Current technology, modern sensors.

VAV-Compact product range for volumetric flow applications

Edition 2023-10/B

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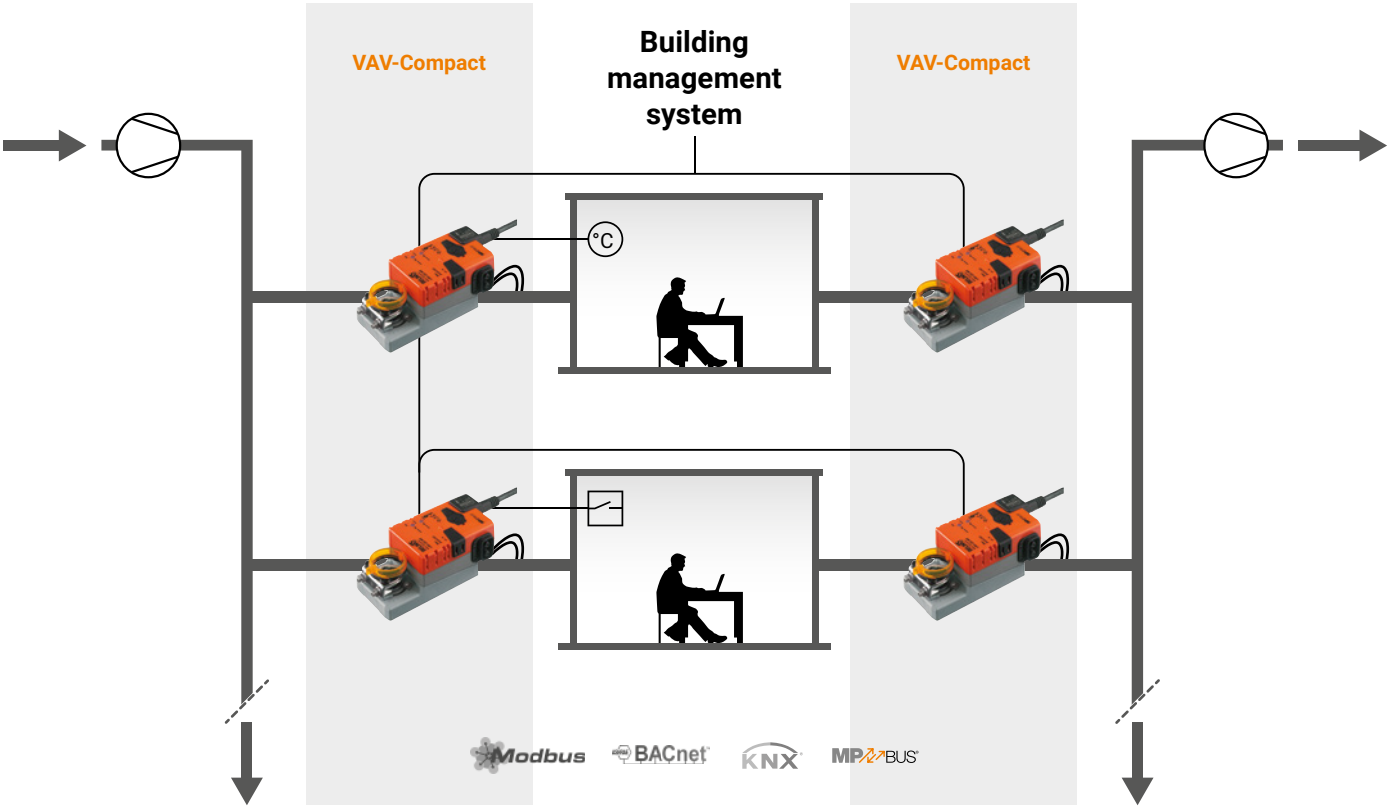
Preface

Thank you for your interest in our products. In this brochure you will find information on volumetric flow applications with the new VAV-Compact product range from Belimo.

At www.belimo.com you will find further solutions from Belimo relating to the areas of room and system solutions, bus and system integration, ventilation applications and sensors.
Please contact us for more information.

Note
The Belimo VAV product range – VAV-Compact and VAV-Universal components incl. replacement devices - is only available from manufacturers of VAV units (OEM).
Please contact the desired supplier. Your local Belimo representative is happy to help you if necessary.

VAV-Compact L/N/SMV-..
The diagram shows an example of the principle of a single room application with VAV units for volumetric flow control.



The cost-efficient overall solution with differential pressure sensor, controller and actuator combined in one compact device for ventilation systems with variable or constant volumetric flow. The extremely sensitive sensor enables precise Δp recording and control of even the smallest of volumetric flows.
– Conventional control by means of 0...10 V or 2...10 V signal or via switching contacts
– Simple direct connection to Modbus, BACnet, KNX and MP-Bus networks
– Flexible standard tools (PC-Tool, ZTH EU, Belimo Assistant App)

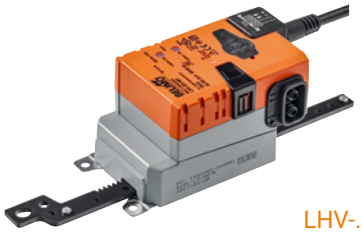
Product range and function overview

VAV-Compact controller with integrated differential pressure sensor, VAV controller and damper actuator for ventilation systems with variable or constant volumetric flow.
Field of application:
- For comfort applications, e.g. office: Δp sensor (D3) with dynamic measuring principle
- For contaminated air[1)], e.g. kitchen extract air: Δp sensor (M1) with static pressure measurement

- Versions:
  - Control 0...10 V / 2...10 V / MP-Bus
  - KNX
  - Modbus / BACnet / MP-Bus / hybrid
- Possibility of connecting sensors and switches
- Service socket for tool connection
- NFC interface for operating via smartphone (MP version only)

LMV-..

NMV-/SMV-..



LHV-..

	Application		Sensor				Actuator		Supply, control							Tool		
	Volumetric flow VAV/CAV	Position control (Open Loop)	Comfort zone	D3, dynamic, 0...500 Pa	Contaminated air [1)]	M1, static, 0...600 Pa	Rotary 0...90°, Running time, 120...300 s	Linear 0...300 mm, 150 N Running time, 120...300 s	AC/DC 24 V supply	Analogue control 0...10 V / 2...10 V	MP-Bus	KNX	Modbus RTU	BACnet MS/TP	Hybrid mode (Modbus / BACnet)	Belimo Assistant App (NFC)	PC-Tool	ZTH EU
Rotary actuators																		
LMV-D3-MP	■	■	■	■	–	–	5 Nm	–	■	■	■	–	–	–	–	■	■	■
NMV-D3-MP	■	■	■	■	–	–	10 Nm	–	■	■	■	–	–	–	–	■	■	■
SMV-D3-MP	■	■	■	■	–	–	20 Nm	–	■	■	■	–	–	–	–	■	■	■
LMV-M1-MP	■	■	–	–	■	■	5 Nm	–	■	■	■	–	–	–	–	■	■	■
NMV-M1-MP	■	■	–	–	■	■	10 Nm	–	■	■	■	–	–	–	–	■	■	■
LMV-D3-KNX	■	■	■	■	–	–	5 Nm	–	■	–	–	■	–	–	–	–	■	■
NMV-D3-KNX	■	■	■	■	–	–	10 Nm	–	■	–	–	■	–	–	–	–	■	■
LMV-D3-MOD	■	■	■	■	–	–	5 Nm	–	■	■	■	–	■	■	■	–	■	■
NMV-D3-MOD	■	■	■	■	–	–	10 Nm	–	■	■	■	–	■	■	■	–	■	■
SMV-D3-MOD	■	■	■	■	–	–	20 Nm	–	■	■	■	–	■	■	■	–	■	■
LMV-M1-MOD	■	■	–	–	■	■	5 Nm	–	■	■	■	–	■	■	■	–	■	■
NMV-M1-MOD	■	■	–	–	■	■	10 Nm	–	■	■	■	–	■	■	■	–	■	■
Linear actuators																		
LHV-D3-MP	■	■	■	■	–	–	–	■	■	■	■	–	–	–	–	■	■	■

[1)] – Compatibility test with the intended media required
– Use of the components in fume hoods or similar is not permitted

VAV-Compact – Generation overview

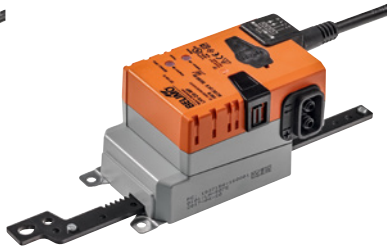
Designation	Produced	Version/functions	Tools
NMV24V/D	Until 1992	VAV-Compact with external V/D sensor	–
NMV-D2	1992–2001	VAV-Compact with integrated D2 sensor	ZTH
NMV-D2M	2001–2006	D2 sensor, MP-Bus/analogue 0/2...10 V	ZTH/PC-Tool V2
NMV-D2LON	2002–2006	D2 sensor, LON	ZTH/PC-Tool V2
L/N/SMV-D2-MP	2006–2008	D2 sensor, MP/analogue 0/2...10 V, new design	ZTH/PC-Tool V3
L/NMV-D2LON	2006–2008	D2 sensor, LON, new design	ZTH/PC-Tool V3
L/N/SMV-D3-MP	2008–...	D3 sensor, MP/analogue 0/2...10 V, new Δp sensor	ZTH/PC-Tool V3
L/NMV-D3LON	2008–2021	D3 sensor, LON	ZTH/PC-Tool V3
L/N/SMV-D3-MOD	2012–...	D3 sensor, Modbus	ZTH/PC-Tool V3
L/N/SMV-D3-MP	2016–...	D3 sensor, MP-Bus/analogue 0/2...10 V NFC interface for Belimo Assistant App	APP/ZTH/PC-Tool V3
L/NMV-D3-KNX	2018–...	D3 sensor, KNX	ZTH/PC-Tool V3
L/N/SMV-D3-MOD	2018–...	D3 sensor, new: Switchable control BACnet/MOD/hybrid mode/MP/analogue 0/2...10 V	ZTH/PC-Tool V3
L/NMV-M1-MP	2023–...	M1 sensor, MP/analogue 0/2...10 V NFC interface for Belimo Assistant App	APP / ZTH / PC-Tool V3
L/NMV-M1-MOD	2023–...	M1 sensor, BACnet/MOD/hybrid mode/MP/analogue 0/2...10 V	ZTH / PC-Tool V3

Terms

CAV	Constant Air Volume
VAV	Variable Air Volume
DCV	Demand Controlled Ventilation
DN	Diameter nominal, international designation for nominal diameter
BMT	Building Management System
STP	Duct pressure controller
RP	Room-pressure controller
Open Loop	Position control (operating mode without VAV control, modulating actuator with volumetric flow measurement)
OEMs	Original Equipment Manufacturer, manufacturer VAV unit
CR24-..	Belimo CR24-B1/2/3 Stand-alone room temperature controller
D3	Δp sensor, D3 flow sensor (dynamic)
M1	Δp sensor, M1 diaphragm sensor (static)
LHV	Belimo VAV-Compact with linear actuator
LMV	Belimo VAV-Compact with rotary actuator 5 Nm
NMV	Belimo VAV-Compact with rotary actuator 10 Nm
SMV	Belimo VAV-Compact with rotary actuator 20 Nm
VC	VAV-Compact product range from Belimo – actuator with VAV controller and Δp sensor in one device
VU	VAV-Universal product range from Belimo – modular solution consisting of VAV controller with integrated Δp sensor plus external actuator
BAC	BACnet interface
KNX	KNX interface
Hybrid mode	VAV-Compact integrated in BACnet/Modbus with analogue control and/or feedback signal
MOD	Modbus interface
MP	MP-Bus interface
NFC	Near Field Communication, interface for wireless tool connection
A/D	Analogue-digital converter
D/A	Digital-analogue converter
M	Motor
U/U5	Actual value output (terminal 5)
Y	Reference value input (terminal 3)
z	Forced switching (override) to input Y
EHO	Energy Hold Off
w	Setpoint controller
ao..	Analogue output..
wK	Setpoint cooling
wH	Setpoint heating
Xp	Proportional band
cw	Clockwise rotation (direction of rotation of actuator)
ccw	Counterclockwise (anticlockwise) rotation (direction of rotation of actuator)
Mode	Setting for voltage range for reference value input/actual value output
V'_{min}	Operating mode min. according to the application V'_{min}
V'_{mid}	Operating mode min. according to the application V'_{min}
V'_{max}	Operating mode max. according to the application V'_{max}
V'_{nom}	VAV applications volumetric flow nominal setting[1)]
$\Delta p@V'_{nom}$	VAV applications calibration value VAV unit [1)]

[1)] OEM factory setting: fixed setting, values cannot be changed

Brief description



Application

The VAV-Compact with its PI control characteristic is used for the pressure-independent control of VAV units in zone and room applications.

