

Differential pressure control with the Belimo Energy Valve[™]

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Electronic differential pressure control

In addition to the control modes position control, flow control and power control, the Belimo Energy Valve[™] can also be used as an electronic differential pressure controller. This document provides an overview of electronic differential pressure control. The product documentation of the Energy Valve and the differential pressure sensor used (e.g. data sheet) is also to be taken into account.

The differential pressure control mode is available for the following devices with DN 15...50:

- EV..R2+BAC 2-way Belimo Energy Valve™
- EV..R2+KBAC 2-way Belimo Energy Valve™ with fail-safe
- EV..R2+MID 2-way Belimo Energy Valve[™] with Thermal Energy Meter (MID/EN 1434)
- Other versions (e.g. IP66/67) upon request



Belimo Energy Valve^ ${\rm TM}$

Accessories for the installation of the Energy Valve can be found in the respective product documentation.

Products

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Required components for differential pressure control

If the Energy Valve is used to control the differential pressure, a corresponding differential pressure sensor is needed. This is not included in the scope of delivery of the Energy Valve. The 22WDP-11.. and 22PDP-18.. differential pressure sensors are used for differential pressure control. They are available for various measuring ranges and can be obtained from Belimo.

Differential pressure sensor water 22WDP-11.. from Belimo

Active sensor (0...10 V) for differential pressure measurement in HVAC systems. The sensor is suitable for water and water-glycol mixtures. The housing is made of stainless steel and corresponds to IP65 / NEMA 4. This differential pressure sensor measures the differential pressure that is transferred to a diaphragm integrated in the sensor via two impulse lines (capillary tubes) installed onsite.



Differential pressure sensor water - 22WDP-11.. from Belimo

The specifications regarding accuracy and long-term stability listed in the data sheet of the 22WDP-11. must be observed.

Differential pressure sensor water 22PDP-18.. from Belimo

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Active sensor (4...20 mA / 0...5 V / 0...10 V) for differential pressure measurement in HVAC systems. The sensor is suitable for water and water-glycol mixtures. IP65 / NEMA 4X rated housing with LCD display. The differential pressure sensor is equipped with two remote pressure transmitters made of stainless steel. They measure the static pressure at the two measuring points. The calculated differential pressure is output and is available as a measured value.



Differential pressure sensor water - 22PDP-18.. from Belimo

The specifications regarding accuracy and long-term stability listed in the data sheet of the 22PDP-18. must be observed.

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Mode of operation

The electronic differential pressure controller is used to maintain the differential pressure (dp) at a constant set value between two points in a hydronic circuit. In addition, it can be used as a flow rate and power limiter.



Differential pressure control with Energy Valve

In this control mode, the Energy Valve does not receive a setpoint from the building management system. The differential pressure sensor connected with the Energy Valve measures the current differential pressure. This value is read out of the Energy Valve and compared with the preset setpoint. If a deviation is detected between the measured value and the setpoint, this is compensated automatically by the logic integrated in the Energy Valve. To accomplish this, the opening angle of the characterised control valve integrated in the Energy Valve is either enlarged or reduced. The following three operating states can occur:

1. Effective differential pressure less than the differential pressure setpoint

To reduce the pressure drop across the Energy Valve and thus increase the differential pressure between the measuring points, the valve is opened further until the setpoint is reached. If the differential pressure on the system side is not sufficiently high, the setpoint may not be reached. In this case, the Energy Valve moves to the maximum opening position of 90°.

2. Effective differential pressure corresponds to the differential pressure setpoint No action of the Energy Valve. The opening position is retained.

3. Effective differential pressure greater than the differential pressure setpoint

To reduce the differential pressure between the two measuring points, more pressure drop must be generated across the Energy Valve. In this case, the valve opening is reduced until the setpoint or minimum position is reached. The ball valve installed in the Energy Valve is never completely closed during standard differential pressure control mode in order to ensure that changes in the system (change in pump head or flow changes due to controlling consumer valves) can be detected.

