PRESSURE RELIEF VALVES

The function of a Pressure Relief Valve is to protect against over-pressure. For safety reasons, excessive over-pressure in any part of the refrigeration system must be avoided

Applications

A typical application for a Henry Technologies pressure relief valve (PRV) is to protect a liquid receiver from being over-pressurised. In the event of a fire, any liquid refrigerant inside the receiver will evaporate resulting in an increase in pressure. The PRV will safely control this increase in pressure by venting the vapour from the receiver. Another application is to protect equipment from compressor over-pressure.

Henry Technologies pressure relief valves are designed to discharge vapour and should not be used to vent liquid refrigerant. The valves are "back-pressure dependent" and are therefore required to discharge to atmosphere.

The brass and stainless steel series valves are suitable for use with HCFC and HFC refrigerant gases. The stainless steel series valves are also suitable for ammonia.

Once a PRV has discharged, replacement is recommended, as the set pressure can no longer be guaranteed. Refer to Installation Section for further information.

In line with the Institute of Refrigeration Guidelines (UK), Henry Technologies recommend that a PRV should be replaced at least every 5 years. These intervals may have to be reduced if other regulations apply.

It is recommended to have a relief valve pressure setting at least 25% higher than the maximum system operating pressure. The PRV set pressure should not be higher than the design pressure (MWP) of the vessel.

How it works

A conventional PRV is designed to open at a predetermined pressure - the set pressure. A spring exerts a sealing force on a valve seat via a piston seal assembly. At a pressure equal to the set pressure, the piston will start to lift resulting in a small amount of flow through the valve. From this point, the pressure force acting on the piston increases significantly and overcomes the spring force. This imbalance of forces causes the valve to "pop" fully open. By design, the difference in pressure from the valve set point to the fully open condition is no more than 10%. System pressure is controlled/reduced by venting the refrigerant vapour through the valve. The valve then re-closes at a pressure where the spring force overcomes the piston force. Under normal system operating conditions, the pressure at the valve inlet is below the set pressure. Only under abnormal operating conditions should the PRV be open.

Main features

- Proven safe design
- Category IV PED compliant
- Precision machined parts for reliability
- High flow capacity
- Compact
- Non-stick teflon valve seal
- Blow-out proof seal design
- Seal material with high chemical resistance
- Tamper proof
- Test Certificates available on request
- Non-standard pressure settings available on request

Technical Specification

All Henry Technologies PRV's are designed and manufactured to the intent of ASME VIII Division 1.

For 526, 5230 and 5231 series models:-

Set pressure range = 14 to 31 barg
Allowable operating temperature = -40°C to +107°C

For 5232 and 524 series models:-

Set pressure range = 10.3 to 31 barg
Allowable operating temperature = -40°C to +107°C

For 53 series models:-

Set pressure range = 10.3 to 31 barg
Allowable operating temperature = -29°C to +135°C

Materials of Construction

For all 52 series valves, the main body and outlet connection are made from brass. Valve internals such as the piston and adjusting gland are either made from brass, plated steel or stainless steel.

