

## 6.6 Relief Devices

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### *Introduction*

Relief devices are used to help prevent a catastrophic failure of equipment and/or minimize the effects of any unanticipated or uncontrolled events. As such, relief devices generally serve as emergency devices not used for normal process control. Relief devices are used for individualized equipment as well as equipment assembled as part of a chemical process. Relief devices are designed to protect a vessel or system from excess pressure by removing or relieving fluid from that vessel or system. Relief devices however are not the only method for over-pressure protection. Equipment and/or process designers also consider the causes of over- pressure as well as the appropriate pressure disposal system during the process design stage. Some considerations during this stage may include:

- Design of process equipment such that there are no credible scenarios which exceed the maximum allowable working pressure of the equipment, possibly eliminating the need for an over-pressure protection device.
- Design of process equipment to minimize the venting/relief rate through the over-pressure protection device, possibly reducing the size of both the relief device and the connected disposal system.
- Design of process equipment such that a single common over- pressure protection device protects several pieces of equipment, possibly reducing the number of relief devices.

The information provided below on over-pressure protection devices does not attempt to define when or where over-pressure protection is required. Rather, the purpose of this summary is to provide some insight on the types of over-pressure protection hardware that have been applied to equipment in phosgene service.

The information provided in this section should not be considered as a directive or as an industry standard that readers must adopt or follow. Instead, the information is intended to provide helpful ideas and guidance that users may wish to consider in a general sense (See Section 1.1 *Preface and Legal Notice*). Also included is a reference list of useful resources.

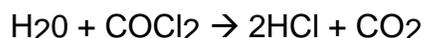
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### 6.6.1 General

There are two main types of mechanical relief devices, the bursting disc and spring-loaded valve. While useful options, both devices have potential disadvantages when dealing with phosgene, but they have also been useful in carefully designed systems. Expansion bottles are another available alternative helping to protect pipelines when in liquid phosgene service and mitigate the hazard of thermal expansion overpressurization. The discharge side of any relief device that could release any phosgene may be a main vent line that is connected directly into a caustic scrubber to help neutralize the toxic hazard of phosgene in the relief gases. In designing a relief vent scrubber, consideration may involve estimating the maximum anticipated flow of phosgene as well as the products of reaction associated with the neutralization process which helps in proper sizing of the scrubber and equipment. (See Section 6.8 *Mitigation*). Reserving the main vent for relief duties only (and not for dual service such as relief or fume extraction duties) helps avoid hazards associated with pipe corrosion or blockage.

Diffusion of water vapor from the caustic scrubber back into the phosgene vent header can cause the formation of hydrochloric acid.



Therefore, vent pipe elevations, materials of construction and line pressure/vacuum merit close attention. For example, phosgene equipment to be vented or its associated relief device may be located in an elevated structure so that vent piping is sloped toward the caustic scrubber. Also a knock out tank on the inlet to the scrubber is sometimes used to prevent caustic and water from backing up into the main vent line. This knock out tank may also serve another purpose to prevent liquid phosgene from the relief valve vent entering directly as a liquid into the scrubber. Consider what materials of construction to use for the knock out tank to prevent hydrochloric acid corrosion (see Section 6.2 *Materials of Construction*).

Use of fully fluorinated fluoropolymer (polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP), tetrafluoroethylene (TFE) and perfluoroalkoxy (PFA)) -lined pipe may help provide corrosion resistance to HCL in relief devices and vent piping systems. Potential difficulties associated with phosgene permeability of fluoropolymer-lined piping, however, have been noted. Carefully evaluate the use of relief devices for phosgene service that are constructed of permeable cores and materials subject to chlorides corrosion. Consider emphasizing a strong mechanical integrity program to help maintain safe usage of relief devices in phosgene service.

Depending on factors such as pipe manufacturer, pipe size, and construction techniques, fluoropolymer-lined pipe may collapse at some particular vacuum value and impede required phosgene flow through the header. Fluoropolymer liner failures due to vacuum are often detected by visually inspecting an open end of the pipe and observing a circular shaped fluoropolymer liner with three folds (lobes) protruding toward the center.

Additionally, phosgene can permeate fluoropolymer and may become trapped between the liner and the steel casing of the fluoropolymer-lined pipe. In many cases, the fluoropolymer-lined pipe has a method to vent the cavity between the liner and the steel casing. If the vent mechanism becomes plugged, the continued permeation will increase pressure in the cavity and could cause the fluoropolymer liner to collapse. Fluoropolymer liner failures due to permeation are often detected by visually inspecting an open end of the pipe and observing a circular-shaped fluoropolymer-liner with one fold (lobe) protruding toward the center.

For these reasons, as well as the potentially corrosive nature of the service, inspecting the vent header system helps ensure the absence of obstacles that impede flow, and that the piping has sufficient wall thickness for maximum operating pressure.

## 6.6.2 Spring-Loaded Valves

*Conventional* type (spring-loaded) valves have been used for pure phosgene duties. However, sealing the valve bonnet vent in some manner (that is, threaded plug, pressure gauge) helps prevent leakage of phosgene to the atmosphere during valve operation. Valves made of a cast or forged steel type with flanged connections conforming to the pipework or vessel specifications have been used previously. The valves, at times, may suffer from minor leakages across the valve seat. Leakage does not impair their operation but causes unnecessary fumes, the source of which may be difficult to detect. This leakage into a vent disposal system consisting of multiple valves may cause damage (corrosion) of the operating parts not normally exposed to phosgene while in service. Use of a valve fitted with a bellows may help protect these parts. Potential risks can be reduced by accounting for the potential presence of hydrochloric acid, which may be formed by phosgene in the presence of water (vapor), during the selection of a material of construction. (See Section 6.2 *Materials of Construction*).