Volumetric flow measurement

Comfort applications
Volumetric flow measurement via the integrated dynamic Δp sensor (D3) is also suitable for controlling very small volumetric flows. The maintenance-free sensor technology enables a wide range of applications: Residential construction, office, hotel, etc.

Applications with increased requirements such as contaminated air
The VAV-Compact with static Δp sensor (M1) is suitable for volumetric flow systems with increased requirements, e.g. kitchen and restaurant extract air or hospital buildings.

Actuator

A variety of actuator versions (rotary or linear actuators) are available to the VAV unit manufacturer for the different VAV unit designs.

Control function

Volumetric flow (VAV/CAV) or position control (Open Loop) for integration in external VAV control loop.

Control

Analogue 0...10 V/2...10 V, switching contacts or direct connection to MP-Bus, Modbus, BACnet, KNX or hybrid mode [1]. In Bus mode, an additional sensor (0…10 V/passive), e.g. temperature, or a switch for the higher-level system can be connected. See separate Bus documentation on www.belimo.com.

[1] Hybrid mode: Integration in BACnet or Modbus system with analogue control 0...10 V/2...10 V

VAV – Variable air volume

Demand-dependent specification of the volumetric flow V'_{min}...V'_{max} via modulating reference variable (0...10/2...10 V/Bus), e.g. room temperature/CO_2 controller, DDC or bus system, for energy-saving air conditioning of individual rooms or zones.

CAV – constant volumetric flow

Step mode (via switching contacts) for applications with constant volumetric flow CLOSED/V'_{min}/V'_{mid}/V'_{max}/OPEN.

DCV – demand controlled ventilation

Via Bus Client with integrated Optimiser function.

Service devices

Smartphone Belimo Assistant App: Contact-free operation via the integrated NFC interface.
Service tool ZTH EU, PC-Tool service socket: Local plug-in or via MP-Bus.

Electrical connection

The connection is made using the integrated connecting cable.

Sales, assembly and setting

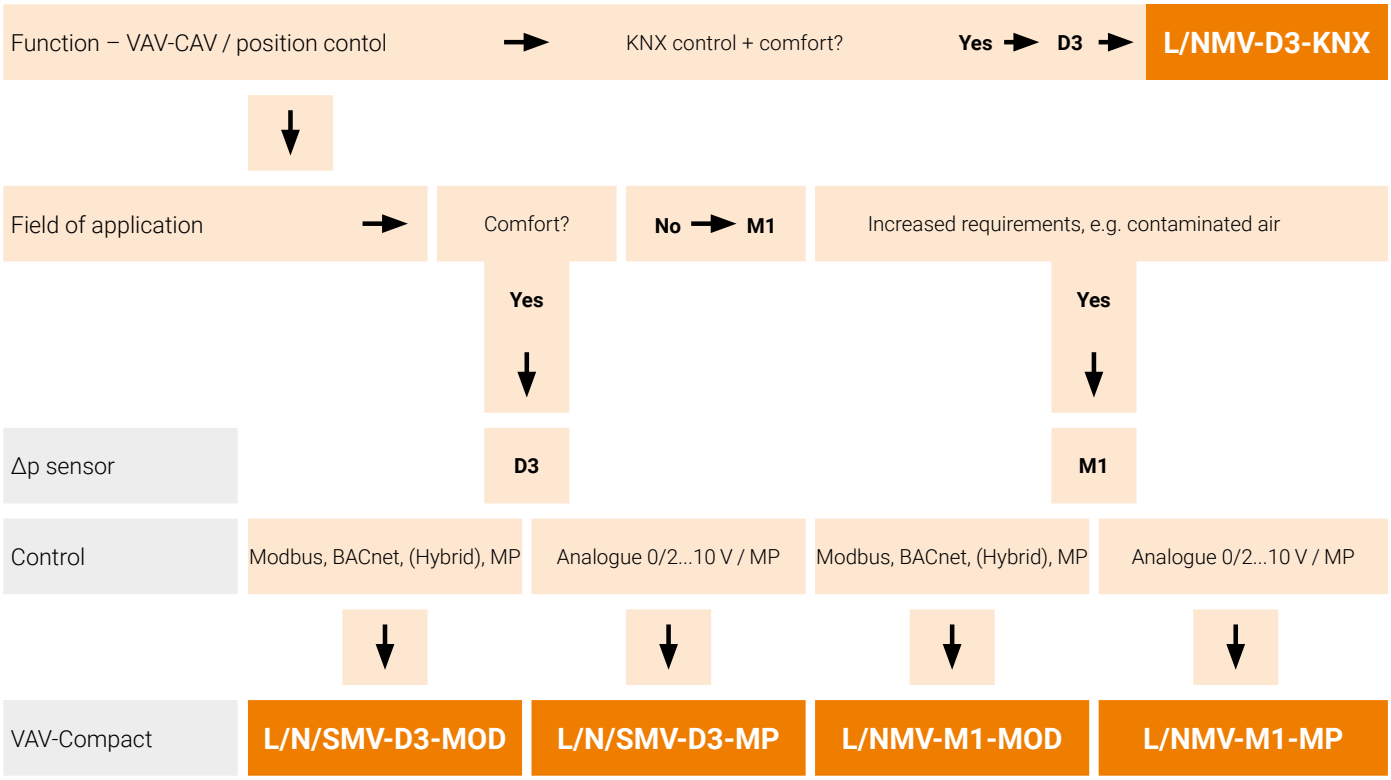
The VAV-Compact is mounted by the VAV unit manufacturer (OEM), and the application is adjusted and calibrated accordingly. The VAV-Compact is sold exclusively via the OEM channel for this reason.

OEM version

In addition to the Belimo standard version, there is also the VAV-Compact in OEM versions, i.e. variants specifically produced for VAV unit manufacturers. These versions receive OEM-specific adjustment and labelling on the differential pressure pickup devices, damper shafts and fastening systems used.
See product information of the corresponding VAV unit manufacturers.

VAV-Compact hardware selection

Compact version / Δp sensor



General comfort applications in residential and non-residential buildings

Applications with increased requirements, e.g. kitchen or restaurant extract air, hospital buildings.
- Compatibility test with the intended media required
- Use of the components in fume hoods or similar are not permitted

Function comparison

	-MP	-KNX	-MOD
	MP-BUS	KNX	BACnet Modbus
Field of application VAV units: in ventilation systems			
– For comfort applications – D3 [1] (dynamic Δp sensor)	■	■	■
– For contaminated air – M1 [1] (static Δp sensor (diaphragm))	■		■
Actuator variants:			
– Rotary actuator	5 / 10 / 20 Nm	5 / 10 / 20[2] Nm	5 / 10 / 20[2] Nm
– Linear actuator	100[2] / 200[2] / 300[2] mm	100[2] / 200[2] / 300[2] mm	100[2] / 200[2] / 300[2] mm
VAV function, CLOSE V'_{min}...V'_{max}	■	■	■
CAV steps V'_{min} / V'_{mid} / V'_{max} / CLOSE	■	–	–
Position control	■	■	■
DCV (optimiser function)	DDC MP partner	Yes, programmable	Yes, programmable
AC/DC 24 V supply	■	■	■
Analogue control	0/2...10 V	–	0/2...10 V
Bus control	■	■	■
Bus specification	MP-Bus	KNX S-Mode	Modbus RTU BACnet MS/TP (RS-485) MP-Bus
Number of devices per bus	8 per line	64 per line segment	32 per line
Sensor integration			
– Passive (resistance)	■	–	–
– Active (0...10 V)	■	■	■
– Switching contact	■	■	■
Hybrid mode (0/2...10 V control)	–	–	■
Local override	CLOSE / V'_{max} / OPEN	CLOSE / V'_{max} / OPEN	CLOSE / V'_{max} / OPEN
Integration tool	PC-Tool	ETS	–
TypeList function (RetroFIT+, OEM)	■	(–)	(–)
Tool connection (U – PP/MP)	PP/MP	PP	PP
Service socket ZTH / PC-Tool	■	■	■
NFC interface	■	–	–
Belimo Assistant App	■	–	–
Service tool ZTH EU	■	■	■
PC-Tool	■	■	■
– Parameters			
– Save data			
– Trend, logbook			
– Print label			

[1] Type overview, fields of application, measuring ranges and technical data see data sheets
[2] on request

Documentation overview

Volumetric flows under control

Complete overview
Belimo Volumetric Flow and Pressure Control
– VAV-Compact
– VAV-Universal
– CMV product range

This document:
VAV-Compact for volumetric flow applications

Product range description VAV-Compact
– Product range overview
– Brief description
– Mode of operation
– Applications
– Functional check

VAV-Compact data sheets

– Brief description
– Technical data
– Connection
– Control functions
– Settings
– Display and operation
– Dimensions
– Model overview

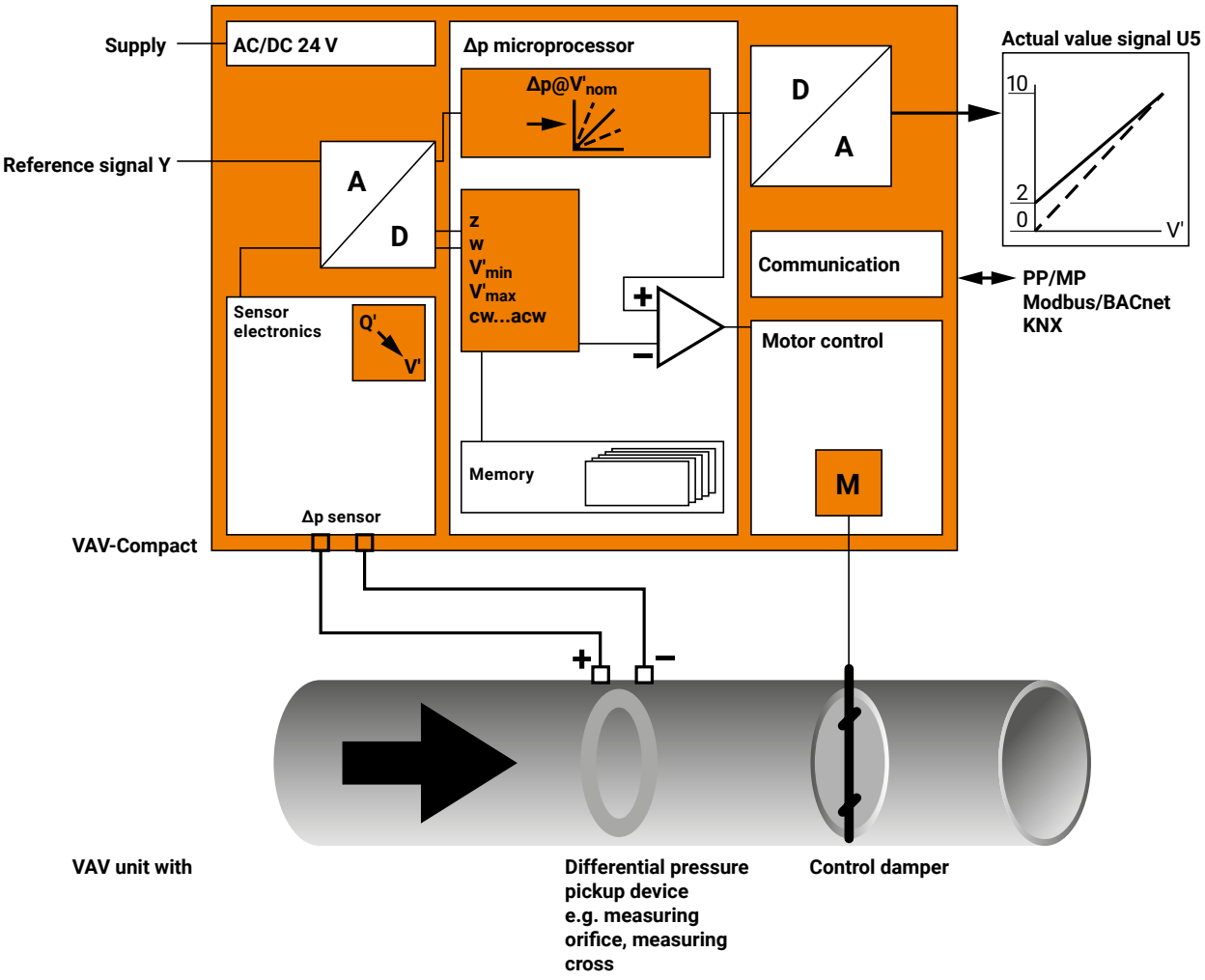
VAV-Universal

Applications of room and system solutions with VAV-Universal
Data sheets
– VRU controllers
– VST actuators