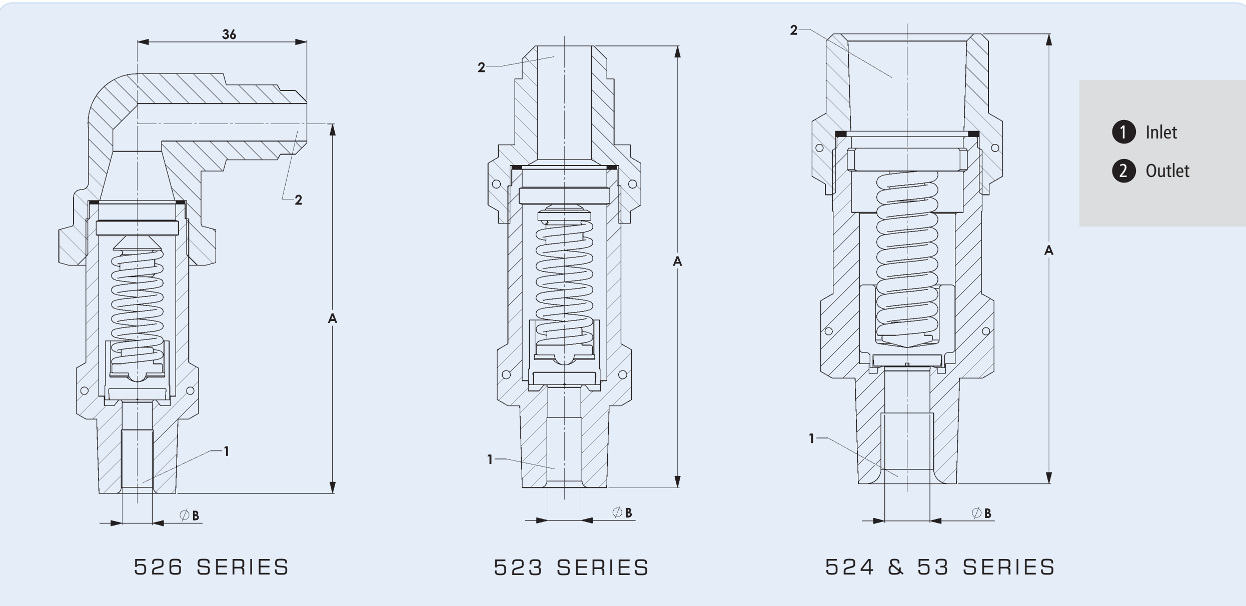
For the 53 series valves, the main body is made from stainless steel. The outlet connection and valve internals are made from either plated steel or stainless steel.

For all valves, the seal is made from premium quality teflon (PTFE). All springs are made from high strength plated alloy steel.

Angle Relief Valve - Brass								
Part No	Conn Size (inch)		Dimensions (mm)		Flow Area (mm^2)	K_{dr}	Weight (kg)	CE Cat
	Inlet	Outlet	A	ØB				
526E-xx.x BAR-CE	3/8 MPT	3/8 SAE Flare	78	6.35	31.67	0.41	0.26	Cat IV

Straight-through Relief Valves - Brass								
Part No	Conn Size (inch)		Dimensions (mm)		Flow Area (mm^2)	K_{dr}	Weight (kg)	CE Cat
	Inlet	Outlet	A	ØB				
5230A-xx.x BAR-CE	1/4 MPT	1/2 SAE Flare	85	6.35	31.67	0.68	0.18	Cat IV
5231A-xx.x BAR-CE	3/8 MPT	1/2 SAE Flare	85	6.35	31.67	0.68	0.19	Cat IV
5231B-xx.x BAR-CE	1/2 MPT	5/8 SAE Flare	91	6.35	31.67	0.68	0.22	Cat IV
5232A-xx.x BAR-CE	1/2 MPT	3/4 SAE Flare	109	9.5	71.26	0.67	0.44	Cat IV
5240-xx.x BAR-CE	1/2 MPT	3/4 FPT	95	9.5	71.26	0.67	0.41	Cat IV
5242-xx.x BAR-CE	3/4 MPT	3/4 FPT	95	9.5	71.26	0.67	0.45	Cat IV
5244-xx.x BAR-CE	1 MPT	1 FPT	106	12.7	126.68	0.68	0.66	Cat IV
5246-xx.x BAR-CE	1 1/4 MPT	1 1/4 FPT	145	17.9	250.41	0.60	1.48	Cat IV

Straight-through Relief Valves - Stainless Steel								
Part No	Conn Size (inch)		Dimensions (mm)		Flow Area (mm^2)	K_{dr}	Weight (kg)	CE Cat
	Inlet	Outlet	A	ØB				
5340-xx.x BAR-CE	1/2 MPT	3/4 FPT	94	9.5	71.26	0.67	0.39	Cat IV
5342-xx.x BAR-CE	3/4 MPT	3/4 FPT	94	9.5	71.26	0.67	0.43	Cat IV
5344A-xx.x BAR-CE	3/4 MPT	1 FPT	106	12.7	126.68	0.68	0.56	Cat IV
5344-xx.x BAR-CE	1 MPT	1 FPT	106	12.7	126.68	0.68	0.62	Cat IV
5345-xx.x BAR-CE	1 MPT	1 1/4 FPT	149	17.9	250.41	0.6	1.25	Cat IV
5346-xx.x BAR-CE	1 1/4 MPT	1 1/4 FPT	145	17.9	250.41	0.6	1.37	Cat IV



