Six-way 270° Control Valve and Actuator

Application Guide

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Highlights

- The first of its kind and a unique solution within the HVAC industry.
- The actuator is the only solution in the HVAC industry for use with either single wire, dual wire analog proportional control or dual wire 24VAC thermostat on/off control.
- Use of the Johnson Controls Six-Way 270° control valve saves considerable energy, material and labor.

Figure 1: Six-way 270° Control Valve and VA-9905 Actuator

Contents

Overview

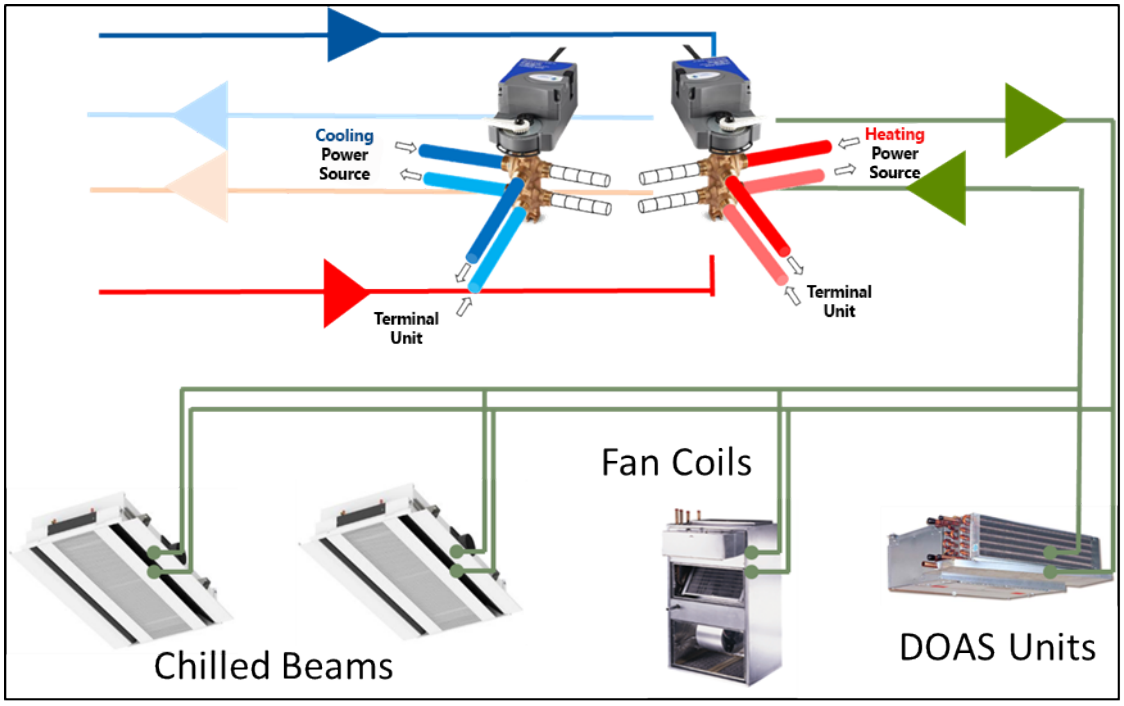
The 270° Six-way Control Valve and Actuator is the easiest and most efficient way to control heating and cooling operational modes. The system consists of a single valve and actuator instead of up to four valves and four actuators or one change over valve and two valves with three actuators. This reduces wired installation requirements and results in savings on setup and maintenance. The 270° Six-way Control Valve and Actuator uses one coil for heating and cooling operational modes and eliminates the need for a change over valve to switch to the correct operational mode circuit. This system simplifies the installation process and results in material and energy cost savings with a true close-off to isolate heating and cooling circuits. A true close-off eliminates the possibility of cross flows that occur in complex systems due to miswiring or imperfect software setup in the BAS.

The 270° Six-way Control Valve and Actuator also means that you can use a two-pipe terminal unit instead of a four-pipe; further reducing operational and maintenance costs without decreasing the unit's efficiency. The 270° Six-way Control Valve and Actuator is an optimal solution to manage heating and cooling hydronic circuits and reduce the cost of the terminal unit. The use of one coil and a two-pipe circuit in the terminal unit saves money and also offers the following advantages:

• Increases performance by up to 34% in heating mode and 28% in cooling mode.
• Achieves a high temperature Delta T in the hot water circuit because the coil is typically sized for the cooling load. This significantly reduces flow rates and boiler temperatures for less pumping, increased boiler efficiency, and lower energy costs.
• The elimination of a coil results in lower initial, distribution, and total costs, and reduces hot water pumping. For some applications, a lower water temperature also reduces the hot water heater size like those found in larger buildings, offering further cost savings.
• Lower energy costs due to improved boiler and pumping efficiencies of between 12% and 15%.
• The 270° Six-way control valve represents an easier solution than traditional setups.

