitable for high-temperature media (hot water, hot air and steam).

Type	6012	6014	0355
			
Process connections			
Diameter [DN in mm]	1.2 … 1.6	1.5 … 2.5	2.0 … 4.0
Pressure range [bar]	0 … 10	0 … 16	0 … 16
Temperature [°C]	-10 … +100	-10 … +100 (Polyamid coil) -10 … +120 (Epoxy coil)	-10 … +180



3/2-way plunger valve type 6014



De-energised **Energised**

Direct-acting toggle valve

Function:

The valve operates according to the lever principle and can therefore also directly switch large diameters. It is available both as a 2/2-way and a 3/2-way valve.

The armature acts horizontally on a fixed coupled toggle arm. The sealing cylinder located on the lower lever is pressed by the horizontal motion onto the valve seats. The plastic encased metal lever comprises one unit with the gas-tight lead-through. Due to this design the actuator is media separated from the fluid body.

Application:

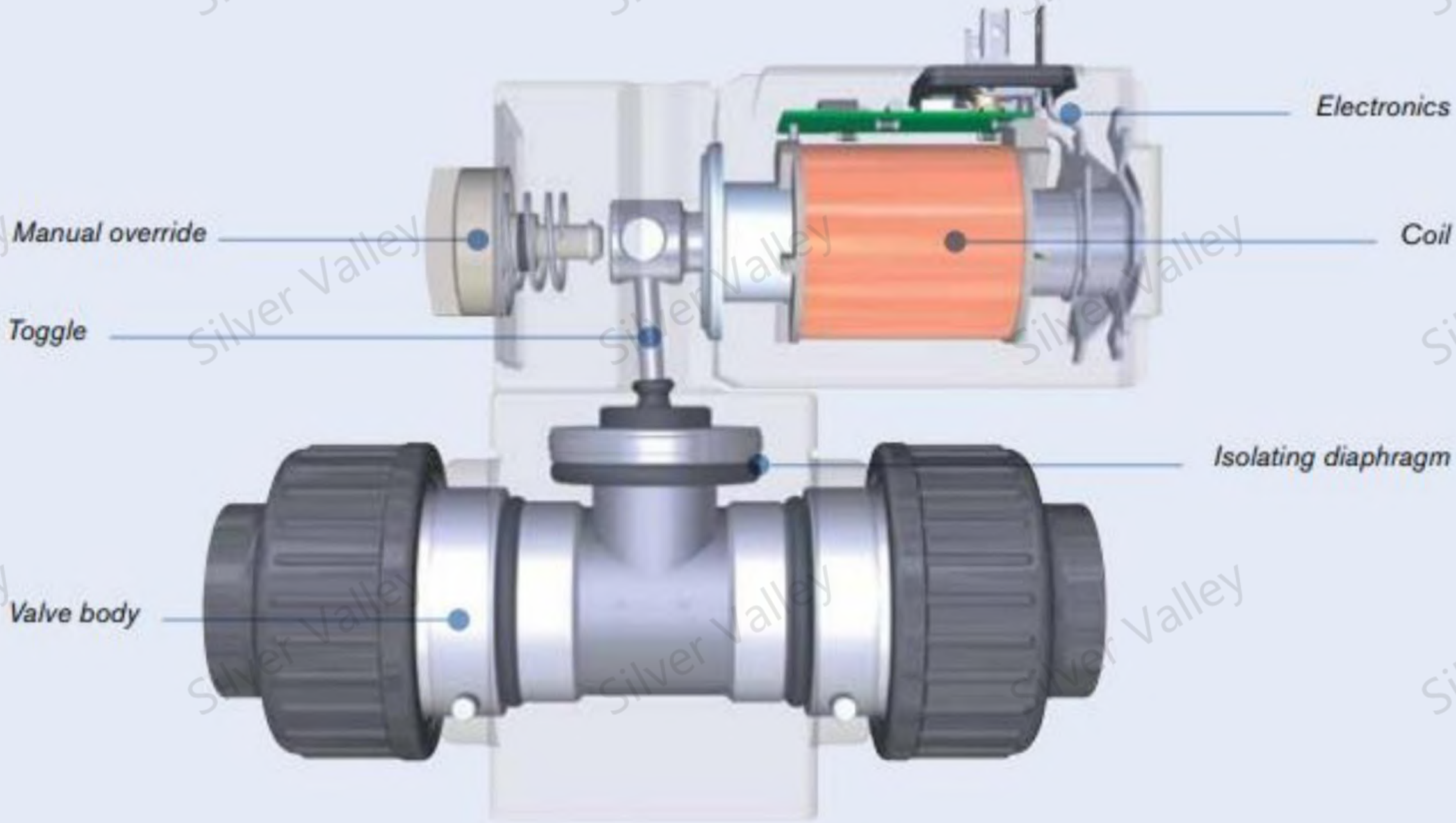
Media separation makes this valve especially suitable for use in critical acidic and alkaline solutions or in media that contain particles. Due to the large diameters it is often used as an emptying and mixing valve.

Special features:

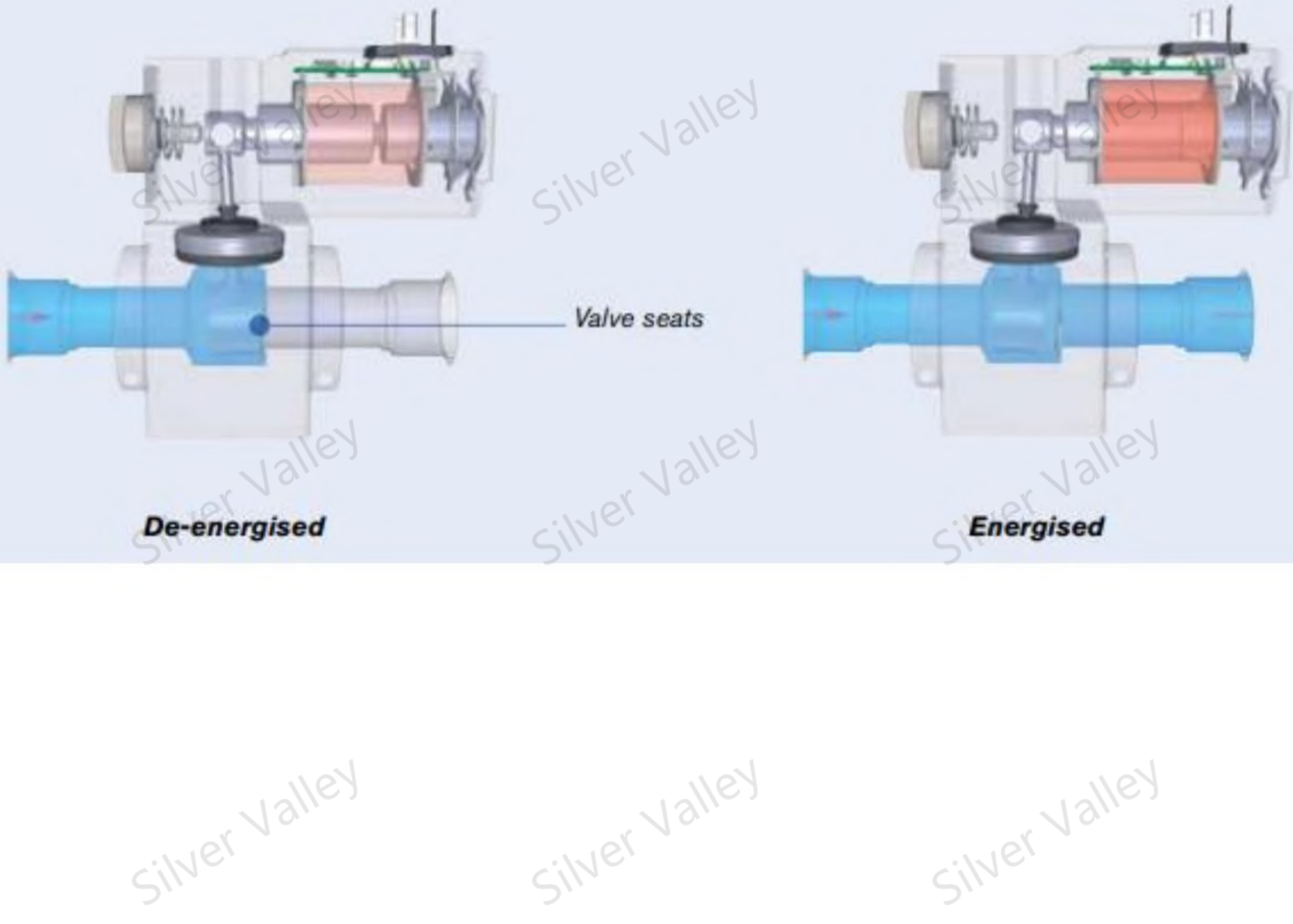
The energy-saving version with power reduction uses the double coil technology with integrated cast electronics. They are certified worldwide as AC, DC and UC versions and fulfil the voltage requirements for European rail transport.