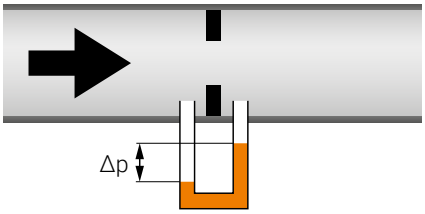
Mode of operation

Block diagram

In the measuring section, the Δp sensor converts the differential pressure signal into a signal proportional to the volumetric flow. The reference signal Y is processed as a setpoint signal according to the operating volumetric flow setting V'_{min}/V'_{max}.
The momentary control offset forms the control signal for the integrated actuator. The current volumetric flow is available as actual value signal U5 for the display and control of subsequent VAV controllers.
The specially designed running time logic of the VAV-Compact – in conjunction with the precise Δp sensor – ensures a high control quality of the VAV unit equipped with it.
For the control itself, you can choose between the traditional control signal or bus, depending on the application.



Volumetric flow measurement



$$\dot{V} = c \cdot \sqrt{\Delta p / \rho}$$

Legend:

$\dot{V}$ = Volumetric flow
c = Device constant of the baffle
Δp = Differential pressure
ρ = Density of the air

The basis of the volumetric flow measurement is a differential pressure pickup device, which is usually installed in the air duct in the form of an orifice plate, a Venturi nozzle or a measuring cross.

Reliable and accurate differential pressure measurement – the key to precise volumetric flow control

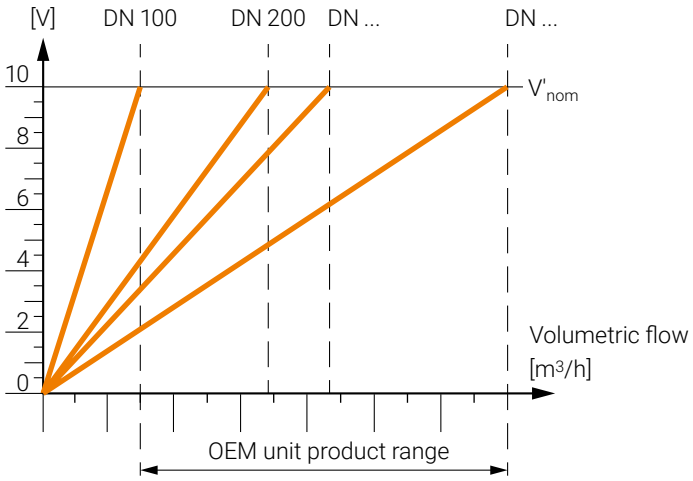
The differential pressure measurement used by Belimo allows reliable, averaging measurement even under unfavourable inflow conditions.
Each measuring body used for differential pressure measurement has its own dynamic behaviour. The impact of this measuring body on the volumetric flow calculation is referred to as the device constant "c".
Features of the Belimo differential pressure sensors:

– D3 – precise dynamic Δp sensor
– M1 – robust static Δp sensor
– Precise, proven heat transfer measuring principle
– Zero-point calibration necessary neither during commissioning nor during operation
– Suitable for any installation position
– Maintenance-free and long-term stability for a wide range of applications

Nominal volumetric flow V'_{nom}

Energy and acoustic considerations necessitate that the specific volumetric flow for each duct diameter may not exceed a certain value. The binding nominal volumetric flow is defined by the unit manufacturer, who is responsible for the functionality of his VAV units. The VAV-Compact is adapted to the VAV unit used with the two parameters V'_{nom} and $\Delta p@V'_{nom}$ of the associated differential pressure. The diameter of the unit, nominal volumetric flow and operating parameters are taken into account and set. V'_{nom} corresponds to the highest possible volumetric flow of the VAV unit at which the pressure loss as well as the noise development are within the permissible operating conditions.
With the active Belimo calibration method, i.e. calibration by reference volumetric flow, deviations caused by mechanical tolerances in the manufacturing process are compensated. Since these values and the operating data of each VAV unit are unique, the process is carried out at the VAV unit manufacturer during factory assembly.
This method makes adjustment work on the system superfluous: An essential point for saving work time and costs during assembly and commissioning.

Actual volumetric
flow signal U5



Calibration value $\Delta p@V'_{nom}$

The parameter $\Delta p@V'_{nom}$ is required for adapting the VAV-Compact controller to the VAV unit. For this purpose, the Δp value [Pa] applied to the differential pressure pickup device at nominal volumetric flow [V'_{nom}] is determined for the corresponding VAV unit version (type, nominal diameter, etc.) and stored in the VAV-Compact. Corresponding OEM tools are available to the manufacturer of the VAV unit for recording, calculating and programming the $\Delta p@V'_{nom}$ calibration values.

Altitude of installation

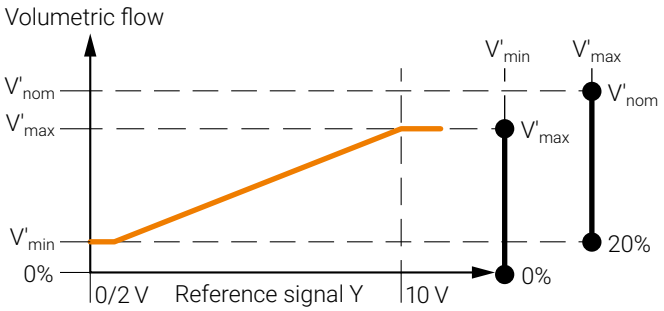
Altitude compensation
Insertion height of the ventilation system [m a.s.l.]. The difference to the sea level (a.s.l.) enables the integration of the local air density into the differential pressure and volume flow calculation of the VAV-Compact.

Operating volumetric flow setting $V'_{min}/V'_{mid}/V'_{max}$

The linear characteristic curve of the volumetric flow controller simplifies adjusting the operating volumetric flows on the system. This adjustment work is normally carried out by the unit manufacturer. V'_{max} defines the upper limit value and corresponds to the maximum thermal load. V'_{min} stands for the lower limit value and corresponds to the minimum air exchange (hygiene proportion). The room demand signal of the room controller (CO_2, temperature) guides the air exchange in the range $V'_{min}...V'_{max}$.
For constant volumetric-flow applications (CAV), an intermediate position V'_{mid} at 50% between V'_{min} and V'_{max} is available if required.

Function	Volumetric flow	Range
V'_{nom}	Nominal	OEM-specific value, corresponding to VAV unit type and application
V'_{max}	Maximum	20...100% of V'_{nom}
V'_{min}	Minimum	*0...100% of V'_{nom} (* depends on OEM)
V'_{mid}	Intermediate position	Between V'_{min} and V'_{max}

* The minimum volumetric flow setting V'_{min} depends on the VAV unit used.



Adaptation

With the Adaptation function, the mechanically available range of rotation of the damper (e.g. 60°) can be adapted to the 0...100% of the control signal. This is done by mechanically moving through the available range. The actuator first moves against the programmed direction to the lower end stop and then to the upper end stop "Damper OPEN". The start of the function is triggered via the "Adaptation" tool function or the "Adaptation" button on the VAV-Compact.

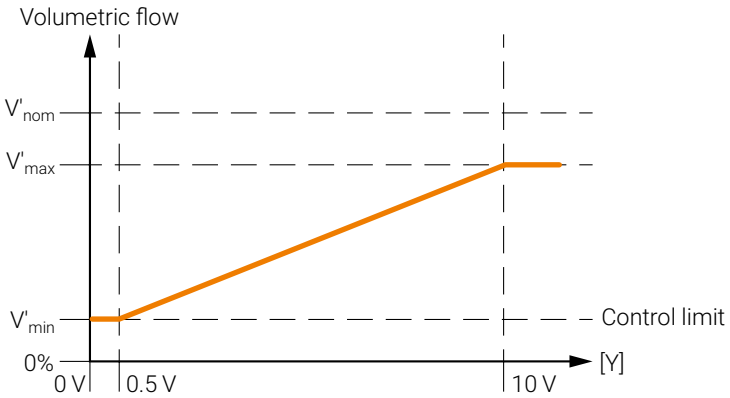
Reference signal Y

Behaviour in the lower control range

The following descriptions explain the behaviour of the VAV-Compact D3 in the lower control range. The different behaviour results on the one hand from the setting of the reference signal (0...10 V/2...10 V) and on the other hand from the set value for V'_{min}.

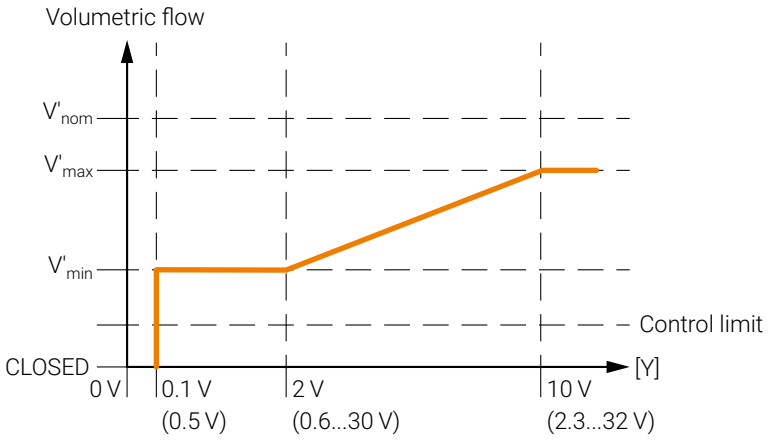
Reference signal 0...10 V and V'_{min} >0%

If the reference signal connected to terminal 3 [Y] of the controller falls below 0.5 V, the volumetric flow unit regulates to V'_{min} or the smallest controllable differential pressure.



Reference signal 2...10 V (or adjustable) and V'_{min} >0%

If the reference signal connected to terminal 3 [Y] of the controller falls below 2.0 V, the volumetric flow unit regulates to V'_{min} or the smallest controllable differential pressure.



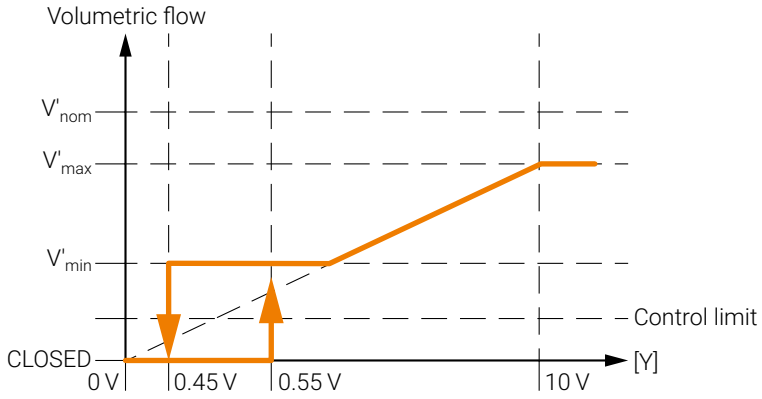
Note:

The shut-off level (damper CLOSED) is fixed at 0.1 V, but can be set to 0.5 V with the PC-Tool if required.

