



# Product Overview

## Proportional Valves

SOLENOID VALVES

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# Product Overview: Proportional Solenoid Valves

All proportional solenoid valves are normally closed, can be used with media at temperatures between -10 °C and +90 °C, and comply with protection class IP65. The robust valves (brass or stainless steel housing) are designed for continuous operation at a typical operating voltage of 24 VDC. Valves of the BASIC series (types 2861, 2863 and 2865) are also available (not shown in this brochure). They are based on the STANDARD series (types 2871, 2873 and 2875) and mainly differ in their span (4:100% in contrast to 0.5-100%).

1) Within one type is generally valid: The bigger the valve orifice, the lower the maximum possible operating pressure at which the valve closes tight  
2) Max. differential pressure allowed: 3 bar



Type	2871	2873	2875	2836	6024 <sup>2)</sup>	6223
Operating principle	Plunger directly on valve seat (NC)	Plunger directly on valve seat (NC)	Plunger directly on valve seat (NC)	Plunger directly on valve seat (NC)	Plunger directly on valve seat (NC)	Plunger directly on servo piston (NC)
Design feature	Frictionless plunger guide	Frictionless plunger guide	Frictionless plunger guide	Slide ring	Slide ring	Servo-assisted
Width	20 mm	32 mm	49 mm	72 mm	49 mm	32-43 mm
Sealing material	FKM, EPDM	FKM, EPDM	FKM, EPDM	FKM, EPDM	FKM	FKM
Media	Neutral gases, liquids on request	neutral gases, liquids on request	Neutral gases, liquids on request	Neutral gases, liquids	Neutral gases, liquids	Neutral liquids
Port connection	1/8", sub-base	1/8", 1/4", sub-base	3/8", 1/2", sub-base	1/2", 3/4"	1/2", 3/4"	3/8", 1/2", 3/4", 1"
Power consumption	2-5 W (depending on application)	9 W	16 W	24 W	18 W	8-15 W
Orifice sizes <sup>1)</sup>	0.05-2 mm	0.8-4 mm	2-8 mm	3-12 mm	8-12 mm	10-20 mm
Repeatability	0.25 % of F. S.	0.5 % of F. S.	0.5 % of F. S.	1 % of F. S.	0.5 % of F. S.	1 % of F. S.
Sensitivity	0.1-0.025 % of F. S.	0.25 % of F. S.	0.25 % of F. S.	0.5 % of F. S.	0.5 % of F. S.	1 % of F. S.
Span	0.5-100 %	0.5-100 %	0.5-100 %	4-100 %	4-100 %	10-100 %
Response time	<15 ms	<20 ms	<25 ms	<100 ms	<50 ms	<200 ms
Typical application	<ul style="list-style-type: none"> <li>- Medical and analytical equipment</li> <li>- Burner controls</li> <li>- Fuel cell technology</li> <li>- Plasma control</li> <li>- Powder coating</li> </ul>	<ul style="list-style-type: none"> <li>- Burner controls</li> <li>- Waste gas treatment</li> <li>- Inert gas dosing</li> <li>- Plasma control</li> <li>- Vacuum control</li> <li>- Fuel dosing</li> </ul>	<ul style="list-style-type: none"> <li>- Fuel cell technology</li> <li>- Test stand technology</li> <li>- Burner controls</li> <li>- Vacuum control</li> <li>- Filling level control</li> </ul>	<ul style="list-style-type: none"> <li>- Cooling</li> <li>- Inert gas dosing</li> </ul>	<ul style="list-style-type: none"> <li>- Combustion gas dosing</li> <li>- Forced air throttling</li> </ul>	<ul style="list-style-type: none"> <li>- Cooling/heating circuits</li> <li>- Water dosing</li> </ul>

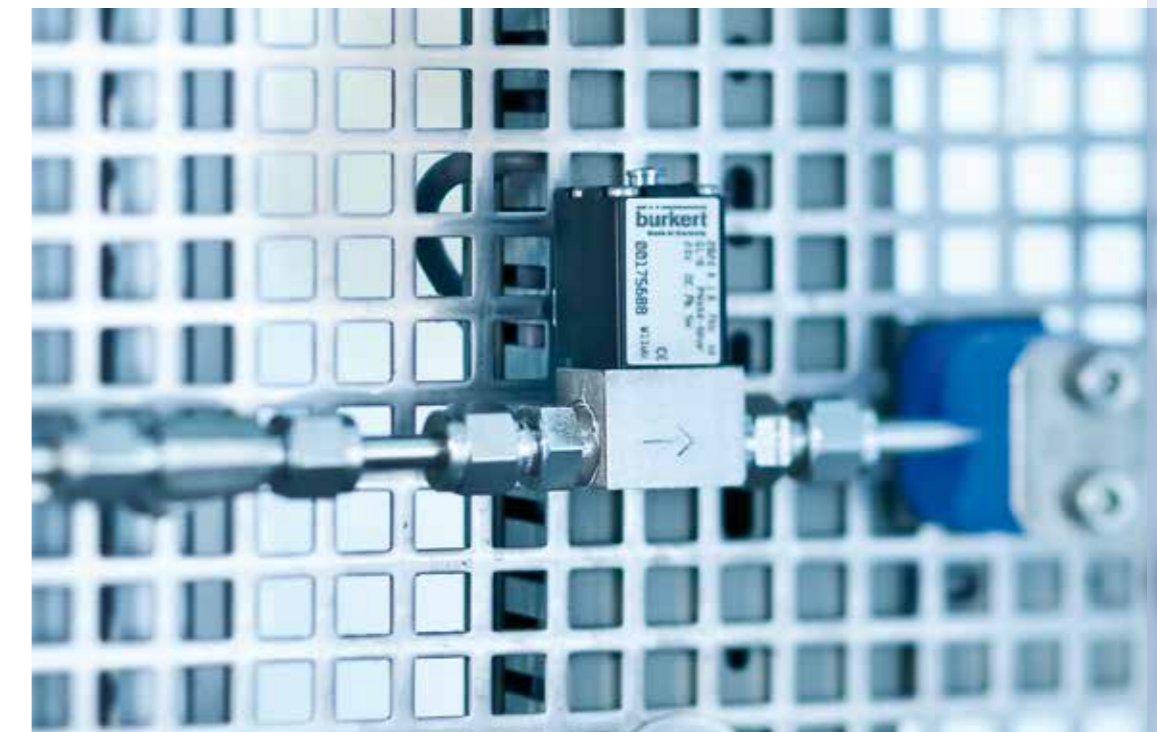
## Control Electronics for Proportional Solenoid Valves



