PROVISIONS FOR SUPERIOR SAFETY RELIEF VALVE PERFORMANCE

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ABSTRACT

There are several important elements that determine the proper selection and operation of safety relief valves. This text will discuss various valve types and show how field experiences and maintenance procedures help to determine which valve is best suited for the application. This paper should be used as an outline for valve selection. Many applications are unique and the valve manufacturer should be consulted when specific information is needed.

INTRODUCTION

Safety relief valves are a vital part of all petroleum producing and processing equipment. These valves are not installed to make the process more efficient by increasing throughput or reducing overhead. Safety valves are just what the name implies; they are a means of venting unsafe pressure levels within a system.

The safety valve is closed and non-functional during normal system operation. The safety valve is truly the last resort to reduce unsafe pressure levels. It is imperative that the user is confident that the safety valve installed will do its job. The consequences of a substandard performing safety valve can be catastrophic.

VALVE TYPES

Weight Loaded (Pallet) Safety Relief Valve

The operation of the weight loaded valve (Figure 1) is very simple. Pressure exerts upward against a pallet which is of a known weight. Additional weights can be added to increase the set pressure.

The advantages of this device are:

1) Economic up-front cost
2) Simple operation
3) Extremely low set pressure to at or below 1 oz/sq in.

The limitations of the weight loaded device are:

1) Inaccurate set pressure adjustment.
2) Maximum practical set pressure limited to 5 psig.

3) Long simmer (leakage just before the pallet lifts) characteristics.
4) Excessive overpressure (pressure build-up over set pressure) to force the pallet into full lift and provide full capacity.
5) Leakage past seat after the valve has cycled.

Conventional Metal Seated, Direct Spring Operated Safety Valve (Figure 2)

This valve senses the system pressure at a metal-to-metal seat seal which is opposed by a spring. Upon set pressure the valve seat partially lifts. The further increase in pressure above the set pressure (called overpressure) drives the seat fully open.

The advantages of this type of valve are:

1) Low cost for smaller orifice sizes and lower pressure classes.
2) Excellent chemical and temperature compatibility.
3) Familiarity with valve type by field personnel.

The limitations include:

1) Leakage before and after relief cycle past metal seats.
2) Operation subject to pressure build-up (called back pressure) in the discharge piping of the valve.
3) Operation subject to pressure losses in the inlet piping to the valve.
4) Long simmer before seat lift or long blowdown (the pressure at which the valve recloses) during closing.
5) High maintenance costs due to seat lapping requirements oftentimes create "throwaway" valve thinking.
6) Limited field testing (checking set pressure in place) capabilities.

Balance Bellows, Metal Seated, Direct Spring Operated Safety Valve (Figure 3)

The opening characteristics of this valve is the same as above. The bellows provides for two things. One is protection for the sliding surfaces from corrosion and debris. The primary function is to balance the areas in the valve to negate the influence of any pressure in the discharge piping upon the set pressure and capacity of the valve.

The balanced bellows valve provides the following advantages:

1) No effect by backpressure upon set pressure.
2) Valve capacity is not affected at lower back pressures.
3) Excellent temperature and chemical compatibility.
4) Protected guiding surfaces.

The limitations to be aware of are:

1) Initial cost is expensive due to bellows.
2) The valve capacity can still be reduced at high back pressures.
3) Leakage of process past the metal seats before and after opening.
4) Long simmer before seat lift or long blowdown during closing.
5) High maintenance cost incurred from seat lapping and bellows replacement.
6) Operation is subject to pressure losses in the inlet piping.
7) Limited field testing capabilities.

Conventional or Balanced Bellows, Soft Seated, Direct Spring Operated Safety Valves (Figure 4)

The operation of the valve is the same as described above. The seat that senses the pressure is manufactured from an elastomer or a plastic.

The advantages to this valve type are:

1) Tightness before and after relief.
2) Low maintenance costs. No seat lapping required.
3) Excellent cycle life.

The disadvantages include similar points noted above:

1) Subject to inlet pressure piping losses.
2) Be aware of discharge piping pressures before and after opening.
3) Soft seats limit use at higher temperatures (+500 F)
4) Make sure soft goods are chemically compatible with process.
5) Limited field testing capabilities.

Pilot Operated Safety Relief Valves

The operation of this valve is based upon force being equal to pressure times the area. Refer to Figure 5. Process pressure is sensed either at the main valve inlet or directly at the pressure source. The main valve seat is located on the bottom of either a piston or diaphragm. The process pressure is working upward on this seat area. That same process pressure is transmitted via tubing to a pilot valve. The pilot valve is simply a direct spring safety valve.

