Products no longer available

4. VAV-3
Product Range 2000/2001
BELIMO VAV-Control
### General
- Demand-related air distribution 2

### VAV-Control
- Standard interfaces 4
- Demand-related control without DDC 5
- Individual-room temperature control 6
- DDC systems with VAV controllers 7

### VAV-Universal
- Supply and exhaust VAV-Boxes 8–9

### Setting parameters 10

### Ratio control 11

### Applications
- VAV-Control 12–13
- VAV-Compact 14
- VAV-Universal 15

---

**Note:**
The main purpose of the [schematic diagrams](#) in this documentation is to illustrate the functionality of our products. Actual cable lists and electrical circuit diagrams must be prepared from the data sheets and other information provided for individual products. The technical information and statements are based on the current status of technological development.
Specific individual-room control for greater comfort and...

Diagrammatic representation of a heating, ventilating and air-conditioning system

Products no longer available
User-friendly

The user can adjust the air-conditions in his/her room according to need.

Air quality

Variable control of air flow rate ensures optimum air quality however much is being used.

Flexible range of products

The carefully chosen range of products ensures that there is always the right product available for every type of application:

- Terminal control
- Section control/air distribution
- Combination with air/water systems

Economic

The consumption-dependent method of controlling the air flow ensures that only the right amount of air needed for optimum air quality is actually supplied.

The proportion of ambient air added can be adjusted so that only an absolute minimum amount of extra air has to be heated, cooled or humidified.

Specific section control ensures that always the same amount of air is distributed regardless of any fluctuations in system pressure.

In partnership with manufacturers

Belimo specialises in the design, development and manufacture of control equipment and actuators for air volume controllers. Belimo designers work closely with the manufacturers of air volume controllers so that Belimo products are tailored precisely to different needs.

This allows manufacturers to adjust their equipment accurately for the specified values of air volume before it leaves the factory and to accept responsibility for those values as well as the proper functioning of the whole unit. This is why BELIMO VAV-Control is only supplied to original equipment manufacturers.

... economic use of energy

Products no longer available


**Clear interfaces and division of responsibility**

Belimo’s variable air volume control systems VAV-Universal and VAV-Compact employ a standard interface in the form of a 0...10 V / 2...10 V signal. This means that there are no problems in connecting up to most types of controller currently available on the market.

Responsibility for maintaining the required values of air flow rate and the maximum permitted noise levels lies with the manufacturer of the terminal control devices. If his air volume controllers are conceived as independent, preset air control actuators, there will be no difficulty in using them in combination with ordinary DDC (Direct Digital Control) systems or analogue control systems.

**Linear standard signals**

Measurement of volumetric flow is based on the use of a differential-pressure sensor which usually takes the form of an orifice plate, a venturi nozzle or a measuring cross installed in the air duct.

The correlation between differential pressure and volumetric flow can be described by means of the equation:

\[ V = k \cdot \sqrt{\Delta p / \varrho} \]

The controller converts the measured signal of differential pressure according to the above equation to a signal that is proportional to the volumetric flow. This output signal is available at Terminal 5 of the controller in the form of a 0...10 V / 2...10 V signal.

It allows a variety of tasks in connection with various applications to be performed with great ease, for example:

- Display of volumetric flow
- Master/Slave control
- Acquisition of power consumption
- Plant monitoring
- Commissioning

**Legend to equation:**

- \( V \) = Volumetric flow
- \( k \) = Geometry-related constant of the baffle device (differential-pressure sensor, dimensions, etc.)
- \( \Delta p \) = Differential pressure
- \( \varrho \) = Density of the flow medium
Demand-related control without DDC

The example opposite shows a simple but efficient method of demand-related ventilation using BELIMO VAV-Control systems. This application is primarily suitable for when combined air/water systems are being used because only the quality of the air is controlled, not the temperature (so no transfer of energy). A manual control switch is provided in the room for the occupant to adjust according to his or her needs.

Unoccupied
When a room is not being used, the control switch must be set to the “Unoccupied” position. In this position the flow of air is reduced to a minimum; the actual value to which it is reduced can be preset at the VAV controller.

Occupied
When someone wishes to use the room, the control switch must be set to the “Occupied” position. The volumetric flow will then be increased to a pre-defined value that can also be preset at the VAV controller – which will ensure optimum air quality for normal usage.

Ventilate
Should the air in the room become very stale due, say, to excessive smoking, the control switch can be set to the “Ventilate” position so that the air flow rate is increased to an again-preset maximum value.