These valves are equipped with a locking service-friendly manual override and offer the capability of potential-free electrical feedback of the switching position.

Type	0131	0131	0131
			
Process connections			
Diameter [DN in mm]	10 ... 20	10 ... 20	10 ... 20
Pressure range [bar]	0 ... 3	0 ... 3	0 ... 1
Temperature [°C]	-10 ... +130	-10 ... +130	-10 ... 80



2/2-way toggle valve type 131



De-energised **Energised**

Direct-acting pivoted armature valve

Function:

This type of valve uses a pivoted armature, a flexible separating diaphragm, two valve seats and one coil. They can be used both as 3/2-way and 2/2-way versions. Under voltage the pivoted armature is pulled against the force of the spring and the path between P and A (outlet) is opened. At the same time the channel between P and B is closed. Without current the pivoted armature closes valve seat 1 and the medium can flow between connection P and B.

Application:

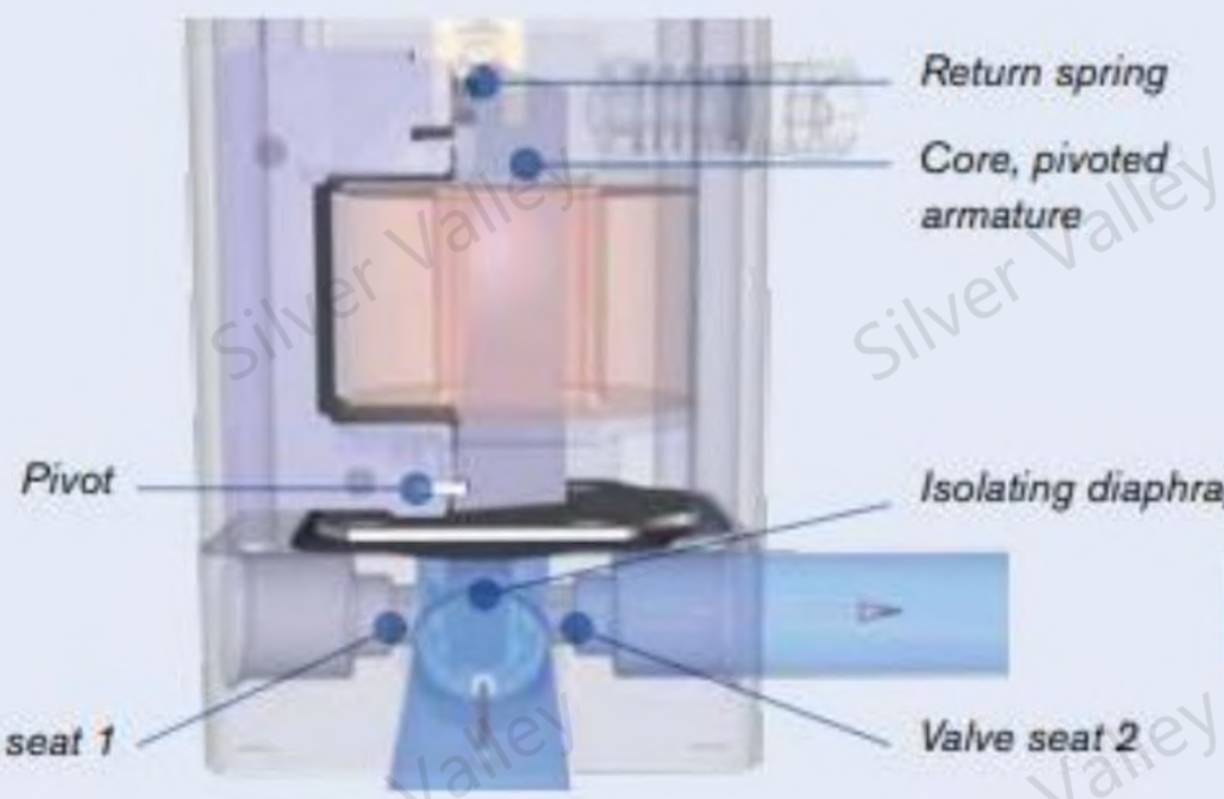
The use of a separating diaphragm, which separates the media chamber from the magnetic system, makes it possible to use these valves for the control of corrosive, contaminated and aggressive fluids as well as for vacuum. These valves are equipped with a lockable manual override and offer the unique capability of electrical feedback of the switching position, which results in increased safety.

Special features:

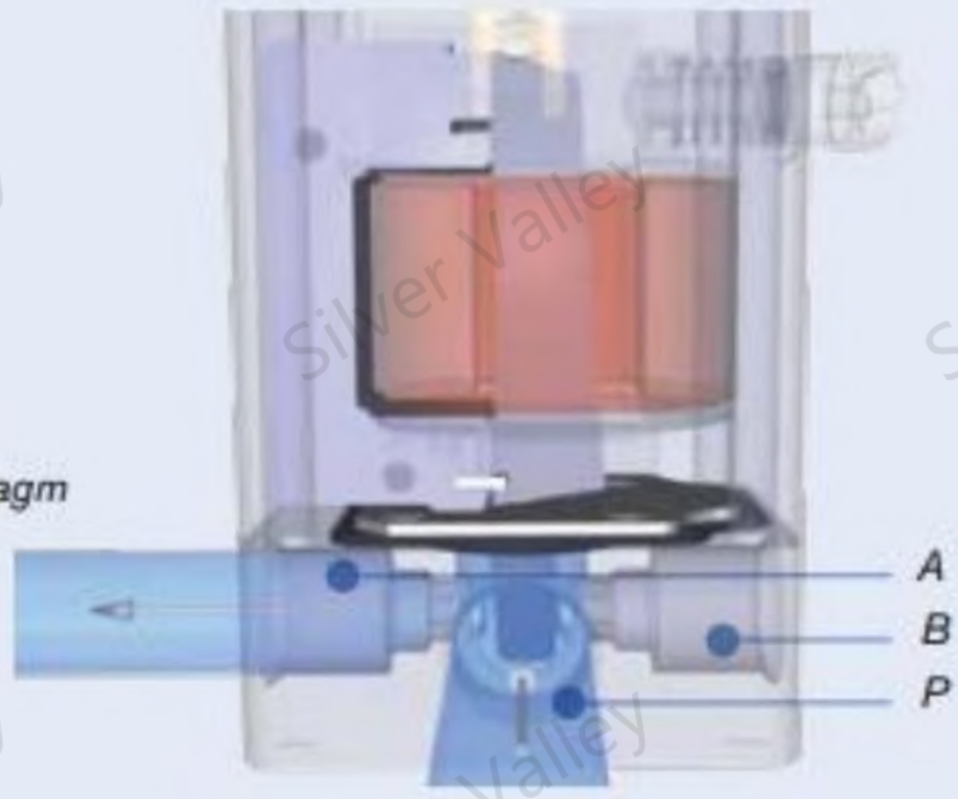
Versions for use in explosive areas are available, as well as different materials for media-contacting components. Decades of engineering experience make it a highly reliable, low-maintenance valve.

Type	0330	0331	0121
			
Process connections			
Diameter [DN in mm]	3.0 … 5.0	2.0 … 4.0	2.0 … 8.0
Pressure range [bar]	0 … 10	0 …16	0 …4
Temperature [°C]	-30 … +80	-30 … +90	-30 … +90

Pivoted armature valve type 330



Distribution valve
De-energised



Distribution valve
Energised

Servo-assisted Valve Anatomy

Pilot Valve

All of the functional principles explained for direct-acting valves (plunger, pivoted armature, rocker and flipper valves) can be used for pilot valves.

Chamber (above diaphragm)

Pressure is equalized in the chamber and is the space into which the diaphragm or piston recedes to allow flow.

Pilot channels

Allow fluid to move out of the chamber and from the pilot to downstream to enable the fluid to assist in opening the main seal.

