SIEMENS

Technical Instructions

Document No. 155-404

May 11, 2016

MVS661..N… Series

Modulating Refrigerant Valves for Ammonia (R717) and Safety Refrigerants

Description

Modulating refrigerant valves designed for modulating control of refrigerant circuits including chillers and heat pumps.

Features

- One valve type for expansion, hot-gas and suction throttle applications.
- Hermetically sealed.
- Selectable standard control signals 0/2 to 10 Vdc or 0/4 to 20 mA.
- High resolution and control accuracy.
- Precise positioning control and position feedback signal.
- Short positioning time (less than 1 second).
- Closed when de-energized.
- Robust and maintenance-free.
- 1-inch (DN 25) with CV (k_{vs}) values from 0.12 to 7.28 (0.10 to 6.3 m³/h).

Application

The MVS661..N refrigerant valves are suitable for use in expansion, hot-gas and suction throttle applications. In addition to ammonia (R717), the valves can handle all standard safety refrigerants, non-corrosive gases/liquids and CO_2 (R744). They are not suitable for flammable refrigerants.

Product Numbers

See *Product Summary*.

Warning/Caution Notations

WARNING:	⚠	Personal injury or loss of life may occur if you do not follow the procedures as specified.
CAUTION:	⚠	Equipment damage or loss of data may occur if you do not follow the procedures as specified.

Product Numbers

The refrigeration capacity refers to applications using ammonia.

Table 1. Product Numbers.

Product Number	Line Size In (mm)	C_V (k_{vs})	C_V (k_{vs}) Reduced	Δp_{max} psi [MPa]	Q_0 E [kW]	Q_0 H [kW]	Q_0 D [kW]	S_{NA} [VA]	P_{med} [W]
MVS661.25-016N	1 (25)	0.18 (0,16)	0.12 (0,10)	363 (2,5)	95	10	2	22	12
MVS661.25-0.4N		0.46 (0,40)	0.29 (0,25)		245	26	5		
MVS661.25-1.0N		1.16 (1,0)	0.73 (0,63)		610	64	12		
MVS661.25-2.5N		2.89 (2,5)	1.85 (1,6)		1530	159	29		
MVS661.25-6.3N		7.28 (6,3)	4.62 (4,0)		3850	402	74		

Cv = Nominal flow rate of refrigerant through the fully open valve (H_{100}) at a differential pressure of 1 psi.

k_{vs} = Nominal flow rate of refrigerant through the fully open valve (H_{100}) at a differential pressure of 100 kPa (1 bar) to VDI 2173. If required k_{vs}-value and refrigeration capacity Q_0 can be reduced to 63% (see *C_V (k_{vs}) reduction*).

Δp_{max} = Maximum permissible differential pressure across the control path of the valve, valid for the entire actuating range of the motorized valve.

Q_0 E = Refrigeration capacity in expansion applications.

Q_0 H = Refrigeration capacity in hot-gas bypass applications.

Q_0 D = Refrigeration capacity in suction throttle applications and Δp = 7.25 psi (0.5 bar).

S_{NA} = Nominal apparent power for selecting the transformer.

P_{med} = Typical power consumption

The pressure drop across evaporator and condenser is assumed to be 4.35 psi (0.3 bar) each, and 23 psi (1.6 bar) upstream of the evaporator (for example, spider).

The capacities specified are based on superheating by 6K and sub-cooling by 2K.

Accessories
Valve insert ASR..N

Table 2. Accessories.

Product Number	Line Size In (mm)	C_V (k_{vs})
ASR0.16N	1 (25)	0.18 (0,16)
ASR0.4N		0.46 (0,40)
ASR1.0N		1.16 (1,0)
ASR2.5N		2.89 (2,5)
ASR6.3N		7.28 (6,3)

The refrigeration capacity for various refrigerants and operating conditions can be calculated for the three types of application using Table 6 through Table 11.

For accurate valve sizing, use the valve selection program **Refrigeration VASP**.

Ordering

The valve body and magnetic actuator form one integral unit and cannot be separated.

Replacement Parts

If the valve's electronics become faulty, the entire electronics housing must be replaced by spare part ASR61, which is supplied with Mounting Instructions (74 319 0270 0).

If the installation is resized, or if excessive wear impacts the valve's performance, a new valve insert (ASR…N) will restore the valve's characteristics to its original specifications.

The valve insert is supplied complete with Mounting Instructions (74 319 0486 0).

Technical Design/ Functions

Features and Benefits

- Four selectable control signals for setpoint and measured value.
- DIP switch to reduce the C_V (k_{vs}) value to 63% of the nominal value.
- Potentiometer for adjustment of minimum stroke for suction throttle applications.
- Automatic stroke calibration.
- Forced control input for "Valve closed" or "Valve fully open".
- LED for indicating the operating state.

Control

The MVS661… Series refrigerant valve can be driven by Siemens or third-party controllers that deliver a 0/2 to10 Vdc, or 0/4 to 20 mA output signal.

For optimum control performance, use a 4-wire connection between the controller and valve. The valve stroke is proportional to the control signal.

The valve stroke is proportional to the control signal.

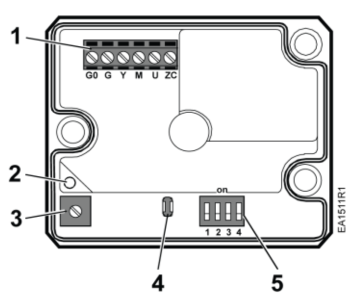
CAUTION:

You must use a four-wire connection with Vdc power supply.

Spring return action

If the control signal is interrupted, or in the event of a power failure, the valve's return spring will automatically close control path.

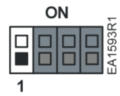
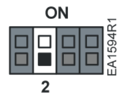
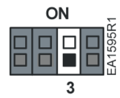
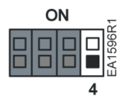
Operator controls and indicators in the electronics housing



1 Connection terminals
2 LED for indication of operating state
3 Minimal stroke setting potentiometer Rv
4 Auto-calibration
5 DIP switches for mode control

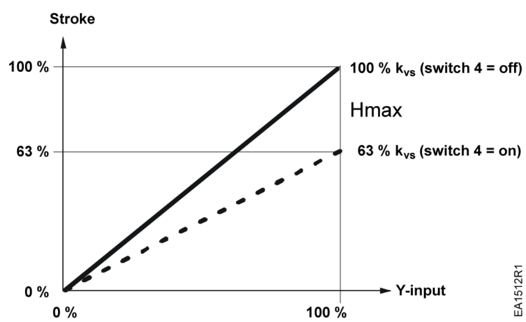
DIP Switch Configurations

Table 3. DIP Switch Configurations.

Switch	Function	ON/OFF	Description
	Positioning signal Y	ON	Current (mA)
		OFF	**Voltage (V)** [1]
	Positioning range Y and U	ON	2 to 10 Vdc, 4 to 20 mA
		OFF	**0 to 10 Vdc**, 0 to 20 mA [1]
	Position feedback U	ON	Current (mA)
		OFF	**Voltage (V)** [1]
	Nominal flow rate C_V (k_{vs})	ON	63%
		OFF	**100%** [1]

[1] **Factory setting**

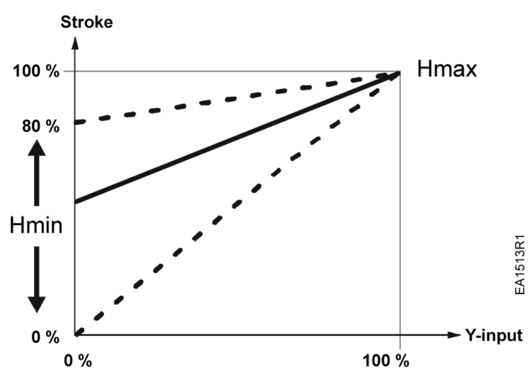
C_V (K_{VS}) reduction



For C_V (k_{vs}) reduction (DIP switch 4 in position **ON**), the stroke is limited to 63% mechanical stroke. 63% of full stroke then corresponds to an input/output signal of 10V.