Additional features

	Thanks to the innovative concept involving measurement of the flow and the supply and return temperatures, the calculation of the currently delivered power and the logic integrated in the device, users have a wide range of additional features at their disposal.
Easily adjustable setpoint	The desired setpoint is simple to adjust on the device. Various options are available:
	 Belimo Assistant 2, simple communication with the Energy Valve thanks to NFC
	 Web server integrated in the Energy Valve, accessible via direct connection or through a network
	 Belimo Cloud, value change from anywhere
	– Communicative, value change via MP-Bus, Modbus or BACnet
Adjustable flow limitation	A maximum flow V' _{max} can be specified for the Energy Valve. Even if the effective differential pressure is below the setpoint, the Energy Valve does not open further when V' _{max} is reached. This makes it possible to avoid situations in which other parts of the hydronic system have too little energy at their disposal.
	Flow limitation adjustment range: V' _{max} = 25100% von V' _{nom}
Adjustable maximum power	A maximum power Q' _{max} can be specified for the Energy Valve. The valve posi- tion is not increased further when the set maximum heating or cooling power is reached. This setting can be used as a simple way to ensure that the controlled system segment is not able draw too much power.
	Maximum power adjustment range: Q' _{max} = 1100% Q' _{nom}
Sensor drift compensation	After a longer operating time, a drift can occur at the differential pressure sensor, which can be compensated for as follows:
	 Close the Energy Valve completely (web server, Belimo Assistant 2, manually) The measured differential pressure is displayed (web server, Belimo Assistant 2)
	3. Measure the existing differential pressure at the measuring points (additional
	4. Calculate and enter the required offset (web server, Belimo Assistant 2)
Shut-off function	If necessary, the characterised control valve integrated in the Energy Valve can be closed completely (lever, web server (automatic reset after 2 hours), communicative override control). The characterised control valve ensures an air-bubble tight shut-off.

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Purpose of use

The best results can be achieved by using a pressure-independent control value at each consumer. In order to achieve BAC efficiency class "A" according to ISO 52120-1 in the BAC and TBM functions¹⁾

- 1.4.a Heat distribution with hydronic balancing

- 3.4.a Cold distribution with hydronic balancing

dynamic balancing for each emitter is needed.

¹⁾ BAC: Building automation and control TBM: Technical building management



Perfect pressure-independent control of the individual consumers with PIQCV, EPIV and Energy Valve

The differential pressure control function of the Energy Valve is not required in this application.

However, if the balancing at the individual consumers is only static (class "D"), the various system segments can be dynamically balanced against one another (class "C") by using additional Energy Valves with differential pressure control function. It should be noted that the mutual hydronic influence of the individual consumer branches within the system segment remains.



Dynamic balancing of the system segment (building floor) and static balancing of the consumers

Thanks to the flow measurement of the Energy Valve, the total quantity of water can be calculated and the control valve in the bypass can be controlled as required in order to ensure a minimum quantity of water (pump protection).

Advantages

to avoid flow noise due to excessive flow rates. Possible losses in comfort and energy wastage due to oversupply are also reduced.

System transparency

The flow and the supply and return temperature are measured in real time. This enables calculation of current power output and current energy consumption. The Energy Valve thus contributes to system transparency. The saved and readily accessible information (Belimo Assistant 2, web server, Belimo Cloud) enables evaluation and optimisation of the hydronic system. The transparency achieved also greatly simplifies troubleshooting in the hydronic system.

Keeping the differential pressure in a system segment constant makes it possible

Additional benefits over conventional mechanical differential pressure controllers are achieved by using the electronic differential pressure controller design:

- Eliminates the need to find and adjust the setting position on the differential pressure controller; simple, direct setpoint input
- No access to the differential pressure controller required to change the setpoint; setpoint change possible via MP-Bus, Modbus, BACnet or Belimo Cloud
- No measuring computer required to measure system values; permanent measurement of differential pressure, flow and fluid temperatures and easy data access via communicative interface, Belimo Assistant 2, web server or Belimo Cloud

Sizing

As described in the chapter Functionality, the Energy Valve in differential pressure control mode adjusts its hydronic resistance by changing the valve opening so that the pressure drop across the Energy Valve occurs that is required to achieve the desired differential pressure between the measuring points.