Typical applications

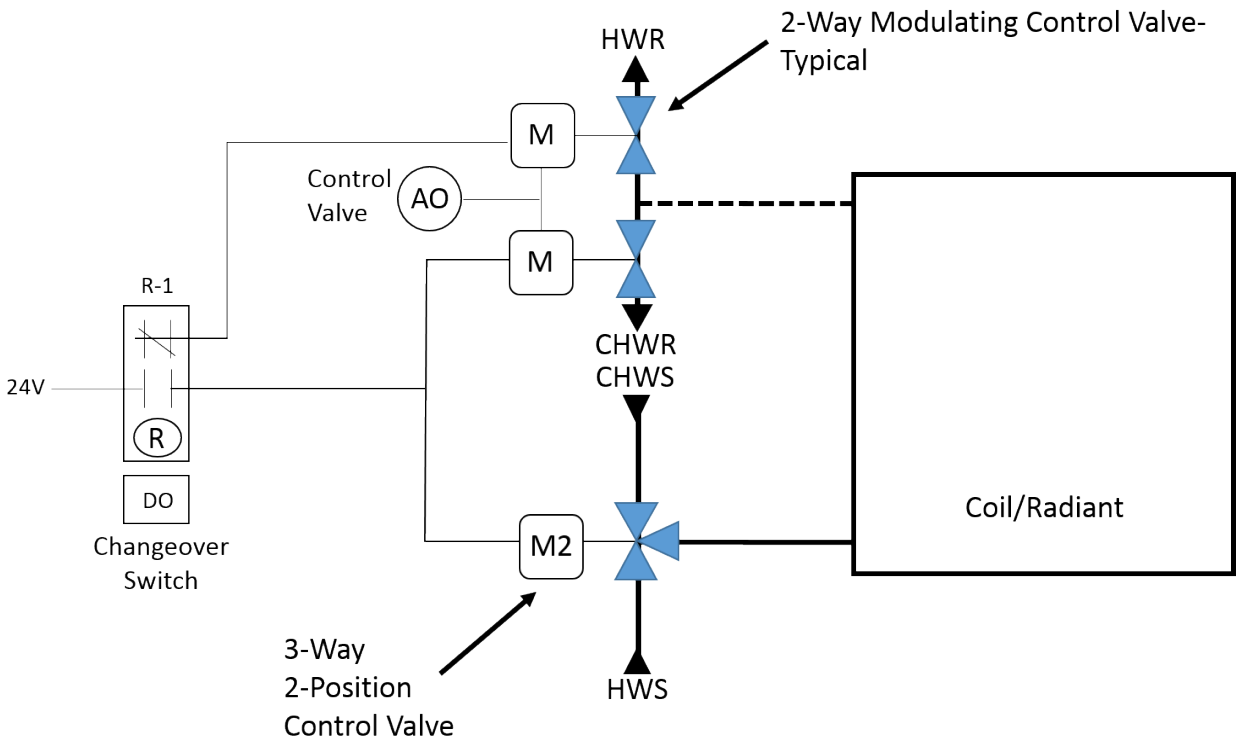
Figure 2: Terminal unit applications



Design considerations

The 270° Six-way Control Valve and Actuator is suitable for any terminal unit application where there is a desire to save costs. The following figure shows three of the most common terminal application types in the market; chilled beams, fan coils, and direct outside air supply (DOAS) units. The following section describes common, traditional, and new six-way configurations and the advantages and considerations of each.