Equalization hole/channel

Ensures that the inlet pressure and the pressure in the chamber above the diaphragm or piston are slowly equalised in order to close the valve.

Above the seat flow

In all pilot-controlled valves the flow takes place above the valve seat.

Spring

The spring in the chamber supports the media pressure during closing of the valve. In valves that are exposed to aggressive chemical fluids the spring is avoided. The media pressure alone then closes the valve.

Main Orifice

The area on which the media pressure will act and the gap through which the media will flow when the valve is energized. Along with the contours of the valve it governs the pressure drop and the flow rate of the valve.

Process connections

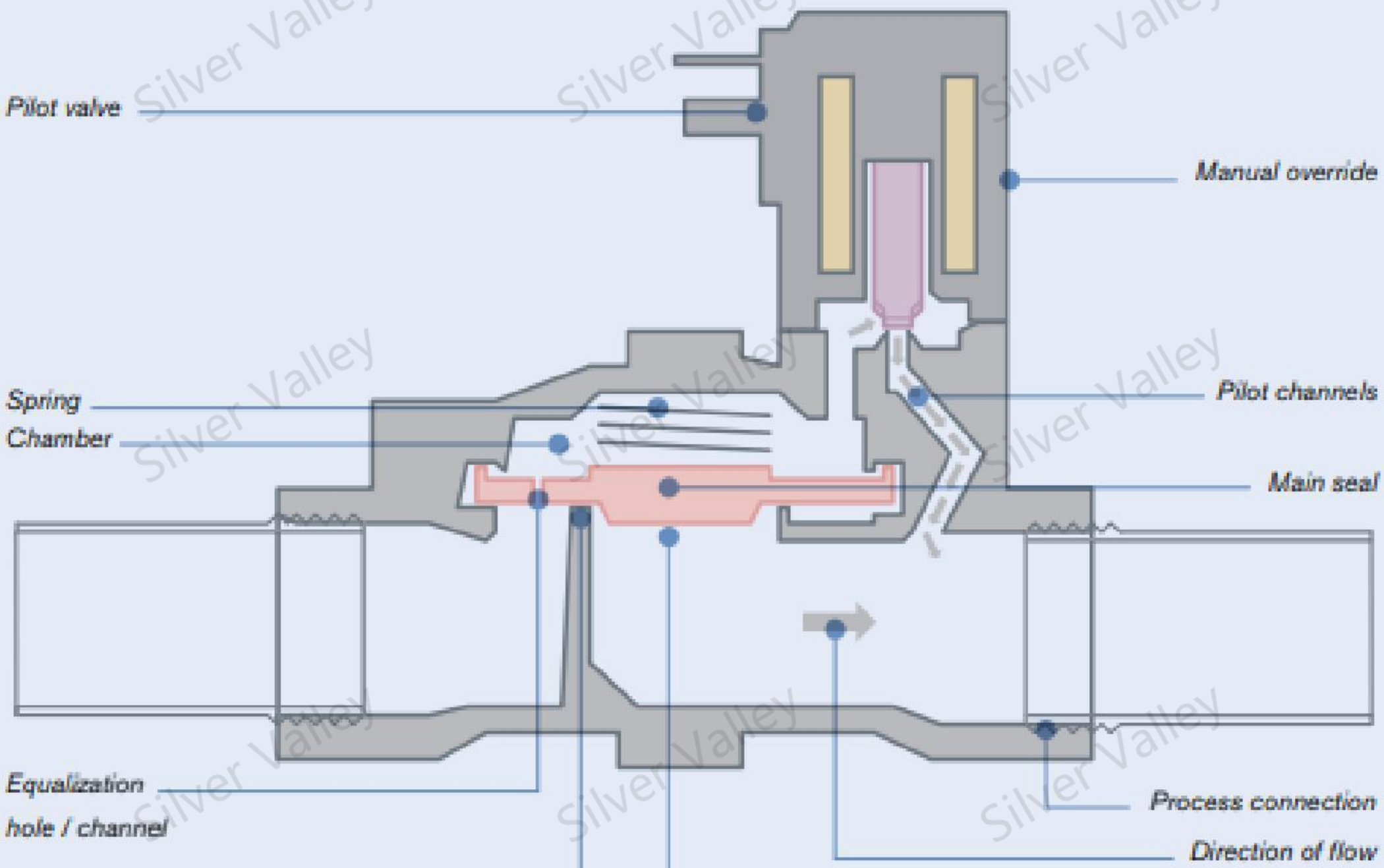
Many fluidic sizes and connections are available to meet local geographic or industry specific standards.

Seal

A soft material, either a diaphragm or a flat seal attached to the underside of a solid piston or a plunger which halts the flow of fluid from one side of the main orifice to the other.

Seat

A raised area at the diameter that concentrates the pressure of the seal. Press-fit seats made of VA are used in case of potential abrasion or cavitation.



Opening large orifices using the direct acting method would require enormous and expensive coils. Therefore servo assisted valves use the power of the fluid to open the flow channel by controlling a small pilot channel to alter the forces on a larger main seal.

Servo-assisted:

Diaphragm valve with plunger pilot control

Function:

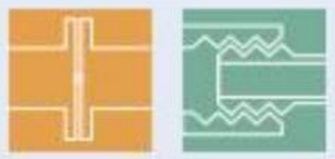
This functioning principle uses a direct-acting plunger valve as the pilot valve and a flexible diaphragm as the seal for the main seat. As soon as the pilot valve opens, the fluid chamber above the diaphragm is emptied. The media pressure within the diaphragm raises the diaphragm and opens the valve so that the medium can flow. If the pilot valve is closed, the media pressure above the diaphragm builds up again through the small compensation opening and the closing process is supported additionally by the compression spring. A minimal differential pressure between the inlet and outlet is necessary for complete opening and closing.

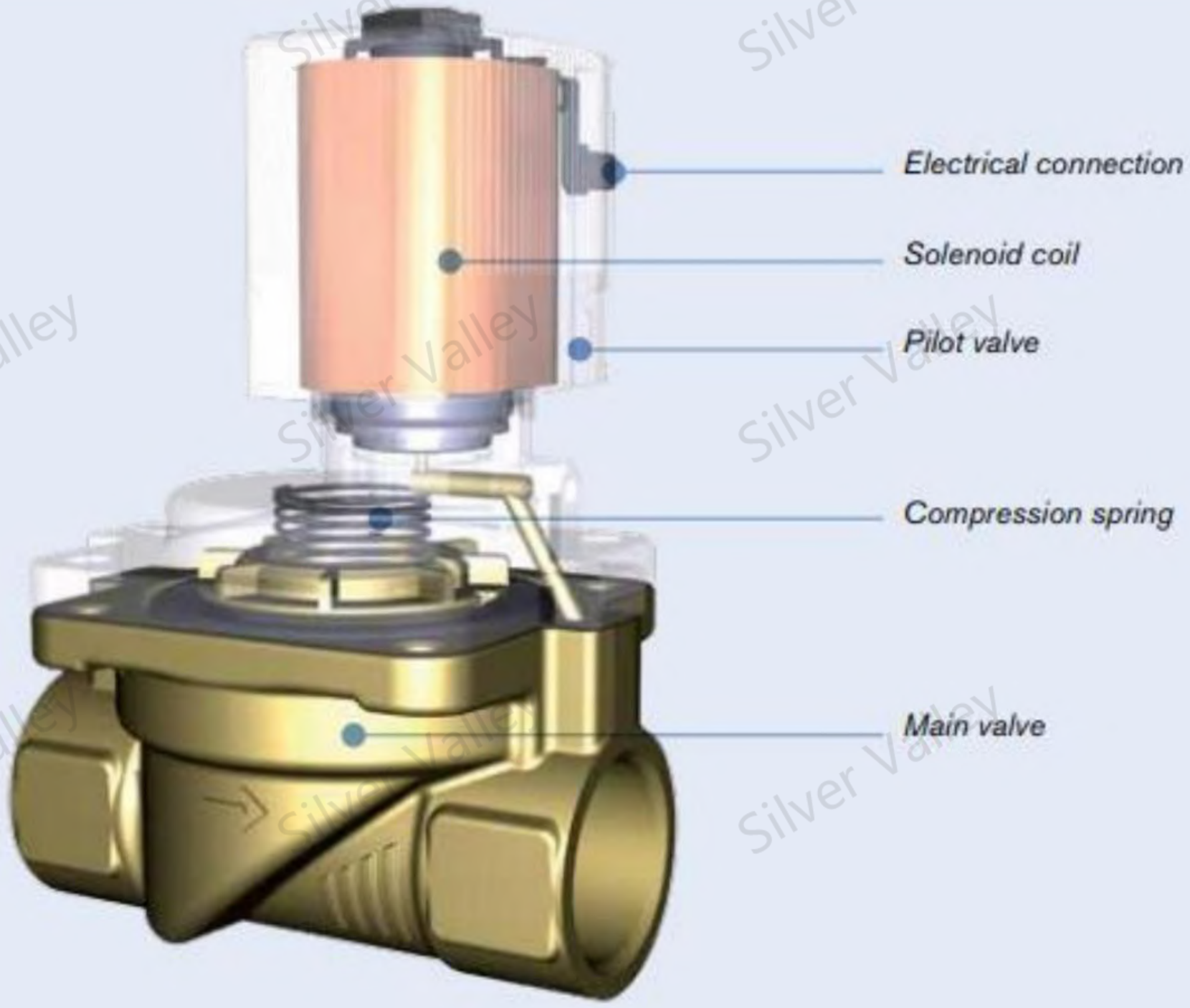
Application:

The main areas of application for this pilot-controlled solenoid diaphragm valve are clean liquid or gaseous media such as compressed air, water, hydraulic oils, etc. The small pilot valve makes them less expensive than direct-acting valves for use with higher pressures and larger diameters.

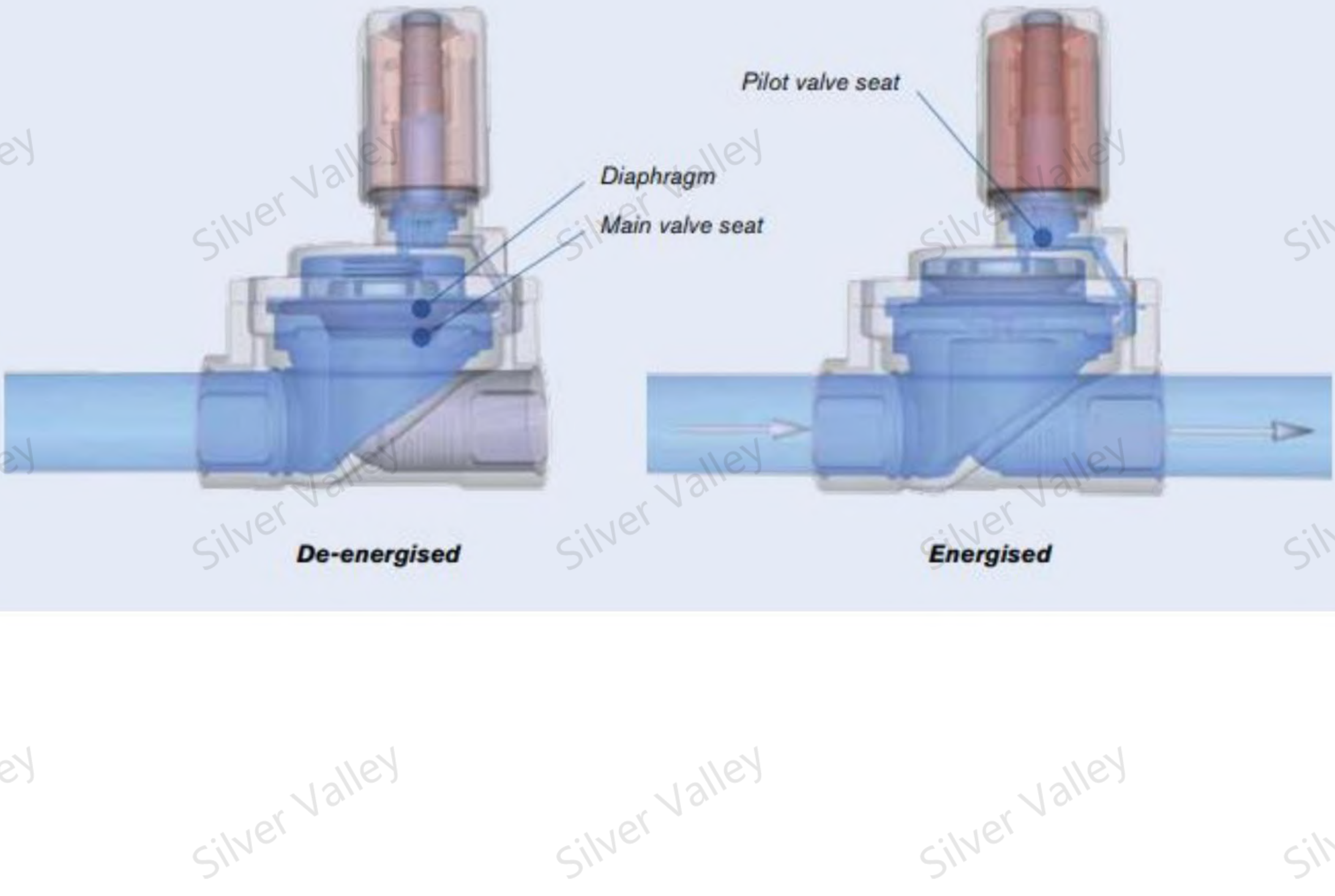
Special features:

Since pilot-controlled valves (also: servo-assisted valves) have only a small pressure equalisation hole in the diaphragm, they are susceptible to dirt particles and crystallising media, which can clog the hole. Bürkert valves are designed as soft stop valves. Ex or low power versions are virtually unproblematic compared with direct-acting valves, since the pilot control valve only has lower power consumption.

Type	6281 EV	6281 EV
		
Process connections		
Diameter [DN in mm]	13 ... 50	13 ... 40
Pressure range [bar]	0.2 ... 16	0.2 ... 16
Temperature [°C]	-30 ... +120	-30 ... +120



Servo-assisted diaphragm valve type 6281 EV



De-energised **Energised**

Servo-assisted:

Coupled diaphragm solenoid valve with plunger pilot control

Function:

This functioning principle uses a direct-acting plunger valve as the pilot valve and a flexible diaphragm as the main seal. As soon as the pilot valve opens, the fluid chamber above the diaphragm is emptied. The media pressure within the diaphragm raises the diaphragm and opens the valve so that the medium can flow. If the pilot valve is closed, the media pressure above the diaphragm builds up again through the small compensation opening and the closing process is supported additionally by the compression spring. This valve type can switch without differential pressure, since the diaphragm holder of the main valve is connected to the armature rigidly or by means of a spring. The pilot valve alone is capable of partially opening the main valve.

