Pressure Relief Valves

Over-pressure can impact weak points in a hydraulic system, which in turn can result in the mechanical failure of the individual system components. Over-pressure also tends to increase the burden on the lubricated surfaces causing abrasion and even catastrophic system failure. Therefore, the working pressure must remain within the safe value. This function can be achieved by using a pressure relief valve (PRV) or a pressure safety valve (PSV). A PRV/PSV provides an alternative path for the fluid to flow back into the reservoir, when no flow can be directed to the working parts of the system.

PSV Vs PRV

A PSV is designed to open completely when the set pressure is reached. However, it does not close automatically after the fluid discharge. A PRV modulates the flow through the system to keep its working pressure at the preset level. It is designed to re-close after the normal pressure condition has been restored.

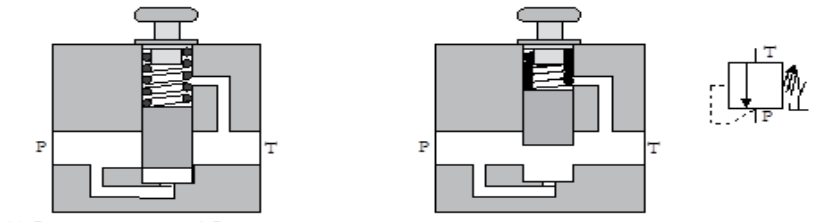
Types of (PRVs)

A direct-acting PRV is regarded as a conventional type valve in which the valve opening is directly controlled by the applied system pressure. A pilot-operated PRV consists of a main valve and an auxiliary valve. The opening of the main valve is indirectly controlled by the applied pressure through the auxiliary valve. A PRV is set at a pressure of 15 bar [220 psi] above the calculated pressure that can meet the heaviest load in the system.

Direct-Acting PRV

A direct-acting PRV consists of a body with an inlet port (P), a tank port (T) and a poppet that remains pressed against the valve seat by a heavy-duty spring. An adjusting screw is provided to vary the spring tension externally and hence to set the system pressure. The system pressure acts directly on the spring-biased poppet.

When the system pressure is below the PRV's set pressure, the flow through the valve is blocked. When the pressure exceeds the preset pressure, the poppet is lifted off its seat, and diverts the fluid away from the pressurized section to the system reservoir. When the excess pressure is relieved, the auxiliary passage closes again.



(a) System pressure < Set pressure (b) System pressure > Set pressure

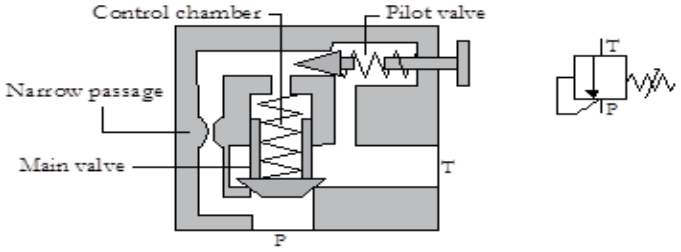
The operating characteristics of a direct-acting PRV are affected by the extent of non-linearity of its spring and any back-pressure on its discharge side.

Advantages and Disadvantages of Directing-acting PRVs

Advantages	Disadvantages
• Simplest and low cost	• Excessive leakage
• Rugged design	• Sensitive to effects of back-pressure
• High-temperature capability	• Unsuitable for high flows
• Quick actuation	• Lower precision

Pilot-operated PRV

It consists of a spring-loaded main spool with a control chamber and a spring-loaded pilot spool with a knob. The pressure can be set by controlling the spring tension acting on the pilot spool. There is also a narrow passage from the inlet side of the main valve to its control chamber.



The system pressure acts on the main spool. The flow is also directed towards the control chamber of the PRV at a controlled rate. Therefore, the system pressure operates on both sides of the main spool causing it to be pressure-balanced. The system pressure also acts on the pilot spool. When the system pressure exceeds the preset value of the PRV, the pilot valve opens permitting the pressurized fluid from the control chamber to return to the reservoir. The pressure in the control chamber drops and the main spool is forced off its seat. The fluid from the pump returns to the reservoir through the main poppet orifice and thus relieving the excess pressure in the system. When the system pressure drops sufficiently, the main spool assumes its normally closed position again. A pilot-operated PRV allows the flow through the valve over a narrow range of pressures. Therefore, pilot-operated PRVs have a much-reduced pressure override as compared to that of the direct-acting type PRVs of comparable rating.

Advantages of Pilot-operated PRVs

Pilot-operated PRVs can be set to open completely, over a narrow range of pressures. A pilot-operated PRV can pass large flows through it with a minimum pressure buildup. It provides a higher precision than that of a direct-acting PRV. It is balanced against the effects of back-pressure.

Disadvantage of Pilot-operated PRVs

Due to its two-stage design, it is not suitable for safety applications where speed of operation is essential. The cost of a pilot-operated PRV is higher than that of a direct-operated PRV of comparable ratings. However, as the advantages of pilot-operated PRVs are overwhelming, they are the most widely used PRVs in industrial hydraulic circuits.

Back-pressure on PRVs

In a PRV, the force of the pressure acting on the inlet side of its poppet is counterbalanced by the sum of opposing forces exerted by the spring and the pressure that exists at the outlet of the PRV. The presence of back-pressure in a PRV can cause many problems in the associated circuit. It tends to modify the set value of the PRV, reduce valve capacity, and cause instability and chattering.

Comparison of PRVs

Direct-acting PRVs	Pilot-operated PRVs
• Single-stage construction	• Two-stage construction
• Employs a large control spring	• Uses a small control spring
• Opens completely over a wider range of pressures	• Opens completely over a narrow range of pressures
• Suitable for low-pressure systems	• Suitable for high-pressure systems
• Used for smaller flows	• Used for heavier flows
• Lower precision	• Higher precision
• Right amount of seat and reseat tightness	• Excellent seat and reseat tightness
• Sensitive to the effects of back-pressures	• Insensitive to the effects of back-pressures

Reference: JOJI PARAMBATH, Industrial Hydraulic Systems – Theory and Practice, Universal Publishers, Boca Raton, USA, 2016. Please visit: http://www.universal-publishers.com/book.php?method=ISBN&book=1627340580

Note: A comprehensive account of the topic is given in the textbook on 'Industrial Hydraulic Systems-Theory and Practice' by Joji Parambath.