Type	8605	8611
Function	Digital PWM control	Digital PI controller, Continuous, 2-point, 3-point and On/Off control
Versions	Rail or valve mounting	Fitting, wall, rail, cabinet or valve mounting
Signals	<ul style="list-style-type: none"> <li>– Set point (0-5 V, 0-10 V, 0-20 mA, 4-20 mA)</li> <li>– PWM output (80 Hz-6 kHz)</li> </ul>	<ul style="list-style-type: none"> <li>– Set point (0-10V or 4-20mA)</li> <li>– Actual process value (4-20mA)</li> <li>– Sensor input (0-10V, 4-20mA, Pt100 or frequency) e. g., pressure, temperature or flow</li> <li>– Control output signal (4-20mA or PWM)</li> <li>– Binary input</li> <li>– Binary output</li> <li>– Outputs (continuous, discontinuous signal)</li> </ul>
Operating voltage	12, 24 VDC	24 VDC
Max. power consumption	1 W (without valve)	2 W (ohne Ventil)
Valve outlet	Max. 2 A (PWM)	Max. 1 A (PWM)
Software functions	<ul style="list-style-type: none"> <li>– Valve setting (frequency, min./max. opening)</li> <li>– Zero point cut-off</li> <li>– Temperature compensation</li> <li>– Ramp function</li> <li>– Down-/upload of parameterization</li> </ul>	<ul style="list-style-type: none"> <li>– Controller setting</li> <li>– Valve setting (all Bürkert proportional solenoid valves stored)</li> <li>– Sensor setting (all Bürkert flow sensors stored)</li> <li>– Configuration of switching (binary) signals</li> <li>– Scaling of set point and process value signals</li> <li>– Valve and sensor setting</li> <li>– Code protection</li> </ul>

## Precision and Dynamics with Solenoid Valves

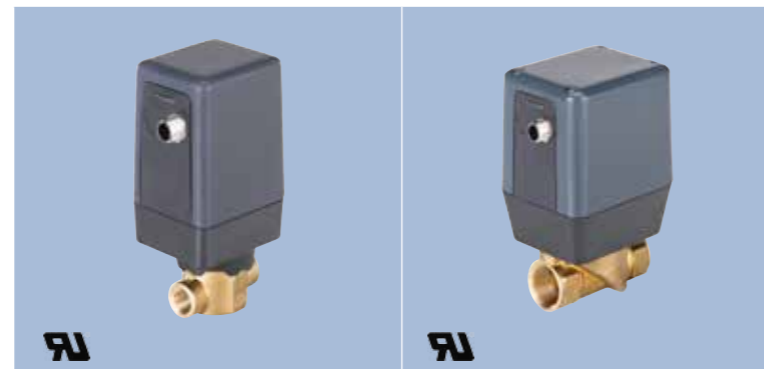
Feature	Benefits
Direct-acting, plunger design	Cost-effective design, Very fast reaction
Epoxy resin moulded coil, tight encapsulation of the valve system	High protection class (IP 65), Safety
Guiding of plunger with flat spring	Excellent repeatability, Very good sensitivity, high span
PWM control	Lower hysteresis, Static friction prevented, Very good response sensitivity
Seat seal integrated in the plunger	Close tight function, no additional shut-off valve required



## Product Overview: Motor-driven Proportional Valves

All motor-driven proportional valves feature a precise electric stepper motor as actuator. The robust valves (brass or stainless steel housing) comply with protection class IP50, can be used with media at temperatures between 0 °C and +70 °C, and are suitable for duty cycles up to 100%. The proportional motor valves (types 3280 and 3285) are also available as shut-off valves (types 3270 and 3275, not shown in this brochure).

In addition to the standard versions shown here, advanced versions with additional features (positioner, process controller) are available on request.



Type	3280	3285
Operating principle	Seat valve with stepper motor	Disc valve with stepper motor
Design feature	Linear stroke movement of the actuating element	180° rotatable ceramic disc
Width	58 mm	77 mm
Sealing material	FKM, EPDM, NBR	FKM, NBR, technical ceramics
Media	Neutral gases, liquids	Neutral gases, liquids
Port connection	1/4", 3/8"	1/2", 3/4", 1"
Power consumption during position changes	Max. 8 W	Max. 12 W
Orifice sizes	2-6 mm	8-25 mm
Repeatability	< 1 % F.S.	< 1 % F.S.
Sensitivity	< 1 % F.S.	< 1 % F.S.
Span	1-100 %	1-100 %
Response time	< 2,5 sec.	< 4 sec.
Typical application	<ul style="list-style-type: none"> <li>- Industrial heat processing technology</li> <li>- Cooling circuits in machine tools</li> <li>- Energy generation plants</li> <li>- Heat generation plants</li> </ul>	






## Energy Efficiency and Robustness with Motor Valves

Feature	Benefits
Media separated, direct-acting design	Suitable for corrosive media, Compact design
Precise stepper motor as actuator	Good dynamics for motor driven valves, High span
Self-retaining construction of the actuating element	Negligible energy consumption for holding the valve's position, Insensitive towards resonances in the process
Integrated control electronics	No additional electronics necessary
Status LED and position feedback	Valve status and position directly visible, Valve openings precisely selectable



# Valve Selection Chart

Type		DN [mm]	$k_{vs}$ [m³/h]	Nenndruck [bar(ü)]
2871		0,05	0,00006	10
		0,1	0,00025	10
		0,2	0,001	10
		0,3	0,002	10
		0,4	0,004	8
		0,6	0,01	6
		0,8	0,018	12
		1	0,027	10
		1,2	0,038	8
		1,6	0,055	6
		2	0,09	3
		2873		0,8
1	0,027			14
1,2	0,04			12
1,5	0,06			10
2	0,1			8
2,5	0,15			5
3	0,22			3,5
2875		2	0,12	25
		3	0,25	10
		4	0,45	8
		5	0,55	5
		6	0,8	4
		8	1,1	2
		9,5	1,4	0,7

