EMERGENCY VENTING OF VESSELS

Table of Contents

Page

1.0 SCOPE ... 3
1.1 Hazards ... 3
1.2 Changes ... 3
2.0 LOSS PREVENTION RECOMMENDATIONS ... 3
2.1 Introduction ... 3
2.2 Equipment and Processes ... 4
2.2.1 Design of Overpressure Relief System ... 4
2.2.2 Installation ... 7
2.3 Inspection, Testing and Maintenance ... 12
2.3.1 General ... 12
2.3.2 Pressure Relief Valves ... 12
2.3.3 Rupture Disks ... 12
2.3.4 Isolation Valves ... 12
3.0 SUPPORT FOR RECOMMENDATIONS ... 13
3.1 General ... 13
3.2 Pressure Relief Devices - Types and Operation ... 13
3.2.1 Pressure Relief Valves ... 13
3.2.2 Rupture Disks ... 15
3.3 Design Considerations ... 17
3.3.1 Relief Scenarios ... 18
3.3.2 Device Selection ... 21
3.3.3 Inlet/Outlet Piping ... 22
3.4 Installation ... 23
3.4.1 Pressure Relief Valves ... 24
3.4.2 Rupture Disks ... 24
3.4.3 Installation of Pressure Relief Devices in Series, Parallel or Combined Arrangements ... 25
3.5 Overpressure Protection by System Design ... 26
3.6 Inspection, Testing and Maintenance ... 26
3.6.1 Causes of Improper Valves Performance ... 27
3.7 Isolation Valves Around Pressure Relief Devices ... 28
4.0 REFERENCES ... 28
4.1 FM ... 28
4.2 Others ... 28
APPENDIX A GLOSSARY OF TERMS ... 29
APPENDIX B DOCUMENT REVISION HISTORY ... 30

List of Figures

Fig. 2.2.1.2.1.1-1. Relative pressure levels for relief devices as related to set pressure – vapor and gas services ... 6
Fig. 2.2.2.3.4-1. Rupture disks mounted in series ... 8
Fig. 2.2.2.4.2-1. Rupture disk mounted under a relief valve ... 9
Fig. 2.2.2.6.1.3-1. Support for relief valve discharge piping ... 10
Fig. 2.2.2.6.3.2-1. Vacuum support for rupture disk ... 11
Fig. 2.2.2.7.2-1. Switching valve with rupture disks (or relief valves) ... 11
Fig. 3.2.1.1-1. Spring loaded pressure relief valves. Left: Conventional PRV. Right: Balanced-bellows PRV ... 14

Fig. 3.2.1.2-1. Pop-action pilot operated valve (non-flowing pilot type) 15
Fig. 3.2.2-1. Typical rupture disk assembly 16
Fig. 3.2.2-2. Reverse acting rupture disk 16
Fig. 3.2.2-3. Forward acting rupture disks 17
Fig. 3.3.2-1. Pressure relief device selection. Adapted from CCPS Guidelines for Pressure Relief and Effluent Handling System 21
Fig. 3.4.2-1. Typical configuration of a rupture disk assembly 25

List of Tables

Table 3.3.1-1. Common Overpressure Process Conditions/Scenarios 19

1.0 SCOPE

This data sheet provides guidelines for design, installation, inspection, testing and maintenance (ITM) of emergency overpressure protection systems. It applies to process or storage vessels operating at a pressure equal to or greater than 15 psig (1 barg). For ignitable liquids storage vessels operating at pressures less than 15 psig (1 barg), see FM Property Loss Prevention Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*.

This data sheet addresses determination of the design basis for overpressure protection of non-reactive systems, highlights some vent-sizing methods, identifies important design factors relative to piping, discharge and containment of materials, and identifies key installation, maintenance, and testing factors. For design basis of overpressure protection for reactive systems see Data Sheet 7-46, *Chemical Reactors and Reactions*.

The following data sheets provide relief venting criteria that supersede recommendations in this data sheet:

- Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*
- Data Sheet 7-58, *Chlorine Dioxide*
- Data Sheet 7-80, *Organic Peroxides and Oxidizing Materials*
- Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*
- Data Sheet 12-3, *Continuous Digesters and Related Process Vessels*
- Data Sheet 12-6, *Batch Digesters and Related Process Vesselsmed*

This data sheet does not apply to hot water supply systems, boilers, condensate tanks, etc. (see Data Sheet 12-43, *Pressure Relief Devices*) or to vapor-air deflagrations, detonations or similar high-velocity reactions in a vessel.

This data sheet does not apply to vessels in hot water, steam or air service. See Data Sheet 12-43, *Pressure Relief Devices*, for vessels such as heaters, boilers, air tanks, etc.

