THE BASICS OF PRESSURE RELIEF VALVES

Contents

Beswick pressure relief valves can be viewed at http://catalog.beswick.com

BPR

Pressure relief valves (safety relief valves) are designed to open at a preset pressure and discharge fluid until pressure drops to acceptable levels. The development of the safety relief valve has an interesting history.

Denis Papin is credited by many sources as the originator of the first pressure relief valve (circa 1679) to prevent overpressure of his steam powered “digester”. His pressure relief design consisted of a weight suspended on a lever arm. When the force of the steam pressure acting on the valve exceeded the force of the weight acting through the lever arm the valve opened. Designs requiring a higher relief pressure setting required a longer lever arm and/or larger weights. This simple system worked however more space was needed and it could be easily tampered with leading to a possible overpressure and explosion. Another disadvantage was premature opening of the valve if the device was subjected to bouncing movement.

<u>Direct-acting deadweight pressure relief valves:</u> Later, to avoid the disadvantages of the lever arrangement, direct-acting deadweight pressure relief valves were installed on early steam locomotives. In this design, weights were applied directly to the top of the valve mechanism. To keep the size of the weights in a reasonable range, the valve size was often undersized resulting in a smaller vent opening than required. Often an explosion would occur as the steam pressure rose faster than the vent could release excess pressure. Bouncing movements also prematurely released pressure.

<u>Direct acting spring valves:</u> Timothy Hackworth is believed to be the first to use direct acting spring valves (circa 1828) on his locomotive engine called the Royal George. Timothy utilized an accordion arrangement of leaf springs, which would later be replaced with coil springs, to apply force to the valve. The spring force could be fine tuned by adjusting the nuts retaining the leaf springs.

Refinements to the direct acting spring relief valve design continued in subsequent years in response to the widespread use of steam boilers to provide heat and to power locomotives, river boats, and pumps. Steam boilers are less common today but the safety relief valve continues to be a critical component, in systems with pressure vessels, to protect against damage or catastrophic failure.

Each application has its own unique requirements but before we get into the selection process, let’s have a look at the operating principles of a typical direct acting pressure relief valve.