If, in addition, the stroke is limited to 80%, for example, the minimum stroke is 0.63 × 0.8 = 0.50 of full stroke.

Minimum stroke setting



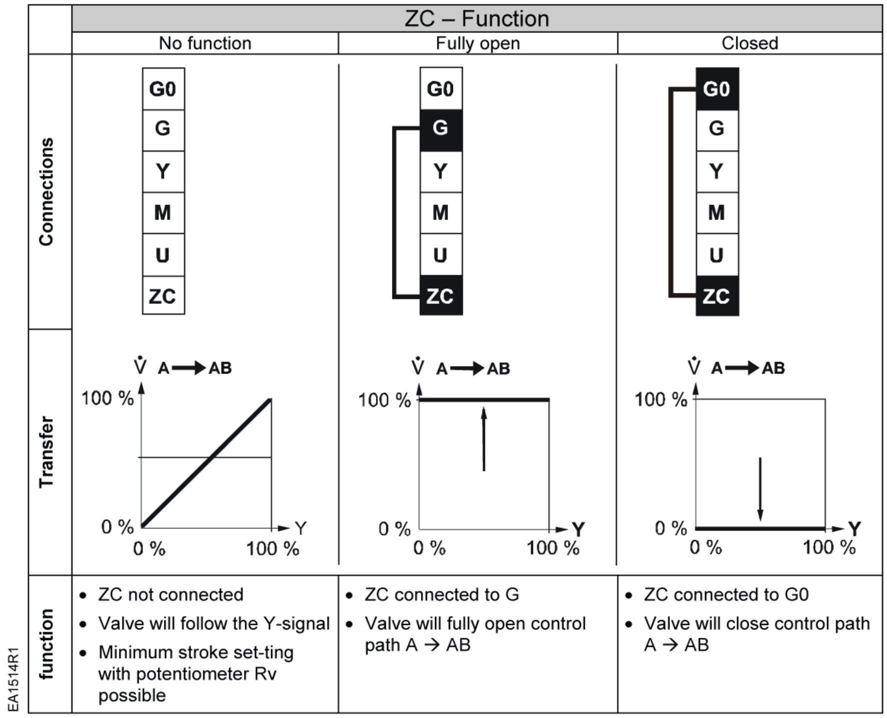
With a suction throttle valve, it is essential that a minimum stroke limit be maintained to ensure compressor cooling and efficient oil return. This can be achieved with a re-injection valve, a bypass line across the valve, or a guaranteed minimum opening of the valve. The minimum stroke can be defined using the controller and control signal Y, or it can be set directly with potentiometer Rv.

The factory setting is zero (mechanical stop in counterclockwise direction, CCW). The minimum stroke can be set by turning the potentiometer clockwise (CW) to a maximum of 80% C_V (k_{vs}).

CAUTION:

Do not use potentiometer Rv to limit the stroke on expansion applications. The valve must be able to fully close.

Forced control input ZC



Signal priority

1. Forced control signal ZC.
2. Signal input Y and/or minimum stroke setting with potentiometer Rv possible.

Calibration

The printed circuit board of the MVS661… Series has a slot to facilitate calibration. To calibrate, insert a screwdriver in the slot so that the contacts inside are connected. As a result, the valve will first be fully closed and then fully opened.

Calibration matches the electronics to the valve mechanism.
During calibration, the green LED flashes for about 10 seconds; see

Table **4**.

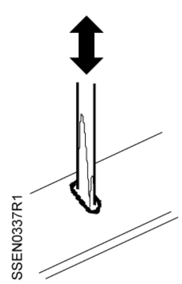


Figure 1. Calibration Slot.

NOTE: MVS661..-.. Refrigerant Valves are supplied fully calibrated.

When is calibration required?

Calibrate after replacing the electronics, when the red LED is lit or flashing, or when the valve is leaking (at seat).

Table 4. Indication of Operating State.

LED	Indication	Operating State, Function	Remarks, Troubleshooting
Green	Lit	Control mode	Automatic operation; everything is OK.
	Flashing	Calibration in progress	Wait until calibration is finished (green or red LED will be lit).
Red	Lit	Calibration error Internal error	Recalibrate (operate button in opening 1×). Replace electronics module.
	Flashing	Main fault	Check electric main network (outside the frequency or voltage range).
Both	Dark	No power supply Electronics faulty	Check electric main network, check wiring Replace electronics module.

Connection type

NOTE: Four-wire connections are always preferred.

	Product Number	(VA)	(W)	(A)	Wire Gauge (AWG) 14	12	10
					Max. Cable Length Ft (m)		
4-wire connection	MVS661..-..	22	12	1.6 to 4A	213 (65)	361 (110)	525 (160)
3-wire connection	MVS661..-..	22	12	1.6 to 4A	65 (20)	115 (35)	164 (50)

S_{NA} = Nominal apparent power for selecting the transformer.
P_{med} = Typical power consumption.
I_F = Required slow fuse.
L = Maximum cable length; with 4-wire connections, the maximum permissible length of the separate 14 AWG (1.5 mm^2) copper positioning signal wire is 656 ft (200 m).

1) All information at 24 Vac.

2) With 10 AWG (4 mm^2) electrical wiring reduce wiring cross-section for connection inside valve to 12 AWG (2.5 mm^2).

Sizing

For straightforward valve sizing, see *Application Examples*, beginning on page 12 for the relevant application.
For accurate valve sizing, Siemens Industry, Inc. recommends using the valve sizing software **Refrigeration VASP**.

NOTE: The refrigeration capacity Q_0 is calculated by multiplying the mass flow by the specific enthalpy differential found in the h, log p-chart for the relevant refrigerant. To easily determine the refrigeration capacity, see the selection chart provided for each application. With direct or indirect hot-gas bypass applications, the enthalpy differential of Q_c (the condenser capacity) must also be taken into account when calculating the refrigeration capacity.

If the evaporating and/or condensing temperatures are between the values shown in the tables, the refrigeration capacity can be determined with reasonable accuracy by linear interpolation. See *Application Examples*.

At the operating conditions given in the tables, the permissible differential pressure Δp_{max} 363 psi (25 bar) across the valve is within the admissible range for these valves.

If the evaporating temperature is raised by 1K, the refrigeration capacity increases by about 3%. If sub-cooling is increased by 1K, the refrigeration capacity increases by about 1 to 2% (this applies only to sub-cooling down to approximately 8K).

Engineering Notes

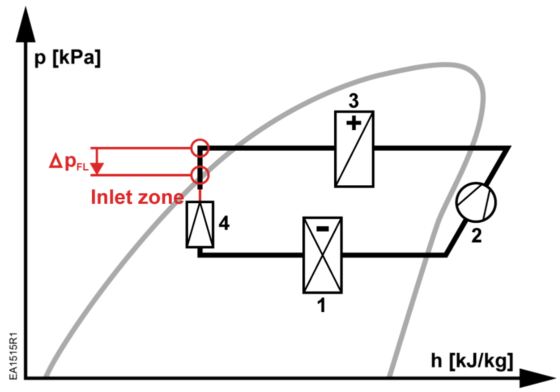
Depending on the application, additional installation instructions may need to be observed and appropriate safety devices (such as pressostats, full motor protection, and so on) fitted.

WARNING:

To prevent damage to the seal inside the valve insert, the plant must be vented on the low-pressure side following a pressure test (valve outlet port), or the valve must be fully open during the pressure test and during venting (power supply connected and positioning signal at maximum or forced opening by G → ZC).