1.1 Hazards

Pressure relief devices represent the last line of defense against overpressure scenarios and catastrophic vessel failures. Inadequate design, installation and ITM practices will result in improper device operation or activation failures.

1.2 Changes

July 2023. This document has been completely revised. The following significant changes were made:

A. Reorganized the document to provide a format that is consistent with other data sheets.

B. Relocated guidance on design cases for pressure relief devices involving runaway chemical reactions and reactive systems to Data Sheet 7-46.

C. Removed equations, tables and charts for calculation of effective discharge area and mass flow through pressure relief devices for non-reactive systems.

D. Reviewed guidance for fire exposure scenarios.

E. Added new recommendations and guidance for rupture disks.

F. Relocated guidance for Safety Instrumented Systems (SIS) used in lieu of overpressure protection from Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks (SCAI)* into Section 2.2.1.6 of this data sheet.

G. Added new guidance for types and operation of pressure relief devices.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

A pressure relief device (PRD) is designed to protect a vessel or system during an event that may cause pressure to increase beyond the specified design pressure or the maximum allowable working pressure (MAWP).

Pressure relief devices must be designed and installed to ensure they operate according to design specifications in a consistent and stable manner. Equally important is the inspection, testing and maintenance of these devices to ensure proper operation. Reliability of pressure relief devices is paramount, since they are considered the last line of defense to prevent catastrophic failures.

2.2 Equipment and Processes

2.2.1 Design of Overpressure Relief System

2.2.1.1 General Design Basis

2.2.1.1.1 Consider all potential overpressure scenarios and modes of operation (including startup, shutdown, and emergency), as well as maintenance, standby and out of service conditions when designing overpressure protection systems.

2.2.1.1.2 Ensure the overpressure relief system design is based on the evaluation of the worst credible scenario that requires the largest relief area. Develop the worst credible scenario based on a thorough study of the process, possible upset conditions, and factors that could cause an increase in operating pressure in the vessel. Examples of scenarios may include, but are not limited to:

- Exposure to external fire
- Flow blockages
- Overfilling
- Loss of cooling/reflux
- Utility failure (air, water, nitrogen, steam, refrigeration, power, etc.)
- Instrument failure
- Loss of heat
- Abnormal heat or vapor input
- Exchanger tube failure
- Thermal or hydraulic expansion
- Chemical reaction. See Data Sheet 7-46 for additional information
- Accumulation of non-condensable gases

2.2.1.1.3 For cases when a single pressure relief device protects multiple vessels, ensure the device is properly sized to handle the total relief capacity, and the interconnected vessels are provided with means to prevent independent isolation. When valves need to be installed between vessels for process functionality, follow the guidance for isolation valves in this data sheet to ensure a permanent open pressure relief path between vessels.

2.2.1.1.4 Fire Exposure Scenario

Exposure of vessels or equipment to fire can produce overpressure scenarios due to vapor generation from boiling liquid and/or fluid expansion. External heat input can also result in overpressure scenarios from gas/vapor generation during decomposition reactions (see Data Sheet 7-46, *Chemical Reactors and Reactions*).

2.2.1.1.4.1 Where fire exposure is conceivable, ensure drainage, fuel inventories, total heat input to the wetted surface of the vessel, external vessel insulation and any applicable environment factors are considered for calculations.

2.2.1.1.4.2 The external fire exposure scenario may be omitted if there is insufficient combustible loading to over-pressurize the vessel. This exception applies if there are limited combustibles, such as at inorganic processing facilities. For very large vessels and modest combustible loading, heating the vessel to the point of over-pressurization before the combustibles are exhausted may not be possible.

2.2.1.1.4.3 The presence of active fire protection (sprinklers, foam, etc.) and/or emergency services cannot be used to omit the fire case.

2.2.1.1.4.4 Provide additional protective measures if any unwetted metal surfaces are exposed to fire, where pressure relief devices alone may not protect the vessel from rupture. Protection can be provided by insulation, mounding or by reducing stress on the vessel by specially engineered depressurization systems (i.e., remote catch tank, flare, etc.).

2.2.1.2 Sizing and Device Selection

2.2.1.2.1 General

2.2.1.2.1.1 Size the pressure relief device(s) to ensure the overpressure that might develop in a vessel are limited as indicated below. Set the relief device to operate at as low a pressure as possible, considering process conditions. See also Figure 2.2.1.2.1.1-1 for additional information.

Single pressure relief device:

- The set pressure does not exceed the maximum allowable working pressure (MAWP) of the protected vessel.
- Accumulated pressure does not exceed 110% of the MAWP.