The *bellows* type relief valve also has the potential to offset the effects of backpressure in a vent/disposal piping system. When a bellows type relief valve is employed to offset backpressure effects, pluggage of the bonnet vent is a potential problem and negates the purpose of the bellows. Cracks or leaks in the bellows may allow transmission of phosgene to the atmosphere. Therefore, procedures such as venting the bonnet to a separate vacuum vent header may be desired.

### 6.6.3 Rupture Disks

Carbon (graphite) rupture disks have been used for phosgene duties when the bodies (armor) were made from either cast or forged steel and flanged to the correct specification. Specific nickel-copper alloys, nickel, or discs with polyfluorinated fluoropolymer liners on each side are other examples that have also been used. (See Section 6.2 *Materials of Construction*).

Rupture disk manufacturers have incorporated special additional physical construction techniques for disks in vacuum service. Therefore, the possibility and effects of negative pressure (vacuum) on the rupture disk are factors for designers and end users to consider.

Rupture disks are non-reclosing devices that release the entire protected equipment contents into a vent system and thus could produce a very high volumetric load on a scrubbing or absorption disposal system.

Dual rupture disks with a three-way selector valve have been used and can minimize the additional load on the disposal system when the three-way selector valve can be switched to bring the parallel disc into service and isolate the ruptured disc. A combination of a rupture disk backed by a spring-loaded relief valve helps avoid the high volumetric load on the disposal system.

Since the opening of a rupture disk has the potential to release significant amounts of phosgene to the disposal system and/or the atmosphere, use of a rupture disk leak/rupture detection system can reduce potential risks. These systems often use a wire bonded to the disk that changes resistance at rupture or leakage.

### 6.6.4 Combinations of Relief Device Systems

One approach that has been used previously and which can help overcome limitations

associated with each individual type of relief device is a bursting disk in conjunction with a spring-loaded valve. A combination of a rupture disk backed by a spring-loaded relief valve helps avoid the high volumetric load on the disposal system associated with use of a rupture disk only (as described above). Additionally, the rupture disk helps protect the valve from corrosion and fouling. Users have placed an additional rupture disk in the line downstream from the pressure relief valve to help prevent corrosion by condensate or liquids associated with the disposal (absorption/scrubber) system or backflow from other phosgene containing relief valves that may be connected to the vent system if ruptured.

Fitting the bursting disk next to the process and backed by a spring-loaded valve has been beneficial. Fitting the space between the disk and the valve with an indicator device to warn of disk failure or leakage has also been helpful. An indicator device such as an electronic pressure switch or pressure gauge, between the rupture disk and the relief valve helps prevent development of a relatively unknown unsafe situation that can be caused by the use of two relief devices in series. The unsafe situation that can arise occurs when a rupture disk leaks through (that is, not a rupture), but the relief valve holds the pressure. Very soon after leak through, the pressure within the cavity between the rupture disk and the relief valve equalizes to the process operating pressure. When this situation occurs, an operating pressure equal to the rupture disk burst pressure plus the backpressure (operating pressure) must be attained in order to rupture the disk. This situation is obviously undesirable and immediate action to replace a leaking disk reduces further situational risks. This potentially unsafe situation may be a reason to avoid use of rupture discs in series with relief valves.

### 6.6.5 Expansion Chambers (Bottles)

Expansion chambers (bottles) can be used to help prevent over-pressurization of pipe lines due to thermal expansion of trapped liquid phosgene. Expansion chambers are fitted to the top of a pipeline at regular intervals and commonly are isolated from the pipe line by a bursting disc. If the line is sealed and the temperature of the contents increased, then the trapped liquid ruptures the disc and expands into the chamber, preventing an excessive build up in pressure. The capacity and location of the chambers is a function of the pipe size and duty.

Expansion chambers have been fitted with indicator devices (pressure gauges or electronic pressure switches) to indicate leakage or rupture of the bursting disc and suitable connections to the scrubbing system to facilitate purging and disc replacement.

### 6.6.6 Installation of Relief Devices

If any isolation valves are installed either upstream or downstream of a relief device, locking the isolation valves in the open position for normal operation helps ensure that the relief device is not inadvertently isolated, which increases the risk of a dangerous occurrence. See *ASME Boiler and Pressure Vessel Code Section VIII – Rules for Construction of Pressure Vessels* for more details.

### References

The following materials may also provide additional information on the subject of relief devices.

- American Petroleum Institute Recommended Practice 521, Guide for Pressure-Relieving and Depressuring Systems
- American Petroleum Institute Recommended Practice 520, Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries
- American Petroleum Institute Recommended Practice 576, Inspection of Pressure-Relieving Devices (Note: this practice document does not provide information on inspection frequencies for which there is no historical basis to provide guidance).
- American Society of Mechanical Engineers Code Case 2211
- American Society of Mechanical Engineers Code Boiler and Pressure Vessel Section VIII
- Chlorine Institute Pamphlet 89, Chlorine Scrubbing Systems
- Chlorine Institute Pamphlet 6, Piping Systems for Dry Chlorine