CHEMICAL ENGINEERING
FACTS AT YOUR FINGERTIPS
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Causes of Overpressurization

The failure of a device or of a group of components can lead to overpressurization and subsequent adverse events, such as fire, explosion, spill or release. The most common causes of overpressurization are listed below. Understanding the circumstances surrounding overpressurization will help an engineer to avoid these failures.

External fire
According to API RP 520 and 521 standards, a fire-exposed area is within an area of 2,500 and 5,000 ft^2, and below a height of 25-ft above the grade. In this scenario, the exposed vessel is blocked in. Potential vapors resulting from the fire must be relieved using a PRV on the vessel, or via a vent path that remains in a locked-open position between the vessel and an adjoining vessel.

Blocked outlets
The closure of a block valve on the outlet of a pressure vessel can cause the vessel's internal pressure to exceed its maximum allowable working pressure if the source pressure exceeds the vessel design pressure. Blocked outlets can be caused by control valve failure, inadvertent valve operation, instrument-air or power failure, and other factors. A PRV must have sufficient capacity to pass a fluid flowrate that is equivalent to the difference between those of the incoming fluids and the outgoing fluids.

Utility failures
These failures can include the following: general power failure, partial power failure, loss of instrument air, loss of cooling water, loss of steam, and loss of fuel gas or fuel oil. For these cases, a flare header should be designed and sized based on the maximum relief load that could result from a potential utility failure.

Loss of cooling duty
Cooling-duty losses can include the following: loss of quench stream, air-cooled exchanger failure, loss of cold feed and loss of reflux. Relieving capacity should be calculated by performing a heat balance on the system, based on the loss of the condensing duty.

Thermal expansion
When liquid is blocked in a vessel or pipeline, external heat input can cause liquid temperature, and hence volume, to rise. This can be caused by the following: liquid that is blocked in a pipeline and is being heated, the cold side of a heat exchanger being filled while the hot side is flowing, or a filled vessel at ambient temperature that is being heated by direct solar radiation. PRVs used in these cases can be easily analyzed and sized.

Abnormal heat input
This failure can be caused by: the supply of heating medium, such as fuel oil or fuel gas to a fired heater, being increased; heat transfer occuring in a new and clean heat exchanger after revamp; control valve for the fuel supply failing to fully open; or supply pressure of the heating steam being changed from normal range to maximum pressure. As a general rule, when sizing a PRV, maximum heat-duty assumed for the abnormal case should be no more than 125% of normal heat duty.

Abnormal vapor input
Abnormal vapor input can be caused by the failure of the upstream control valve to fully open, or upstream-relieving or inadvertent valve opening. The required relieving capacity must be equal to or greater than the amount of the vapor accumulation expected under the relieving conditions.

Loss of absorbent flow
When gas removal by absorbent is more than 25% of the total inlet-vapor flow, an interruption of absorbent flow could cause pressure to rise in the absorber. The PRV should be sized base on the net accumulation of the vapor at the relieving conditions.

Entrance of volatile materials
The entrance of a volatile liquid, such as water or light hydrocarbons into hot oil during a process upset, can cause instantaneous phase expansion. Instead of relying on PRVs, processes should be properly designed with the use of double block valves, the avoidance of water-collecting pockets and use of steam condensate traps and bleeds on water connections.

Accumulation of non-condensibles
Accumulation can result from blocking of the normal non-condensible vent or accumulation in the pocket of a piping configuration or equipment. Because this can result in a loss of cooling duty, PRV analysis should be handled the same way.

Valve malfunction
Check-valve malfunction results in backflow, which can be from 5 to 25% of the normal flowrate. Required relief capacity should be based on this.

Inadvertent valve operation results in a valve position that is opposite from normal operating conditions, which is largely caused by human error and can be avoided by careful operation.

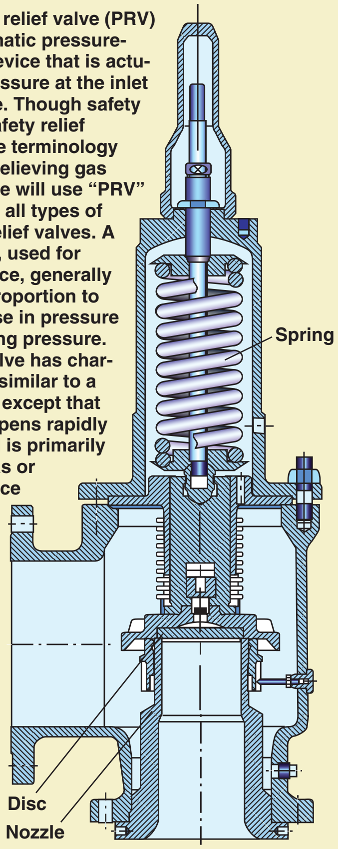
Control valve failure to open or close is caused by electronic- or mechanical-signal failure. This typically will affect just one valve at a time and should be analyzed on a case-by-case basis.

Process control failure
This situation refers to the failure of process controllers, such as programmable logic controllers and distributed control systems. The potential impact of failure of every control loop should be analyzed, as well as the impact if one loop fails but all others remain active. As a general rule, the required relief capacity must be greater than the vapor generated because of heat buildup in the system.

Exchange tube rupture
When an upstream vessel is relieving by discharge fluid to a downstream vessel, the downstream vessel should should be designed to handle the pressure and volume of the incoming stream without overpressurizing. If the upstream vessel does not have adequate relief capacity, the downstream vessel should have a PRV of its own.

When two vessels are connected by an open path and the first has its own PRV and discharges to a flare header, the second will experience the impact from the relieving pressure of the first vessel and should be analyzed accordingly.

A pressure relief valve (PRV) is an automatic pressure-relieving device that is actuated by pressure at the inlet of the valve. Though safety valve, or safety relief valve, is the terminology for valves relieving gas or vapor, we will use "PRV" to describe all types of pressure relief valves. A relief valve, used for liquid service, generally opens in proportion to any increase in pressure over opening pressure. A safety valve has characteristics similar to a relief valve except that it usually opens rapidly (pops), and is primarily used for gas or vapor service



Source: Farris Engineering, Brecksville, Ohio

Upstream relieving
Required relief capacity should be greater than the vapor generated because of heat buildup in the system.

Runaway chemical reaction
Runaway reactions tend to accelerate with rising temperature; extremely high volumes of non-condensibles with high energy can cause the internal pressure of a vessel or pipeline to rise rapidly. PRVs may not provide sufficient relief, so vapor-depressurizing systems, rupture disks and emergency vents are preferable.

References
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