Do not use "0.5 V shut-off" with:
– 2...10 V mode and MP-Bus mode
– 2...10 V mode and CAV control

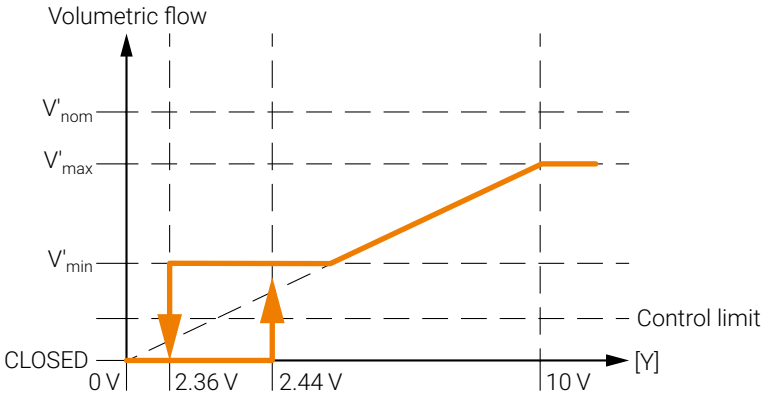
Reference signal 0...10 V and V'_{min} = 0%

The damper is closed as soon as the reference signal connected to terminal 3 [Y] of the controller drops below 0.45 V. The controller returns to control mode as soon as the signal exceeds 0.55 V.



Reference signal 2...10 V and V'_{min} = 0%

The damper is closed as soon as the reference signal connected to terminal 3 [Y] of the controller drops below 2.36 V. The controller returns to control mode as soon as the signal exceeds 2.44 V.



Actual value signal U5

Three measured variables

The VAV-Compact optionally provides three measured variables as actual value signals:

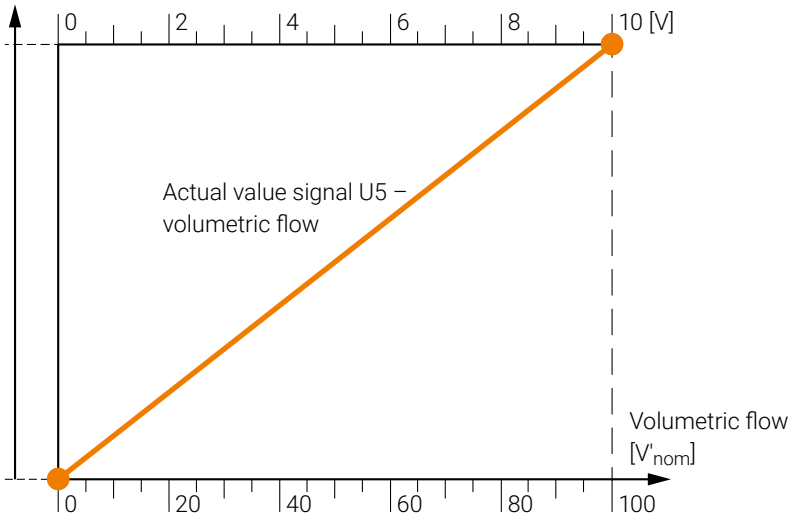
– Volumetric flow as 0...100% V'_{nom} (default setting)
– Damper position as 0...100% of the available angle of rotation
– Δp actual value from 0...100% of $\Delta p@V'_{nom}$

The changeover can be changed with the PC-Tool.

Actual value signal U5 — volumetric flow

The actual value signal volumetric flow U5 shows the current volumetric flow, measured via the differential pressure pickup device of the VAV unit. This value corresponds to 0...100% of the set nominal volumetric flow. V'_{nom} is set at the factory by the unit manufacturer and is visible on the type plate of the VAV unit.

Example with 0...10 V mode



The U5 volumetric flow actual value signal:

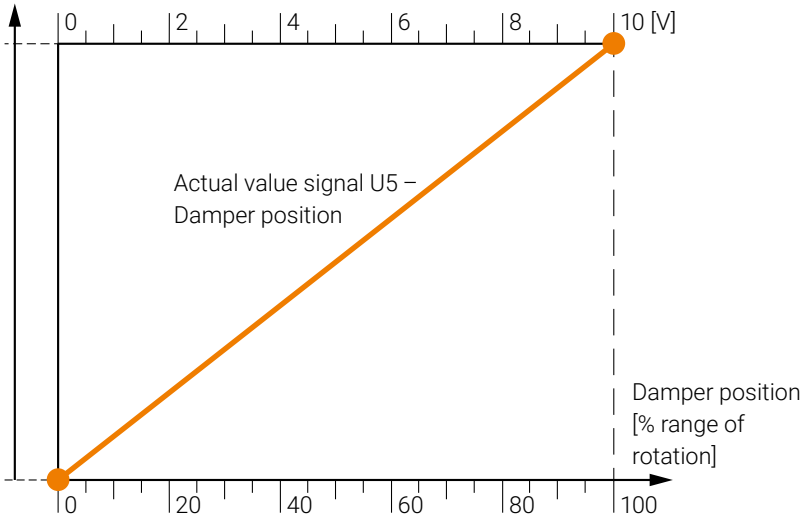
– Corresponds to 0...100% $\Delta p@V'_{nom}$
– Displays the current actual volumetric flow
– Is not influenced by the V'_{min} and V'_{max} setting
– Can be adjusted by the mode or variable setting, e.g. to 3.0...8.0 V
– U5 signals of multiple VAV-Compact units must not be interconnected in conventional operation

Application:

– Reference signal for secondary unit in primary/secondary operation applications - SUP/ETA
– Volumetric flow display, e.g. display on building management technology, summing function

Actual value signal U5 — damper position
The actual value signal damper position shows the current damper position. The value is displayed in 0...100% of the adapted, i.e. available, damper range of rotation.

Example with 0...10 V mode

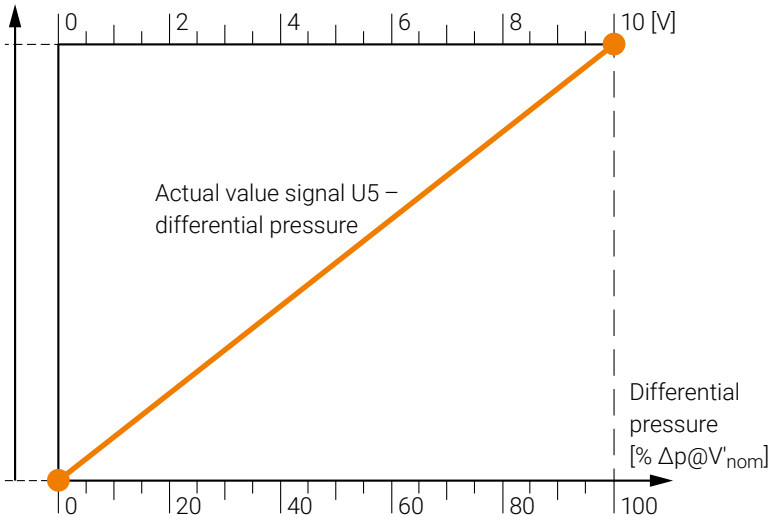


The actual value signal U5 — damper position:
– Corresponds to 0...100% of the adapted damper range of rotation
– Display the current damper position
– Cannot be used to determine the current volumetric flow, but is primarily a function of the prevailing system inlet pressure
– Can be adjusted by the mode or variable setting, e.g. 5.5...10.0 V
– U5 signals of multiple VAV-Compact units must not be interconnected in conventional operation

Application:
– Display, e.g. display on building management technology
– Evaluation of the damper position for analogue-controlled fan optimisation for DCV applications

Actual value signal U5 — differential pressure
The actual value signal differential pressure U5 shows the current differential pressure, measured via the differential pressure pickup device of the VAV unit. This value corresponds to 0...100% of the set $\Delta p@V'_{nom}$. This value is set by the unit manufacturer at the factory.

Example with 0...10 V mode



The actual value signal U5 – differential pressure:
– Corresponds to 0...100% $\Delta p@V'_{nom}$
– Shows the current differential pressure
– Can be adjusted by the mode or variable setting, e.g. 2...10 V
– U5 signals of multiple VAV-Compact units must not be interconnected in conventional operation

Application:
– Δp display during operation, position control, e.g. filter monitoring
– Display, e.g. display on building management technology

Actual value signal U5 — setting 0...10 V/2...10 V
Influence of mode setting on actual value signal U5
The actual value signal U5 is characterised by the set operating range. This means that if the mode is set to 0...10 V, the display range of the U5 signal is 0...10 V or 2...10 V for mode 2...10 V.

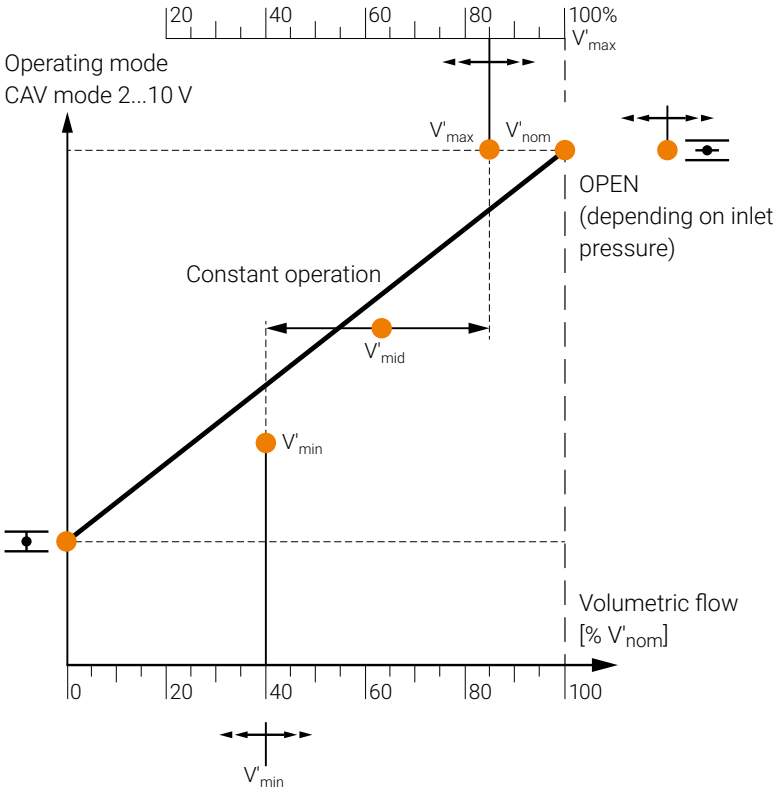
Adjustable actual value signal U5 — custom setting
The U5 signal can be adjusted for special applications with the PC-Tool U5 Feedback function. Adjustable operating range:
– Start point DC 0.0...8 V
– End point DC 2.0...10 V

Control functions

The VAV-Compact can be operated in two control functions:
– Volumetric flow CAV/VAV
– Position control (Open Loop)
The changeover can be changed with the PC-Tool.

CAV – constant volumetric flow

This control function corresponds to the conventional CAV/VAV function:
– CAV – Constant volumetric flow in step mode
CLOSED/V'$_{min}$/V'$_{mid}$/V'$_{max}$/OPEN.
Step control acting on input terminal 3, see data sheet MP/MOD.