Expansion application

To prevent formation of flash gas on expansion applications, the velocity of the refrigerant in the fluid pipe may not exceed 3.3 ft/s (1 m/s). To assure this, the diameter of the fluid pipe must be greater than the nominal size of the valve.



1 = Evaporator
2 = Compressor
3 = Condenser
4 = Expansion valves

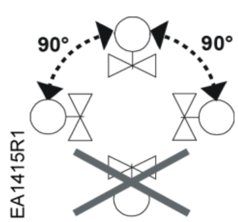
a) The differential pressure over reduction must be less than half the differential pressure Δp_{FL}.
b) The inlet path between diameter reduction and expansion valve inlet:
   - Must be straight for at least 2 feet (600 mm).
   - Must not contain any valves.

WARNING:

A filter/dryer must be mounted upstream of the expansion valve.
The valve is not explosion-proof.

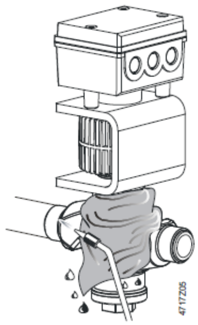
Installation Notes

The valve should be mounted and commissioned by a qualified installer. The same applies to the replacement electronics and the configuration of the controller.



- The refrigerant valves can be mounted in any orientation above horizontal, but upright mounting is preferable.
- Arrange the pipework so that the valve is not located at a low point in the plant where oil can collect.
- Fit the pipes so that the alignment does not distort the valve connections. Fix the valve body so that that it cannot vibrate. Vibration can cause connection pipes to burst.
- Before soldering the pipes, ensure that the direction of flow through the valve is correct.
- Carefully solder the pipes. To avoid dirt and the formation of scale (oxide), inert gas is recommended for soldering.

Installation Notes, Continued



- The flame should be large enough to ensure that the junction heats up quickly and the valve does not get too hot.
- The flame should be directed away from the valve.
- During soldering, cool the valve with a wet cloth, for example, to ensure that it does not become too hot.
- The valve is supplied complete with mounting instructions (Document Number 74 319 0232 0).

Maintenance

The refrigerant valve is maintenance-free.

Repair

The electronics can be replaced by ordering the ASR61 Service Kit. If the valve's interior is subjected to extensive wear, the valve can be repaired by replacing the ASR.N valve insert.

Warranty

Observe all application-specific technical data.

NOTE: If you ignore specified limits, Siemens Industry, Inc. will not assume any responsibility.

Specifications

Electrical	Power supply (extra low-voltage use only)	(SELV, PELV)
	24 Vac	
	Operating voltage	24 Vac ± 20%
	Frequency	45 to 65 Hz
	Typical power consumption	
	P_{med}	12W
	Standby	<1 W (valve fully closed)
	Rated apparent power, S_{NA}	22 VA (for selecting the transformer)
	Required fuse	Slow, 1.6 to 4A
	24 Vdc	
	Operating voltage	20 to 30 Vdc
	Current draw	0.5A/2A (maximum)
Signal inputs	Control signal Y	0/2 to 10 Vdc, 0/4 to 20 mA
	Impedance 0/2 to 10 Vdc	100K ohm/5nF (load <0.1 mA)
	0/4 to 20 mA	240 ohm/5nF
	Forced control ZC	
	Input impedance	22K ohm
	Closing the valve (ZC connected to G0)	<1 Vac; <0.8 Vdc
	Opening the valve (ZC connected to G)	>6 Vac; >5 Vdc
	No function (ZC not wired)	Positioning signal Y active
Signal outputs	Position feedback signal U Voltage	0/2 to 10 Vdc; load resistance ≥ 500 Ω
	Current	0/4 to 20 mA; load resistance ≤ 500Ω
	Stroke measurement	Inductive
	Non-linearity	Accuracy ±3% full scale
Positioning time		Less than 1 second
Electrical connections	Connection terminals	Screw terminals for 12 AWG wire

Functional valve data	Permissible Operating pressure [1)]	max. 914 psi (63 bar)
	Maximum differential pressure Δp_{max}	363 psi (25 bar)
	Valve characteristic	Linear
	Leakage rate (internally across seat)	Max. 0.002% C_V (K_{Vs}) resp. Max. 1 Nl/h gas at Δp = 58 psi (4 bar) Shut/off function, like solenoid normally closed (NC) function
	External seal	Hermetically sealed
	Permissible media	Ammonia (R717), CO2 (R744) and all safety refrigerants (R22, R134a, R404A, R407C, R507, and so on). Not suited for use with inflammable refrigerants
	Media temperature	-40°F to 248°F (-40°C to 120°C), Max. 284°F (140°C) for 10 min.
	Stroke resolution $\Delta H/H_{100}$	1:1000 (H = Stroke)
	Hysteresis	Typically 3%
	Mode of operation	Modulating
	Position when de-energized	Closed
	Orientation[2)]	Upright to horizontal
Materials	Valve body and parts	Steel/CrNi steel
	Seat/piston	CrNi steel
	Sealing disk/O-rings	PTFE/CR (chloroprene)
Pipe connections	Solder (weld-on-ends)	Referring to EN 1092-1 and ASME B16.25 schedule 40
	Inner diameter	0.88 in (22.4 mm)
	Outer diameter	1.33 in (33.7 mm)
Ambient conditions	Temperature	-13°F to 131°F (-25°C to 55°C)
	Humidity	10 to 100% rh
Miscellaneous	Weight	11.40 lb (5.17 kg)
	Dimensions **found.**	See **Error! Reference source not**
Agency approvals	Degree of protection	IP65 as per EN 60529 [2)] Conforms to CE requirements UL Certified to UL 873 cUL Certified to CSA C22.2 No. 24 Conforms to RCM requirements
	Electrical safety	EN 60730-1
	Protection class	Class III as per EN 60730
	Pollution degree	Degree 2 as per EN 60730
	Vibration [3]	EN 60068-2-6 5g acceleration, 10 to 150 Hz, 2.5 h (5g horizontal, max. 2g upright)

Agency approvals, Continued

Environmental compatibility	ISO 14001 (environment) ISO 9001 (quality) SN 36350 (environmentally-compatible products) RL 2002/95/EG (RoHS)
Permissible operating pressure	PED 97/23/EC
Pressure accessories	As per article 1, section 2.1.4
Fluid group 1	Without CE-marking as per article 3, section 3 (sound engineering practice)

1) To EN 12284 tested with 1,43 × operating pressure at 1305 psi (90 bar).
2) At 113°F (45°C) < T_{amb} < 131°F (55°C) and 176°F (80°C) < T_{med} < 248°F (120°C) the valve must be installed on its side to avoid shortening the service life of the valve electronics.
3) Transformer 160 VA.
4) In case of strong vibrations, use high-flex stranded wires for safety reasons.

Connection Terminals

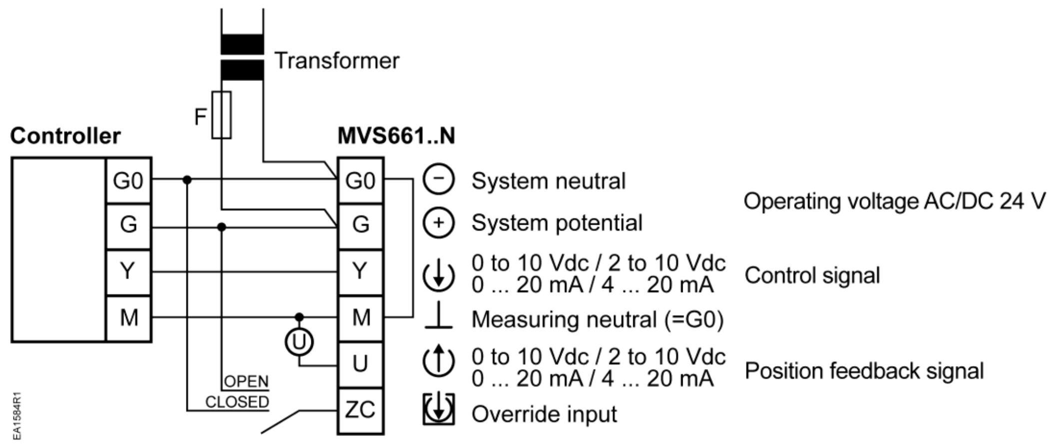


Figure 2. Connection Terminals.