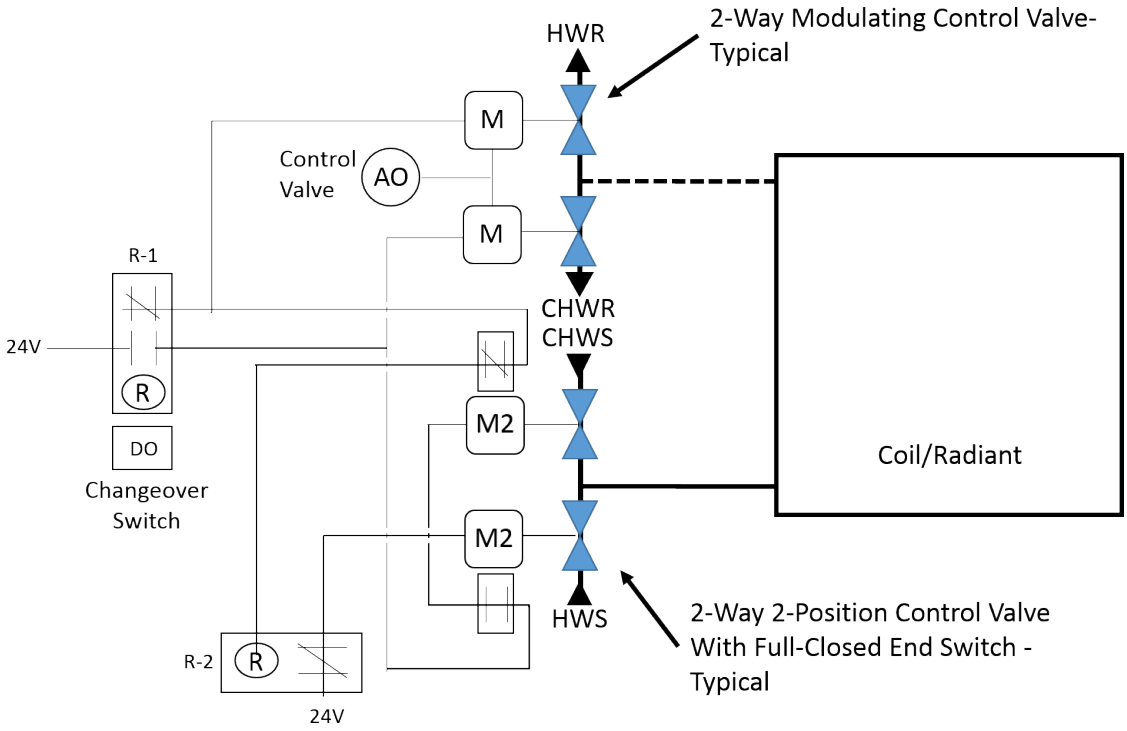
Figure 3: Three valves common setup - 2 two-way modulating valves and a three-way two-position valve



Advantages: The system uses a more complex set of contacts, relays, and end switches to ensure water flow in case of power outage.

Considerations: This system is only on/off flow control. It takes the three-way valve between 25 seconds and 90 seconds to change position. The hot water (HW) and chilled water (CHW) are open to each other during this time. This action causes a crossflow and pressure differential that reduces the overall efficiency of the system.

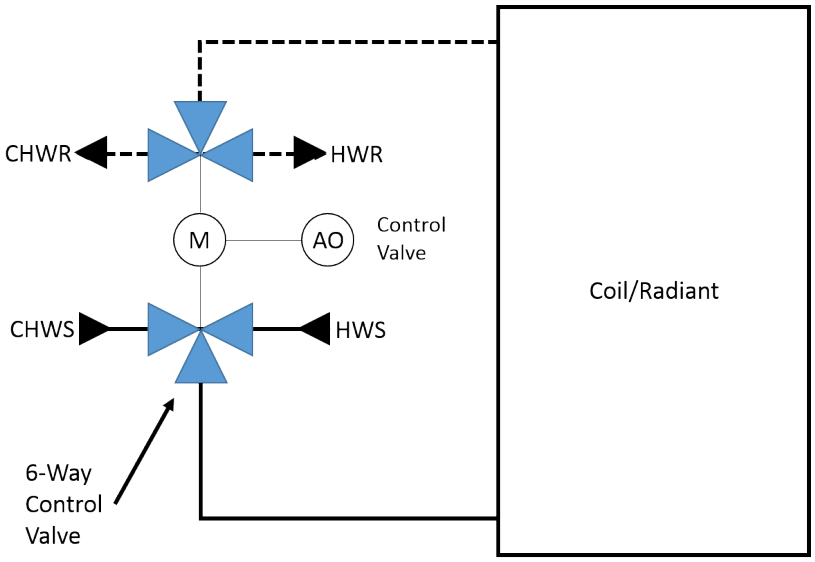
Figure 4: Four valves traditional setup - 2 two-way modulating valves and 2 two-way two-position valves



Advantages: The system uses a more complex set of contacts, relays, and end switches to ensure water flow in case of power outage and that valves are in the correct open or closed position.