Application:
– Occupancy switch V'$_{min}$ / V'$_{max}$
– Meeting room with veto button for flushing mode V'$_{min}$/V'$_{max}$

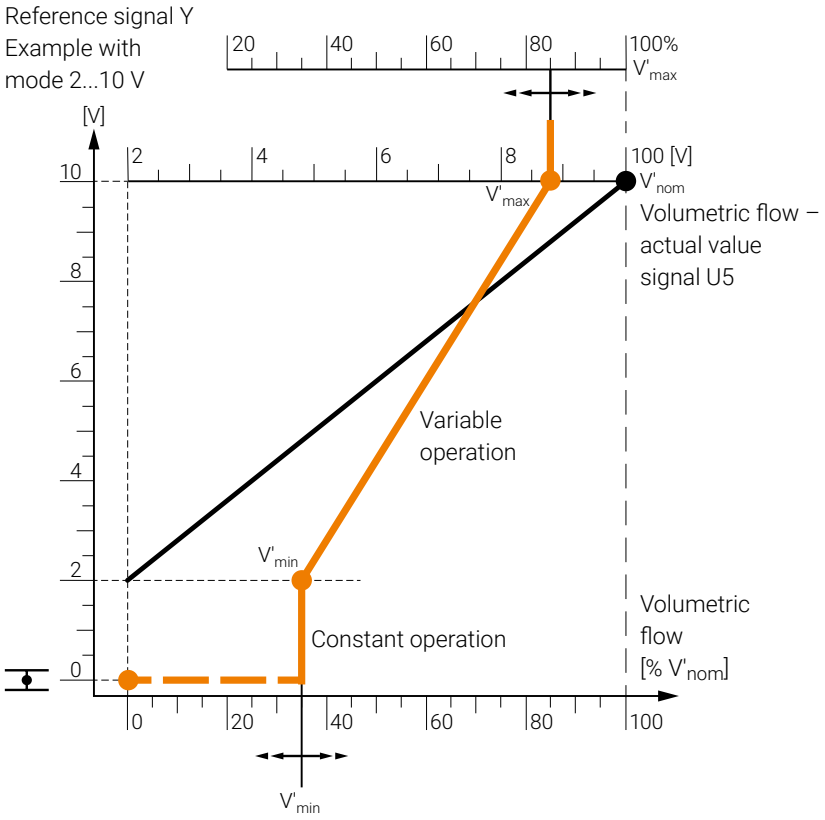
In CAV applications, the VAV-Compact regulates to a constant volumetric flow. One or several operating modes can be prescribed thereby, according to requirements.

The following operating modes are available: CLOSED/V'$_{min}$/V'$_{mid}$/V'$_{max}$/OPEN
– Shut-off operation – Damper CLOSED:
The damper is moved into the CLOSED position in a defined manner (0%)
– Operating modes V'$_{min}$/V'$_{mid}$/V'$_{max}$
The VAV-Compact constantly controls the set volumetric flow
— Flushing mode – damper OPEN:
The damper can be opened 100% for maximum ventilation, in which case volumetric flow control is deactivated

VAV – variable air volume

Modulating control in the range $V'_{min}...V'_{max}$ by an analogue room controller or a bus system.

Application:
Air-quality or room-temperature-controlled VAV application.



VAV — reference signal Y
Via the reference signal Y, the volumetric flow can be continuously adjusted to the current demand within the band width of the set operating volumetric flows. This enables demand-dependent ventilation controls, for example, in a meeting room, where the volumetric flow can be steadily increased from the set minimum (hygiene ventilation) to the maximum value.
For this purpose, the output signal of the primary controller is fed to the reference value input of the VAV-Compact. The signal guides the volumetric flow in a modulating manner in the range of the set operating volumetric flow.

The reference signal Y
– Runs linearly in the range $V'_{min}...V'_{max}$
– Serves to control the VAV-Compact in VAV and CAV applications
– Can be adjusted by mode or variable setting, e.g. from 0...10 V to 2.5...7.5 V

Variable volumetric flow operation (VAV)
The desired volumetric flow is specified linearly within the setting $V'_{min}...V'_{max}$ with an analogue reference signal or via the bus system.

Shut-off operation (CLOSED) with V'_{min} 0%
If shut-off is required in VAV mode, this can be achieved by setting V'_{min} to 0%.

Shut-off operation (CLOSED)
In 2...10 V mode, the following function can be achieved with a 0...10 V signal:

Reference signal Y (VAV)	Volumetric flow	Function
<0.1 V [1)]	0	Damper CLOSED, VAV control inactive
0.2...2 V (0.6...2 V)	V'_{min}	Operating mode V'_{min} active
2...10 V	$V'_{min}...V'_{max}$	Modulating operation $V'_{min}...V'_{max}$

[1)] Note on connection Y (3) - shut-off level 0.1 V/0.5 V
VAV mode:
If the required switching threshold of 0.1 V cannot be reached, the value can be changed to 0.5 V with the PC-Tool.
CAV mode:
The shut-off level must not be set to 0.5 V, otherwise the open connecting cable (Y) will be interpreted as a CLOSED damper.

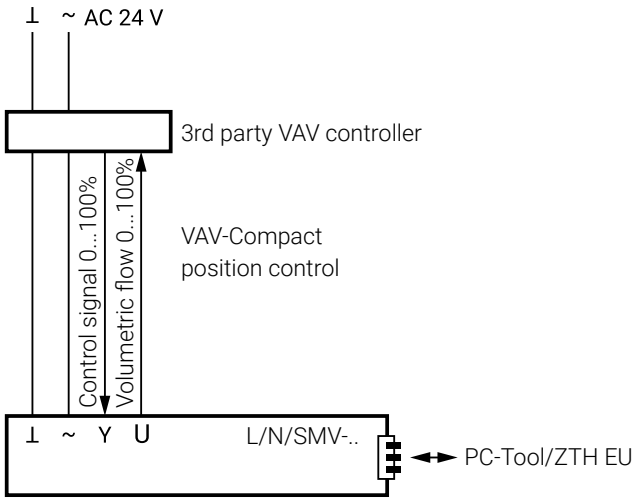
Position control (Open Loop)

With this control function, the internal volumetric flow controller is deactivated and the VAV-Compact functions as a modulating actuator with a volumetric flow sensor.
Field of application: Pressure-independent control of a VAV unit, using an external volumetric flow controller.

Actuator, control via Y:
– Control: The actuator is connected with an analogue control signal, e.g. 0...10 V, and moves to the specified position
– Running time: The running time is fixed at 150 s

Note:
Responsibility for the VAV control loop
– in open loop operation – is with the supplier of the VAV controller

Volumetric flow measurement via U5:
– Actual value signal: Selectable signal (0...10 V or 2...10 V) corresponding to 0...100% V'_{nom}. The V'_{nom} setting is made by the manufacturer of the VAV unit.



Application
New or retrofit solutions in conjunction with VAV controllers without actuator and sensor unit from various third-party manufacturers.

Differential pressure measurement via U5:
Actual value signal: Selectable signal (0...10 V or 2...10 V) corresponding to 0...100% $\Delta p@V'_{nom}$. The $\Delta p@V'_{nom}$ setting is made by the manufacturer of the VAV unit.
The changeover between volumetric flow and differential pressure display (U5) is accomplished with the PC-Tool from Belimo.

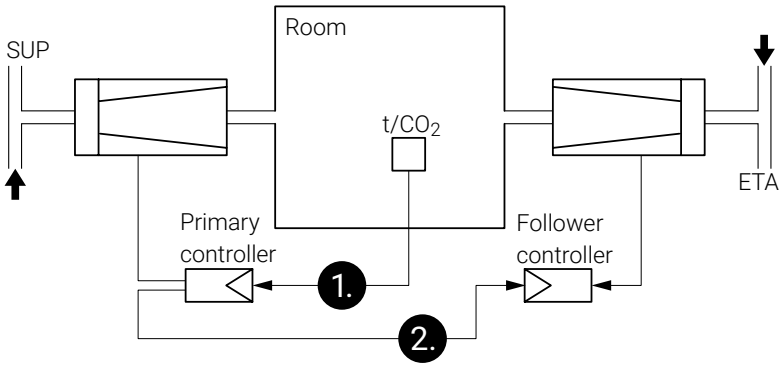
Position control in bus mode
The function is also available in bus mode, but the transmission time of the data is subject to the cycle time of the bus system. The system integrator is responsible for this.

Primary/secondary operation CAV/VAV

Changes in the air network of the primary controller (upstream pressure too low, e.g. due to malfunction of the pressure control) are detected and transmitted to the secondary controller. This ensures an equal percentage supply/extract air ratio.
In primary/secondary operation, only one controller can be designated as the primary controller. However, a primary controller can control several secondary controllers connected in parallel.

Principle:

1. Reference signal, e.g. room controller t/CO_2, is connected to input Y of the primary controller.
2. The actual volumetric flow signal of the primary controller forms the setpoint of the secondary controller.
   Depending on the application, the primary controller is mounted on the SUP or ETA side.
   Wiring diagram, see Page 31.



Where is primary/secondary operation used?

– Systems with volumetric flow controllers in supply and extract air that must operate in sequence
– Equal-percentage ratio between supply and extract air

Master controller - operating volumetric flow setting

The parameters V'_{min}, V'_{max} for the room are set on the primary controller.

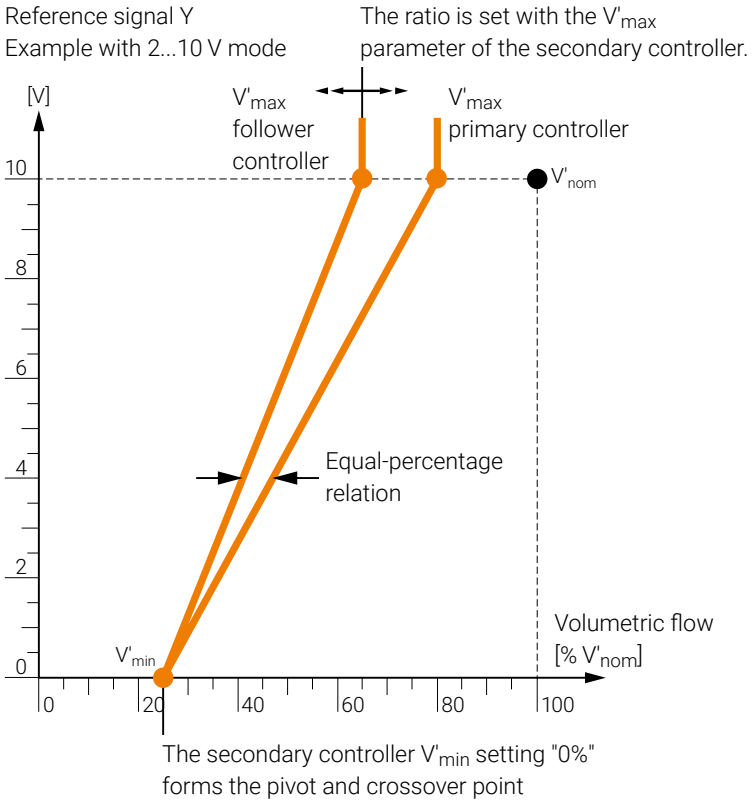
CAV application

The operating mode control (CLOSED/V'_{min} etc.) is connected only to the primary controller.

Note on room pressure control:

For controlled room pressure applications, use the VAV-Universal controller VRU-M1R-BAC.
Further information: www.belimo.com

Secondary controller - operating volumetric flow setting
The setting for the same nominal diameter is: V'_{min} 0% and V'_{max} 100%.