Connection Diagrams

Terminal assignment for controller with four-wire connection (preferred method)

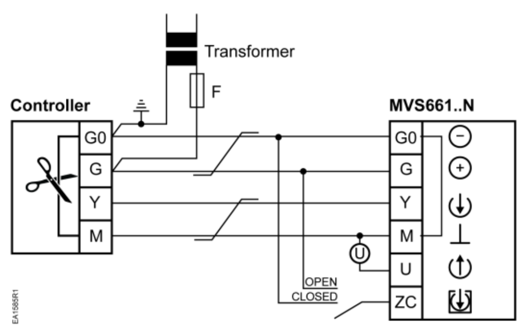


Figure 3. Common Transformer.

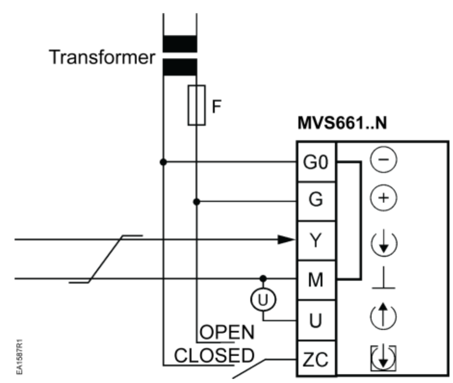


Figure 4. Separate Transformer.

Terminal assignment for controller with three-wire connection

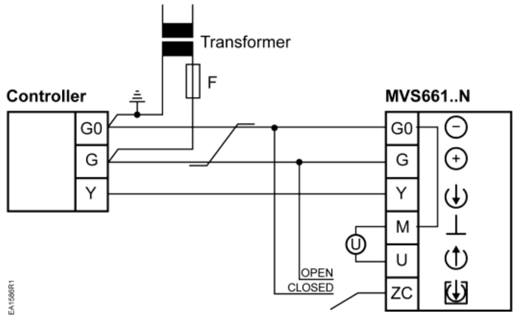


Figure 5. Common Transformer.

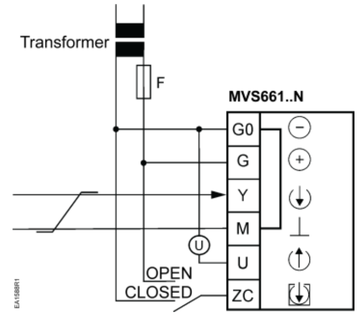


Figure 6. Separate Transformer.

Ⓤ Valve position indication (only if required). 0 to 10 Vdc → 0 to 100% volumetric flow 100.

Twisted pairs. If the 24 Vac power supply and the 0/2 to 10 Vdc, 0/4 to 20 mA positioning signal are routed separately, the 24 Vac line does not need to be twisted.

WARNING:

Piping must be connected to potential earth.

Valve Sizing and Correction Factor

The applications and tables on the following pages are designed to help with selecting the valves. To select the correct valve, the following data is required:

- Application
  - Expansion (see *Use of the MVS661…as an expansion valve*)
  - Hot-gas (see *Use of the MVS661…as a hot-gas valve*)
  - Suction throttle (see *Use of the MVS661…as a suction throttle valve*)
- Refrigerant type
- Evaporating temperature t_0 °F (°C)
- Condensing temperature t_c °F (°C)
- Refrigeration capacity Q_0 (kW)

To calculate the nominal capacity, use the following formula:

- **k_{vs} [m³/h] = Q_0 [kW] / K...*** ***K…** for expansion = **KE**
  for hot-gas = **KH**
  for suction throttle = **KS**

- $C_V = 1.156 \times kvs$
- The theoretical C_V (kv) value for the nominal refrigeration capacity of the plant should not be less than 50% of the C_V (kvs) value of the selected valve.
- For accurate valve sizing, Siemens Industry, Inc. recommends using the valve selection program **Refrigeration VASP**.

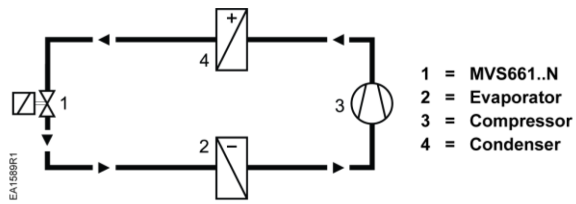
Application Examples

The application examples below reflect principles only. They do not include installation-specific details such as safety elements refrigerant collectors, and so on.

Use of the MVS661… as an expansion valve

- Typical control range is 20 to 100%.
- Increased capacity through better use of the evaporator
- The use of two or more compressors or compressor stages significantly increases efficiency with low loads.
- Especially suitable for fluctuating condensing and evaporating pressures
- For more information, see *Engineering Notes*.

Capacity optimization



Electronic superheat control is achieved by using additional control equipment.

Application example

Refrigerant R717C; Q_0 = 205 kW; t_o = 25°F (–5°C); t_c = 95°F (35°C)

The correct C_V (k_{vs}) value for the MVS661..-.. valve must be determined.

The important section of table KE for R717C (see Table 6 or Table 7) is the area around the working point. The correction factor KE relevant to the working point should be determined by linear interpolation from the four guide values.

Note on interpolation

In practice, the KE, KH or KS value can be estimated because the theoretical C_V (k_{vs})-value ascertained will be rounded off by up to 30% to one of the ten available C_V (k_{vs})-values, allowing you to proceed directly at Step 4.

Step 1: For t_c = 95°F (35°C), calculate the value for t_o = 14°F (-10°C) between values 68°F (20°C) and 104°F (40°C)in the table; result: **574.**

Step 2: For t_c = 95°F (35°C), calculate the value for t_o = 32°F (0°C) between values 68°F (20°C) and 104°F (40°C) in the table; result: **553.**

Step 3: For t_0 = 23°F (-5°C), calculate the value for t_c = 95°F (35°C) between correction factors 574 and 553; calculated in steps 1 and 2; result: **450.**

Step 4: Calculate the theoretical C_V (k_{vs}) value; result: **0.53** (**0.46 m^3/h).**

Step 5: Select the valve; the valve closest to the theoretical C_V ($k_{vs)}$ value is the **MVS661.25-0.4N.**

Step 6: Check that the theoretical C_V (k_{vs}) value is not less than 50% of the nominal C_V (k_{vs}) value.

Table 5. Interpolation Table.

KE-R717C	t_0 = 14°F (–10°C)	t_0 = 32°F (0°C)
t_c = 68°F (20°C)	**481**	**376**
t_c = 95°F *(35°C)*	574	553
t_c = 104°F (40°C)	**605**	**612**

Interpolation at	t_c = 95°F (35°C)
481 + [(605 – 481) × (35- 20)/(40 - 20)]	574
376 + [(612 - 376) × (35 - 20)/(40 - 20)]	553

Interpolation at	t_0 = 23°F (-5°C)
574 +[(553 - 574) × (-5 - 0)/(-10 - 0)]	450

k_v theoretical = 205 kW/450 = 0.46 m^3/h (C_V=kvs × 1.156=0.46×1.156=0.53).
Valve MVS661.25-0.4N is suitable, since: 0.46 $m^3/h/0.4\ m^3/h$ × 100% = 115% (> 50%).