The same process pressure is also delivered to the top of the main valve piston or diaphragm. The process pressure is working downward on the seals on top of the piston or on top of the diaphragm. These seals have greater area than the main valve seat so the net force is downward and the main valve stays closed.

The pilot valve opens at its set pressure and releases the pressure on top of the piston or diaphragm. This pressure release can be immediate to snap open the main valve or controlled by the process pressure to throttle the main valve such as a back pressure regulator.

The pilot valve recloses after a pressure reduction in the system and in turn closes the main valve.

The advantages of the pilot operated valves are:

1) They allow the user to operate closer to set pressure without simmer or leakage.
2) The valve can be into full lift immediately at set pressure.
3) Proportional (modulating) opening action available to conserve product, reduce emissions, noise, vibrations, etc.
4) Field testing is accurate.
5) Cost of larger sizes and/or higher pressure class valves is lower.
6) Wide set pressure available from inches of water to 10,000 psig.
7) Not affected by inlet pressure losses with remote pressure sense of modulating action.
8) Not affected by back pressure considerations.

The limitations include:

1) High viscous, polymer type fluids limit use.
2) Cost is higher in smaller sizes and lower pressure classes.
3) Non-familiarity of valve type by field personnel.

APPLICATIONS

The following are examples of the importance of proper valve selection in common oil and gas production and processing applications. By selecting the best valve to fit the installation, time and money can be saved from reduced maintenance and downtime.

Liquid Service

One of the common misconceptions is that any valve can be used with equal success in both gas and liquid service. A safety valve is designed to work on compressible fluids such as gases. This valve utilizes the energy released by gas during depressurization to force the seat into lift. In liquid service this energy is not available. Therefore a valve designed to use this energy to lift will be unstable in liquid services.

This instability can cause valve chatter or rapid opening and closing action during relief. Valve chatter causes reduced capacity through the safety valve, damaging forces upon the valve internals and creates interaction with other control valves in the system.

The solution is to select a relief valve that is designed to open in proportion to the severity of the system upset. The user should make sure that the valve selected has been capacity certified on liquid service. This will decrease the likelihood of valve chatter.

Carbon Dioxide Service

The tightness specifications of a safety valve in CO2 service are extremely important. The fact is that all metal seated valves leak and this leakage increases as the pressure builds. A fluid such as CO2 expanding past a leaking seat will form "dry ice" which will block the safety valve discharge. This blockage will limit the capacity of the valve or cause the valve to be inoperative.

The best fit for this application is the use of soft seated safety valves. Bubble-tight operation to 95% of set pressure is the standard for these types of valves. No leakage, no freeze-up. Also desirable is a valve that exhibits strong opening forces to put the valve into full lift at set pressure. This will reduce the chance of blockage due to "throttling" the CO2 during relief. A snap-action pilot operated safety valve is ideal.

Reciprocating Compressor

A positive displacement compressor delivers pressure pulsations with each compression stroke. Local pressure indicators are very often not sensitive enough to pick up these spikes. These pulsations can exceed the simmer pressure of the safety valve protecting the compressor discharge causing leakage. The user will naturally think that the safety valve is opening prematurely. In reality, the valve is working properly.

The fix is to select a soft seat valve, either a direct spring or a pilot operated valve. For severe pulsating service there are spike snubber accessories available that dampen these pulsations before reaching the safety valve.

GENERAL MAINTENANCE GUIDELINES AND TROUBLESHOOTING

The user should follow the maintenance and start-up procedures provided by the manufacturer. An excellent reference for proper valve maintenance is API standard 520 Part II.

Typical problems found in the field include:

1) Valve Chatter

Cause: Excessive inlet piping losses "choking" valve.
Solution: Lengthen blowdown of valve or use remote sensing for pilot valve.

Cause: Back pressure prohibiting lift of valve.
Solution: Use balanced bellows or pilot operated valve.

2) Erratic set pressures

Cause: Debris between moving parts.
Solution: Scheduled preventive maintenance.

Cause: Valve mounted in horizontal position.
Solution: Follow guidelines of API 520 and mount in vertical position.

3) Full lift not achieved

Cause: Improper spring installed.
Solution: Follow manufacturer's spring charts.

Cause: Nozzle ring too low to allow for proper lift.
Solution: Follow manufacturer's recommendations.