DN [mm]	$k_{vs}$ [m³/h]	Nenndruck [bar(ü)]		Type
3	0,25	25		2836
4	0,4	16		
5	0,7	10		
6	0,9	8		
8	1,5	5		
10	2	3		
12	2,5	2		6024
8	1,4	0,7		
10	2	0,4		
12	2,8	0,2		6223
10	1,4	10		
13	2,5	10		
20	5	10		3280
2	0,15	6		
3	0,3	6		
4	0,5	6		
6	0,9	6		
8	1,8	6		
10	2,5	6		
12	3,9	6		3285
15	6	6		
20	8,8	6		
25	12,3	6		

# Solenoid Proportional Valves

Solenoid shut-off valves are the basis for Bürkert solenoid control valves. Without electrical power the spring forces the plunger directly on the valve seat. With that the valve is closed. Electrical current through the solenoid (coil) causes a magnetism which lifts the plunger against the spring force. The valve opens. With constructive changes in the solenoid shut-off valves, a balance between spring and magnetic force can be produced for any coil current. The intensity of the coil current or the magnetic power influences both the stroke of the plunger and the valve's opening degree, whereby valve opening (flow rate) and coil current (control signal) are ideally linear dependent on one another (see fig. 2).

The flow direction in direct-acting solenoid control valves is typically from below seat. The medium flowing in from below presses together with the generated magnetic force against the tension force of the return spring, pressing from above. For this reason alone it makes sense to set the minimum and maximum flow rate value of the working range (coil current) under operating conditions. Bürkert solenoid control valves are closed without electrical power (NC, normally closed).

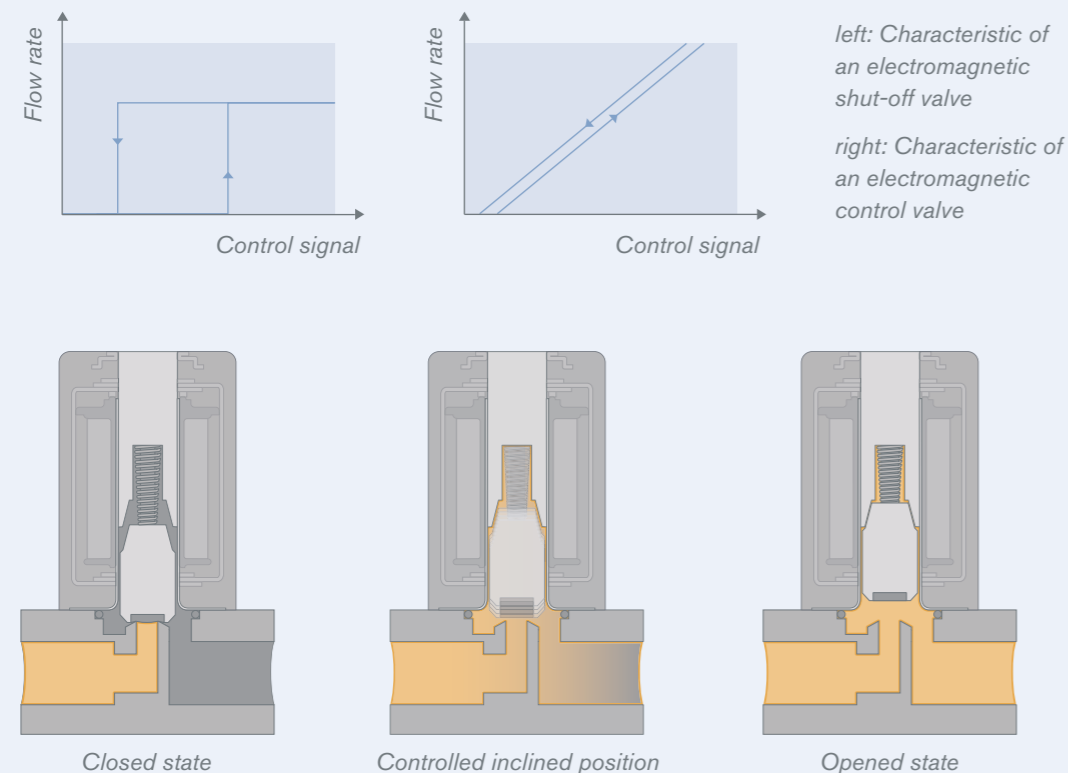


Fig. 2: Functional principle of direct-acting solenoid control valves

With an even geometry of the plunger and the plunger counterpart/stopper (flat stopper geometry) the magnetic force drops too much with rising air gap making it impossible to use the valve as a control valve. Equal balance states between spring and magnetic force at different values of the electrical current can only be achieved with a specific design of both components. With the design of a conically shaped area on the outside part of the stopper and a virtually mirror-inverted slant in the top part of the plunger (see conical stopper geometry in fig. 3).

In the power off state the spring force alone closes the valve. A seal integrated in the bottom of the plunger ensures that the fluid does not leak through the closed valve.

The plunger is guided precisely through the valve unit by a guide pin (top) and a flat spring (bottom). The more flexibly the plunger slides through the coil, the more pronounced the response sensitivity and the more reproducible the control positions. This is because, in addition to the magnetic force and spring force, a third unavoidable force, unwanted because of its consequences, enters the picture: friction force. Friction disturbs the adjustment characteristic. It can, however, be significantly reduced with a precise guiding of the plunger and special electronic controlling.