Capacity control

- Refrigerant valve MVS661..-.. for capacity control of a dry expansion evaporator. Suction pressure and temperature are monitored with a mechanical capacity controller and re-injection valve.
  - Typical control range 0 to 100%.
  - Energy-efficient operation with low loads.
  - Ideal control of temperature and dehumidification.

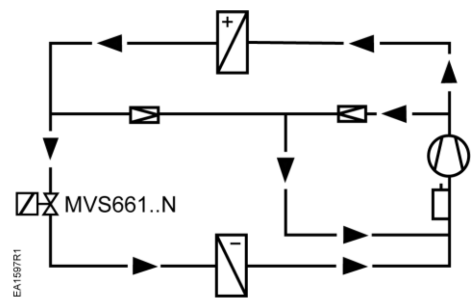


Figure 7. Dry Expansion Evaporator Capacity Control.

- Refrigerant valve MVS661..-.. for capacity control of a chiller.
  - Typical control range 10 to 100%.
  - Energy-efficient operation with low loads.
  - Allows wide adjustment of condensing and evaporating temperatures.
  - Ideal for use with plate heat exchangers.
  - Very high degree of frost protection.

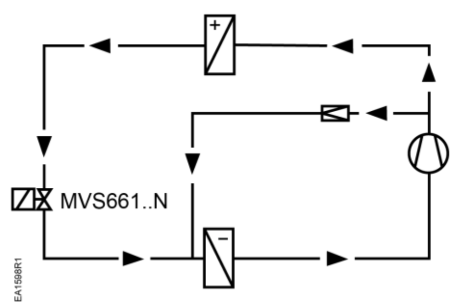


Figure 8. Chiller Capacity Control.

NOTE: A larger valve may be required for low load operation than is needed for full load conditions. To ensure that the selected valve will not be too small for low loads, sizing should take both possibilities into account.

Table 6. Correction Table, Expansion Valve (Fahrenheit).

	R717					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	324	265	124			
68	481	488	494	481	376	124
104	581	590	598	605	612	618
140	662	673	683	693	701	708

	R22					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	82	68	37			
68	101	104	107	105	81	18
104	108	111	114	118	120	123
140	104	108	112	116	119	122

	R744					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
-4	226	149				
32	262	264	241	166		
68	245	247	247	246	213	

	R134a					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	27					
68	71	74	77	66	43	
104	74	78	81	85	89	92
140	67	72	76	81	85	89

	R401A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	31					
68	80	83	85	72	46	
104	87	90	94	97	101	102
140	85	89	94	98	102	106

	R402A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	73	69	50			
68	77	81	85	88	74	35
104	71	75	80	84	88	91
140	50	55	60	65	69	74

	R404A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	69	63	44			
68	70	74	78	81	68	30
104	61	65	70	74	78	81
140	36	41	46	51	55	59

	R407A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	79	67	40			
68	91	95	98	102	82	30
104	89	94	98	102	106	110
140	72	77	82	87	92	96

	R407B					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	72	66	45			
68	77	80	84	88	75	34
104	69	74	78	83	87	91
140	46	51	56	61	66	70

	R407C					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	79	65	31			
68	98	101	105	108	85	21
104	100	104	109	113	117	121
140	87	93	98	103	108	113

	R410A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	116	117	91	12		
68	125	130	133	137	120	69
104	119	124	129	133	137	140
140	90	96	101	106	110	114

	R507					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	72	66	47			
68	78	81	83	86	71	33
104	74	78	81	84	87	90
140	53	57	61	64	68	71

- With superheat = 6 K With subcooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

Table 7. Correction Table, Expansion Valve (Celsius).

	R717					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	324	265	124			
20	481	488	494	481	376	124
40	581	590	598	605	612	618
60	662	673	683	693	701	708

	R22					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	82	68	37			
20	101	104	107	105	81	18
40	108	111	114	118	120	123
60	104	108	112	116	119	122

	R744					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
-20	226	149				
00	262	264	241	166		
20	245	247	247	246	213	

	R134a					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	27					
20	71	74	77	66	43	
40	74	78	81	85	89	92
60	67	72	76	81	85	89

	R401A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	31					
20	80	83	85	72	46	
40	87	90	94	97	101	102
60	85	89	94	98	102	106

	R402A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	73	69	50			
20	77	81	85	88	74	35
40	71	75	80	84	88	91
60	50	55	60	65	69	74

	R404A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	69	63	44			
20	70	74	78	81	68	30
40	61	65	70	74	78	81
60	36	41	46	51	55	59

	R407A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	79	67	40			
20	91	95	98	102	82	30
40	89	94	98	102	106	110
60	72	77	82	87	92	96

	R407B					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	72	66	45			
20	77	80	84	88	75	34
40	69	74	78	83	87	91
60	46	51	56	61	66	70

	R407C					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	79	65	31			
20	98	101	105	108	85	21
40	100	104	109	113	117	121
60	87	93	98	103	108	113

	R410A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	116	117	91	12		
20	125	130	133	137	120	69
40	119	124	129	133	137	140
60	90	96	101	106	110	114

	R507					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	72	66	47			
20	78	81	83	86	71	33
40	74	78	81	84	87	90
60	53	57	61	64	68	71

- With superheat = 6 KWith sub-cooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

MVS661… as a hot-gas valve

The control valve throttles the capacity of a compressor stage. The hot gas passes directly to the evaporator, and allows capacity control in the range from 100% down to approximately 0%.

Indirect hot-gas bypass application

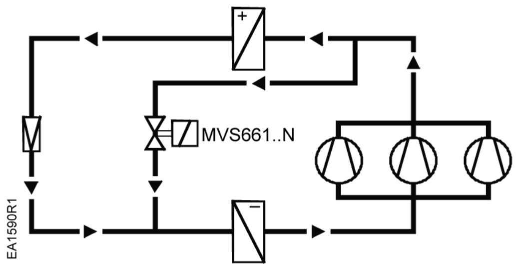


Figure 9. Indirect Hot-Gas Bypass Application.

Suitable for use in large refrigeration systems in air conditioning plant, to prevent unacceptable temperature fluctuations between the compressor stages.

Application example

With low loads, the evaporating and condensing pressures can fluctuate depending on the type of pressure control. In such cases, evaporating pressure increases and condensing pressure decreases. Due to the reduction in differential pressure across the fully open valve, the volumetric flow rate will drop – the valve is undersized. This is why the effective pressures must be taken into account when sizing the valve for low loads.

Refrigerant R507; 3 compressor stages; Q_0 = 75 kW; t_0 = 39°F (4°C); t_c = 104°F (40°C).
Part load Q_0 per stage = 28 kW; t_0= 39°F (4°C); t_c = 73.4°F (23°C).

KH-R507	t_0 = 32°F (0°C)	t_0 = 50°F (10°C)
t_c = 68°F (20°C)	**14.4**	**9.0**
t_c = 73°F (23°C)	*15.6*	*11.0*
t_c = 104°F (40°C)	**22.4**	**22.0**

Interpolation at	t_c = 73.4°F (23°C)
14.4 + [(22.4 – 14.4) × (23 - 20)/(40 - 20)]	15.6
9.0 + [(22.0 – 9.0) × (23 - 20)/(40 - 20)]	11.0

Interpolation at	t_0 = 39°F (4°C)
15.6 + [(11.0 – 15.6) × (4 - 0) (10 - 0)]	13.8

k_{vs} theoretical = 28 kW/13.8 = 2.03 m^3/h (C_v = k_{vs} × 1.156 = 2.03 × 1.156 = 2.35)
Valve MVS661.25-2.5 is suitable, since: C_V = k_{vs} × 1.156 = 2.03 × 1.56 = 2.35
(2.03 m^3/h / 2.5 m^3/h × 100% = 81% [> 50%])

Direct hot-gas bypass application

The control valve throttles the capacity of one compressor stage. The gas is fed to the suction side of the compressor and then cooled using a reinjection valve. Capacity control ranges from 100% down to approximately 10%.