Multiple pressure relief devices:

- Accumulated pressure does not exceed 116% of the MAWP. The set pressure of the first device should not exceed the MAWP.
- The set pressure of additional devices should not exceed 105% of the MAWP.

Fire Exposure:

- The set pressure does not exceed the MAWP where the vessel is protected by a single device sized for fire exposure.
- For pressure generated by fire exposure, accumulated pressure should be limited to 121% of the MAWP. This applies to single, multiple and supplemental devices.

2.2.1.2.1.2 Size pressure relief devices, and determine the required relieving capacity according to calculation methodologies of recognized codes and standards and data provided by manufacturers or other reliable sources. Select methodologies according to the effluent phase at the release conditions. For large relieving capacities, more than one device may be used in parallel to meet the total demand.

Document and maintain records of all calculations.

2.2.1.2.1.3 Select the appropriated pressure relief device for the specific application, considering backpressure that may develop in discharge piping or manifolds, compatible construction materials to process fluids, resistance to process/environment conditions and the type of relief or vent system (e.g., directed to the atmosphere or routed to a containment or treatment system).

2.2.1.2.2 Pressure Relief Valves

2.2.1.2.2.1 When selecting a pressure relief valve, ensure the total nominal relieving capacity of the valve(s) is equal to or greater than the required capacity calculated from the worst credible scenario.

2.2.1.2.3 Rupture Disks

2.2.1.2.3.1 Select rupture disks considering the pressure and temperature at which the disk is expected to burst. Include normal operating and upset conditions, as well as any environmental effects.

2.2.1.2.3.2 When selecting a rupture disk, ensure the upper burst tolerance of the manufacturing design range is considered so as not to exceed the MAWP of the protected equipment.

2.2.1.2.4 Combination of Pressure Relief Valve/Rupture Disk

2.2.1.2.4.1 When designing a pressure relief valve in combination with a rupture disk, evaluate the backpressure that may accumulate between the valve and rupture disk to ensure the pressure relief valve or rupture disk will open at its proper pressure settings.

2.2.1.3 Inlet/Outlet Piping

2.2.1.3.1 Design inlet piping to relief devices so any pressure drop will not reduce the relieving capacity of the pressure relief device below that required to prevent overpressure scenarios or malfunction of the device.

2.2.1.3.2 Design discharge piping so backpressure, which may develop during the operation of any relief device or downstream containment or disposal equipment, will not reduce the relieving capacity of that device below that required to protect the vessel from overpressure.

2.2.1.3.3 Ensure the pipe size of the inlet/outlet piping is no less than the diameter of the relief device inlet.

2.2.1.3.4 Ensure piping materials and design are selected considering the type of fluid and discharge conditions and are in accordance with applicable codes and standards such as ASME B31.3 or other equivalent international standard.

