Pressure Safety Valve Credibility During a PHA

Are you ensuring that the Pressure Safety Valves (PSVs) that you credit during a PHA are truly reliable? Overpressure is a major concern for engineers where the pressure within a vessel or pipework exceeds the maximum design pressure of the equipment. This can lead to a leak or rupture of the equipment resulting in the loss of containment of a hazardous material that can cause a significant impact to the safety of personnel, the environment, and/or the process equipment. Typical scenarios that can lead to overpressure would include blocked outlets, thermal expansion, external fires, and valve malfunctions. Although this concept may be commonly identified during the Process Hazard Analysis (PHA), the reliability of the equipment's safety features may be assumed to be greater than they really are.

Pressure Safety Valves (PSVs) are the most common safety feature to prevent or mitigate the release of toxic/flammable material associated with the overpressure of process equipment. They are Pressure Relieving Devices (PRDs) that release gases or liquids once a pressure setpoint is reached to relieve the pressure within the process equipment. This type of safety device is considered the last line of defense in preventing or mitigating this overpressure scenario; therefore, their reliability is extremely important.

Understanding the different configurations of PSVs can increase effectiveness of alleviating the overpressure scenario. To ensure that a PSV can be considered a credible safeguard during the PHA, it is important for the valve to be able to operate at any time in any condition. The operation of the PSV is reliant on the process fluid to open and close the valve and the specifics for how this valve operates depends on if it is spring-loaded or pilot-operated, shown in **Figure 1**. A spring-loaded PSV is closed by the force of the spring. As long as this force is greater than the force applied by the process fluid, the valve will remain closed, and the disc is sealed against the nozzle seat to prevent any flow from leaking through the PSV. Once the process fluid force increases, flow will leak by and produce an audible sound that may be heard by personnel to indicate an increase in pressure. Once the setpoint is exceeded, the valve will pop open and relieve the pressure. This type of PSV is most suitable for high-pressure setpoints, corrosive process fluids, and for applications that do not allow for back pressure. Pilot-operated PSVs utilize a pilot to signal the main valve to open and close; therefore, the pilot can actuate to relieve the pressure in an overpressure scenario. This allows for greater fluctuation or a high amount of back pressure due to its ability to vent the pressure and prevent cycling.

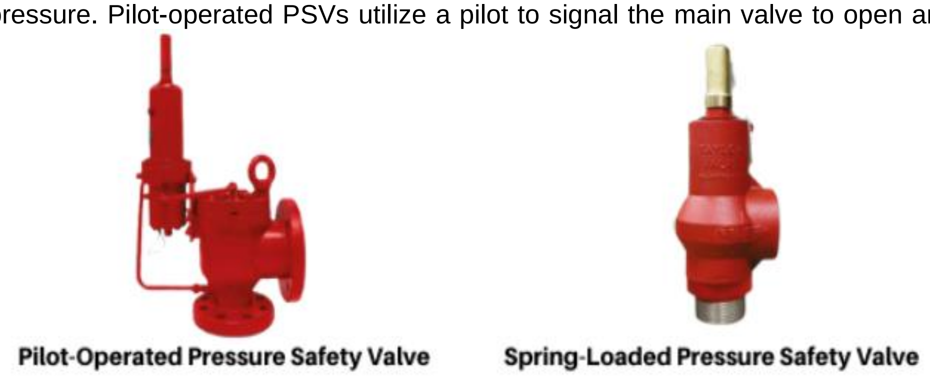

Figure 1: Common Safety Valves

The following factors should be considered when determining what type of PSV is most effective for the application:

- **Set pressure** – A higher required set pressure will be favored by spring-loaded PSVs. This set pressure should be determined depending upon the maximum allowable working pressure (MAWP) AND accumulation as per API Standard 520 Part I, and ASME Section I or Section VIII Division I.
- **Temperature** – This can affect the process fluid's volume and is important in determining the valve's material. The valve manufacturer's literature must be referenced to ensure the temperature is considered to prevent failure due to operating outside of mechanical limits of the valve design. It is important to consider both the operating temperature and the relieving temperature when selecting the material of construction for the PSV.
- **Back Pressure** – The presence of back pressure will limit the options for an effective PSV with constant back pressure requiring the use of a pilot-operated valve. This should be calculated with the PSV's discharge location in consideration.
- **Process Medium** – Liquid, gas, or steam flowing through the PSV will play a part in valve component selection. To ensure proper valve material is selected, steam valves are tested with saturated steam, gas valves are tested with ambient temperature air, and liquid valves are tested using water.
- **Connection Size** – PSV size should be large enough to connect to the inlet and discharge piping to ensure full capacity can flow through the valve to properly relieve pressure. It is also important to ensure that the overall vent piping is properly protected from rainwater, dirt, and debris as these can inhibit the overall performance of the relief system.
- **Required Capacity** – This is the most critical calculation to ensure that the PSV is selected to withhold the maximum capacity of the application and the factors that should be considered include the geometry of the valve, temperature of the fluid, and relief discharge area. Valve capacity is marked on the PSV with a value assuming a standard condition which needs to be converted depending upon the service fluid temperature using equations found in ASME Code Section VIII, Appendix 11, shown in **Figure 2**.

For steam,

$$W_s = 51.5KAP$$

For air,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$C = 356$$

$$M = 28.97$$

$$T = 520 \text{ when } W_a \text{ is the rated capacity}$$

For any gas or vapor,

$$W = CKAP\sqrt{\frac{M}{T}}$$

where

W_s = rated capacity, lb/hr of steam
W_a = rated capacity, converted to lb/hr of air at 60°F, inlet temperature
W = flow of any gas or vapor, lb/hr
C = constant for gas or vapor which is function of the ratio of specific heats, $k = c_p/c_v$ (see Fig. 11-1)
K = coefficient of discharge [see UG-131(d) and (e)]
A = actual discharge area of the safety valve, sq.in.
P = (set pressure x 1.10) plus atmospheric pressure, psia
M = molecular weight
T = absolute temperature at inlet (°F + 460)

Figure 2: Capacity Conversions for Safety Valves

TECH TIP

Frequent inspection and testing are also imperative for the reliability of a PSV. Even after following the above considerations, this may not be enough to ensure the PSV will save the day. Improper maintenance may significantly reduce the reliability of the PSV during an overpressure scenario. It is important to perform calibration and testing regularly to verify that the PSV is still within the set pressure, identify visible wear of mechanical parts, identify contaminants leading to a future leak, and to prevent sticking of the valve due to a prolonged period without every lifting. It is important to perform a visual inspection of the PSVs every 6-12 months to identify any potential missing seal wires, corrosion, leakage, or missing nameplate. If any deficiencies are identified, it is important to immediately replace this relief device to prevent the potential failure of a safeguard when needed during an overpressure scenario. Following the opening of a PSV to relieve pressure for any reason, it is important to ensure that debris did not get into the seat valve by visually inspecting the valve for any potential leakage.

For operating facilities that have been in service for decades, PSVs can go a long time without ever going off. This can lead to PSVs going uninspected if they are not properly maintained on a Mechanical Integrity (MI) program list. An MI Program is a management process used to ensure critical process equipment is designed, installed, and maintained correctly to mitigate the potential for equipment failure. These PSVs that go uninspected have the potential to be credited during a PHA leading to a false sense of security. By ensuring that PSVs are properly selected for the intended service, installed accurately, and inspected routinely on an MI basis, this can dramatically increase the reliability of a PSV and ensure the safety of personnel is maintained.

Resources

Figure 1: What is a Pressure Safety Valve? - Croft Supply

Figure 2: ASME Section VIII, Appendix 11 Division 1, 1992 Edition
Capacity Conversions for Safety Valves

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