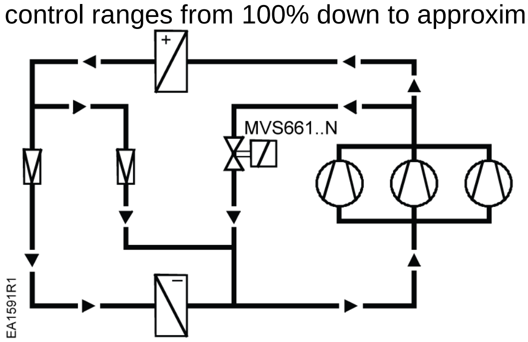


Figure 10. Direct Hot-Gas Bypass Application.

Suitable for large refrigeration systems in air conditioning applications with several compressors or compressor stages, and where the evaporator and compressor are some distance apart (attention must be paid to the oil return).

Table 8. Correction Table, Hot Gas Valve (Fahrenheit).

	R717					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	20	19	14			
68	38	38	38	38	35	19
104	67	66	65	64	64	63
140	110	107	105	103	102	100

	R22					
$t_c \backslash t_o$	-40	-22	-4	-14	32	50
32	8.9	8.4	6.3			
68	15.3	15.1	14.8	14.6	13.2	6.5
104	24.2	23.7	23.2	22.8	22.4	22.1
140	35.7	34.7	33.8	33.0	32.3	31.7

	R744					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
-4	38.1	30.5				
32	60.9	59.8	58.1	47.1		
68	87.3	84.9	82.5	80.2	76.1	

	R134a					
$t_c \backslash t_o$	-40	-22	-4	-14	32	50
32	4.5					
68	9.8	9.6	9.5	9.2	7.4	
104	15.9	15.6	15.3	15.1	14.9	14.7
140	23.8	23.2	22.7	22.3	21.9	21.6

	R401A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	4.7					
68	10.2	10.0	9.9	9.5	7.6	
104	16.9	16.6	16.2	16.0	15.8	15.6
140	25.9	25.2	24.6	24.1	23.7	23.3

	R402A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	9.7	9.5	8.3			
68	15.9	15.7	15.4	15.2	14.5	9.3
104	23.7	23.2	22.7	22.4	22.0	21.7
140	31.5	30.7	29.9	29.2	28.7	28.1

	R404A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	9.4	9.2	7.8			
68	15.2	15.0	14.8	14.6	13.9	8.6
104	22.3	21.8	21.5	21.1	20.9	20.6
140	28.8	28.0	27.4	26.8	26.4	25.9

	R407A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	8.9	8.6	6.7			
68	15.7	15.4	15.2	15.0	14.1	8.0
104	24.9	24.4	23.9	23.5	23.1	22.8
140	35.9	34.9	34.0	33.2	32.6	32.0

	R407B					
$t_c \backslash t_o$	-40	-22	-4	-14	32	50
32	9.0	8.8	7.4			
68	15.3	15.1	14.8	14.7	14.0	8.8
104	23.3	22.8	22.4	22.0	21.7	21.5
140	31.6	30.7	30.0	29.3	28.8	28.3

	R407C					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	8.6	8.1	5.9			
68	15.3	15.0	14.8	14.6	13.6	7.0
104	24.7	24.2	23.7	23.3	22.9	22.6
140	36.3	35.3	34.4	33.6	33.0	32.4

	R507					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	9.8	9.5	8.1			
68	16.1	15.8	15.5	15.3	14.4	9.0
104	24.5	23.8	23.3	22.8	22.4	22.0
140	33.1	31.8	30.7	29.8	29.0	28.3

	R410A					
$t_c \backslash t_o$	-40	-22	-4	14	32	50
32	14.5	14.3	13.2	6.2		
68	24.2	23.7	23.3	23.0	22.1	15.9
104	36.8	35.9	35.1	34.4	33.7	33.1
140	50.0	48.5	47.2	46.0	44.9	43.8

- With superheat = 6 K With subcooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

Table 9. Correction Table, Hot Gas Valve (Celsius).

	R717					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	20	19	14			
20	38	38	38	38	35	19
40	67	66	65	64	64	63
60	110	107	105	103	102	100

	R22					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	8.9	8.4	6.3			
20	15.3	15.1	14.8	14.6	13.2	6.5
40	24.2	23.7	23.2	22.8	22.4	22.1
60	35.7	34.7	33.8	33.0	32.3	31.7

	R744					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
-20	38.1	30.5				
00	60.9	59.8	58.1	47.1		
20	87.3	84.9	82.5	80.2	76.1	

	R134a					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	4.5					
20	9.8	9.6	9.5	9.2	7.4	
40	15.9	15.6	15.3	15.1	14.9	14.7
60	23.8	23.2	22.7	22.3	21.9	21.6

	R401A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	4.7					
20	10.2	10.0	9.9	9.5	7.6	
40	16.9	16.6	16.2	16.0	15.8	15.6
60	25.9	25.2	24.6	24.1	23.7	23.3

	R402A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	9.7	9.5	8.3			
20	15.9	15.7	15.4	15.2	14.5	9.3
40	23.7	23.2	22.7	22.4	22.0	21.7
60	31.5	30.7	29.9	29.2	28.7	28.1

	R404A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	9.4	9.2	7.8			
20	15.2	15.0	14.8	14.6	13.9	8.6
40	22.3	21.8	21.5	21.1	20.9	20.6
60	28.8	28.0	27.4	26.8	26.4	25.9

	R407A					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	8.9	8.6	6.7			
20	15.7	15.4	15.2	15.0	14.1	8.0
40	24.9	24.4	23.9	23.5	23.1	22.8
60	35.9	34.9	34.0	33.2	32.6	32.0

	R407B					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	9.0	8.8	7.4			
20	15.3	15.1	14.8	14.7	14.0	8.8
40	23.3	22.8	22.4	22.0	21.7	21.5
60	31.6	30.7	30.0	29.3	28.8	28.3

	R407C					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	8.6	8.1	5.9			
20	15.3	15.0	14.8	14.6	13.6	7.0
40	24.7	24.2	23.7	23.3	22.9	22.6
60	36.3	35.3	34.4	33.6	33.0	32.4

	R507					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	9.8	9.5	8.1			
20	16.1	15.8	15.5	15.3	14.4	9.0
40	24.5	23.8	23.3	22.8	22.4	22.0
60	33.1	31.8	30.7	29.8	29.0	28.3

	R410A)					
$t_c \backslash t_o$	-40	-30	-20	-10	0	10
00	14.5	14.3	13.2	6.2		
20	24.2	23.7	23.3	23.0	22.1	15.9
40	36.8	35.9	35.1	34.4	33.7	33.1
60	50.0	48.5	47.2	46.0	44.9	43.8

- With superheat = 6 K   With subcooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

MVS661… as a suction throttle valve

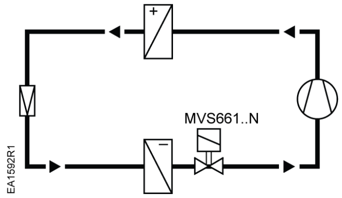


Figure 11. Suction Throttle Valve Application.

Typical control range 50 to 100%.