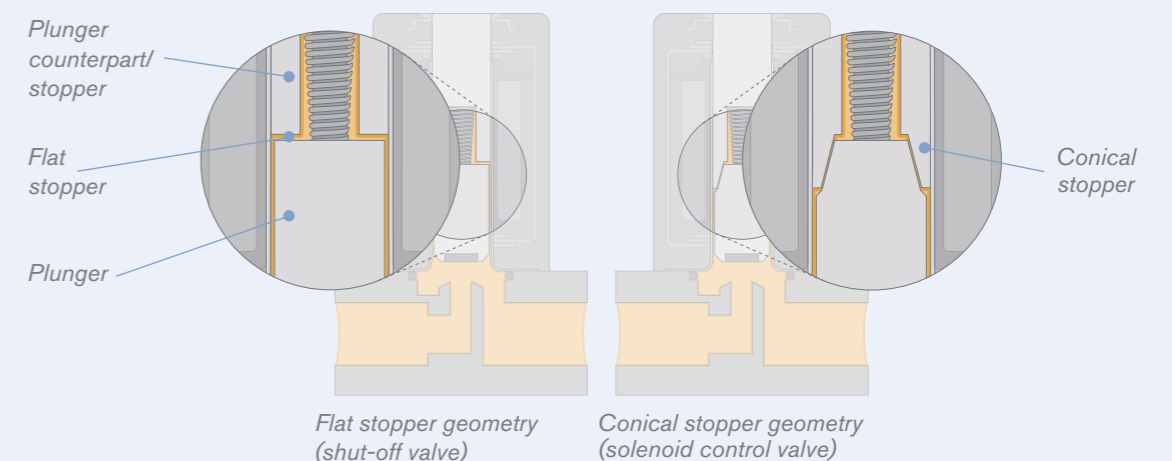


Fig. 3: Comparison flat stopper design – conical stopper design

## Controlling of Solenoid Proportional Valves

In principle it is possible to control the proportional magnet with variable DC voltage, but static friction can appear here on the plunger's guide points. This impairs the sensitivity of the valve, and results in greater hysteresis effects. To prevent static friction, the normal inlet signal is converted with a special control electronics – usually into a pulse width modulated voltage signal (PWM controlling, see fig. 4). This kind of control puts the plunger into a very fast but weak amplitude oscillation. Despite, or moreover because of the oscillation, the plunger's balanced state is maintained, as is its constant sliding friction. And the plunger's oscillation motion has absolutely no effect on the fluid's flow behaviour.

With PWM control the effective coil current with constant voltage supply is set via the duty cycle of the rectangular signal. The PWM frequency is harmonized here on the one hand with its resonance frequency and the damping of the spring-plunger-system, and on the other hand with the magnetic circuit's inductance. If the duty cycle  $t_1/T$  ( $t_1$ : power-on time,  $T$ : cycle duration,  $f=1/T$ : frequency) increases, the effective coil current  $I$  also increases, because the rectangular signal has also increased. If, however, the duty cycle falls, the effective coil current also falls.

Generally speaking: Small coils (e. g., type 2871) with low magnetic force react sensitively to higher frequencies. With low frequencies these generate high motion amplitudes and an unnecessarily high noise level. Big coils with a high magnetic force (e. g., type 2875), however, only result in dither movements, and therefore sliding friction with low frequencies.

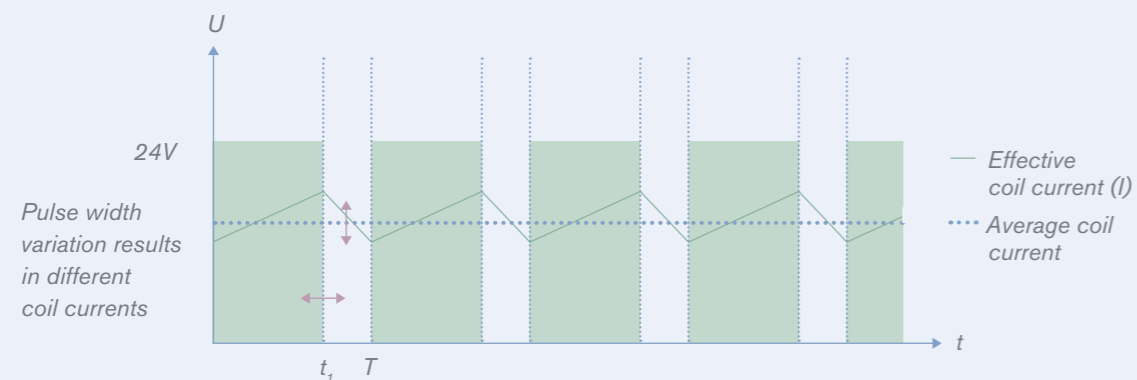


Fig. 4: PWM control signal

## Typical Functions of the Control Electronics

### Current control for coil heating compensation

Coil heating changes the temporary effective electrical resistance. It is therefore beneficial to control the coil current electronically. Current control is especially important in open control loops, whereby it is irrelevant in closed process control loops.

### Adjusting the minimum and maximum coil current to application-specific pressure conditions

The current values must be set under operating conditions – when the valve begins to open, and when the valve is fully opened. The working range of the respective valve types depends on their orifice and the respective pressure conditions in the system (primary pressure and back pressure). For all direct-acting solenoid control valves that are inflow under the seat, the current value for the opening start falls with increasing inlet pressure. With an increasing pressure drop via the valve, the current value at which maximum flow rate is reached falls.

### Zero point shut-off for closing the valve tight

Zero point shut-off can be set up to a value of 5 % of the maximum inlet signal. This guarantees that the valve is closed tight. With inlet signals that are lower than originally set, the coil current is immediately set to zero. This then closes the valve. If no zero point shut-off is specified, the valve is controlled with the lowest duty cycle, even with 0 % set point given.

### Ramp function

Set point changes (with rising or falling flank) can be set with an effective delay of up to 10 seconds. This balances the effects of volatile set point changes, which can cause fluctuations in some systems.

## Motor-driven Proportional Valves

Integrated electric stepper motors are the centrepiece of Bürkert's motor-driven proportional valves. Depending on the orifice, two different actuator versions are available (valve designs see Fig. 5). In both cases, the valve fitting has been optimized in favour of a high flow coefficient.

The seat valve covers orifice ranges from 2-6 mm. A linear stepper motor transfers its stroke motion via a coupling to the control plug. In closed state the plug presses onto the valve seat. It can be gradually raised and therefore is able to control the flow rate. The flow direction for the seat valve is from below seat. The disc valve is used for orifices between 8-25 mm. The rotary movement of the stepper motor is transferred to the drive shaft via a coupling. A sealing disc rotatable by 180° is connected to the shaft. It presses onto a specially designed ceramic seat. By rotating the sealing disc, the flow rate can be varied proportionally to the rotary movement. The flow direction for the disc valve is from above seat.