Variants
Instead of a manual switch it is also possible to employ a proximity switch which changes automatically from “Occupied” and “Unoccupied” and vice versa. Another option is for the “Ventilate” mode to be triggered through a time-delay switch so that maximum ventilation does not remain on permanently.

The room exhaust air is linked to the supply air under slave control in order to ensure balanced pressure conditions in the room and so avoid draughts.

Note on circuit wiring
Whenever possible, always run the U5 signal (actual value of volumetric flow) to an easily accessible terminal (in the electrical cubic, room controller, etc.). It is needed for connecting the ZEV Adjuster (refer to the documentation on the connection and use of the ZEV Adjuster).

Demand-related ventilation

The example opposite shows a simple but efficient method of demand-related ventilation using BELIMO VAV-Control systems. This application is primarily suitable for when combined air/water systems are being used because only the quality of the air is controlled, not the temperature (so no transfer of energy). A manual control switch is provided in the room for the occupant to adjust according to his or her needs.

Unoccupied
When a room is not being used, the control switch must be set to the “Unoccupied” position. In this position the flow of air is reduced to a minimum; the actual value to which it is reduced can be preset at the VAV controller.

Occupied
When someone wishes to use the room, the control switch must be set to the “Occupied” position. The volumetric flow will then be increased to a pre-defined value that can also be preset at the VAV controller – which will ensure optimum air quality for normal usage.

Ventilate
Should the air in the room become very stale due, say, to excessive smoking, the control switch can be set to the “Ventilate” position so that the air flow rate is increased to an again-preset maximum value.

Variants
Instead of a manual switch it is also possible to employ a proximity switch which changes automatically from “Occupied” and “Unoccupied” and vice versa. Another option is for the “Ventilate” mode to be triggered through a time-delay switch so that maximum ventilation does not remain on permanently.

The room exhaust air is linked to the supply air under slave control in order to ensure balanced pressure conditions in the room and so avoid draughts.
When BELIMO VAV-Control is used for simple, temperature-sensitive individual-room control, the temperature controller works in conjunction with the VAV-Boxes independently of any master control system that there might be.

The advantage of this is that retrofitting is very easy. It is an especially important factor when the eventual partitioning and uses of rooms in a new building have not been decided during the construction stage.

The required temperature and functions such as night reduction, ventilation, etc. can be preset by the occupants afterwards from the room thermostat.

In the example opposite the supply-air and exhaust-air boxes are connected in series although they can also be controlled in parallel if necessary (see page 8, Using supply and exhaust VAV-Boxes).

\[
\begin{align*}
\text{yh} &= \text{“Heating” output} \\
\text{yk} &= \text{“Cooling” output} \\
\text{t} &= \text{Temperature} \\
\dot{V} &= \text{Volumetric flow}
\end{align*}
\]
Incorporating BELIMO VAV-Control into DDC systems provides maximum flexibility. With their standard inputs and outputs of 0...10 V and 2...10 V, the VAV controllers can be connected directly to most commercially-available DDC control systems.

The DDC controller measures and controls all the important values for operating the plant. The values of volumetric flow can be controlled according to a very wide range of criteria, e.g., according to the use of the building (night reduction, night cool-down, etc.).

The actual-value signals (U5) perform a number of valuable tasks, mainly connected with energy-saving: they allow the actual volume of each VAV-Box to be acquired at any instant so that the plant operator is able to see and assess the consumption of air in each individual zone. Using this information it is a very simple matter to produce programs that provide optimum distribution of the air supply.

Typical example of Master/Slave DDC – 0...10 V DC control

Using only one modulating output (0...10 V DC), VAV controllers can be used for controlling the supply air and the exhaust air through a “Master/Slave” arrangement. By feeding the slave’s actual-value signal back to the DDC controller it is possible to monitor both the supply air and the exhaust air with only a single 0...10 V input.

Note on circuit wiring
Whenever possible, always run the U5 signal (actual value of volumetric flow) to an easily accessible terminal (in the electrical cubicle, room controller, etc.). It is needed for connecting the ZEV Adjuster (refer to the documentation on the connection and use of the ZEV Adjuster).
Using supply and exhaust VAV-Boxes

**Supply and exhaust flow control: Master/Slave system**

This system of control is used for:

- Plants with air volume controllers in the supply-air and exhaust-air systems that must work in series
- Supply-air and exhaust-air units of various sizes and settings for minimum and maximum limit values
- Differential control between supply air and exhaust air
- Plants with several supply-air and/or exhaust-air units

The reference signal $w$ from the temperature controller is connected to the input of the supply-air air volume controller (Master).

The actual-value signal from the Master is the reference signal for the exhaust-air air volume controller (Slave).