Standard settings are (barg): 10.3, 13.8, 14.0, 16.2, 17.2, 20.7, 24.1, 24.8, 25.9, 27.6, 29.3 and 31.0

Part No	Valve Capacity Ratings (kg Air/min) @ 20ºC. Standard Pressure setting (barg)							
	10.3	14	16.2	20.7	24.1	24.8	27.6	31
*526E-CE	N/A	3	3.4	4.4	5	5.1	5.8	6.5
*5230A-CE *5231A-CE *5231B-CE	N/A	4.9	5.8	7.3	8.4	8.6	9.6	10.8
5232A-CE 5240-CE 5242-CE 5340-CE 5342-CE	8.4	11.5	12.7	16	18.6	19.1	21.2	23.9
5244-CE 5344-CE 5344A-CE	15.1	20.7	23	29	33.6	34.5	38.2	42.8
5246-CE 5345-CE 5346-CE	26.5	34.5	40.2	50.7	58.8	60.5	66.9	75.0

*Minimum set pressure is 14 barg.

Performance data

The valve discharge capacities are presented in the table for standard pressure settings.

For other pressure settings, the capacity can be determined by using a standard pressure setting as a basis.

Example:

The 526E valve capacity is required for a pressure setting of 15 barg.

$$\text{Capacity (new setting)} = \left(\frac{\text{P (new setting)} + 1.013}{\text{P (std setting)} + 1.013}\right) \times \text{Capacity (std setting)}$$

In this case, the most convenient standard pressure set to use is 14 barg.

$$\text{Capacity (15 barg)} = \left(\frac{15 + 1.013}{14 + 1.013}\right) \times 3.0 = \left(\frac{16.013}{15.013}\right) \times 3.0 = 3.2\text{kg/min of air}$$

All capacities are shown in kg/min of air @ 20°C. Air is used as a reference medium.

To convert from air to refrigerant capacity, the following formula can be used:-

$$W_r = \frac{W_{air}}{r_w}$$

Where:-

W_r = Mass flow of refrigerant, kg/min
W_{air} = Mass flow of air, kg/min
r_w = Conversion factor

For simplicity, r_w factors are presented for a number of common refrigerants. Using these factors will give an approximate solution. If a high degree of accuracy is required, the user should consult reference (1). This reference details a formula for the r_w factor.

Refrigerant	Conversion factor, r_w
R22	0.61
R134a	0.57
R404A	0.59
R407C	0.62
R410A	0.67
R717	1.33

Current European Refrigeration Standards do not use air capacity for valve selection. To suit some users Henry Technologies has however included this information.

In line with current European standards, an alternative approach is recommended by Henry Technologies. Flow capacity is calculated using the valve flow area, A, and the de-rated coefficient of discharge, K_{dr}. These parameters are listed in the Dimension Tables.

Selection Guidelines

For safety reasons, relief valve selection should only be carried out by suitably qualified engineers.

It is important to select/size a relief valve taking into account all possible sources of over-pressure such as external heat, internal heat, compressor operation and liquid expansion. System control methodology, type of equipment used, etc. dictate the number of over-pressure sources that need to be taken into account for PRV selection.

Henry Technologies pressure relief valves are designed to discharge refrigerant vapour and are therefore not recommended for protection against liquid over-pressure.

As a pressure relief valve is a safety device, it is essential that a proper selection is made. The European Standards EN378 (reference 2) and EN13136 (reference 3) are recommended for selection. In some cases, existing National Standards should be consulted.

An example selection is included using the recommended approach from the above references. This example shows the calculation for an external fire case only. Different formulae are required for the other sources of over-pressure.

Example

A liquid receiver is to be protected from over-pressure due to fire.

Receiver dimensions = 2.2m long (L) x 0.254m outside diameter (D)

Refrigerant = R404A

Pressure setting = 20.7 barg

$$Q_{md} = \frac{3600 \times \varphi \times A_{surf}}{h_{vap}}$$

Q_{md} = Minimum required discharge capacity, of refrigerant, of the pressure relief valve, kg/hour

φ = Density of heat flow rate, kW/m^2. The standards assume a value of 10 kW/m^2 but state that a higher value can be used if necessary. This figure relates to an un-lagged vessel.