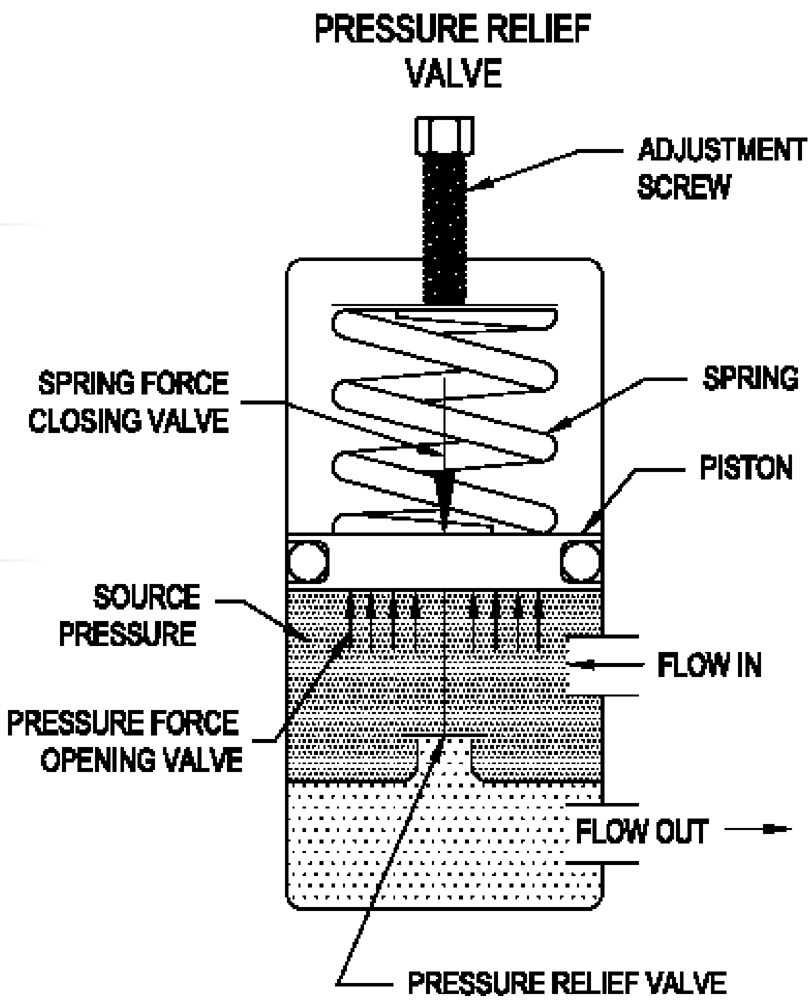
RVD

RV2

Excellence in Miniature
beswick engineering

A pressure relief valve is comprised of three functional elements:
(1) Valve element, typically a spring loaded poppet valve.
(2) Sensing element typically a diaphragm or piston.
(3) Reference force element. Most commonly a spring.

In operation, the pressure relief valve remains normally closed until pressures upstream reaches the desired set pressure. The valve will crack open when the set pressure is reached, and continue to open further, allowing more flow as over pressure increases. When upstream pressure falls a few psi below the set pressure, the valve will close again.



(1) VALVE ELEMENT (poppet valve)

Most commonly, pressure relief valves employ a spring loaded "poppet" valve as a valve element. The poppet includes an elastomeric seal or, in some high pressure designs a thermoplastic seal, which is configured to make a seal on a valve seat. In operation, the spring and upstream pressure apply opposing forces on the valve. When the force of the upstream pressure exerts a greater force than the spring force, then the poppet moves away from the valve seat which allows fluid to pass through the outlet port. As the upstream pressure drops below the set point the valve then closes.

(2) SENSING ELEMENT (piston or diaphragm)

Piston style designs are often used when higher relief pressures are required, when ruggedness is a concern or when the relief pressure does not have to be held to a tight tolerance. Piston designs tend to be more sluggish, compared to diaphragm designs due to friction from the piston seal.

In low pressure applications, or when high accuracy is required, the diaphragm style is preferred. Diaphragm relief valves employ a thin disc shaped element which is used to sense pressure changes. They are usually made of an elastomer, however, thin convoluted metal is used in special applications. Diaphragms essentially eliminate the friction inherent with piston style designs.

Additionally, for a particular relief valve size, it is often possible to provide a greater sensing area with a diaphragm design than would be feasible with a piston style design.

(3) THE REFERENCE FORCE ELEMENT (spring)

The reference force element is usually a mechanical spring. This spring exerts a force on the sensing element and acts to close the valve. Many pressure relief valves are designed with an adjustment which allows the user to adjust the relief pressure set-point by changing the force exerted by the reference spring.

Excellence in Miniature
beswick engineering

RELIEF PRESSURES

The expected relief pressure is an important factor in determining which product is best suited to the application.

FLOW REQUIREMENTS

What is the maximum flow rate that the application requires? How much does the flow rate vary? Porting configuration and effective orifices are also important considerations.

FLUID USED - (GAS, LIQUID, TOXIC, or FLAMMABLE)

The chemical properties of the fluid should be considered before determining the best materials for your application. Each fluid will have its own unique characteristics so care must be taken to select the appropriate body and seal materials that will come in contact with the fluid. The parts of the pressure relief valve in contact with the fluid are known as the “wetted” components.

If the fluid is flammable or hazardous in nature the pressure relief valve must be capable of discharging it safely.

SIZE & WEIGHT

In many high technology applications space is limited and weight is a factor. Some manufactures specialize in miniature components and should be consulted. Material selection, particularly the relief valve body components, will impact weight. Also carefully consider the port (thread) sizes, adjustment styles, and mounting options as these will influence size and weight.