To select a suitable Energy Valve, the required $K_{\rm v}$ value must be calculated. The sizing is made for nominal flow.

- Required specifications:
- Nominal flow V^{\prime}_{max} in the system segment
- Desired differential pressure $\mbox{dp}_{\mbox{setpoint}}$ between the measuring points
- System differential pressure dp_{connection} between the connection points of the system segment

1. Calculation of the necessary pressure drop across the Energy Valve $- dp_{EV} = dp_{connection} - dp_{setpoint}$

Note: If additional high pressure losses occur between dp_{connection} and dp_{setpoint} (e.g. long pipeline), these must also be taken into account

2. Calculation of the necessary flow coefficient of the Energy Valve K_{VEV}

$$K_{vEV} = \frac{V'_{max}}{\sqrt{\frac{\Delta p_{EV}}{100}}} \quad K_{vEV} [m^3/h] / V'_{max} [m^3/h] / \Delta p_{EV} [kPa]$$

3. Selection of the Energy Valve

– The previously calculated K_{vEV} must be less than the $K_{\text{vtheor.}}$ of the selected type

K_{vtheor.} and V'_{max} for differential pressure control with Energy Valve

Valve type	DN	K _{vtheor.} [m³/h]	V' _{max} *) [I/s]	V' _{max} *) [m ³ /h]
EV015R2+	15	3.2	0.1050.42	0.3751.5
EV020R2+	20	5.3	0.1730.69	0.6252.5
EV025R2+	25	8.8	0.2430.97	0.8753.5
EV032R2+	32	14.1	0.4181.67	1.56
EV040R2+	40	19.2	0.6952.78	2.510
EV050R2+	50	30.4	1.0434.17	3.7515

*) Flow limitation adjustment range

For the best possible control capability, the smallest possible nominal diameter should be selected. V'_{max} must also be considered.

Example: V'_{max} = $9.3 \text{ m}^3/\text{h}$ $\Delta p_{setpoint} = 45 \text{ kPa}$ $\Delta p_{connection} = 110 \text{ kPa}$

1. $\Delta p_{EV} = \Delta p_{connection} - \Delta p_{setpoint} = 110 \text{ kPa} - 45 \text{ kPa} = 65 \text{ kPa}$

^{2.}

$$K_{vEV} = \frac{V'_{max}}{\sqrt{\frac{\Delta p_{EV}}{100}}} = \frac{9.3 \text{ m}^3/\text{h}}{\sqrt{\frac{65 \text{ kPa}}{100}}} = 11.5 \text{ m}^3/\text{h}$$

3. Selection EV040R2+.. (K_{vtheor.} = 19.2 m³/h / V'_{max} = 2.5...10 m³/h)

Operating range

In differential pressure control mode, the Energy Valve automatically changes its opening position to achieve the pressure drop required to reach the desired differential pressure setpoint. The flow that occurs is specified by the system segment supplied. The following limitations must be taken into account:

Maximum flow

– The specified V^{\prime}_{nom} value of the Energy Valve must not be exceeded

V'_{nom} Energy Valve

Valve type	DN	V' _{nom} *) [I/s]	V' _{nom} * ⁾ [m³/h]
EV015R2+	15	0.42	1.5
EV020R2+	20	0.69	2.5
EV025R2+	25	0.97	3.5
EV032R2+	32	1.67	6
EV040R2+	40	2.78	10
EV050R2+	50	4.17	15

*) Flow limitation adjustment range

- Maximum flow at which dpsetpoint is reached:

max. V' = K_{vtheor.}
$$\cdot \sqrt{\frac{\Delta p_{EV}}{100}}$$

Minimum flow with flow reduction

Reduction of the flow through the control valves in the system segment
 Differential pressure control is carried out up to a minimum flow of 0.7%

V'_{nom}

– The position of the angle reached at 0.7% of V^{\prime}_{nom} is retained ("freeze position")

Behaviour when the minimum flow is undercut

Start-up behaviour after the flow has fallen below the minimum flow

Differential pressure control mode is resumed when a differential pressure is present and one of the following conditions is met:

– The measured flow is higher than 1.2% V^{\prime}_{nom}

– The measured differential pressure is less than 50% of the differential pressure setpoint and a flow of at least 0.2% V^\prime_{nom} is detected



Differential pressure control operating range

Note:

- In differential pressure control mode, the valve is never completely closed
- Instead of the "freeze position" described above, an actuator position of 27% is approached as the starting position for the control mode in the following situations:
 - The valve has been restarted
 - After a voltage interruption
 - The manual override was previously operated
 - Switching from another control mode (e.g. flow control) to differential pressure control mode
 - No differential pressure is present at a flow <0.7% V'nom
- If the flow cannot be measured due to a malfunction in the flow sensor or due to air bubbles in the system, the differential pressure is controlled within the valve opening range from 27% to 100%
- The actuator switches from actuator position 27% to control mode if a differential pressure is present and one of the following conditions is met (both for at least 30 seconds):
 - The measured flow is higher than 0.7% V^{\prime}_{nom}
 - or
 - The measured differential pressure is less than 50% of the differential pressure setpoint and a flow of at least 0.2% $\rm V'_{nom}$ is detected

or

Differential pressure sensor selection

The following differential pressure sensors can be used:

- Differential pressure sensor 22WDP-11.. from Belimo
- Differential pressure sensor 22PDP-18.. from Belimo

The specifications in the respective sensor data sheets are to be observed. The desired setpoint must be within the possible adjustment range. It is recommended to use a differential pressure sensor with a maximum setpoint that does not deviate too strongly from the desired setpoint. The dead band used must be observed.

Selection 22WDP-11...

Sensor type	Measuring range [kPa]	Overpressure [kPa]	Burst pressure [kPa]	Fluid temperature [°C]	Possible adjustment range differential pressure setpoint Energy Valve [kPa]	Dead band differential pressure control [kPa]	
22WDP-111	0100	600	2100	-1080	1080	+/-4	
22WDP-112	0250	600	2100	-1080	25200	+/-10	
22WDP-114	0400	1600	2100	-1080	40320	+/-16	
22WDP-115	0600	1600	2100	-1080	60400	+/-16	

Differential pressure sensor specification

Selection 22PDP-18..

Differential pressure sensor specification

Sensor type	Measuring range [kPa]	Permissible operating pressure [kPa]	Overpressure [kPa]	Burst pressure [kPa]	Fluid temperature [°C]	Possible adjustment range differential pressure setpointEnergy Valve [kPa]
22PDP-185	0500	500	1000	10000	-40105	10400
22PDP-186	01000	1000	2000	20000	-40105	10400
22PDP-189	03500	3500	7000	70000	-40105	28400

Minimum permissible fluid temperature Energy Valve: –10°C Maximum permissible operating pressure Energy Valve: 1600 kPa

The measuring range and the differential pressure setpoint that is adjustable on the Energy Valve are dependent in the case of sensor type 22PDP-18.. on the setting that is selected on the differential pressure sensor.

Possible adjustment range differential pressure setpoint Energy Valve [kPa] Setting Setting Setting Setting Range 1 Range 2 Sensor type Range 3 Range 4 20...200 10...80 10...40 22PDP-185 40...400 22PDP-186 _ 40...400 16...160 10...80

_

40...400

28...280

Dead band differential pressure control [kPa]

22PDP-189

Sensor type	Setting Range 1	Setting Range 2	Setting Range 3	Setting Range 4
22PDP-185	+/- 16	+/- 10	+/- 4	+/- 4
22PDP-186	_	+/- 16	+/- 8	+/- 4
22PDP-189	-	-	+/- 16	+/- 14

Integration

In differential pressure control mode, the Energy Valve is operated as a stand-alone device without external control signal. Nonetheless, it can be integrated to enable simple access via communicative interface to all operating data and measured values or easily adjust the setpoint. The following communicative interfaces are available in every Energy Valve EV..R2+..:

- MP-Bus
- Modbus TCP, Modbus RTU
- BACnet/IP, BACnet MS/TP

Information regarding communicative integration can be found in the following documents:

- Data sheet Energy Valve
- Installation instructions Energy Valve
- MP-Bus Data-Pool Values
- Modbus interface description
- BACnet interface description

In addition to the communicative interface, the analogue feedback signal U can be used to display **one** of the following measured values:

- Differential pressure
- Heating/cooling power 1)
- Flow
- Actuator position
- Supply temperature
- Return temperature
- Differential temperature
- ¹⁾ of the connected system segment

Installation

When installing the differential pressure sensor, the corresponding installation instructions are to be observed. The connection of the differential pressure sensor is described in the installation instructions for the Energy Valve.