Minimum stroke limit control:
To ensure optimum cooling of the compressor, either a capacity controller must be provided for the compressor, or a minimum stroke must be set using the valve electronics.

The minimum stroke is limited to a maximum of 80%. At zero load, the minimum stroke must be sufficient to ensure that the minimum gas velocity in the suction line is > 0.7 m/s and that the compressor is adequately cooled.
As the control valve closes, the evaporating temperature rises, and the air cooling effect decreases continuously. The electronic control system provides demand-based cooling without unwanted dehumidification and costly retreatment of the air.
The pressure at the compressor inlet falls and the power consumption of the compressor is reduced. The energy savings to be anticipated with low loads can be determined from the compressor selection chart (power consumption at minimum permissible suction pressure). Compressor energy savings of up to 40% can be achieved.

NOTE: The recommended differential pressure Δp_{v100} across the fully open control valve is between 2.2 psi (0.15 bar) < Δp_{v100} < 7.25 psi (0.5 bar).

Application example

Refrigerant R134A; Q_0 = 9.5 kW; t_0 = 39°F (4°C); t_c = 104°F (40°C);
Differential pressure across MVS661: Δp_{v100} = 3.6 psi (0.25 bar)

In this application example, t_0, t_c and Δp_{v100} are to be interpolated.

KS-R134a	t_0 = 32°F (0°C)	t_0 = 50°F (10°C)	Interpolation at	t_0 = 39°F (4°C)
0.15/20	2.2	2.7	2.2 + [(2.7 – 2.2) × (4 - 0)/(10 - 0)]	2.4
0.15/50	1.7	2.1	1.7 + [(2.1 – 1.7) × (4 - 0)/(10 - 0)]	1.9
0.45/20	3.6	4.5	3.6 + [(4.5 – 3.6) × (4 - 0)/(10 - 0)]	4.0
0.45/50	2.7	3.4	2.7 + [(3.4 – 2.7) × (4 - 0)/(10 - 0)]	3.0

t_0 = 39°F (4°C)	t_c = 68°F (20°C)	t_c = 122°F (50°C)	Interpolation at	t_c = 104°F (40°C)
Δp_{v100} 0.15	2.4	1.9	2.4 + [(1.9 – 2.4) × (40 - 20)/(50 - 20)]	2.1
Δp_{v100} 0.45	4.0	3.0	4.0 + [(3.0 – 4.0) × (40 - 20)/(50 - 20)]	3.3

t_c = 104°F (40°C)	Δp_{v100} 2.2 psi (0.15 bar)	Δp_{v100} 6.5 psi (0.45 bar)	Interpolation at	Δp_{v100} 3.6 psi (0.25 bar)
	2.1	3.3	2.1 + [(3.3 – 2.1) × (0.25 – 0.15)/(0.45 – 0.15)]	2.5

k_{vs} theoretical = 9.5 kW / 2.5 = 3.8 m^3/h (CV = k_{vs} × 1.156 = 3.8 × 1.156 = 4.4).
Valve MVL661.25-6.3 is suitable, since 3.8 m^3/h / 6.3 m^3/h x 10 % = 60% (> 50%).
It is recommended that the C_V (k_{vs}) value be set to 63% = 4.6 (4 m^3/h).

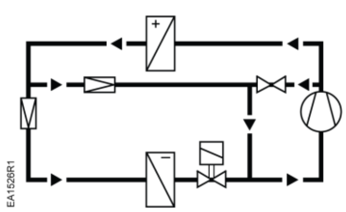


Figure 12.

Typical control range 10 to 100%.

The capacity controller ensures that the compressor is adequately cooled, making it unnecessary to set a minimum stroke in the refrigerant valve.

Table 10. Correction Table, Suction Throttle Valve (psi/Fahrenheit).

t_c	R717					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	2.7	3.7	4.8	6.0	7.3	8.8
2.2/122	2.3	3.2	4.2	5.2	6.4	7.8
6.5/68	3.2	5.2	7.4	9.7	12.1	14.8
6.5/122	2.8	4.6	6.5	8.5	10.7	13.1

t_c	R22					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.2	1.5	1.9	2.4	2.9	3.4
2.2/122	0.9	1.2	1.5	1.9	2.3	2.7
6.5/68	1.5	2.3	3.0	3.9	4.8	5.7
6.5/122	1.2	1.8	2.4	3.0	3.8	4.6

t_c	R152A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	0.9	1.3	1.7	2.2	2.7	3.3
2.2/122	0.7	1.0	1.4	1.7	2.2	2.7
6.5/68	1.0	1.5	2.4	3.3	4.3	5.3
6.5/122	0.7	1.2	1.9	2.6	3.5	4.4

t_c	R134a					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	0.7	1.0	1.4	1.8	2.2	2.7
2.2/122	0.5	0.7	1.0	1.3	1.7	2.1
6.5/68	0.7	1.2	1.9	2.7	3.6	4.5
6.5/122	0.5	0.9	1.4	2.0	2.7	3.4

t_c	R401A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	0.8	1.1	1.5	1.9	2.3	2.9
2.2/122	0.6	0.8	1.1	1.5	1.8	2.3
6.5/68	0.8	1.3	2.1	2.9	3.7	4.7
6.5/122	0.6	1.0	1.6	2.3	3.0	3.7

t_c	R402A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.1	1.4	1.8	2.2	2.7	3.3
2.2/122	0.7	0.9	1.2	1.5	1.8	2.3
6.5/68	1.5	2.2	2.9	3.7	4.6	5.6
6.5/122	0.9	1.4	1.9	2.4	3.1	3.8

t_c	R404A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.0	1.3	1.7	2.2	2.7	3.3
2.2/122	0.6	0.8	1.1	1.4	1.7	2.1
6.5/68	1.4	2.1	2.8	3.6	4.5	5.5
6.5/122	0.8	1.2	1.7	2.3	2.9	3.6

t_c	R407A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.0	1.4	1.8	2.3	2.9	3.5
2.2/122	0.7	1.0	1.3	1.6	2.1	2.6
6.5/68	1.3	2.0	2.9	3.8	4.7	5.9
6.5/122	0.9	1.4	2.0	2.7	3.4	4.3

t_c	R407B					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.0	1.3	1.7	2.2	2.7	3.3
2.2/122	0.6	0.8	1.1	1.4	1.8	2.2
6.5/68	1.3	2.0	2.7	3.5	4.5	5.5
6.5/122	0.8	1.2	1.7	2.3	3.0	3.8

t_c	R407C					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.0	1.4	1.8	2.3	2.9	3.5
2.2/122	0.7	1.0	1.3	1.7	2.1	2.6
6.5/68	1.3	2.0	2.8	3.8	4.8	5.9
6.5/122	0.9	1.4	2.1	2.8	3.5	4.4

t_c	R507					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.1	1.4	1.8	2.3	2.7	3.3
2.2/122	0.7	1.0	1.3	1.6	1.9	2.4
6.5/68	1.6	2.2	2.9	3.7	4.6	5.6
6.5/122	1.1	1.5	2.0	2.6	3.2	4.0

t_c	R410A					
Δp_{v100} \ t_o	-40	-22	-4	14	32	50
2.2/68	1.5	2.0	2.5	3.0	3.6	4.4
2.2/122	1.0	1.3	1.7	2.1	2.6	3.1
6.5/68	2.3	3.1	4.0	5.0	6.1	7.4
6.5/122	1.6	2.1	2.8	3.5	4.4	5.3

- With superheat = 6 K   With sub-cooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

Table 11. Correction Table, Suction Throttle Valve (bar/Celsius).