Considerations: This system is only on/off flow control and is a more costly design due to the extra two-way valve, end-switches, relays, and wiring. The possibility of reversed wiring polarity and reversed software configurations increases. This situation could lead to cross-flow and could significantly reduce the overall efficiency of the system."

Figure 5: Six-way modulating valve solution



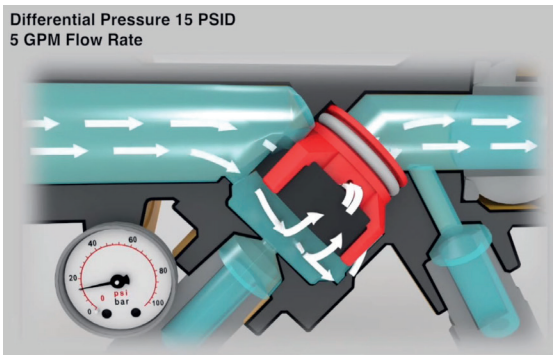
Advantages: This system uses a less complex setup and provides all the benefits of the four two-way valve solution but at a lower first cost. The chance of failure decreases due to fewer parts and a less complex controls setup.

Considerations: Both CHW and HW must run the same water solution or treatment. There is also estimated to be a coils worth of cold water or hot water which transfers into the opposite system. The unit is furnished with a non-spring return actuator; in the event of power failure, the unit remains in its last position and chilled water could run through the chilled beam and create condensation.

Fixed Flow Control Considerations

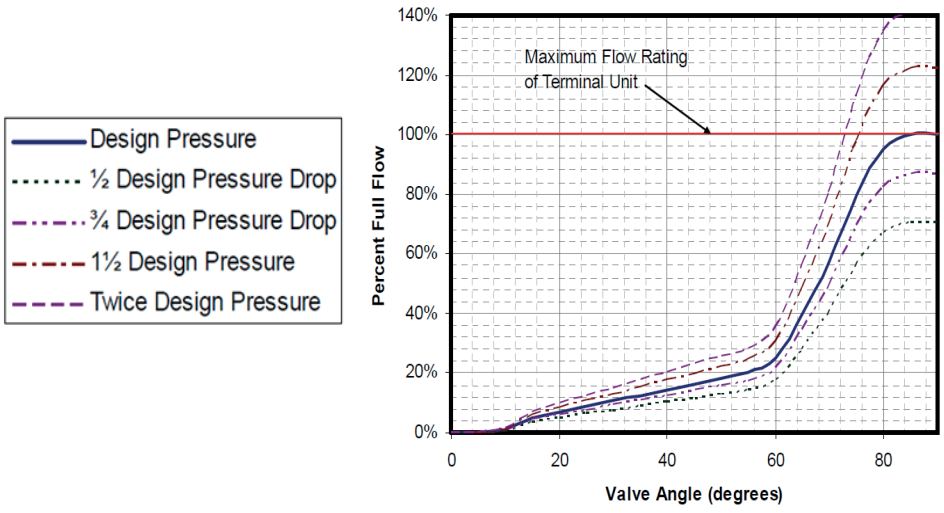
You may need to control the total amount of flow differential between the HW and CHW flows through the use of a single coil. A fixed flow controller is responsible for maintaining flow regardless of changes in differential pressure. When a low differential pressure condition occurs, the rubber bladder opens and increases the flow of water through the system based on the required gallons per minute (GPM). As differential pressure increases the rubber bladder gets smaller and increases pressure to maintain the required GPM. Typical fixed flow is 0.5 GPM on the heating side and 2 GPM on the cooling side in a chilled beam application. Johnson Controls offers a range of fixed flow controller types.

Figure 6: Fixed flow controller type



The following figure illustrates that it is possible to incur more flow than required without the use of a flow controller. The bold line in the graph is designed pressure. If the system experiences an increase in pressure it is likely the system will receive more flow which can force heating and cooling loops out of balance. Meanwhile if the system experiences low pressure it is also possible that heating and cooling loops can become imbalanced. In a low pressure condition, even if the valve is 100 % open it is not certain the required flow pressure will be achieved. It is best practice to use a flow control device.