Determination of the primary controller
Both units are present
- Unequal V'_{nom} settings, the one with the smaller V'_{nom} is the reference
- With the same V'_{nom} setting, the controller with the larger air volume determination becomes the primary controller:
  - Positive room pressure
    Primary controller: SUP unit
    Secondary controller: ETA unit
  - Negative room pressure
    Primary controller: ETA unit
    Secondary controller: SUP unit

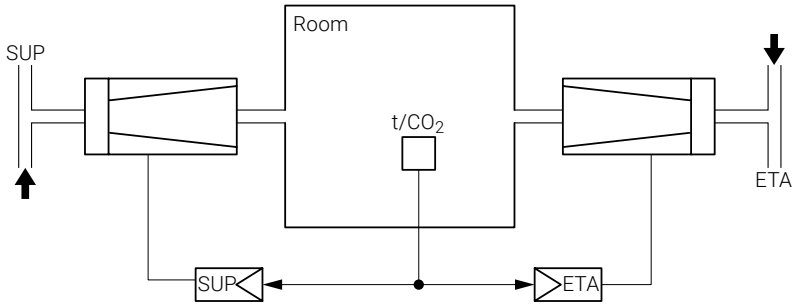
Note on room pressure control:
For controlled room pressure applications, use the VAV-Universal controller VRU-M1R-BAC.
Further information: www.belimo.com

Parallel circuit CAV/VAV

With the parallel circuit, both VAV units are operated independently of one another with a shared reference signal.

Supply and extract air controllers operated in an open ratio, i.e. if a malfunction occurs in one of the two air networks of the supply or extract air, then the room pressure ratio will be impaired as a result of the system. The tolerances of the units could add together in the worst-case scenario. This circumstance must be taken into account at the project planning stage.

Principle:
The reference signal of the room controller is connected parallel to the reference value input of the supply air and the extract air controller. The operating volumetric flows V'_{max} and V'_{min} are set on both controllers.
Wiring diagram, see Page 31.

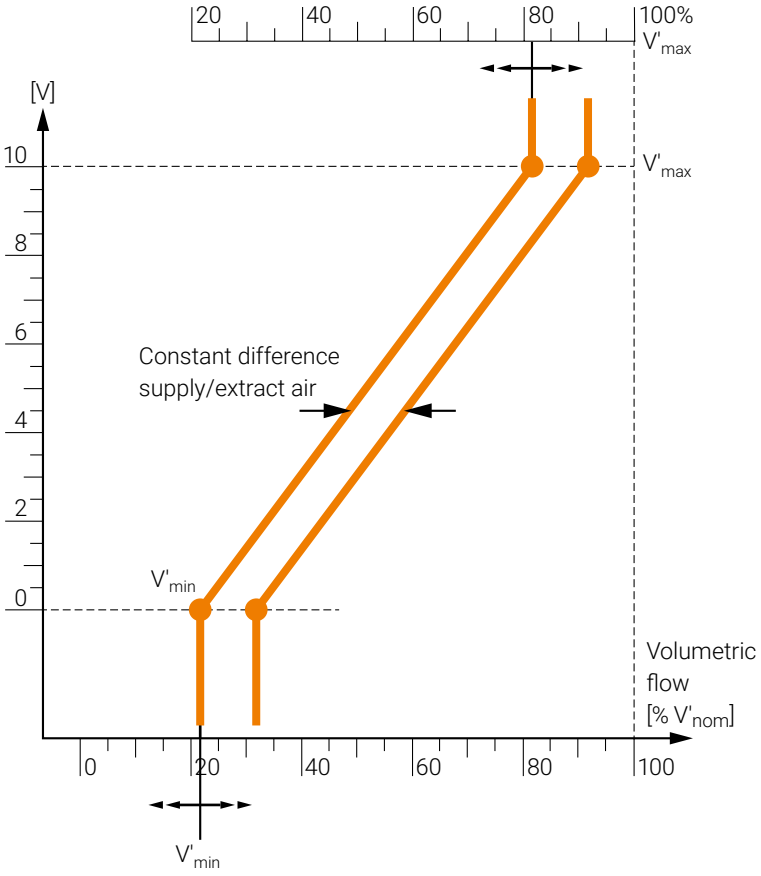


Where are parallel circuits used?
- Volumetric flow controllers operating in parallel in supply air and extract air (connected with the same reference variable)
- Supply and extract air units of different sizes and different V'_{min} and V'_{max} settings
- Constant difference between supply and extract air
- Systems with several supply or extract air units
- Recirculation air systems for air-tight rooms

Operating volumetric flow setting
The V'_{max} and V'_{min} values used for the desired volumetric flow must be set on each VAV controller.

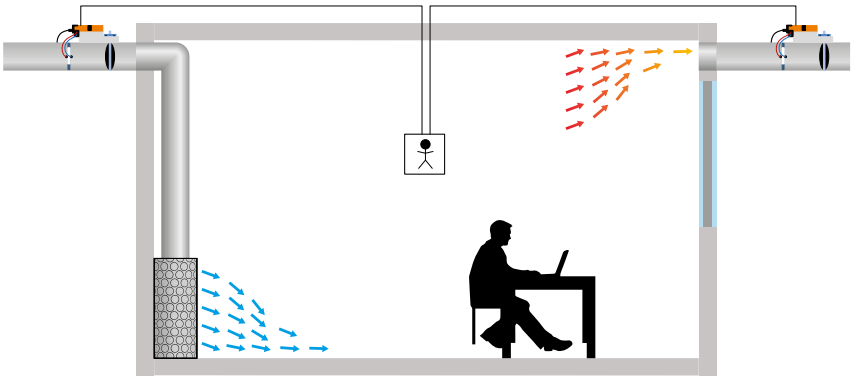
CAV application
In CAV applications, the operating level control (CLOSED/V'_{min} etc.) is routed to both VAV controllers.

SUP / EXT controller – operating volumetric flow setting



Note on room pressure control:
For controlled room pressure applications, use the VAV-Universal controller VRU-M1R-BAC.
Further information: www.belimo.com

Application
Single-duct installation – CAV room solution with motion sensor



Single-duct installation – occupancy-controlled CAV

Brief description

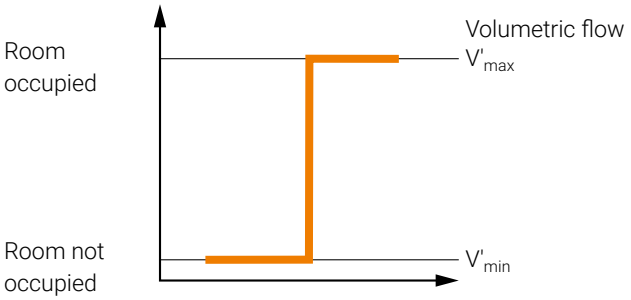
Control solution for CAV single-room application
Single-duct installation – occupancy-controller CAV, in standalone operation.

Functions
Depending on occupancy, the CAV controller is connected – via the motion sensor – in two-stage operation V'_{min}...V'_{max}:
– Room not occupied Constant volumetric flow V'_{min}
– Room occupied Constant volumetric flow V'_{max}

Motion sensor
With switching output for small switching capacity.

VAV-Compact control device Belimo L/N/SMV-D3-MP
VAV-Compact control device for SUP, ETA or mixing units, consisting of Δp sensor, VAV controller and actuator for pressure-independent volumetric flow controls.

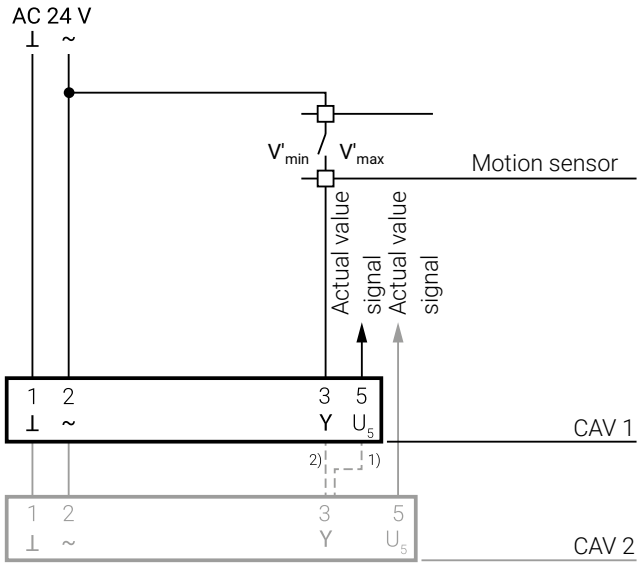
Function diagram



Wiring diagram

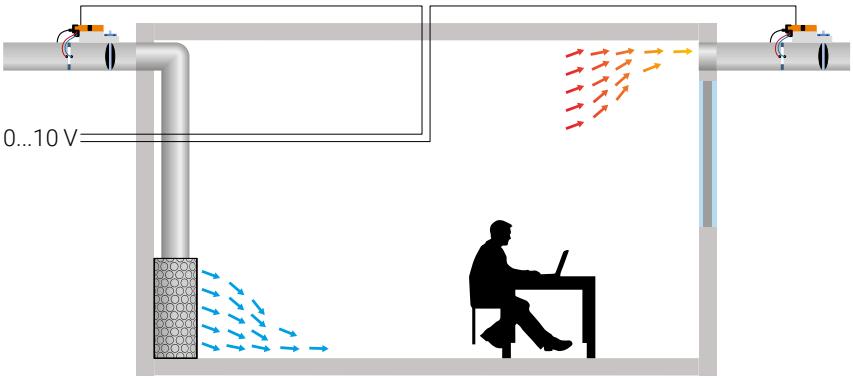
Note:

- Connection and terminal designations of the motion sensor according to the manufacturer's specifications
- Mode setting CAV controller: 0...10 V or 2...10 V



[1] Primary/secondary operation or
[2] Parallel

Application
Single-duct installation – VAV room solution with 0...10 V control



Single-duct installation – VAV room solution, air quality/room temperature controlled

Brief description

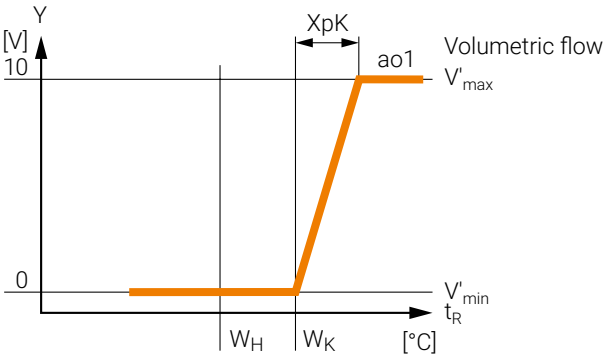
Control solution for VAV single-room application
Single-duct installation – VAV room solution, air quality/room temperature controlled in standalone mode (0...10 V).

Functions
The 0...10 V single-room or DDC controller guides the VAV controller, depending on the air quality or the room cooling demand, in a volume-variable manner in the range V'_{min}...V'_{max}.

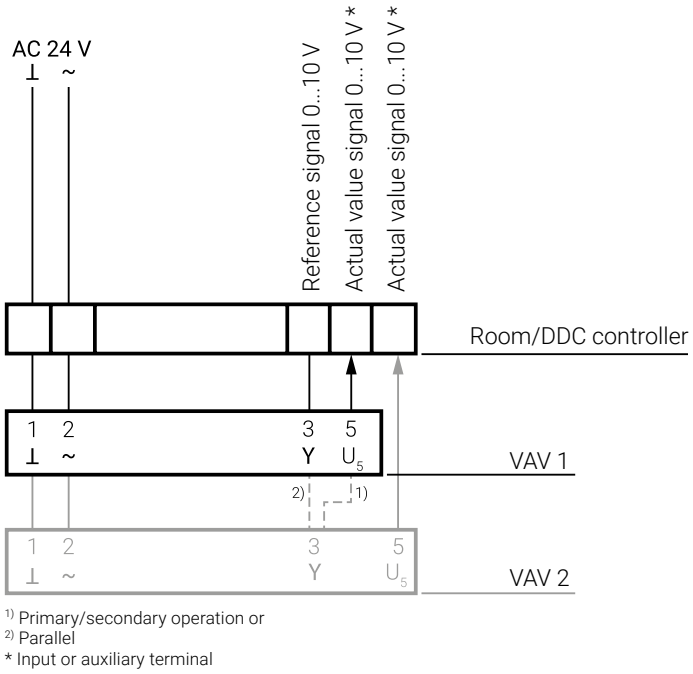
Air quality controller/single-room temperature controller or DDC controller
With 0...10-V output signal for air quality/cooling sequence. Control functions according to the specifications of the controller make.