For both designs of motor actuated proportional valves, the following applies: If no power is applied the last selected position is maintained with almost vanishing energy consumption.

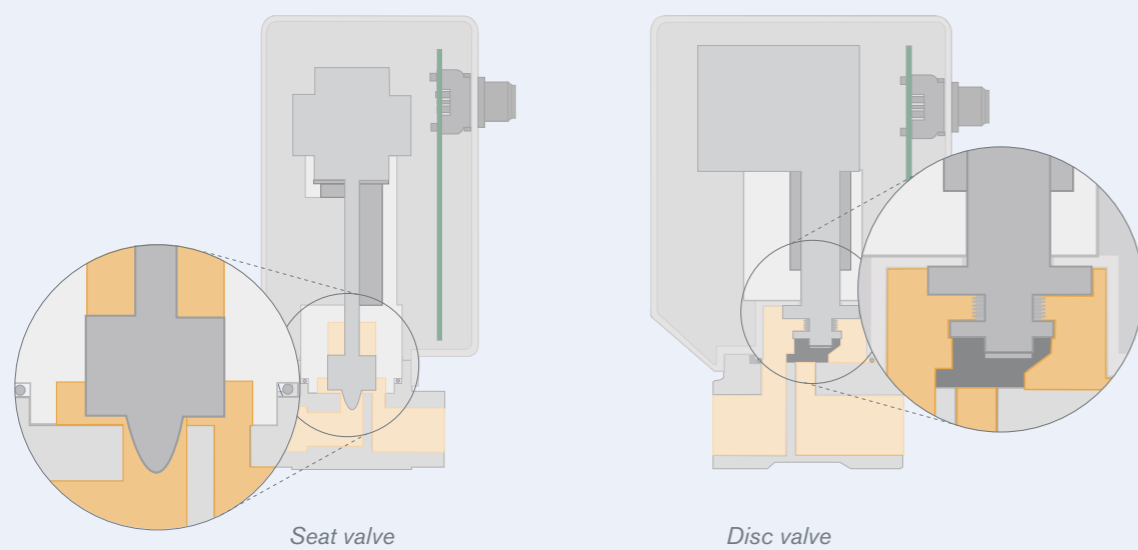


Fig. 5: Comparison of Seat valve and disc valve

There are three different versions of motor valves:

- Standard version for analogue signals with end position detection
- Positioner version for fieldbus communication with position sensor system
- Process controller version based on positioner with additional signal input for sensors

All versions have integrated control electronics. Commissioning is significantly easier since no additional piloting is necessary due to the electronics integrated in the valve.

A decisive advantage of motor valves in contrast to solenoid valves is that the motor only needs electrical power during setpoint changes, the holding power is almost eliminated. Once the valve has reached the required opening, the motor turns off and consequently consumes no more energy. As an example, the energy consumption of a proportional solenoid valve and a motor-driven proportional valve is compared in Fig. 6: Both valves have been gradually opened and closed again within defined intervals. The areas under each graph show the energy needed. The results show: For applications that do not require high dynamic regulation, motor valves can be used to achieve crucial energy savings.

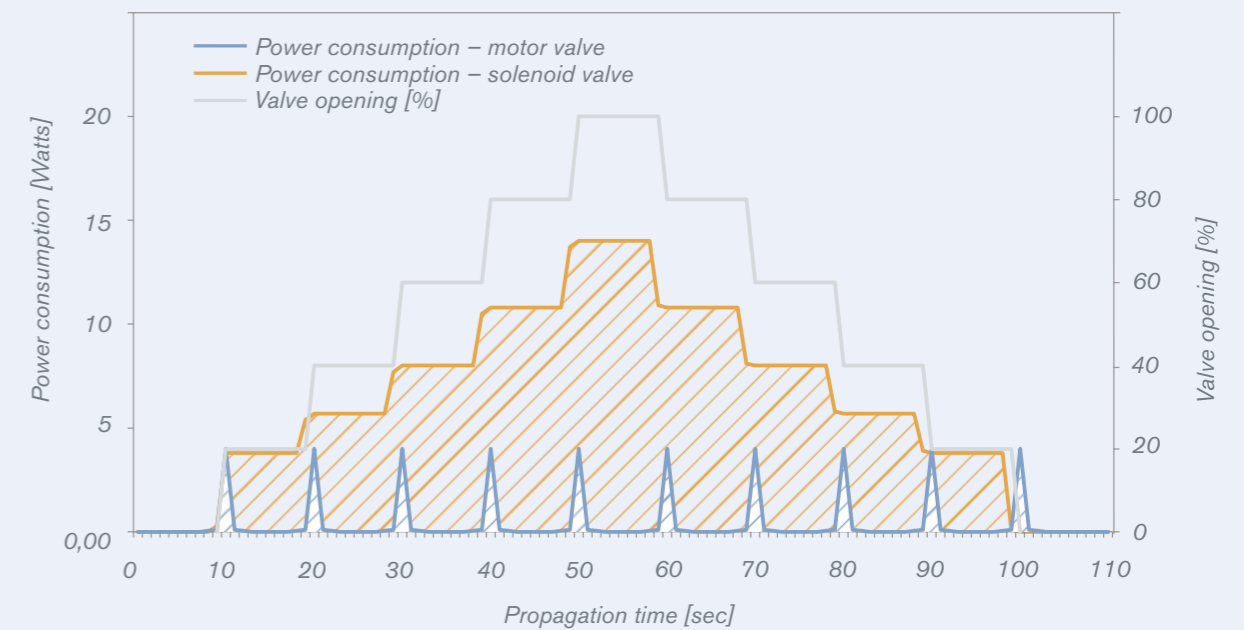


Fig. 6: Power consumption of a motor valve compared to a solenoid valve with identical orifice





## Characteristic Data of Solenoid Control Valves

### **$k_{Vs}$ value/ $Q_{Nn}$ value**

Fluidic valve comparisons can be made via the  $k_{Vs}$  value ( $m^3/h$  unit). This value is measured at water's flow rate at 20 °C and 1 bar relative pressure at the valve inlet, compared with 0 bar at the valve outlet. A second flow rate value is often given for gases. This is the  $Q_{Nn}$  value. The  $Q_{Nn}$  value provides the nominal flow rate value in  $l_N/min$  air (20 °C) at 6 barg at the valve inlet and 1 bar pressure loss via the valve. Standard conditions for the gas are 1013.25 mbar absolute and a temperature of 273.15 K (0 °C).