A_{surf} = External surface area of the vessel, m^2

h_{vap} = Heat of vapourisation calculated at 1.1 times the set pressure, in bar a, of the pressure relief valve, kJ/kg

Note:
When the relief valve setting is close to the critical pressure of the refrigerant, this sizing method may not be applicable.

$$A_{surf} = (\pi \times D \times L) + 2\left(D^2 \times \frac{\pi}{4}\right)$$

Hence,

$$A_{surf} = (\pi \times 0.254 \times 2.2) + 2\left(0.254^2 \times \frac{\pi}{4}\right) = 1.86\text{m}^2$$

Calculate the heat of vapourisation, h_{vap}, taken at 1.1 times set pressure:-

(20.7 x 1.1) + 1.013 = 23.78 bar a

From refrigerant property tables, use saturated vapour and liquid enthalpies at the above pressure.

Vapor = 285.8 kJ/kg; Liquid = 181.2 kJ/kg

h_{vap} = (285.8-181.2) = 104.6 kJ/kg

$$Q_{md} = \frac{3600 \times 10 \times 1.86}{104.6} = \underline{640\text{ kg/hr}}\text{, R404A}$$

To calculate the mass flow rate through a PRV, the equation is:-

$$Q_m = 0.2883 \times C \times A \times K_{dr} \times \sqrt{\frac{P_o}{V_o}}$$

This equation assumes critical flow.

C = Function of the isentropic exponent

A = Flow area of PRV, mm^2

K_{dr} = De-rated coefficient of discharge of PRV

P_o = Actual relieving pressure, $P_o = 1.1P_{set} + P_{atm}$, bar a

V_o = Specific volume of saturated vapor @ P_o, m^3/kg

Refrigerant data should be referenced for the C and V_o values.

The objective is to select a PRV which results in $Q_m > Q_{md}$. In this way, the relieving capacity of the PRV is greater than required thus avoiding excessive vessel pressure. The user must select a valve model with an adequate (A x K_{dr}) factor.

For this example, a 523 series model has been selected with an orifice size of 6.35mm. From the dimension table, A = 31.67 mm^2, K_{dr} = 0.68

$$Q_m = 0.2883 \times 2.49 \times 31.67 \times 0.68 \times \sqrt{\frac{23.78}{0.0074}} = \underline{876.4\text{ kg/hr}}\text{, R404A}$$

Therefore, for this example suitable models are 5230A, 5231A or 5231B. The final choice depends on the preferred inlet and outlet connection sizes.

Additional notes:-

1. If a Henry Technologies rupture disc is used in conjunction with a Henry Technologies PRV, then the PRV capacity should be de-rated by 10%. In the above example, the PRV capacity would be de-rated to 788.8 kg/hr (876.4 x 0.9).
2. It is important not to grossly over-size a PRV as the performance can be affected. Contact Henry Technologies for further guidance.
3. Inlet and outlet piping must be sized to an appropriate standard to avoid excessive pressure losses. Excessive pressure losses affect valve performance. Consult reference 3.

References:-

(1) ANSI/ASHRAE 15-2004 (2) EN 378-2:2000* (3) EN 13136:2001*

*Latest revisions at time of publication. At time of publication, these standards were under review. The user should ensure the latest revisions are referenced.

Installation – Main issues

1. Connect the relief valve at a location above the liquid refrigerant level, in the vapour space. Stop valves should not be located between the vessel and the relief valve except the three-way type.
2. Do not discharge the relief valve prior to installation or when pressure testing the system.
3. Pressure relief valves should be mounted vertically.
4. Relief valves should be changed out after discharge. Most systems are subject to accumulations of debris. Particles of metal and dirt are generally blown onto relief valve seats during discharge. This inhibits the relief valve from re-sealing at the original set pressure. A valve can also relieve at a lower pressure than the stamped valve setting due to the force of the re-closing action.
5. The pipe-work must not impose loads on the relief valve. Loads can occur due to misalignment, thermal expansion, discharge gas thrust, etc.