VAV-Compact control device Belimo L/N/SMV-D3-MP
VAV-Compact control device for SUP, ETA or mixing units, consisting of Δp sensor, VAV controller and actuator for pressure-independent volumetric flow controls.

Function diagram



Wiring diagram

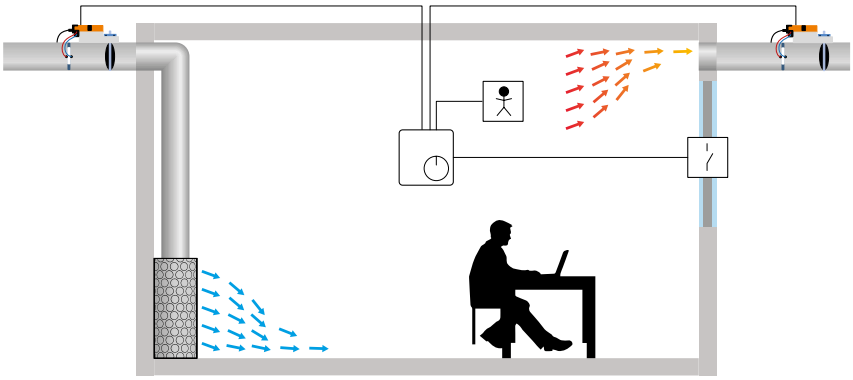


[1] Primary/secondary operation or
[2] Parallel
* Input or auxiliary terminal

Note:

- Connection and terminal designations of the room/DDC controller according to the manufacturer's specifications
- Mode setting VAV controller: 0...10 V

Application
Single-duct installation – VAV room solution with Belimo CR24 room temperature controller



Single-duct installation – VAV room solution, room temperature controlled

Brief description

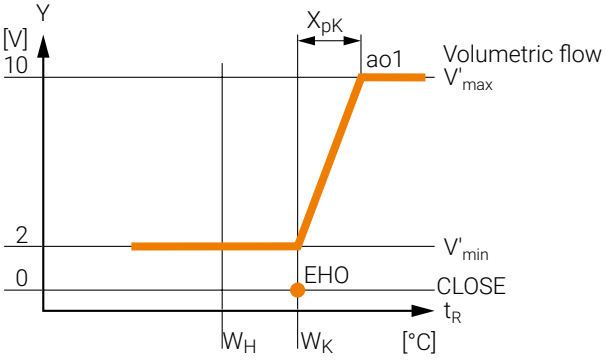
Control solution for VAV single-room application
Single-duct installation – VAV room solution, with Belimo CR24 room temperature controller (2...10 V).

Functions
The CR24-B1 (B2/B3) single room controller controls the connected VAV controllers, depending on the room cooling demand, with variable volume in the range V'_{min}...V'_{max}. Optionally, further functions can be connected (motion sensor): Energy hold-off, stand-by mode.

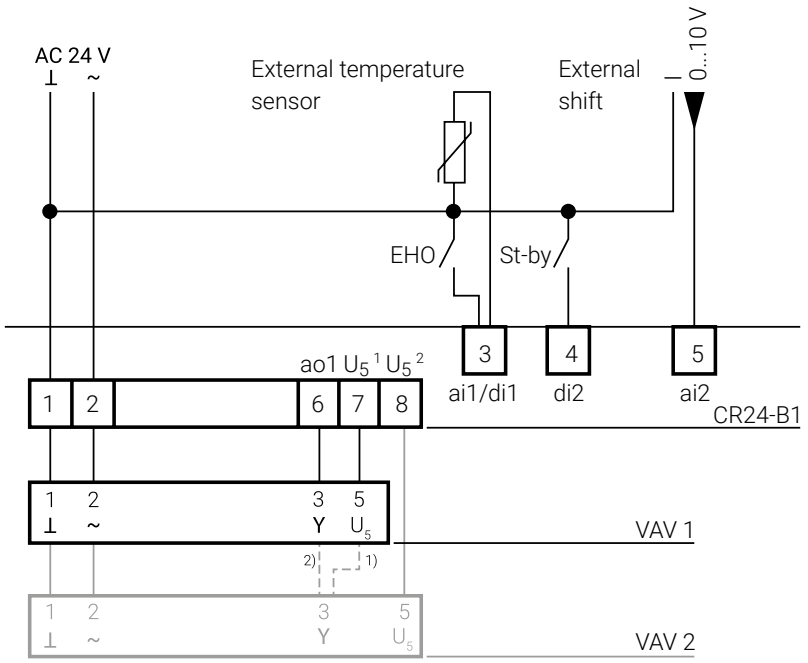
Room temperature controller CR24-B1
Room temperature controller (15...36° C) with integrated temperature sensor
Control functions:
- Mode selection with push-button and LED display: AUTO, ECO (reduced room temperature, for standby, night mode) and MAX (flushing mode with 15' timer)
- Room protection function (frost/overtemperature)
- Inputs for energy hold-off (EHO), stand-by mode, external temperature sensor, summer-winter compensation
- VAV system output
- Self-resetting commissioning and service function
- Tool connection for diagnostics, setting work and trend recordings

VAV-Compact control device Belimo L/N/SMV-D3-MP
VAV-Compact control device for SUP, ETA or mixing units, consisting of Δp sensor, VAV controller and actuator for pressure-independent volumetric flow controls.

Function diagram



Wiring diagram



1) Primary/secondary operation or
2) Parallel

Note:
– Mode setting of the VAV controller for this application: 2...10 V

Functions	Description	Occupancy CR24-B1
VAV	VAV system output (0) 2...10 V	Output ao1
Optional functions	**Description**	**Occupancy**
EHO	Energy hold-off (window)	Input di1
Sensor	External temperature sensor NTC 5K	Input ai1
Shift	External shift 0...10 V (Summer-winter compensation)	Input ai2

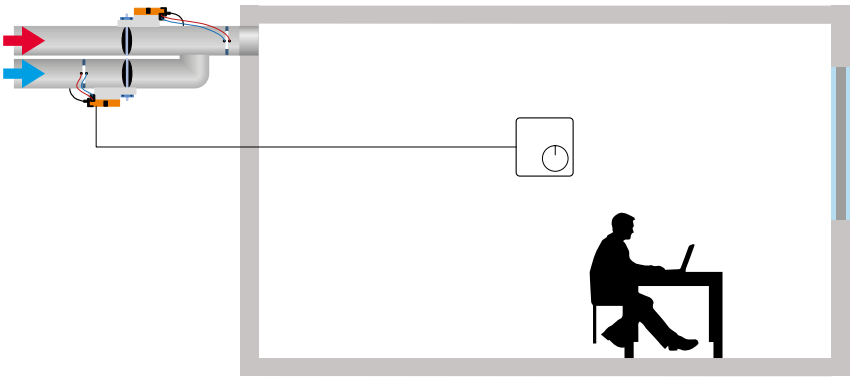
Configuration, settings

(DIP switch on CR24-B1 controller)

1 proportional band	2 input di2
Advanced	Changeover
Normal	Standby (St-by)

Setpoint Wh adjustment range: 15...36°C

Application
Dual-duct installation – VAV mixing unit with room temperature controller Belimo CR24



VAV mixing unit, room temperature controlled

Brief description

Control solution for VAV single-room application
Dual-duct installation – VAV mixing unit, room temperature controlled.

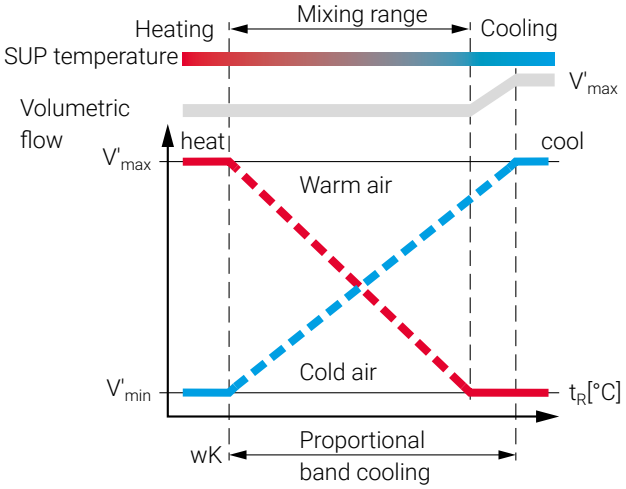
Functions
The two volumetric flow controllers mix the hot and cold air provided by the dual-duct air-conditioning system to the condition requested by the CR24-B1 room temperature controller. The warm air constant volumetric flow controller (CAV) regulates the set V'_{max} volume in heating mode. The cold air controller (VAV) mixes in the variable cold air component requested by the room temperature controller. If the cooling demand exceeds the warm air volume, the warm air section is shut off and only cold air is supplied.
Option: The cold air component can be switched off via a switching contact on input di1.

Room temperature controller CR24-B1
Room temperature controller (15...36°C) with integrated temperature sensor
- Mode selection with push-button and LED displays: AUTO, ECO (reduced room temperature, for standby, night mode) and MAX (flushing mode with 15' timer)
- Room protection function (frost/overtemperature)
- Inputs for shut-off cold air mode, external temperature sensor, summer-winter compensation
- VAV system output
- Self-resetting commissioning and service function
- Tool connection for diagnostics, setting work and trend recordings

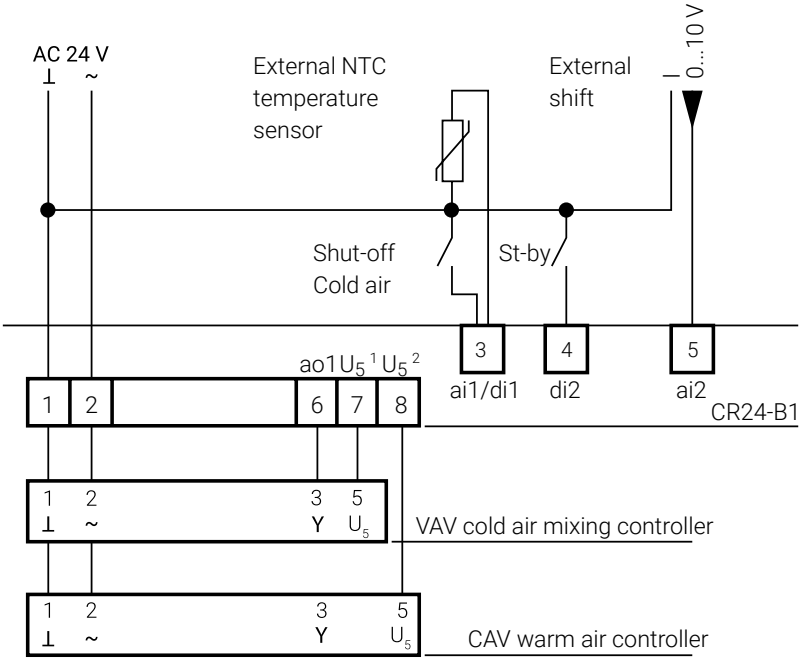
Note:
Technical data and detailed functional description of the CR24 controllers, see www.belimo.com.

VAV-Compact control device L/N/SMV-D3-MP
VAV-Compact control device for SUP, ETA or mixing units, consisting of Δp sensor, VAV controller and actuator for pressure-independent volumetric flow controls.