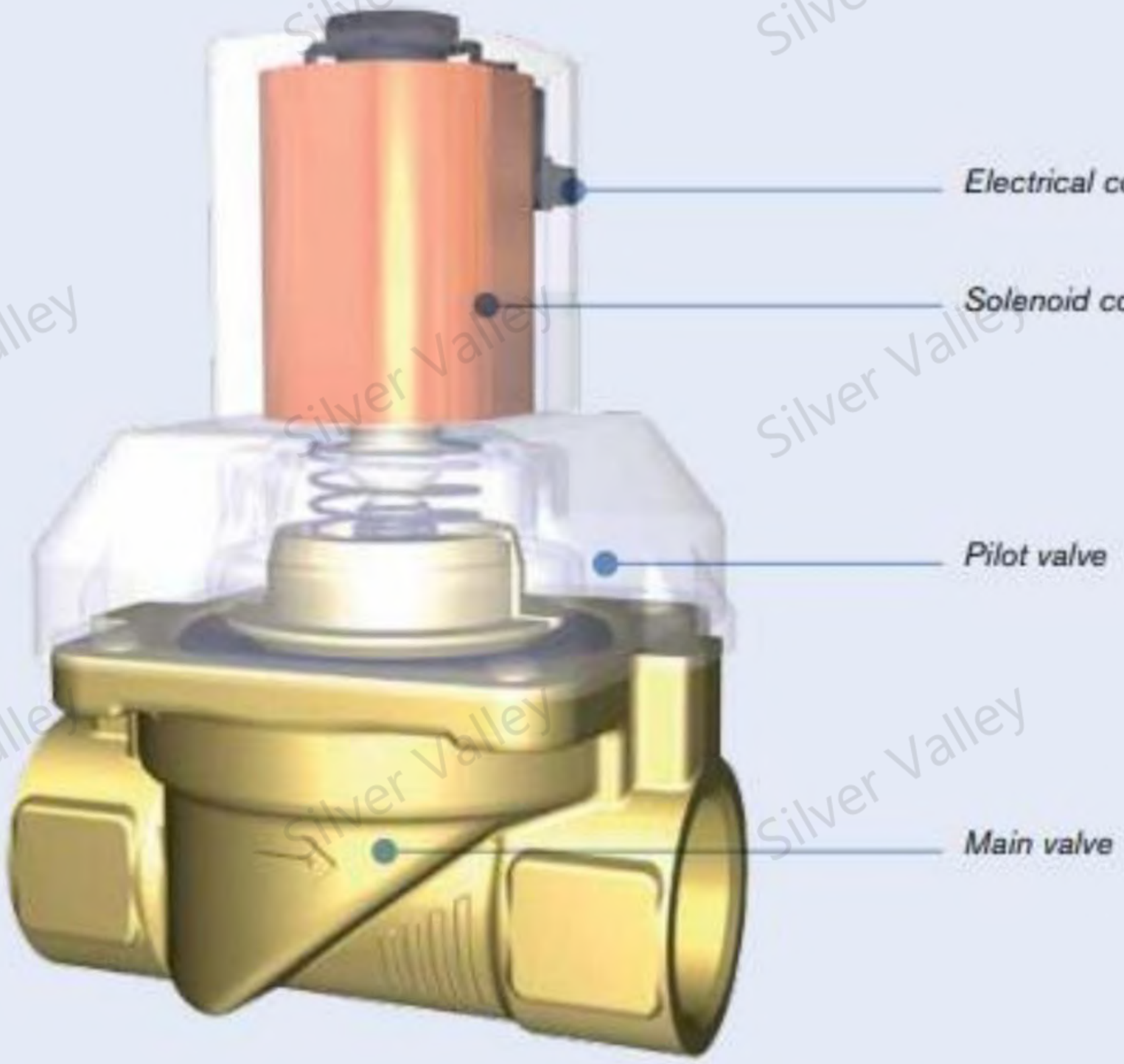
Application:

The main areas of application for pilot-controlled diaphragm solenoid valves are liquid or gaseous media such as compressed air, water and hydraulic oils in closed circuits in which little or no differential pressure is present for opening and closing.

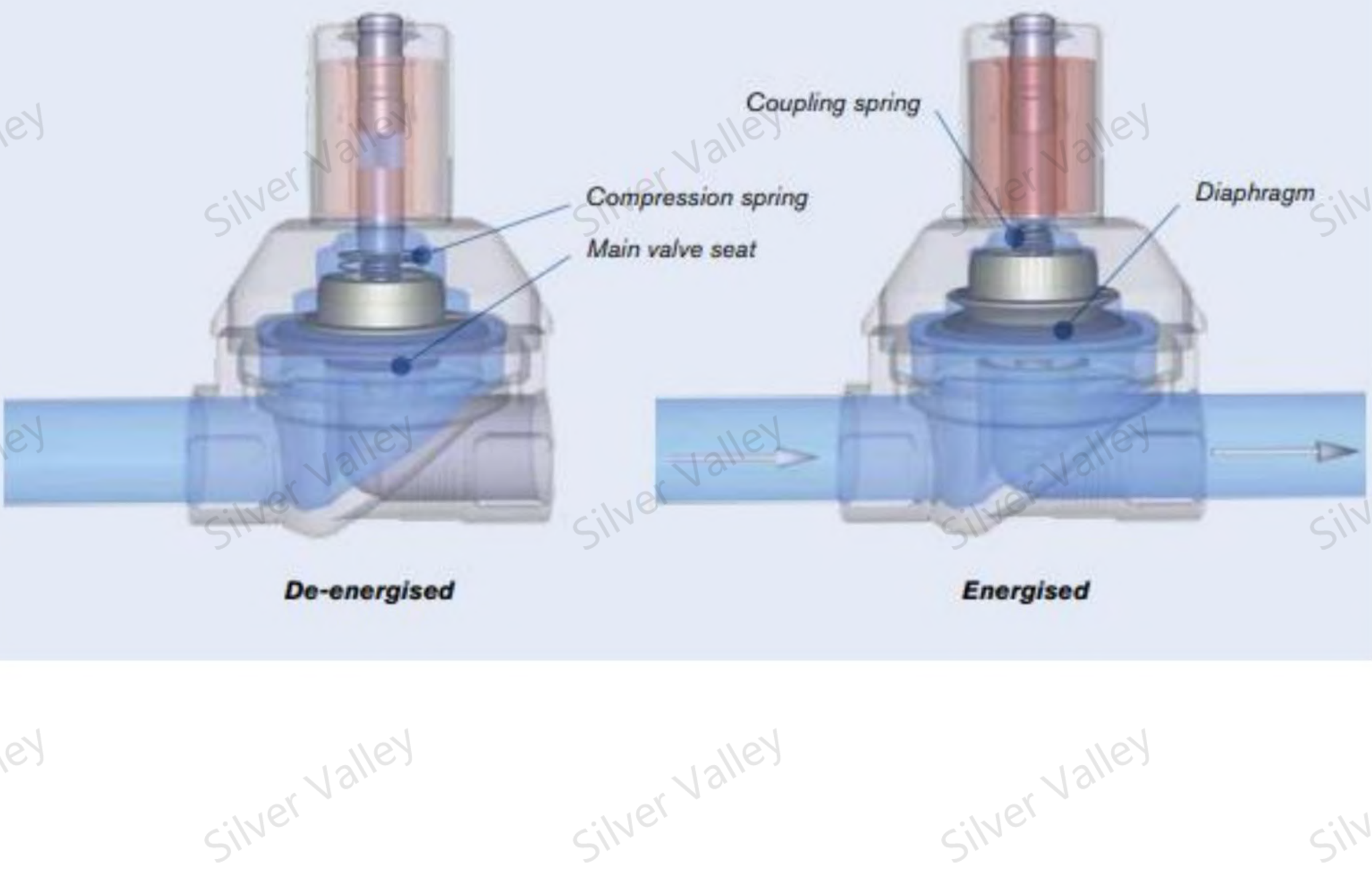
Special features:

Type 290 features a soft-kick function for a longer service life. All of the DC versions feature energy-saving power reduction. Type 6213 EV uses a spring as a coupling for "diaphragm-friendly" opening of the main seat in frequent working cycles.

Type	0290 EV	6213 EV	6213 EV HP00
			
Process connections			
Diameter [DN in mm]	12 ... 50	10 ... 40	13 ... 20
Pressure range [bar]	0 ... 16	0 ... 10	0 ... 10
Temperature [°C]	-30 ... +120	-30 ... + 90 (Polyamid coil) -30 ... + 120 (Epoxy coil)	0 ... +120 (Epoxy coil)



2/2-way spring coupled servo-assisted solenoid valve type 6213 EV



De-energised **Energised**

Servo-assisted:

Piston valve with plunger pilot control

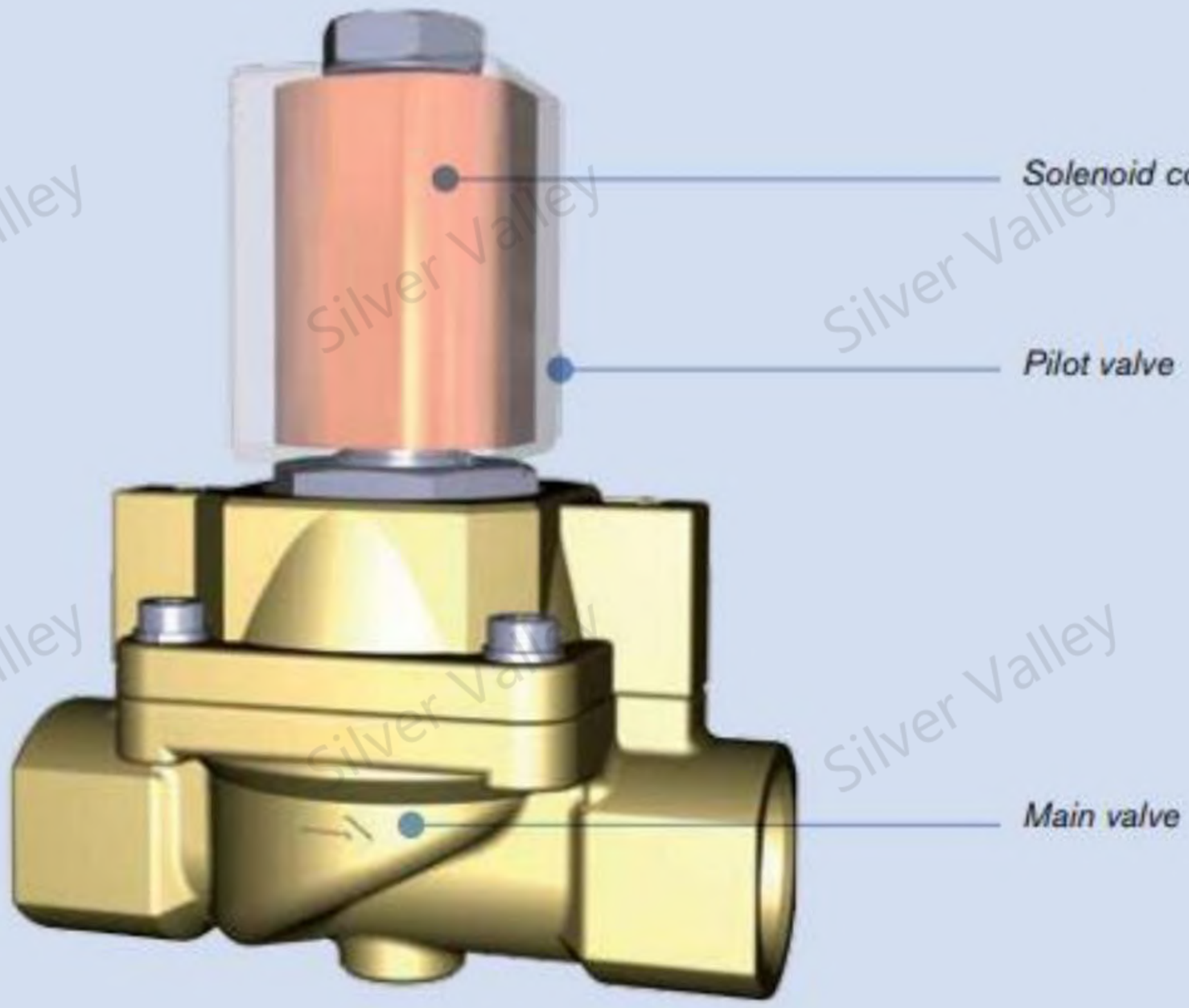
Function:

This operating method uses a direct acting plunger valve as the pilot valve and the main valve seal located on the base of a solid piston which moves vertically through a cylindrical chamber. The fluid chamber above the piston is relieved when the pilot opens. The medium pressure beneath the piston lifts the piston and opens the valve allowing flow. When the pilot valve is closed, the medium pressure is allowed to build up again above the piston through the equalizing orifice in the piston body and closing is aided by the force of the compression spring.
These valves require a minimum pressure differential to exist between the inlet port and the outlet port and are limited to controlling the same clean media as the non-isolated plunger pilot.

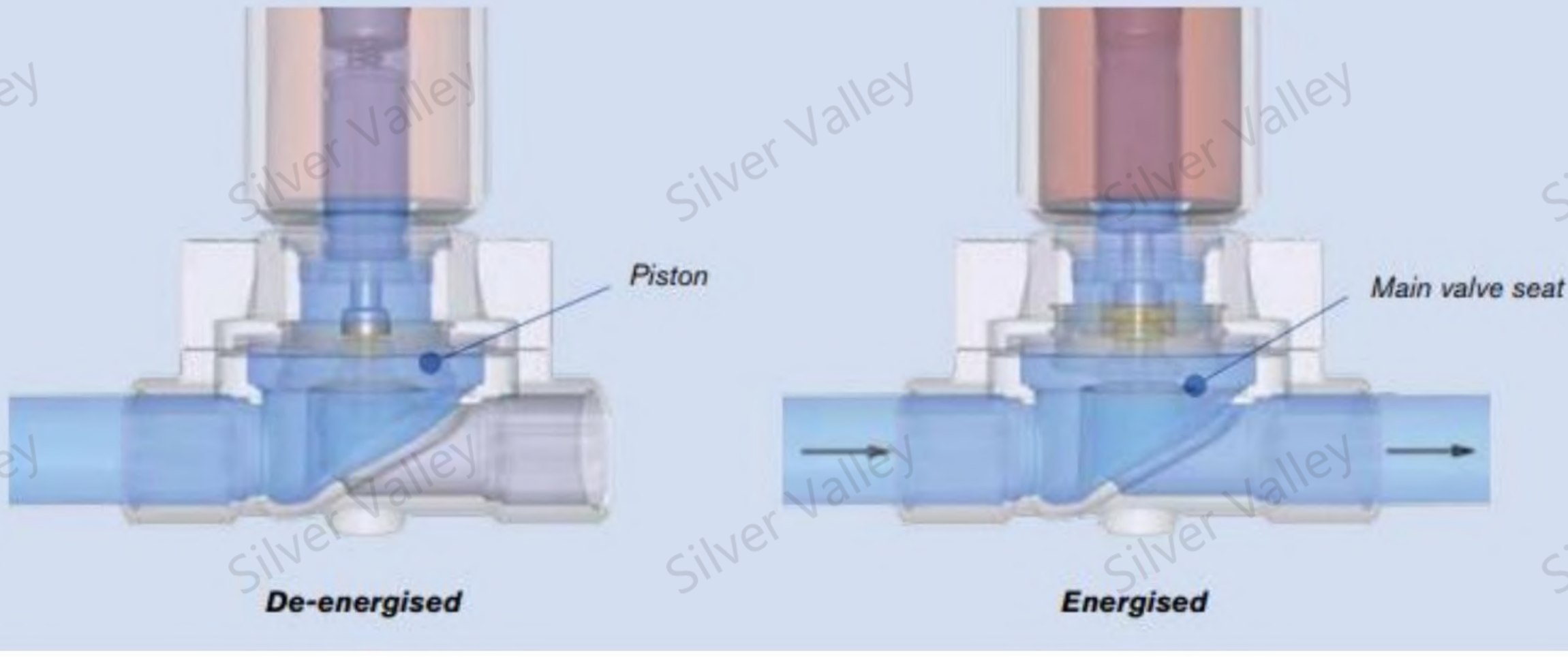
Application:

The main area of application for this servo-assisted solenoid piston valve is the reliable control of compressed air, neutral gases and steam up to 180 °C with a high number of strokes in diameters from DN 10 to 65 mm. Piston valves are especially robust for switching of compressible media such as gas and steam.

Type	0406	0404	5404
			
Process connections			
Diameter [DN in mm]	12 ... 40	12 ... 50	12 ... 25
Pressure range [bar]	1 ... 12	1 ... 12	1 ... 50
Temperature [°C]	-10 ... +180	-10 ... +90	-10 ... +90



2/2-way servo-assisted piston valve type 0406



De-energised **Energised**

Servo-assisted:

Fixed coupled piston valve with plunger pilot control

Function:

This functioning principle uses a direct-acting plunger valve as the pilot valve and a fixed coupled piston as the main seal. In closed state the piston seals the main valve seat. If the valve is energised, the pilot valve opens the pilot seat. The media pressure and the armature of the pilot valve cause the piston to move upward and release the main valve seat. If the pilot valve is switched off, this design provides for slow, impact-free closing of the valve. As opposed to the other pilot-controlled valve models, these valve types switch also without differential pressure, since the pilot valve alone opens the main valve seat.