### **Hysteresis**

The highest fluidic output signal difference with an upward and downward run through of the full electric input signal range; given in % of the maximum fluidic output signal. Hysteresis is a result of friction and magnetism.

### **Sensitivity**

The lowest set point difference that results in a measurable change in the fluidic output signal; given in % of the maximum fluidic output signal.

### **Linearity**

Dimension for maximum deviation from the linear (ideal) characteristics; given in % of the maximum fluidic output signal.

### **Repeatability**

Range in which the fluidic output value disperses when the same electric input signal coming from the same direction is repeatedly set; given in % of the maximum output signal.

### **Turn-down ratio (span)**

Ratio of the  $k_{Vs}$  value ratio to the lowest  $k_{Vs}$  at which the height and incline of the characteristics remains within a tolerance range in the ideal characteristic curve.

In applications in practice the correct configuration of the valve is a prerequisite for proper functioning (see "Sizing of Valve Orifice").

## Use as Control Valve: Sizing of Valve Orifice

For correct and accurate control functioning, solenoid control valves must be configured and selected according to their special purpose. The most important parameters for selecting a solenoid control valve are, on one hand, the  $k_v$  value (given in cubic meters per hour) and, on the other hand, the application's pressure range. The lower the valve's orifice or the stronger the coil, the higher the pressure the valve can shut-off. The highest  $k_v$  value needed is calculated on the basis of the following parameters: Valve inlet pressure, valve outlet pressure, the fluid's density, maximum flow rate required, and the fluid's temperature. With the sizing formulas (see one of Bürkert's data sheets for solenoid control valves), supercritical or subcritical flow and aggregate states (gaseous, liquid or vaporous) are distinguished.

On the basis of the calculated  $k_v$  value and the pressure range of the planned application, a correspondingly appropriate valve type and its required orifice can now be determined. The spreadsheets with the valve performance data on pages 10 to 13 of this brochure will help you to find the right valve type for this. Please observe: The application's  $k_v$  value must be lower than the valve's  $k_{vs}$  value that is reached at maximum opening.

You will find more information on the  $k_{vs}$  value on page 21.

Some countries use the  $c_v$  value instead of the  $k_{vs}$  value. This flow rate is given in US gallons per minute (1 GPM = 0.227 m<sup>3</sup>/h) and determined with water at 60° Fahrenheit and a pressure difference via the valve of 1 psi (equal to 0.069 bar). The conversion factor between  $k_v$  and  $c_v$  is 0.857 ( $k_v$  is smaller than  $c_v$ ).

The correct configuration (determining the valve's orifice) is extremely important for the solenoid control valve's correct functioning. With a high orifice setting the valve can already reach full flow rate at a very small opening (stroke). The remaining stroke then is useless, which, more to the point, impairs resolution and the general control quality of the valve. With an orifice size that is too small on the other hand, the valve won't reach full flow rate. In the interests of the system's acceptable flow characteristics, the valve authority should not be below 0.3. That means that 30 % of the system's pressure should be available to drop over the control valve.

Bürkert provides a calculation tool for the correct control valve sizing: This makes finding the optimum valve orifice so easy.

## Brief Instructions – How do I Find the Right Solenoid Control Valve?

### 1. What medium (fluid) do you want to control?

With regard to its chemical-physical reaction behaviour, it must be checked whether the valve parts in contact with the medium are compatible with the medium itself.

### 2. How high is the maximum operating pressure?

The valve must be able to shut off the highest pressure in the application.

### 3. What are the process data?

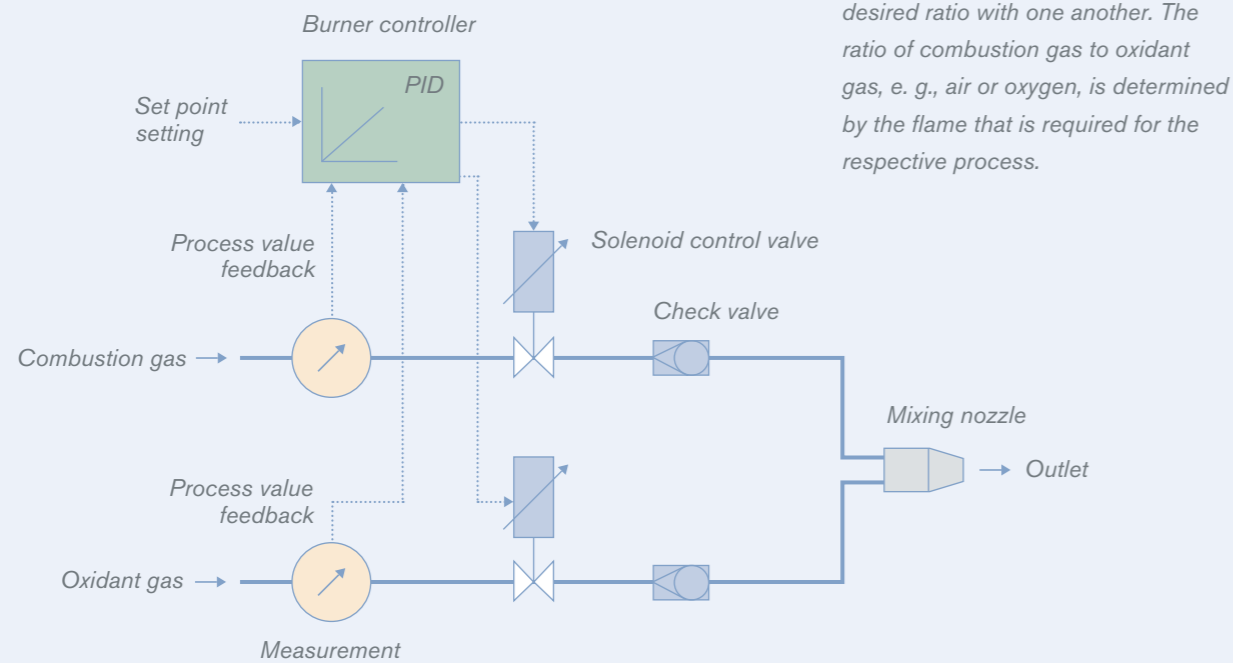
For optimal sizing of the valve orifice there are some issues to be cleared up. At first there is the scope of the required maximum flow rate,  $Q_{nom}$ , which typically has to be controlled. The valve's maximum flow rate can, however, actually be higher, and the figures of the pressure values at  $Q_{nom}$  must be measured immediately before and after the valve ( $p_1, p_2$ ). These values are often not identical to the inlet and outlet pressure of the overall system, because additional flow resistances have an effect both before and after the valve (pipes, shut-off valves, nozzles, etc.). If the inlet ( $p_1$ ) and outlet pressure ( $p_2$ ) cannot be determined, both must be estimated taking all pressure drops into account. Information on the medium temperature ( $T_1$ ) and the standard density ( $\rho_N$ ) of the medium at 273 Kelvin (0 °C) and 1013 mbar (1 bar) also helps in calculating the valve orifice. Whether or not the minimum flow rate can be adjusted ( $Q_{min}$ ) is checked using the achievable turn-down ratio of the valve considered.