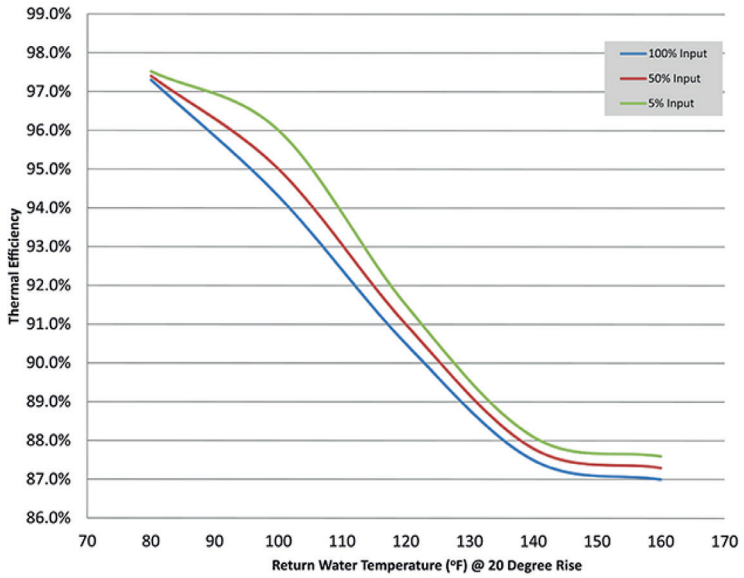
Figure 7: Pressure minus a flow control device



Benefits

The benefits of converting from a traditional setup to one that uses a 270° Six-way Control Valve and Actuator are many. The following examples illustrate more savings, the following figure demonstrates the relationship between thermal efficiency and return water temperature. The use of the 270° Six-way Control Valve and Actuator single coil configuration can significantly reduce boiler water temperature. A typical four-pipe boiler runs at an average of 180°F with a less than 87% efficiency rating. Whereas, a typical two-pipe boiler runs at an average 130°F with an approximate efficiency of 95% or better.
The transition from a four-pipe to a two-pipe coil system can result in real energy cost savings.