MATERIALS

A wide range of materials are available to handle various fluids and operating environments. Common pressure relief valve component materials include brass, plastic, and aluminum. Various grades of stainless steel (such as 303, 304, and 316) are available too. Springs used inside the relief valve are typically made of music wire (carbon steel) or stainless steel.

Brass is suited to most common applications and is usually economical. Aluminum is often specified when weight is a consideration. Plastic is considered when low cost is of primarily concern or a throw away item is required. Stainless Steels are often chosen for use with corrosive fluids, when cleanliness of the fluid is a consideration or when the operating temperatures will be high.

Equally important is the compatibility of the seal material with the fluid and with the operating temperature range. Buna-n is a typical seal material. Optional seals are offered by some manufacturers and these include: Fluorocarbon, EPDM, Silicone, and Perfluoroelastomer.

TEMPERATURE

The materials selected for the pressure relief valve not only need to be compatible with the fluid but also must be able to function properly at the expected operating temperature. The primary concern is whether or not the elastomer chosen will function properly throughout the expected temperature range. Additionally, the operating temperature may affect flow capacity and/or the spring rate in extreme applications.

RVD8

Excellence in Miniature

beswick engineering

BESWICK PRESSURE RELIEF VALVE OPTIONS

Beswick Engineering manufactures four styles of pressure relief valves to best suit your application. The RVD and RVD8 are diaphragm based pressure relief valves which are suited to lower relief pressures. The RV2 and BPR valves are piston based designs.

MAXIMUM SOURCE PRESSURE

1. RVD model can be used with inlet pressures up to 80 psig
2. RVD8 model can be used with inlet pressure up to 80 psig
3. RV2 model can be used with inlet pressures up to 500 psig
4. BPR model can be used with inlet pressures up to 500 psig

RELIEF PRESSURE RANGE

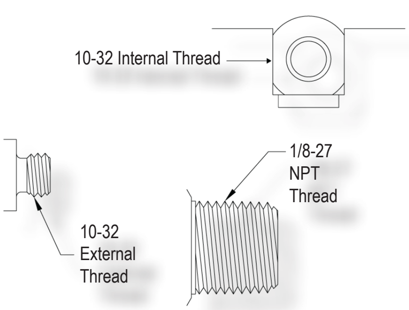
1. RVD model cracks open in the (3-30) psig range. Please contact us if you need a higher setting.
2. RVD8 model cracks open in the (3-30) psig rang. Please contact us if you need a higher setting.
3. RV2 model cracks open in the (3-30) psig range
4. BPR model cracks open in the (0-400) psig range

MATERIALS OF CONSTRUCTION

A wide range of materials are available but varies between the models.

1. RVD: 303 and 316 stainless steel, brass and aluminum
2. RVD8: 303 stainless steel and brass
3. RV2: 303 and 316 stainless steel and brass
4. BPR: 303 stainless steel, brass and aluminum

PORTING SIZE



1. RVD: Inlet and outlet ports are 10-32 UNF internal
2. RVD8: Inlet port is comprised of four 3/64 inch diameter holes and the outlet port is 10-32 UNF external
3. RV2: Inlet and outlet ports are 10-32 UNF internal
4. BPR: Inlet and outlet ports are 10-32 UNF internal for most models
   Type 2: Outlet port is 1/8-27 NPT external (which is also tapped 10-32 internal). Inlet port is 10-32 UNF internal.
   Type 8: Outlet port is 10-32 UNF external. Inlet port is a 1/32 inch diameter hole.

WEIGHT

1. RVD weighs 25 grams in brass and stainless steel
   15 grams in aluminum
2. RVD8 weighs 25 grams in brass and stainless steel
3. RV2 weighs 41 grams in brass and stainless steel
4. BPR weighs 72 grams in brass and stainless steel
   33 grams in aluminum

Excellence in Miniature
beswick engineering