t_c	**R717**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	2.7	3.7	4.8	6.0	7.3	8.8
0.15/50	2.3	3.2	4.2	5.2	6.4	7.8
0.45/20	3.2	5.2	7.4	9.7	12.1	14.8
0.45/50	2.8	4.6	6.5	8.5	10.7	13.1

t_c	**R22**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.2	1.5	1.9	2.4	2.9	3.4
0.15/50	0.9	1.2	1.5	1.9	2.3	2.7
0.45/20	1.5	2.3	3.0	3.9	4.8	5.7
0.45/50	1.2	1.8	2.4	3.0	3.8	4.6

t_c	**R152A [1)]**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	0.9	1.3	1.7	2.2	2.7	3.3
0.15/50	0.7	1.0	1.4	1.7	2.2	2.7
0.45/20	1.0	1.5	2.4	3.3	4.3	5.3
0.45/50	0.7	1.2	1.9	2.6	3.5	4.4

t_c	**R134a**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	0.7	1.0	1.4	1.8	2.2	2.7
0.15/50	0.5	0.7	1.0	1.3	1.7	2.1
0.45/20	0.7	1.2	1.9	2.7	3.6	4.5
0.45/50	0.5	0.9	1.4	2.0	2.7	3.4

t_c	**R401A**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	0.8	1.1	1.5	1.9	2.3	2.9
0.15/50	0.6	0.8	1.1	1.5	1.8	2.3
0.45/20	0.8	1.3	2.1	2.9	3.7	4.7
0.45/50	0.6	1.0	1.6	2.3	3.0	3.7

t_c	**R402A**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.1	1.4	1.8	2.2	2.7	3.3
0.15/50	0.7	0.9	1.2	1.5	1.8	2.3
0.45/20	1.5	2.2	2.9	3.7	4.6	5.6
0.45/50	0.9	1.4	1.9	2.4	3.1	3.8

t_c	**R404A**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.0	1.3	1.7	2.2	2.7	3.3
0.15/50	0.6	0.8	1.1	1.4	1.7	2.1
0.45/20	1.4	2.1	2.8	3.6	4.5	5.5
0.45/50	0.8	1.2	1.7	2.3	2.9	3.6

t_c	**R407A**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.0	1.4	1.8	2.3	2.9	3.5
0.15/50	0.7	1.0	1.3	1.6	2.1	2.6
0.45/20	1.3	2.0	2.9	3.8	4.7	5.9
0.45/50	0.9	1.4	2.0	2.7	3.4	4.3

t_c	**R407B**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.0	1.3	1.7	2.2	2.7	3.3
0.15/50	0.6	0.8	1.1	1.4	1.8	2.2
0.45/20	1.3	2.0	2.7	3.5	4.5	5.5
0.45/50	0.8	1.2	1.7	2.3	3.0	3.8

t_c	**R407C**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.0	1.4	1.8	2.3	2.9	3.5
0.15/50	0.7	1.0	1.3	1.7	2.1	2.6
0.45/20	1.3	2.0	2.8	3.8	4.8	5.9
0.45/50	0.9	1.4	2.1	2.8	3.5	4.4

t_c	**R507**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.1	1.4	1.8	2.3	2.7	3.3
0.15/50	0.7	1.0	1.3	1.6	1.9	2.4
0.45/20	1.6	2.2	2.9	3.7	4.6	5.6
0.45/50	1.1	1.5	2.0	2.6	3.2	4.0

t_c	**R410A**					
Δp_{v100} \ t_o	-40	-30	-20	-10	0	10
0.15/20	1.5	2.0	2.5	3.0	3.6	4.4
0.15/50	1.0	1.3	1.7	2.1	2.6	3.1
0.45/20	2.3	3.1	4.0	5.0	6.1	7.4
0.45/50	1.6	2.1	2.8	3.5	4.4	5.3

- With superheat = 6 K With subcooling = 2 K Δp upstream of evaporator = 23 psi (1.6 bar)
- Δp condenser = 4.4 psi (0.3 bar) Δp evaporator = 4.4 psi (0.3 bar)

Dimensions

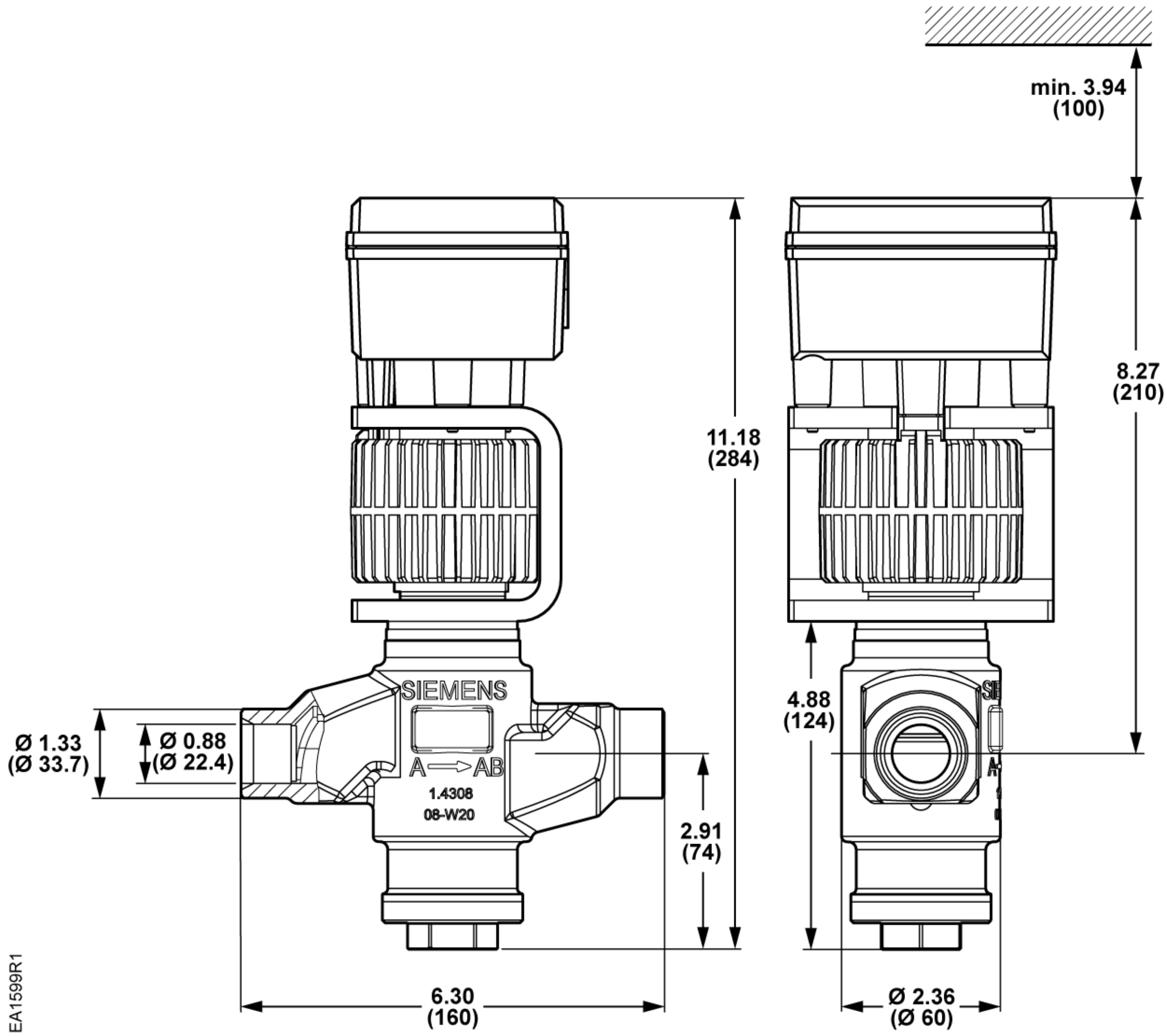


Figure 13. Dimensions in Inches (mm).