Figure 8: Thermal efficiency curves

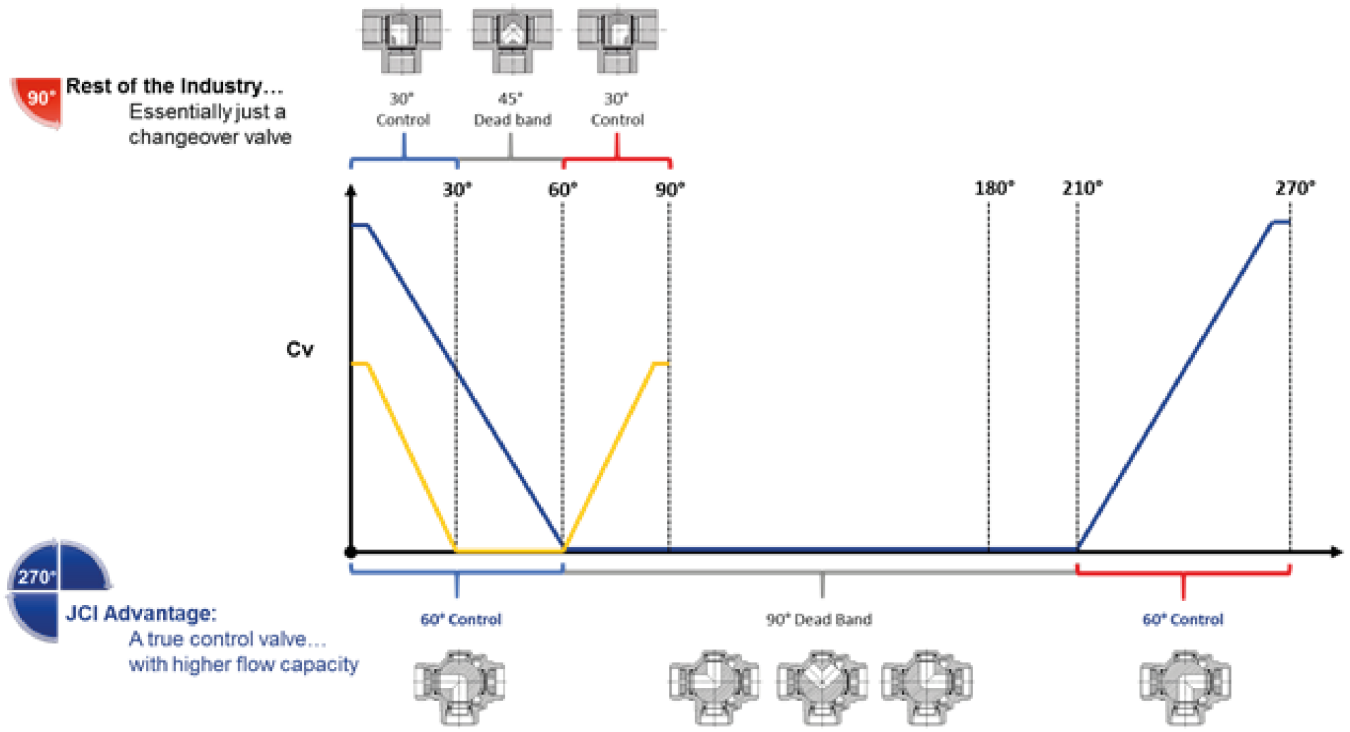


The following table illustrates a real life total cost differential between a traditional four-pipe setup and three different examples of two-pipe configurations. The two-pipe savings options include the use of a six-way valve and illustrate options to either drop a coil row, adjust water temperature or downsize a unit. The cost savings are noteworthy and significant. Average savings run between 19% and 46%. This is just one example of how switching from a traditional setup to a six-way setup can save on the mechanical components of the terminal unit. Beyond the mechanical savings, users can expect to save between 5% and 10% on energy costs.

Table 1: Typical fan coil savings model

Option	Pipe configuration	Cost (list $)	Savings %	Coil rows	Unit size	CLG BTU	HTG BTU	Hot water (F°)	Chilled water (F°)	Max watts
Base Four-pipe system	Four pipe	$4,916	Base	4	10	22,342	45,518	180/140	45/55	310
Option 1 w/six-way Drop coil row	**Two pipe**	**$3,848**	**Over base - 28%**	**3**	**10**	**22,342**	**43,498**	**145/105**	**45/55**	**310**
Option 2 w/six-way Adjust water temps	Two pipe	$4,122	Over base - 19%	4	10	22,585	46,498	140/100	47/57	310
Option 3 w/six-way Unit down size	**Two pipe**	**$3,357**	**Over base - 46%**	**4**	**8**	**21,505**	**43,035**	**140/100**	**45/55**	**233**

Figure 9: 270° Six-way Control Valve vs. competitors 90° control angle and resolution of flow



The 270° Six-way Control Valve solution provides distinct advantages over a competitors 90° valve:
1) Greater control angle for true modulation of chilled or hot water flow when under proportional control. The 90° valves essentially can only provide on/off control.
2) Much higher resolution of control via two dedicated analog control inputs. One dedicated to the hot water side of the valve and the other to the chilled water side of the valve. The entire 0-10V, 2-10V or 4-20mA signal of each wire controls fine modulation of cold water and hot water flow. The 90° valves generally use a single wire actuation which cannot provide the same level of control.
3) The Johnson Controls 270° also is configurable for 24VAC thermostat on/off control which allows use with a standard two wire thermostat.
4) Lastly, the Johnson Controls 270° is also configurable for single wire analog proportional control. The advantage here is that the 270° valve provides a much greater control angle, 60° vs the industry 25°-30°.

Typical cooling sequence
When a cooling signal occurs, the chilled water 270° Six-way Control Valve begins to modulate open. As the demand for cooling increases, the chilled water side of the valve continues to open until the discharge fan coil air temperature reaches 52°F (11ºC). As there is an ongoing call for cooling, the fan modulates toward the maximum cooling fan airflow. The chilled water increases flow through the 270° Six-way Control Valve as the valve continues to modulate open for 52°F (11ºC) discharge air temperature. This process continues until the fan reaches the cooling maximum airflow and the chilled water side of the 270° Six-way Control Valve reaches maximum flow. When the cooling demand decreases, the sequence begins to reverse.

Deadband
When no demand for either heating or cooling in the space, the fan coil runs at minimum airflow. The 270° Six-way Control Valve remains in the off or zero flow position.

Typical heating sequence
When a heating signal occurs, the hot water valve begins to modulate open. As the demand for heating increases, the hot water side of the 270° Six-way Control Valve continues to modulate open as the fan begins to modulate from deadband towards the maximum heating fan airflow. This process continues until the fan reaches the heating maximum airflow and the hot water side of the 270° Six-way Control Valve reaches maximum flow. When the heating demand decreases, the sequence begins to reverse.