Here is a brief summary of the sizing criteria once again:

- The valve's  $k_{vs}$  is greater than the application's  $k_v$ ; ideally by approx. 10 %
- The pressure that can be withstood by the valve is greater than the max. operating pressure before the valve

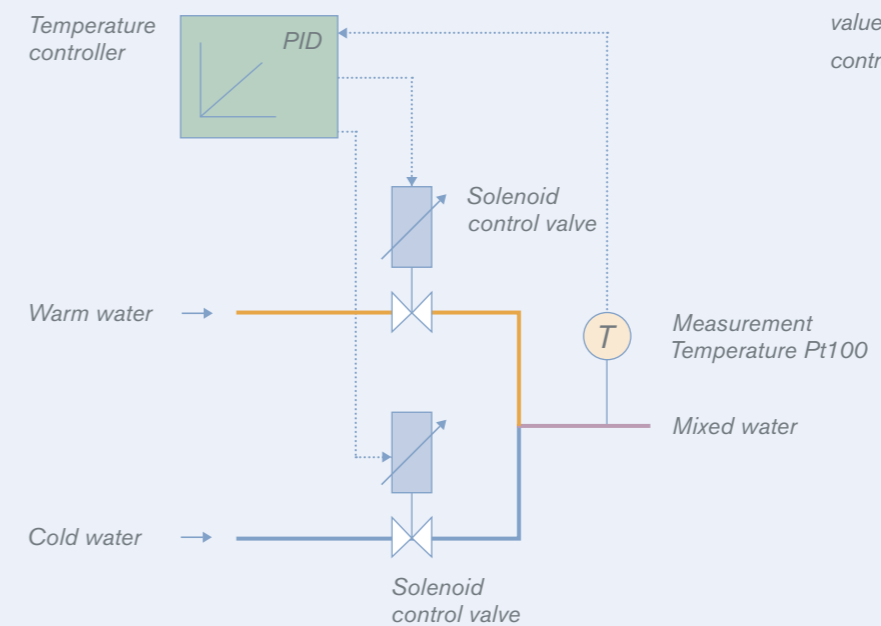
# Typical Applications

## Burner / Flame Control



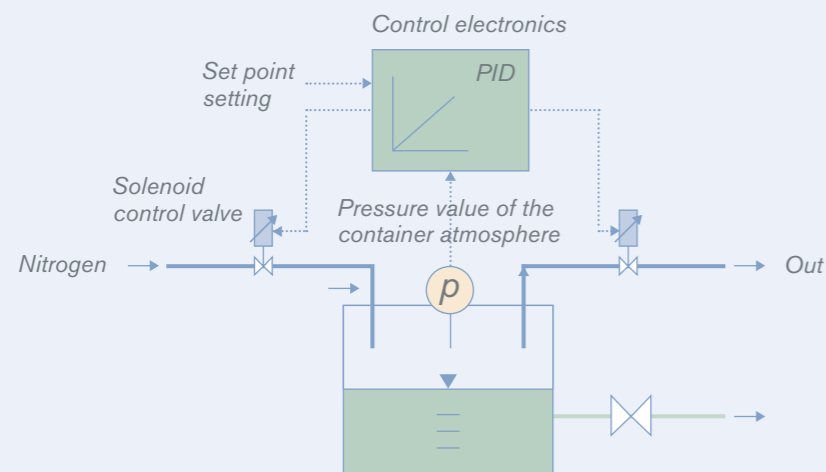
Two gases must be controlled in a burner control system; both are in a desired ratio with one another. The ratio of combustion gas to oxidant gas, e. g., air or oxygen, is determined by the flame that is required for the respective process.

## Mixture of Cold and Warm Water



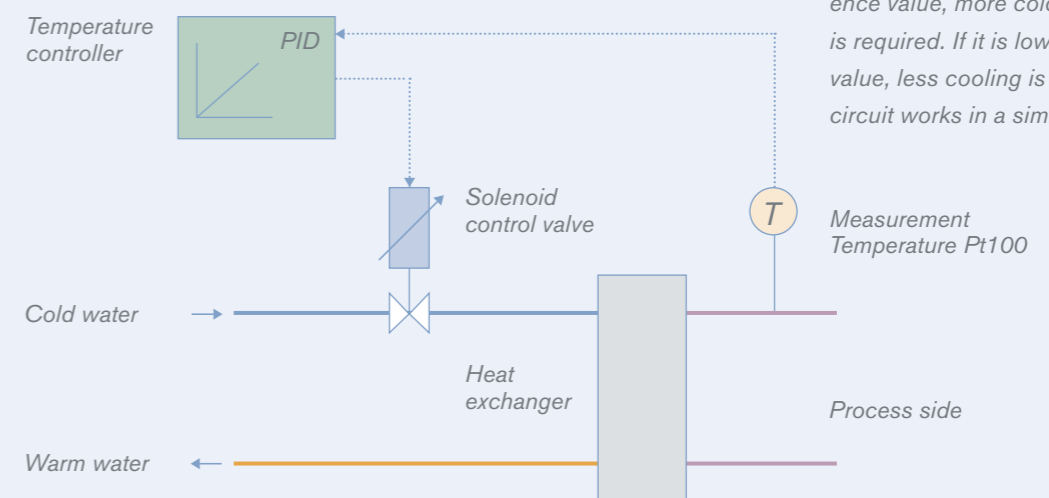
A Pt100 temperature sensor measures the temperature of the mixed water. The temperature controller brings this temperature to the given reference value by controlling the two solenoid control valves accordingly.