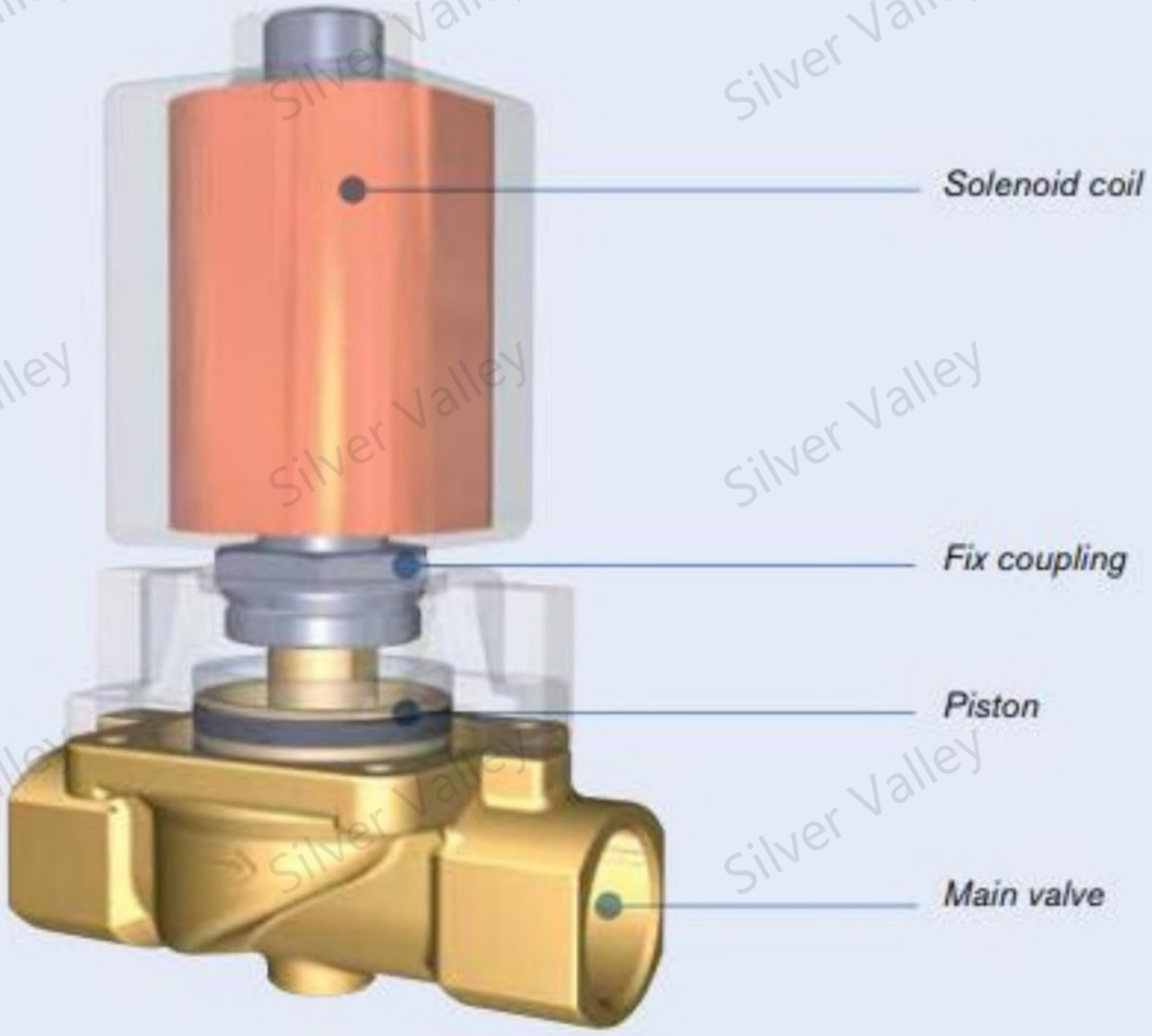
Application:

Fixed coupled valves are used in applications with little or no differential pressure, since the force of the pilot control valve alone is also sufficient to open the main seat. Neutral gases and steam are among the primary applications.

Special features:

Special features of the 407 series are a longer service life due to sliding ring bearings and integrated power reduction. Steam versions have a press-fit stainless steel seat. Type 6240 features a very compact design, stainless steel body and a plastic piston. In addition, the latter valve is also available in an explosion-protected version.

Type	0407	6240
		
Process connections		
Diameter [DN in mm]	13 ... 50	6 and 12
Pressure range [bar]	0 ... 10	0 ... 40
Temperature [°C]	-20 ... +180	-40 ... +180



Servo-assisted piston valve, fixed coupled, type 407

De-energised **Energised**

Servo-assisted:

Diaphragm / piston valve with pivoted armature pilot control

Function:

This unique functioning principle uses a media separated, direct-acting 3/2-way valve as the pilot valve, while the seal of the main valve is a larger flexible diaphragm or a piston. As soon as the pilot valve opens, the chamber above the piston opens so that the media pressure raises the diaphragm, therefore allowing the media to flow. If the pilot valve is closed, the channel to the outlet side is also closed and the media pressure can build up again through the inlet-side pilot channel. The closing process is additionally supported by the compression spring. A minimal differential pressure between the inlet and outlet is needed for complete opening and closing.

Application:

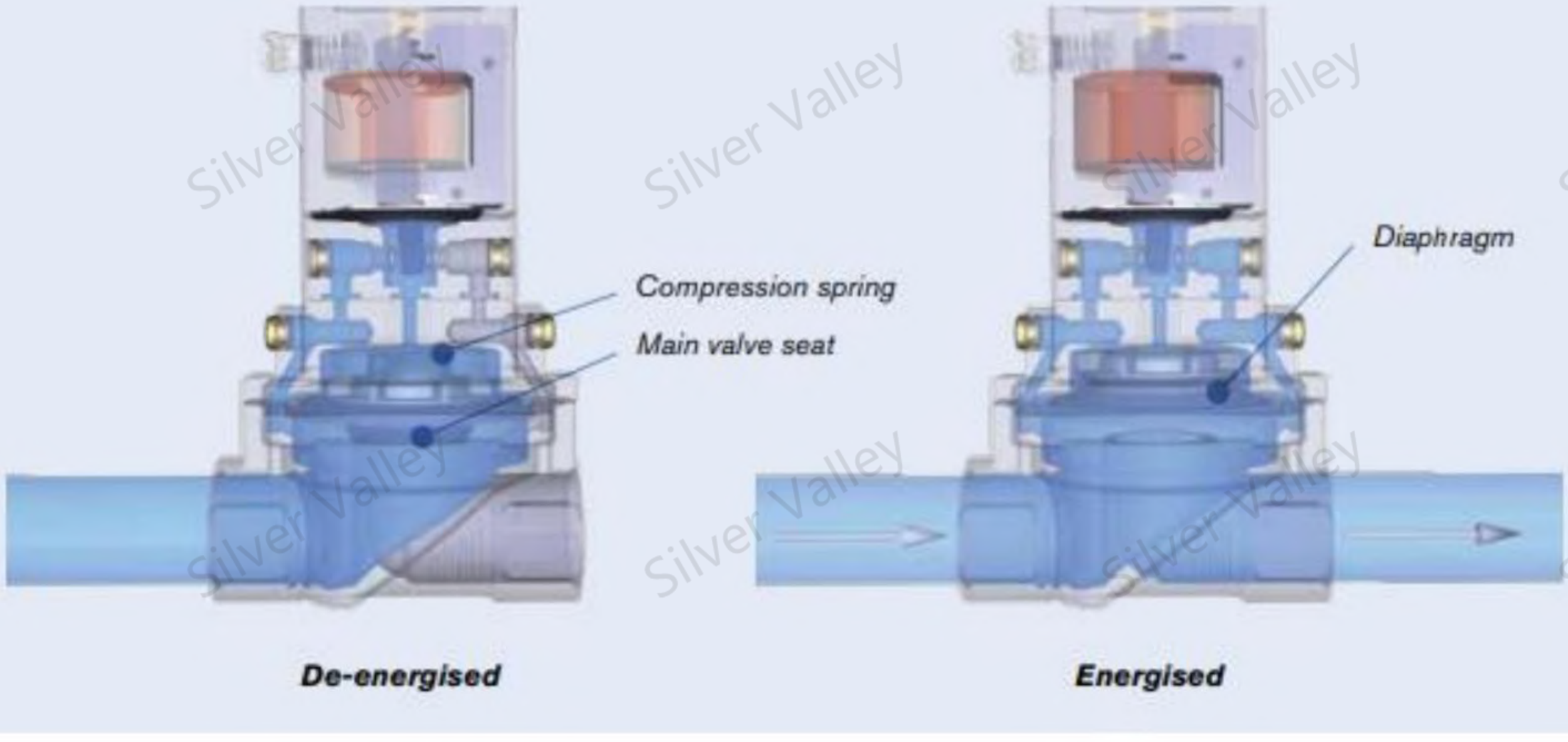
The main area of application for this unusual valve is the reliable switching of mildly contaminated and aggressive gases and fluids for diameters DN 10 to 65 mm. This type is designed for universal use. With this valve type there is very little danger of clogging, since the actuator and media chamber are separated by a diaphragm.