Benefits

VA9905 Series Electric Non-Spring Return Actuator

2 analog inputs, 1 analog input and 2 24VAC inputs	Configurable, programmable or conventional field controllers and thermostats. Improves control and precision.
Microprocessor-controlled brushless DC motor	Provides constant runtime independent of torque and increases lifecycle by reducing wear.
Mode configuration switches	Permits input signal range selection plus type of control.
Integral cables with colored and numbered conductors	Simplifies installation and field wiring.
Optional integral 1/2 in. (13 mm) threaded conduit connectors	Simplify installation and field wiring.
Plenum-rated models	Enables use in other environmental air spaces (plenums) in accordance with section 300.22(C) of the National Electric Code.
Small footprint	Allows application in smaller spaces.
Position Indicator Handle and Manual override	Allows intuitive indication of valve position and manual shut off.
NEMA5/IP54 enclosure	Enhances the range of application environments.
Underwriters Laboratories Inc.® (UL), CE Mark, and RCM Compliance	Provides internationally recognized regulatory agency approvals.
Manufactured under International Standards Organization (ISO) 9001 quality control standards	Ensures quality.
100,000 cycles and 2.5 million repositions	Ensures reliability over time.
5-Year warranty	Protects consumer investment.

VG1600 Series 270° Six-Way Ball Valves

National Pipe Thread (NPT), British Standard Pipe Parallel (BSPP) and Sweat Union Fittings	Provides the right valve for a broad range of applications, reduce installation time while reducing the need for adapters, and increase system reliability.
Forged brass body	Provides PN16 (300 psi) static pressure rating.
350kPa (50 psi) closeoff pressure rating	Provides tight shutoff.
Ethylene Propylene Diene Monomer (EPDM) double O-ring stem seal	Provides a leak-free seal; the packing has been tested and is leak-free after 100,000 cycles in iron-oxide contaminated water.
Graphite-Reinforced Polytetrafluoroethylene (PTFE) seats	Includes 15% graphite-reinforced ball seats, providing better wear resistance.
Maintenance – free design	Performs without failure in excess of 100,000 full stroke cycles in iron-oxide contaminated water.
Wide selection of styles for a variety of applications	Offers various valve configurations with just one valve size.
Factory- mounted VA9905 Series Electric Actuator	Reduces installation time, thus reducing overall installation cost

Selection

Actuator ordering codes

Code number	Name	Description
VA9905-KGA-1	Multi-input actuator 5 N·m furnished with 2x0(2)...10V, 1 x 0(2)... 10V Analog Inputs, 2 x 24V Inputs	Europe/Asia
VA9905-KGA-2	Multi-input actuator 5 N·m furnished with 2x0(2)...10V, 1 x 0(2)... 10V Analog Inputs, 2 x 24V Inputs	North America

Note: Optional 0(4)...20mA control with field furnished 500 ohm 1/4” resistor for proportional control

Valve ordering codes

Code number	Name	Description
VG1611AF	½ in. BSPP external threads	Europe/Asia
VG1641AF	½ in. NPT internal threads	North America
VG1671AF	½ in. BSPP external threads and 6x sweat union fitting	North America
VG1611BL	¾ in. BSPP external threads	Europe/Asia
VG1641BL	¾ in. NPT internal threads	North America
VG1671BL	¾ in. BSPP male and 6x sweat union fittings	North America

Accessory ordering codes

Code number	Name	Description
VG1600-01	½ in. Mounting bracket	Europe/North America/Asia
VG1600-02	½ in. Flow disk kit (2 x flow disk sets and 2 x ring nut)	Europe/North America/Asia
VG1600-03	½ in. Insulation shell	Europe/North America/Asia
VG1600-04	½ in. Sweat union fitting kits (6x sweat union fitting)	North America
VG1600-05	¾ in. Flow disk kit (2 x flow disk sets + 2 x ring nut)	Europe/North America/Asia
VG1600-06	¾ in. Insulation shell	Europe/North America/Asia
VG1600-07	¾ in. Sweat union fitting kits (6x sweat union fitting)	North America