The ratio of $V_{\text{Slave}}$ to $V_{\text{Master}}$ is set with the $V_{\text{MAX}}$ potentiometer at the Slave.

Override $V_{\text{MIN}}$ Slave should only be entered at the Master; “CLOSE” at both Master and Slave.

**Note on circuit wiring**

Whenever possible, always run the $U_5$ signal (actual value of volumetric flow) to an easily accessible terminal (in the electrical cubicle, room controller, etc.). It is needed for connecting the ZEV Adjuster (refer to the documentation on the connection and use of the ZEV Adjuster).

**Supply and exhaust flow control: Parallel system**

This system of control is used for:

- Plants with parallel-connected air volume controllers for supply air and exhaust air (both controlled from and with the same reference variable)
- Supply-air and exhaust-air units of various sizes and settings for minimum and maximum limit values
- Differential control between supply air and exhaust air

The reference signal $w$ from the temperature controller is connected in parallel with the setpoint inputs of the VR... supply-air and exhaust-air volume controllers. The minimum and maximum limit values of volumetric flow must be set individually for each controller.

Schematic diagram

**Schematic diagram**

AC 24 V
VAV zone control, supply and exhaust air

The arrangement shown in the example opposite uses several VAV controllers for the supply air and one common controller for the exhaust air.

The controller in the common exhaust-air system is controlled by the actual-value signal of the volumetric flow sensor in the common supply-air duct which measures the variation in volumetric flow according to the load status. The volumetric flow of the zone air is controlled from the output of the temperature controller. Room-related overrides such as V_MIN, V_MAX and “CLOSE” are accepted automatically.

**Note on circuit wiring**
Whenever possible, always run the U5 signal (actual value of volumetric flow) to an easily accessible terminal (in the electrical cubicle, room controller, etc.). It is needed for connecting the ZEV Adjuster (refer to the documentation on the connection and use of the ZEV Adjuster).

Twin-duct mixing boxes with variable volumetric flow

The control zones have a single mixing section and separate VAV controllers in the common supply-air and exhaust-air systems.

The room temperature controller first throttles the volumetric flow of cold air down to the preset V_MIN value (e.g. 50%). Mixing of the cold-air and warm-air flows then takes place. Thus, in the upper range (cooling) the air flow rate is variable and in the lower range (heating) it is constant.
Setting parameters and modes of operation

Nominal volumetric flow $V_{\text{NOM}}$

Energy consumption and noise considerations demand that the specific value of volumetric flow for each diameter of duct should not exceed a certain maximum. With BELIMO VAV-Control the manufacturer can calibrate his air volume controller to a maximum possible value of $V_{\text{NOM}}$ before despatch from the factory. This produces the versatile, linear actuator for volumetric flow.

The presetting of the units for a standard value of $V_{\text{NOM}}$ greatly simplifies and shortens the procedures of manufacture (OEM), planning and installation or commissioning, making a major contribution to cost-saving.

Rated volumetric flow $V_{\text{MIN}}$ and $V_{\text{MAX}}$

The linear characteristic of the air volume controller facilitates the setting of the values of rated volumetric flow for the plant by means of two potentiometers, a task that can be performed either at the factory (OEM), during installation or during commissioning. $V_{\text{MAX}}$ is the upper limit value in relation to the nominal volumetric flow. $V_{\text{MIN}}$ can be adjusted as a percentage of the set value of $V_{\text{MAX}}$.

The actual-value output $U_5$ is unaffected by the settings of $V_{\text{MIN}}$ and $V_{\text{MAX}}$. The reference signals w/z allow the setpoint of volumetric flow to be varied within the preset limits either continuously or in steps.

Modes of operation

Multi-step constant operation via overrides:

By means of simple override signals it is possible, when necessary, to change the controller to different steps of operation. Accordingly, the controller then either maintains a constant value of rated volumetric flow for $V_{\text{MIN}}$ or $V_{\text{MAX}}$ or the mean of the two, or closes or opens the damper as demanded by the control signal.

Modulating:

By means of the reference signal w (DC 0...10 V) it is possible to modulate the volumetric flow between the limit values $V_{\text{MIN}}$ and $V_{\text{MAX}}$. The effective working range DC 2...10 V or DC 0...10 V can be preselected. The override functions are also active in the modulating mode and so can be used in almost any combination.

Operating controls for mode and parameter setting

The NMV-D2 has no operating controls other than the gearing disengagement pushbutton. The plant-specific operating parameters $V_{\text{MIN}}$ and $V_{\text{MAX}}$ and the working ranges can be preset using the ZEV Adjuster through the PP communications interface $U_5$. 