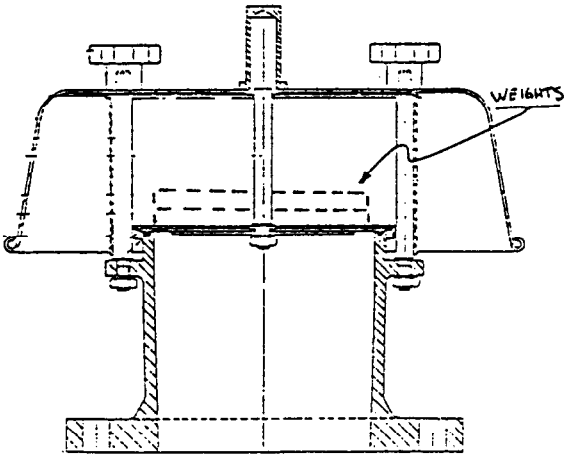

Figure 1 - Weight-loaded SRV

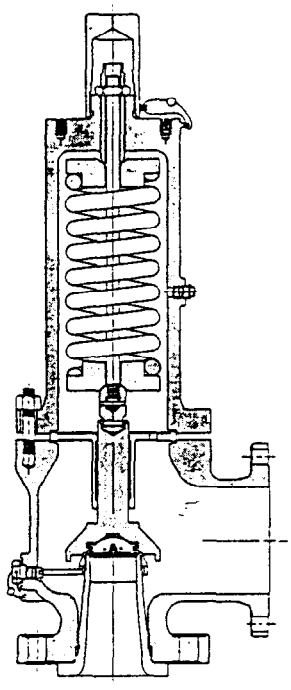

Figure 2 - Conventional metal seated direct spring-operated SRV

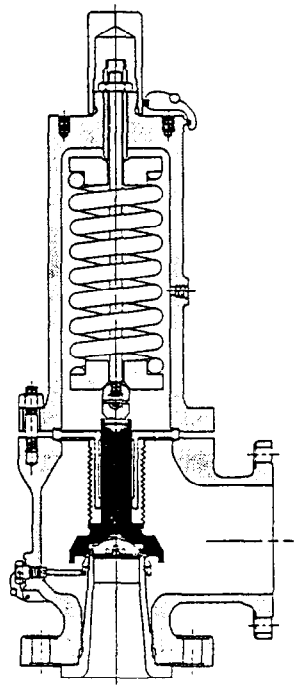

Figure 3 - Balanced bellows, metal seated direct spring-operated SRV

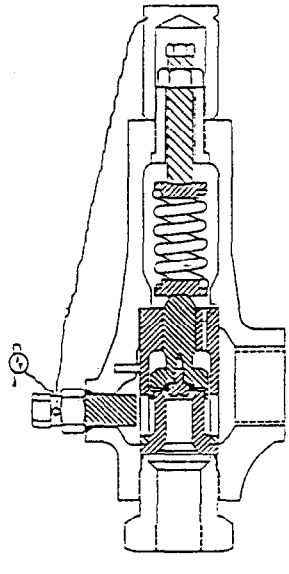

Figure 4 - Conventional or balanced bellows, soft seated, direct spring-operated SRV

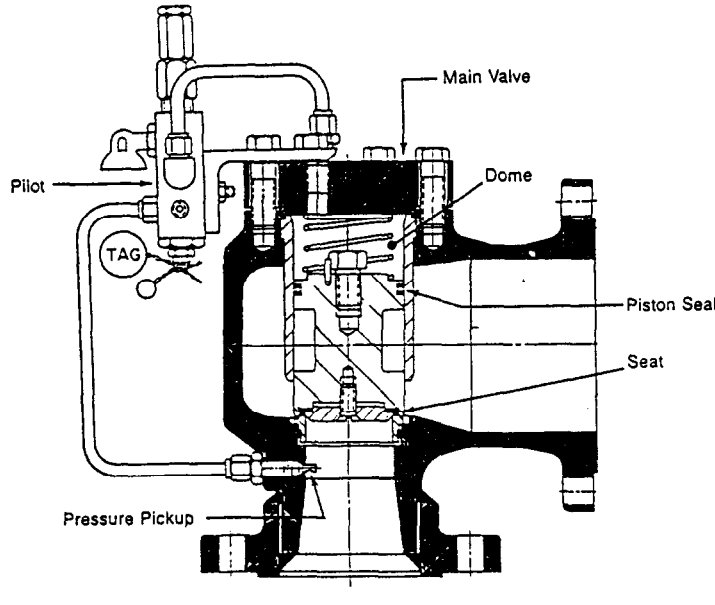

Figure 5 - Pilot-operated safety relief valves