Actuator technical specifications

Product description	**VA9905-KGA-1:** Multi-Input signal mode, **VA9905-KGA-2:** Multi-Input signal mode	
Power requirements	AC 24 V ±20% at 50/60 Hz, Class 2 (North America) or SELV (Europe), 4.7 VA Running; DC 24 V ±10% Class 2 (North America) or SELV (Europe), 1.4 W Running.	
Transformer sizing requirements	≥6 VA	
Input signal/adjustments	0 (2) to 10 VDC or 0 (4) to 20 mA with field furnished 500 ohm 1/4 W resistor for proportional control or 24VAC dual wire on/off control.	
Control impedance	100K ohm DC, 4.7k ohm AC	
Rotation rate	1.5° per second	
Cycles	100,000 full stroke cycles; 2.5 million repositions.	
Audible noise	<35 dBA at 1 m (0.03 in.)	
Electrical connections	**-1 halogen-free** 1.2 m (48 in.) halogen free cable with 0.82 mm² (18 AWG) conductors and 6 mm (0.25 in.) ferrule ends	**-2 plenum-rated** 3.05 m (120 in.) UL 444 type CMP plenum rated cable with 0.75 mm² (19 AWG cable) conductors and 6 mm (0.25 in.) ferrule ends
Conduit connections	13 mm NPSM (1/2 in.) threaded conduit connectors with M9300-100 conduit.	
Ambient conditions	**Operating:** 0 to 60°C (32 to 140°F), 90% RH, noncondensing. **Storage:** -40 to 85°C (-40 to 185°F), 95% RH, noncondensing.	
Enclosure	IP54/NEMA 5	
Dimensions	Width: 89 mm (3.5 in.), Height: 74 mm (2.9 in.), Length: 170 mm (6.6 in.)	
Shipping weight	0.8 kg (1.75 lb)	
Compliance CE	**United States:** UL Listed, CCN XAPX, File E27734; to UL 60730-1: Automatic Electrical Controls for Household and Similar Use, Part 1; and UL 60730-2-14: Part 2, Particular Requirements for Electric Actuators. Plenum Rated (UL 2043). Suitable for use in Other Environmental Air Space (Plenum) in accordance with section 300.22 (c) of the NEC. **Canada:** UL Listed, CCN XAPX7, File E27734; to CAN/CSA E60730-1:02: Automatic Electrical Controls for Household and Similar Use, Part 1; and CAN/CSA-E60730-2-14, Particular Requirements for Electric Actuators.	
	Europe: Johnson Controls declares that this product is in compliance with the essential requirements and other relevant provisions of the EMC Directive. IEC 60730-1: Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements and IEC 60730-2-14, Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Electric Actuators.	
	Australia and New Zealand: RCM—Australia/NZ Emissions Compliant	

The performance specifications are nominal and conform to acceptable industry standard. For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls shall not be liable for damages resulting from misapplication or misuse of its products.

Valve technical specifications

	VG16x1AF	VG16x1BL
Total operation angle	270°	
Sequence 1	0...>90°	
Deadband	>90…<180°	
Sequence 2	>180…270°	
Characteristic curve	Linear	
ID	10.5 mm	15 mm
Fluid type	Water, glycol solutions (max 50%) for HVAC applications	
Fluid temperature	5 to 95°C (41 to 203°F)	
Nominal pressure	PN16 (232 psi)	
Close off pressure	350 kPa (50 psi)	
Max. differential pressure	240 kPa (35 psi)	
Rangeability	100:1	
Max. Kv (Cv)	2.3 (2.7) 1/2 in. pipe size	4.5 (5.2) 3/4 in. pipe size
Body	Brass CW 617N (UNI EN 12420)	
End connection	Brass CW 617N (UNI EN 12420)	
Balls	Brass chrome plated	
Stems	Brass chrome plated	
Ball seat	PTFE 15% graphite filled	
O-ring	EPDM PEROX	
Ring nut	Brass CW 614N (UNI EN 12164 – UNI EN 12168)	
Connections	Valve Body with Male 1/2 in. BSPP Thread (external) Valve Body with Female 1/2 in. NPT Thread (internal) 1/2 in. Sweat Union Fitting kit	Valve Body with Male 3/4 in. BSPP Thread (external) Valve Body with Female 3/4 in. NPT Thread (internal) 3/4 in. Sweat Union Fitting kit
Shipping weight	VG1611AF: 0.7 kg (1.55 lb) VG1641AF: 0.8 kg (1.85 lb) VG1671AF: 1.0 kg (2.20 lb)	VG1611BL: 1.4 kg (3.01 lb) VG1641BL: 1.7 kg (3.69 lb) VG1671BL: 1.9 kg (4.13 lb)
Flow coefficient	Flow control disk	
Leakage rate	A, 100,000 cycles in iron-oxide contaminated water and air-bubble-tight (EN 12266-1)	
Water quality	Iron-oxide contaminated water (900 ppm)	
Maintenance	Maintenance free	
Warranty	Minimum 5 years	

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls shall not be liable for damages resulting from misapplication or misuse of its products.

⚠ WARNING This product can expose you to chemicals including lead, which is known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

WARNING: BRASS MAY CONTAIN LEAD

To fulfill our obligations towards Article 33, in accordance to the European REACH Regulation No 1907/2006 EC, we hereby inform you that this article contains the following Substances of Very High Concern mentioned on the Candidate list:

- Lead