Products no longer available
Positive or negative room pressure

BELIMO VAV provides a simple means of operating systems with too little or too little volumetric flow (i.e. positive or negative room pressure). A positive pressure will prevent air, gases or vapour from outside entering a room and, similarly, a negative pressure will prevent air, gases or vapour escaping from a room.

Such positive and negative pressure conditions are very easy to produce with BELIMO VAV. Ideally, the VAV controllers should be used in a Master/Slave arrangement, the controller with the smaller value of nominal volumetric flow being appointed Master. When both controllers have the same value of nominal volumetric flow the one with the higher value of VMAX should be appointed Master.

The different pressure conditions can be achieved by making appropriate adjustments to VMAX at the Slave controller. The simple equation below should be used for determining the value of VMAX to be set at the Slave controller. The VMAX setting of the Master controller can be calculated from the following relationship:

\[
V_{\text{MAX}}\%_{\text{M}} = \frac{V_{\text{MAX}} \cdot VNOM_{\text{M}}}{V_{\text{MAX}} \cdot VNOM_{\text{S}}} \cdot 100
\]

**Example 1:** Positive pressure in a room is required brought about by 20% more air being supplied than exhausted. The controller with the smaller value of nominal volumetric flow is appointed Master, the SUPPLY controller in the case of the adjacent example.

Ascertain the value of VMAX in % that is to be set at the Slave controller in order to produce the 20% differential required.

**Answer:**

\[
1200\ m^3/h \cdot 1600\ m^3/h
\]
\[
1500\ m^3/h \cdot 2400\ m^3/h
\]

Therefore the VMAX-potentiom. of the Slave controller must be set to 53%.

**Example 2:** Negative pressure in a room is required brought about by 20% less air being supplied than exhausted. The controller with the smaller value of nominal volumetric flow is appointed Master, the SUPPLY controller in the case of the adjacent example.

Ascertain the value of VMAX in % that is to be set at the Slave controller in order to produce the 20% differential required.

**Answer:**

\[
1500\ m^3/h \cdot 1600\ m^3/h
\]
\[
1200\ m^3/h \cdot 2400\ m^3/h
\]

Therefore the VMAX-potentiom. of the Slave controller must be set to 83%.
The right measuring system for all applications

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

Several different methods have become popular for measuring volumetric flow. The differential-pressure method used by Belimo allows a good averaging measurement to be taken even when the inlet flow conditions are unsatisfactory.

- Dynamic differential-pressure measurement:
  Wide measuring range and high accuracy in conjunction with specific makes of conventional differential-pressure sensors
- Static differential-pressure measurement:
  Suitable for contaminated air and special-purpose installations

Both methods of measurement can be used together in the same installation. Different VAV controllers with different working ranges can be used in parallel if necessary.

Measurement of differential pressure by dynamic flow probe

- Precise, proven principle of thermo-anemometric measurement with temperature compensation
- Unaffected by contamination as the measuring element is not in the air flow
- Measurement unaffected by position
- High accuracy of measurement – even in the low range of differential pressure
- Pressure measuring range 3...300 Pa

Measurement of differential pressure by static diaphragm sensor

- Suitable for use with heavily contaminated or corrosive air
- Measurement performed outside the air flow
- High accuracy of measurement – even in the low range of differential pressure
- Pressure measuring range 3...300 Pa
- Other measuring ranges available

Legend to equations:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\dot{V}$</td>
<td>Volumetric flow</td>
</tr>
<tr>
<td>$\bar{v}$</td>
<td>Mean velocity</td>
</tr>
<tr>
<td>$A$</td>
<td>Area</td>
</tr>
<tr>
<td>$\Delta p$</td>
<td>Differential pressure</td>
</tr>
<tr>
<td>$k$</td>
<td>Geometry-related constant of the baffle device (differential-pressure sensor, dimensions, etc.)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Density of the flow medium</td>
</tr>
</tbody>
</table>

Measuring methods used in the HVAC industry

Measuring air velocity in the duct

Due to the irregular flow profile, the mean air velocity is not identical to that measured at a specific point; it must be corrected according to the measuring arrangement being employed.

$\dot{V} = \bar{v} \cdot A$

Measuring differential pressure

Specific inlet flow conditions for the sensor and mean-value-forming devices such as measuring crosses, etc. provide the standard of accuracy needed by the HVAC industry.

A flow of air encountering an obstruction exerts a corresponding pressure of resistance that is proportional to the square of the velocity. It is the resulting difference in pressure across the baffle known as «differential pressure».