Installation 22WDP-11..



Installation 22WDP-11..

Installation 22PDP-18..



Installation 22PDP-18..

Commissioning / Configuration

Commissioning / Configuration with the web server

Detailed information regarding the web server can be found in the *Web Server instructions* – *Belimo Energy Valve*[™] / *Thermal Energy Meter* document. The specific settings for differential pressure control are described in the following.

BELIMO	Energy Valve	- Differential Pre	ssure Control	
	Belimo Energy Valve	2" DN 50	Override	
Overview	Vnom 4.167 l/s	Pnom 850 kW	None	None 🗸
Data				
Status (1) Settings	Startup Assistant	Commissioning Report		
Application Site Information	Settings Import	Settings Export		
Date & Time	Configuration			
User Administration	Units		2 Control setting	
BACnet/MP/Modbus	Tomporatura	10	Control mode	Eleve control
IP	Flow	l/s 🗸	Setpoint source	Analog
Maintenance	Power	kw 🔽		_
Commissioning Report	Energy	kWh 🔽	Control signal DDC	0,5-10V
Configuration			Invert signal	not Inverted

Web server - changing the control mode (step 1)

Control settings



Web server - changing the control mode (step 2)

Control settings



Web server – differential pressure control setting

- 1. Selection of the installed differential presure sensor
- 2. Selection of ranges 1 to 4 for the measuring range set on the 22PDP-18.. (this selection option is not available with the 22WDP-11..)
- 3. Adjustment of the desired differential pressure setpoint
- 4. Possibility of correcting sensor drift

Maximum and limitation

	Vmax		3.000 l/s	(1)
		Range	1.042 - 4.167	\smile
	Pmax		210.0 kW	\bigcirc
		Range	4.3 - 850.0	
	Web server – limitation function setting			
	 Definition of the maximum flow V'm When the set V'max value is reach increased any further, even if the sectory setting V'max = V'nom Definition of the maximum heating/corresponding system segment When the maximum power is rea increased any further, even if it fa Factory setting P'max = P'nom 	^{ax} ed, the differenti setpoint has not cooling power F ched, the differe Is below the set	ial pressure is not yet been reached ^p m _{ax} in the ntial pressure is no point	t
	If no specific limitations are required,	10 settings need	to be made here.	
Commissioning / Configuration with Belimo Assistant 2	The above settings can also be ma Assistant 2.	de quickly and	intuitively using E	Belimo
Configuration with MP-Bus, Modbus or BACnet	The settings can be changed via bus (ising the corresp	ponding data points	5.
Configuration via Belimo Cloud	For devices connected to the Belimo Clo	ud, settings can b	be made from any lo	cation.
Restrictions	 Note that the delta T manager is not mode Specially configured control parame However, they are not designed for it water control Series connection of the electronic of electronic pressure-independent con control is not recommended 	available in diff ters ensure stab apid control pro differential press ntrol valves in flo	erential pressure co ole control quality. ocesses, i.e. domest sure controller with ow control or power	ic other

All inclusive.

Belimo is the global market leader in the development, production, and sales of field devices for the energy-efficient control of heating, ventilation and air-conditioning systems. The focus of our core business is on damper actuators, control valves, sensors and meters.

Always focusing on customer value, we deliver more than only products. We offer you the complete product range for the regulation and control of HVAC systems from a single source. At the same time, we rely on tested Swiss quality with a five-year warranty. Our worldwide representatives in over 80 countries guarantee short delivery times and comprehensive support through the entire product life. Belimo does indeed include everything.

The "small" Belimo devices have a big impact on comfort, energy efficiency, safety, installation and maintenance.

In short: Small devices, big impact.