Function diagram



Wiring diagram



Input and output assignment

Functions	Description	Occupancy CR24-B1..
VAV	VAV system output (0) 2...10 V	Output ao1
Optional functions	**Description**	**Occupancy**
Shut-off	Cold air shut-off	Input di1
Sensor	External temperature sensor NTC 5K	Input ai1
Shift	External shift 0...10 V (Summer-winter compensation)	Input ai2

Configuration, settings

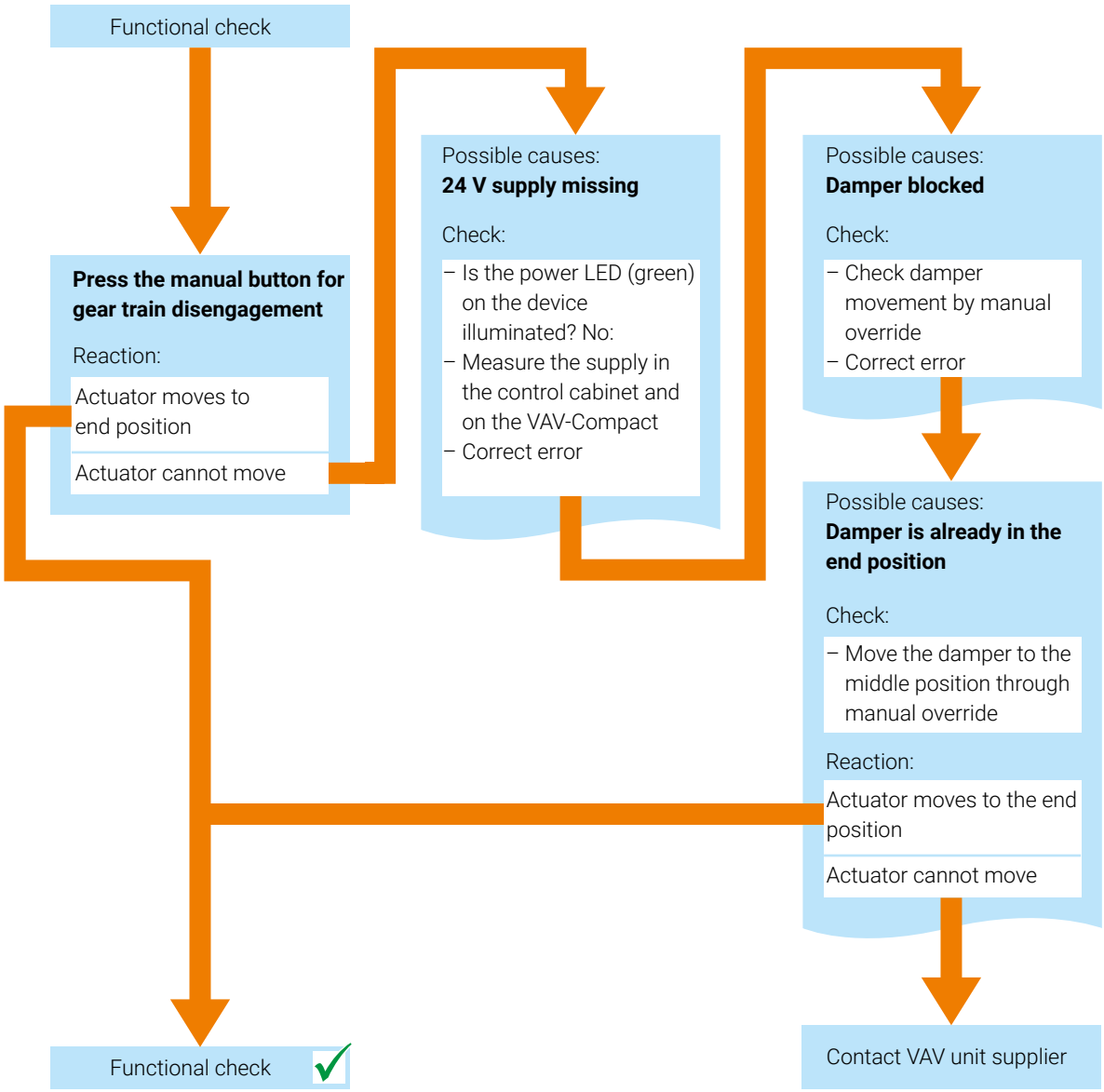
(DIP switch on CR24-B1 controller)

1 proportional band	2 input di2
Advanced	Changeover
Normal	Standby (St-by)

Setpoint Wh adjustment range: 15...36°C

Functional check

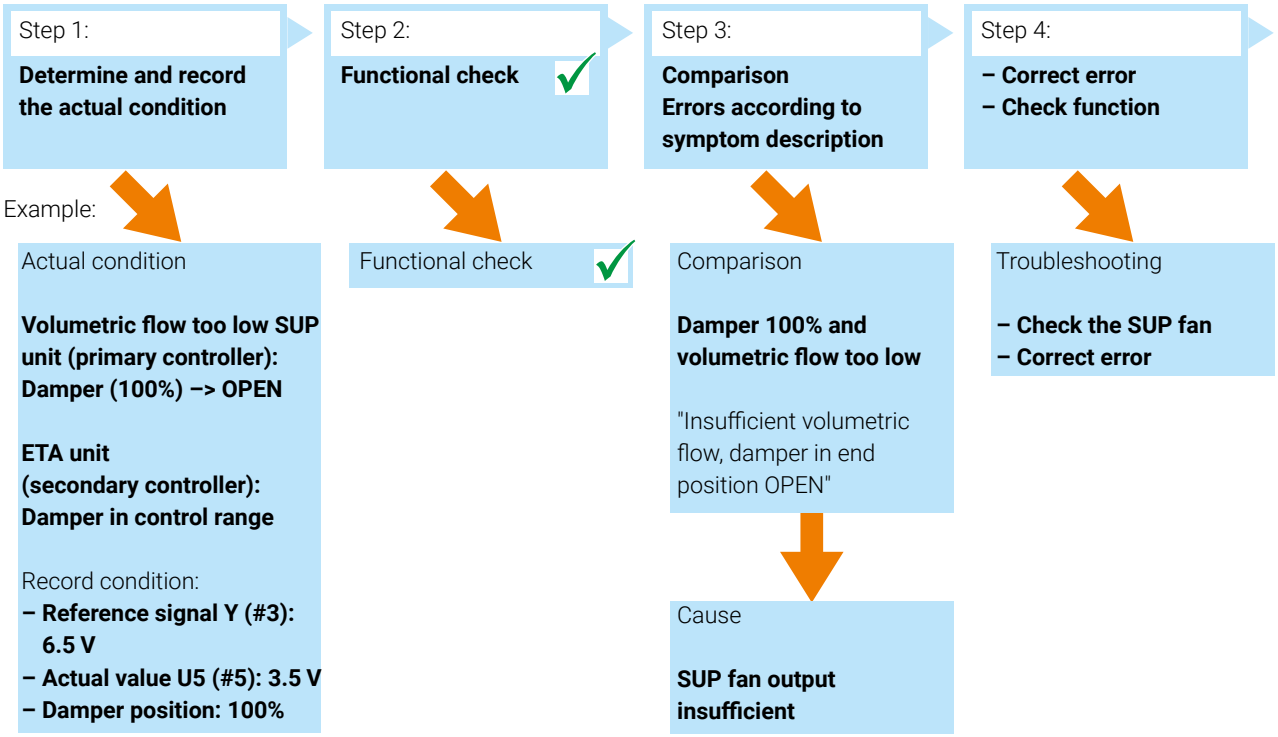
Procedure



Failure evaluation

Symptoms, causes and problem solving

Symptoms, causes and possible procedures for solving the problem are described below. Experience has shown that faulty behaviour is usually not due to the volumetric flow controller itself, but to its settings or control. In order to be able to remedy an error efficiently, we recommend following a structured procedure:



Symptoms, causes and troubleshooting

Insufficient volumetric flow, damper in end position OPEN

Symptom	Possible causes	Troubleshooting – procedure
Set volume is not reached even though the damper is 100% open (end stop)	Air hoses between differential pressure pickup device and pressure sensor are reversed or not connected	Check with ZTH EU Connect the air hoses correctly Check +/− connection
	Fan failure	Check fan incl. control and regulation and correct faults
	Fire dampers triggered, i.e., closed	Check whether all fire dampers or shut-off damper between the fan and the VAV unit are open
	Air output of the fan insufficient	Measure the air output and increase it if necessary, e.g. by increasing the setpoint of the frequency converter
	During commissioning, several or all rooms are often forcibly (manually) set to the max. volumetric flow. Consequence: The fan cannot provide the required air output (simultaneity factor)	Cancel override control or reduce reference signal

Insufficient volumetric flow, damper primary unit OPEN/secondary unit CLOSED

Symptom	Possible causes	Troubleshooting – procedure
Set volume not reached: – Primary unit damper is open – Secondary unit damper is closed	For VAV units in primary/secondary operation: – Primary unit experiencing air shortage (fan defective or OFF), i.e. damper is 100% open – Secondary unit does not receive a reference signal from the primary controller because it does not measure the actual volume Damper CLOSED	Check the fan in the line of the primary unit and correct the error Check whether all fire dampers or shut-off damper between the fan and the primary unit are open

Insufficient volumetric flow, damper primary unit OPEN/secondary unit CLOSED

Symptom	Possible causes	Troubleshooting – procedure
Set volume is not reached, damper is closed although a reference signal is present	See "Operating volumetric flow setting", Page 16	Increase V'_{min} setting parameters, adjust reference signal or adapt VAV-Compact mode setting
Instead of moving to the V'_{min} value, damper closes (0%)	VAV-Compact with mode setting 2...10 V is connected with 0...10 V reference signal	Change VAV-Compact mode setting to 0...10 V

Volumetric flow too high, damper OPEN

Symptom	Possible causes	Troubleshooting – procedure
Actual volume too high, damper is open at end stop	Pressure tube compressed (pinched)	Check pressure tubes: – Mark ± connection – Remove pressure tubes from the VAV-Compact – Blow out pressure tubes
	Sensor, pressure tube or pressure sensor dirty	Check parts and clean them if necessary: – Mark ± connection – Remove pressure tubes from the VAV-Compact – Clean the sensor and blow it out – Blow out pressure tubes – Remove any dirt that may escape – Mount pressure tubes – Carry out functional check

Volumetric flow too low, damper in control range

Symptom	Possible causes	Troubleshooting – procedure
Desired volumetric flow is not achieved	Reference signal (DDC, room controller) is limited on the software side	Check reference signal (DDC, room controller) and adjust limit
	VAV-Compact with mode setting 2...10 V is connected with 0...10 V reference signal	Correct VAV-Compact mode setting

Volumetric flow too high, damper in control range

Symptom	Possible causes	Troubleshooting – procedure
Permanent deviation of the volumetric flow (too high) to the reference signal	VAV-Compact with mode setting 0...10 V is connected with a 2...10 V reference signal	Adjust the reference signal or the VAV-Compact mode setting

Positive room pressure/negative room pressure, damper in control range

Symptom	Possible causes	Troubleshooting – procedure
Unwanted overpressure or negative pressure in the room	Loose shaft clamp, rotates without mechanical interface	Check shaft clamp mounting
	Room pressure ratio not set correctly	Check the operating volumetric flow setting
	Primary/secondary operation with limited Operating volumetric flow setting of the secondary controller	Check the operating volumetric flow setting If the room pressure balance is balanced, the secondary controller setting is: V'_{min} 0% / V'_{max}, 100% (with the same nominal diameter and air volume)
	Incorrect cabling, mixing up VAV units (sequential or parallel circuit)	Check and correct the wiring
	Example: SUP office a with ETA office b SUP office b with ETA office a	
	VAV units with primary/secondary operation are connected in parallel	Check and correct the wiring

Positive room pressure/negative room pressure, damper in control range

Symptom	Possible causes	Troubleshooting – procedure
VAV controller regulates to a fixed value, does not react to changes in the reference signal	The reference of the 0/2...10 V reference signal, i.e. the earth connection, (GND) is missing	Measure signal at VAV-Compact terminal 1 (GND) to 3 (0/2...10 V) Check and correct the wiring
	The polarity of the reference signal and ground (GND) has been reversed	Measure signal at VAV-Compact terminal 1 (GND) to 3 (0/2...10 V) Check and correct the wiring
	AC 24 V connection reversed. If several devices are connected to the same AC 24 V transformer, the connection must be made in phase	Check and correct the wiring
	Operating mode (override control) active	Check control

Positive room pressure/negative room pressure, damper in control range

Symptom	Possible causes	Troubleshooting – procedure
Damper cannot move	Loose shaft clamp, rotates without mechanical interface	Check shaft clamp mounting

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