Baffles come in a great variety of forms (orifice plates, nozzles, baffle rings, baffle bars, etc.). Static or dynamic pressure sensors (diaphragm-type for static and flow-type for dynamic) are suitable for measuring differential pressure.
The right equipment for all applications

**BELIMO VAV-Universal**
Suitable for almost any application in the HVAC industry:
- Two different methods of measurement that can be combined as necessary with four different types of damper actuator
- Suitable for variable and constant volumetric flow
- Control by standard modulating signals
- Limit values $V_{\text{MIN}}$ and $V_{\text{MAX}}$ adjustable at the controller
- Override control of individual controllers or several at the same time

**Belimo VAV Compact**
A cost-effective combination of dynamic differential-pressure sensor, controller and actuator.
The NMV-D2 is suitable for:
- 3-stage constant volumetric flow control including full shutoff
- Modulating volumetric control for individual-room applications (0...10 V / 2...10 V)

**ZEV Adjuster**
The ZEV Adjuster is suitable for use by commissioning engineers or service technicians in order to change values of $V_{\text{MIN}}$ or $V_{\text{MAX}}$ in the system or to check the function of the controller.

Products no longer available
The combination of controller and actuator

**BELIMO VAV-Compact NMV-D2**

This system is used with the widest possible variety of VAV-Boxes and its key feature is its compactness. The dynamic pressure sensor, the controller, and the 8 Nm damper actuator are combined into a single unit.

**ZEV Adjuster**

The ZEV Adjuster can be used for editing or checking existing air volume controllers already installed in plants; it can also be used for setting the $V_{\text{MIN}}$ and $V_{\text{MAX}}$ operating parameters and the 0...10 V / 2...10 V operating modes. The reset function allows the original OEM values to be reset.

---

**Block diagram**

In the measuring section (sensor electronics and linearisation) the non-linear differential-pressure signal from the sensor is converted to a linear signal proportional to the volumetric flow. The signal is also available for other external uses. The input signal is conditioned in accordance with the preset limit values to produce an internal setpoint signal that is subsequently compared with the actual value. The control signal for the actuator is formed from the difference between the setpoint and the actual value. The smaller the system deviation, the lower the actuator speed.
The right answer for all applications

The key feature of this range of products is its modular design. There are two different methods of measurement available to the manufacturers of VAV controllers. The controllers can be combined with damper actuators with a variety of torque outputs and functions. This allows the manufacturers of VAV Boxes to offer their customers a customised solution for any particular application.

**LM24-V**
The smallest with a torque output of 4 Nm. Also with linear motion.

**NM24-V**
The most compact with a torque output of 8 Nm. Covers the majority of applications. Auxiliary switches (SN1/SN2) are available.

**AM24-V**
The newest with a torque output of 18 Nm. Can also operate the larger dampers and be fitted with up to four auxiliary function (potentiometers/switches).

**GM24-V**
The powerful one with 30 Nm torque. For operating large dampers; with auxiliary switches (S1/S2) if necessary.

**AF24-V**
The spring-return actuator with a torque output of 15 Nm. Used when a damper safety function is required. The pretensioned spring moves the damper to the safe position in the event of a power failure.

---

**Block diagram**

In the measuring section (sensor electronics and linearisation) the non-linear differential-pressure signal from the sensor is converted to a linear signal proportional to the volumetric flow. The signal is also available for other external uses. The input signal is conditioned in accordance with the preset limit values to produce an internal setpoint signal that is subsequently compared with the actual value. The control signal for the actuator is formed from the difference between the setpoint and the actual value. The smaller the system deviation, the lower the actuator speed.
Products no longer available
Belimo Subsidiaries

A H BelIMO Automation
Handelsagentur mbH
Gaiselweg 2
1110 Wien, Austria
Tel. +43 (0)711 1 67 83-0
E-Mail: info@belimo.de

Belimo Subsidiaries

Belimo Headquarters

of good HVAC systems. Extra-strong safety features for motorizing fire and smoke extraction dampers help raise safety standards in buildings.

Air box volume boxes – equipped with VAV-Control ensure higher standards of comfort for the occupants of air-conditioned single rooms as well as saving energy.

Globe valves with MFT2 actuators allow easy adaptation to the needs of HVAC systems.

Damen actuators and spring-return actuators for air control dampers are invaluable elements for good HVAC systems. Extra-strong safety features for motorizing fire and smoke extraction dampers help raise safety standards in buildings.

Air applications

Water applications

Rotary actuators for heating system mixing valves and motorized ball valves ensure reliable control of HVAC water systems.

The worldwide leading actuator technology for all controlled devices in heating, ventilation and air-conditioning plants.