## Level Control with Pressurization (Flow Pressure Control)



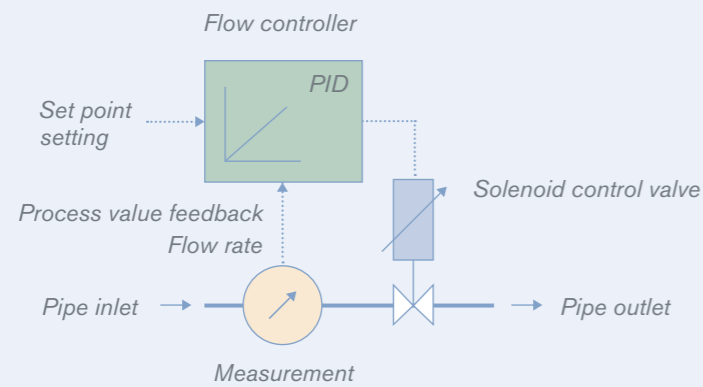
Atmospheric pressure control is one possible type of level control. Via two solenoid control valves, a PID controller supplies enough air or nitrogen here so that there is always the same pressure pressing against the fluid that changes when the fluid pressure drops through removing a portion of the fluid.

## Temperature Control



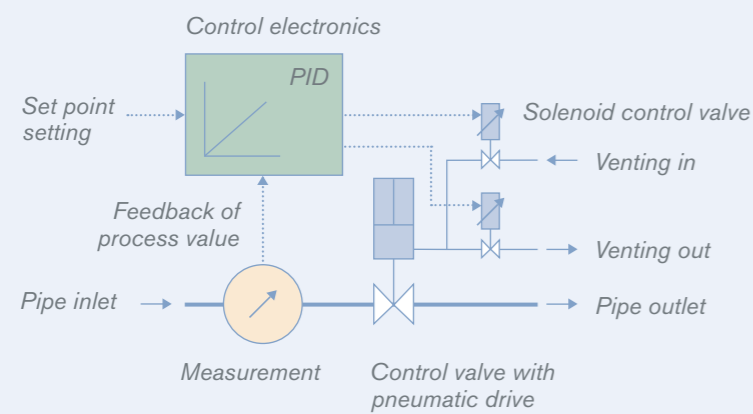
The solenoid control valve sets the cold water supply to the heat exchanger in accordance with the measured process water temperature. If this is higher than the reference value, more cold water (cooling water) is required. If it is lower than the reference value, less cooling is required. A heating circuit works in a similar way.

### Flow Control



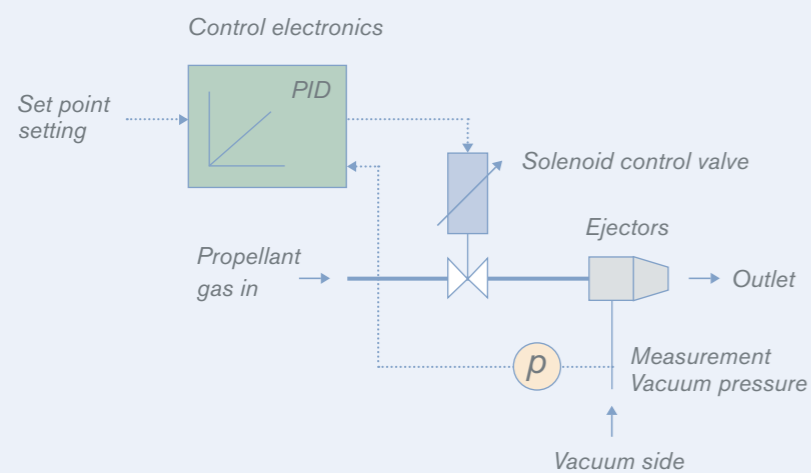
A solenoid control valve can be used directly as a control valve, for direct flow control, for example.

### Actuator Control (Static Pressure Control)



Two solenoid control valves control the air for pneumatic drive (piston valve, cylinder, etc.). The PID controller determines which of the two valves must open. The control electronics set the drive via the solenoid control valves so that the process value corresponds with the set point given.

### Ejectors / Pressure Control

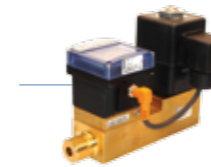


The solenoid control valve controls the propellant gas flow rate. More propellant gas creates greater suction power and a deeper vacuum in the suction line. The controller sets the valve according to the vacuum pressure.

## System Engineering

A global network of Bürkert system engineering facilities and long-standing years of experience in the systems business allow us to develop and quickly implement tailor-made solutions for your requirements. Engineers and scientists from the most diverse specialist fields are at your disposal for competent and expert consulting. Our range of customized solutions is highly diversified and ranges from connection plates, plastic injection components, the integration of additional components, electronics, software and connections via special interfaces, right through to the use of customized bus technology.

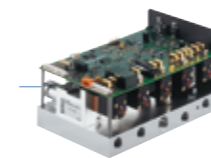
We can therefore ensure that you get the perfect product for your application. The focus of our work is both on the optimization of procurement and installation costs, and a higher level of integrating functions into the system. Furthermore, with its geometric dimensions and the mechanical and electrical interfaces we put in place, the system is optimized to fit into its later application environment.



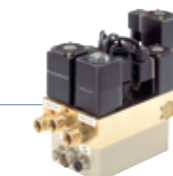
System for controlling cooling water with reference to the temperature of the process water



Compact, space-optimized solenoid control valve system with plastic moulded base



Five channel gas controller, featuring one common electronic board only



Fieldbus controlled, three channel pressure controller



System for controlling cooling water into different transmission lines