Special features:

In some versions of this valve type the opening and closing speed can be adapted to the application and configured for continuous adjustment.

Type	5282	0142	0340
			
Process connections			
Diameter [DN in mm]	13 ... 65	15 ... 50	8 ... 40
Pressure range [bar]	0.2 ... 10	0.5 ... 6	0.5 ... 16
Temperature [°C]	-30 ... +90	0 ... +70	0 ... +90

Servo-assisted solenoid valve with 3/2-way pilot type 5282

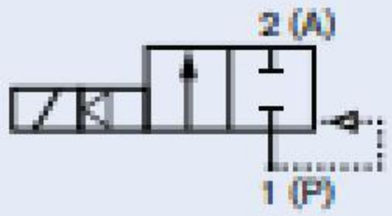
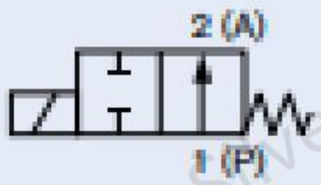
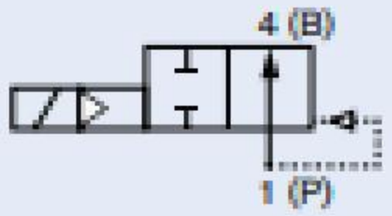
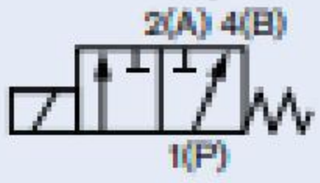


De-energised **Energised**

Code	Materials of Construction	General chemical resistance
PA	Polyamide	Resistant to greases, oils, waxes, fuels, weak bases, aliphatic and aromatic hydrocarbons.
EP	Epoxy	Resistant to nearly all chemicals. Not resistant to low-molecular organic acids in high concentrations and highly oxidising substances.
1.4305 1.4401 1.4581	Stainless steel	Resistant to light acids and caustic solutions.
PVC PVC-HT	Polyvinyl chloride, hard	Resistant to most acids and caustic solutions, and saline solutions.
PP PE	Polypropylene Polyethylene	Resistant to many organic solvents, aqueous solutions of acids, bases and salts.
PTFE	Polytetrafluore-thylene	Resistant to nearly all chemicals. Not resistant to liquid sodium and fluorides.
PVDF	Polyvinylidene fluoride	Not resistant to hot solvents such as ketone, ester and highly alkaline solutions.

Code	Materials of Construction	General chemical resistance
PPS	Polyphenyl sulfide	Resistant to aqueous mineral acids, bases, aliphatic and aromatic hydrocarbons, many ketones, alcohols, halogenated hydrocarbons, oils, greases, water and hydrolysis.
PEEK	Polyetherether-ketone	Resistant to most chemicals. Not resistant to concentrated sulphuric and nitric acid and certain halogenated hydrocarbons.
PTFE*	Polytetrafluore-thylene	Resistant to nearly all chemicals. Not resistant to liquid sodium and fluorides.
EPDM	Ethylene propy-len diene rubber	Resistant to ozone and hot water. Not oil and grease resistant.
FKM	Fluorocarbon rubber	Resistant to oil and many chemicals, as well as heat.
NBR	Nitrite rubber	Resistant to oil.
FFKM	Perfluorinated elastomers	Resistant to extreme heat, weather and most chemicals.

Circuit symbols

WW	Circuit symbol	Circuit function
A		2/2-way valve; normally closed
A		Servo-assisted 2/2-way valve; normally closed, pilot channel inside
B		2/2-way valve; normally open
B		Servo-assisted 2/2-way valve; normally open, pilot channel inside
C		3/2-way valve; normally closed, outlet A relieved
C		Servo-assisted 3/2-way valve; outlet A normally relieved, pilot channel inside
D		3/2-way valve; outlet B normally pressurized
D		3/2-way valve; outlet B normally pressurized, pilot channel inside
E		3/2-way mixer valve; normally pressure port P2 connected to outlet A, P1 closed
F		3/2-way distributor valve; normally pressure port P connected to outlet B
T		3/2-way valve; universally usable

Sectors and Industries

Sectors	Example application
Water supply	Treatment of drinking water
Waste water treatment	Purification / treatment of grey and black water
Machine and plant engineering	Cooling, lubrication and dosing
Building services	Large heating systems, climate control
Safety engineering	Water mains protection and fire extinguishing systems
Compressors	Pressure relief and drainage
Fuel supply	Transport and tank facilities
Firing systems	Oil and gas burner control
Gas chromatography	Gas mixture regulation
Blood analysis instruments	Control of cleaning processes
Sterilisers	Control of steam sterilisation
General process engineering	Mixing processes
Textile industry	Ironing machines, dyeing and washing systems
Domestic installations	Heating and sanitary technology
Biogas plants	Gas and heat control
Shipbuilding	Control of diesel and auxiliary fuels, separator technology
Rail and motor vehicle construction	Emptying and filling, pneumatic door controls
Car washes	Water and cleaning agent dosing

• What is a solenoid Valve

A solenoid valve is basically an electromechanical valve. Solenoid valves are the most frequently used control elements in fluidics. Their role can be to shut-off, release, dose, distribute or mix fluids or gases, all of which can pose a wide range of requirements and environments that must be accommodated in order to deliver reliable and effective service.

• Solenoid valve anatomy

Essentially solenoid valves are split between two designs, direct acting and pilot-operated. The former relies solely on the power of the magnetic coil to make or break the seal with the seat of the valve. In normally closed (NC) configurations, the coil is energised and the valve opens until the voltage is removed and the spring pressure closes the valve. The pressure and flow capabilities of these valves are determined by the power of the solenoid. A pilot operated solenoid valve uses the pressure differential between the inlet and the outlet to assist the solenoid coil and spring in opening and closing the valve. This design concept can be applied to various styles of solenoid valve in order to accommodate a wide range of applications where higher pressures and flows are required.

Selection of a solenoid valve

The type of solenoid valve most appropriate for each application is governed by a number of factors. Many of the solenoid valve components, such as the plunger, return spring and seals are all exposed to the media and therefore information on the chemical compounds, temperature and pressure are all necessary to make an informed material selection.

In the case of solenoid valve design, the general rule-of-thumb is: Plunger-type direct acting solenoid valves are best suited to neutral and clean fluids, while pivoted armature solenoid valves employ a media-separating membrane and are therefore suitable for controlling corrosive, contaminated or aggressive fluids. If the production process involves liquid food products, the plastics and elastomers used should also conform to the local food and hygiene regulations. In addition, some processes require a cleaning cycle to be performed in between production processes and so the data is also required for this procedure as well to ensure there is no undue material degradation caused by steam or cleansing chemicals. Design choices determine reliability

Advantages and disadvantages of a solenoid Valve

There are many advantages of using solenoid valves. Cost, size, versatility and the fact that they can be used in an array of industries. The applications are limitless as are the body and seal materials and can be used on a broad range of liquids and gaseous media.
One of the main disadvantages of using a standard solenoid valve is its capability to handle dirty or contaminated fluids. We do have a solution though and isolating or separating diaphragms offer a unique technology to help overcome this problem.

Difference between DC and AC coils

DC and AC coils differ based on the frequency influence in the power data and in the response.

DC Coil

- No buzzing
- No shading ring required
- Lower starting force than the AC coil
- Lower switching pressure

AC Coil

- Valve tends to buzz
- Shading ring required
- Higher starting force than DC coils
- Higher switching frequency causes higher temperature rise
- A blocked plunger can result in overheating or failure

Servo-Assisted 2/2 Solenoid Valve

A minimum differential pressure is required for complete opening.

To explain basically :-when the differential pressure is greater on one side of the valve and more than the other side, a servo assisted valve will work perfectly. The problem occurs when the differential pressure is the same or near too on the other side of the valve. This could cause the valve to leak or not open fully. If you can ensure a differential pressure then the servo valve is both economically better as in most cases of higher pressures can be achieved.

Direct-Acting 2/2 Solenoid Valve

No minimum differential pressure is required for complete opening.

The direct acting valve for liquid applications assures a tight shut off when the differential pressure is the same and works at zero Bar. The downside of using a direct acting solenoid valve is that initially they are more expensive to buy and to run. The coil of this valve if held open for prolonged periods can get very hot, however this factor will not effect the operation of the valve.