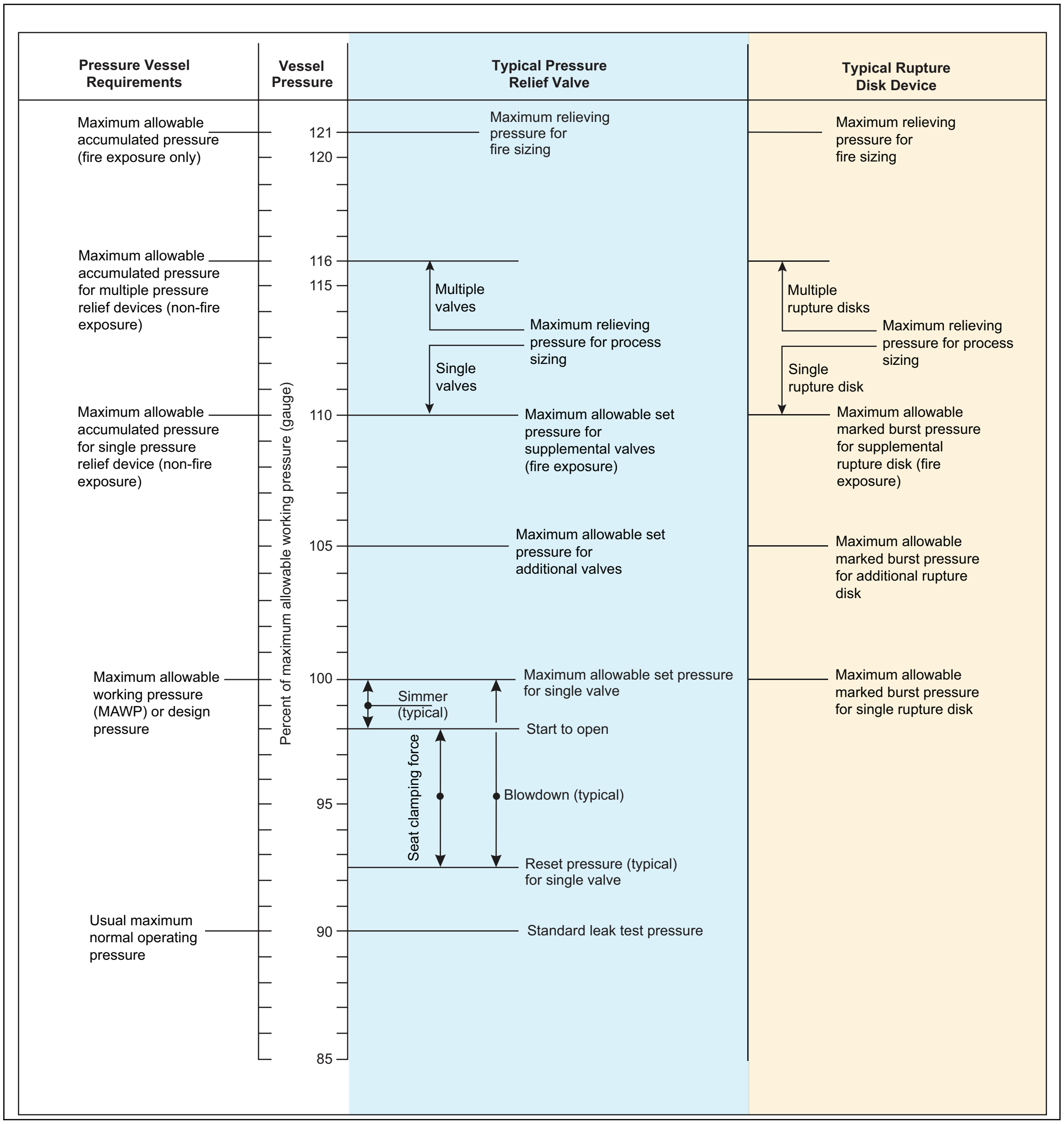

Fig. 2.2.1.2.1.1-1. Relative pressure levels for relief devices as related to set pressure – vapor and gas services

2.2.1.4 Containment and Disposal

2.2.1.4.1 When vessel contents cannot be safely discharged directly to the atmosphere, a catch tank, knock-out drum, scrubber, flares, etc., may be used to contain, treat or dispose of the release material.

2.2.1.4.2 Design containment or disposal systems in accordance with current industry standards (e.g., API 521, API 537) to ensure all components are suitable in size, pressure rating and construction materials for the expected service conditions. Ensure they are designed considering the largest discharge capacity.

2.2.1.5 Manifold Discharge Piping Systems

2.2.1.5.1 Size a discharge manifold, into which a number of relief devices are connected, for the device having the greatest discharge capacity. However, if the simultaneous operation of two or more relief devices is considered credible, design the discharge manifold to carry the discharge capacity of all relief devices that are expected to operate.

2.2.1.6 Overpressure Protection by System Design

2.2.1.6.1 When using overpressure protection via system design instead of a pressure relief device, carefully review the design philosophy, documentation and supporting studies to confirm the vessel will not fail catastrophically under worst credible case conditions.

This situation also applies for cases where the pressure is not self-limited, and overpressure protection by system design is used instead of providing an adequate relief device as required by code (see ASME Boiler & Pressure Vessel Code, Section XIII, Part 13 [2021 Ed.] or similar international codes).i

2.2.1.6.2 Safety Instrumented Systems (SIS) may be used in lieu of mechanical overpressure devices (e.g., rupture disks or safety relief valves) provided all the following criteria are met:

A. A detailed process hazard analysis (PHA) has been conducted to ensure all potential overpressure sources are protected and evaluated according to 2.2.1.1.1 and 2.2.1.1.2. Protection can be achieved through reliable instrumentation and/or mechanical overpressure devices.

B. The installed safety instrumented system (SIS) has an adequate reliability for the service. A safety integrity level (SIL) is determined by a PHA. In most cases, the result of the PHA is either a SIL 2 (requiring a minimum of 99% availability) or a SIL 3 (requiring a minimum of 99.9% availability) system.

C. The safety instrumented system (SIS) is designed to detect the upset condition and actuate quickly enough to prevent the overpressure condition. This may be difficult or impossible to accomplish for some upset conditions.

D. The safety instrumented system (SIS) design considers common failure modes that may simultaneously initiate an unsafe condition and compromise the reliability of the SIS to function as designed. Common cases include the failure of the primary control system or loss of power.

E. The omission of mechanical overpressure protection is permitted by local codes and the authority having jurisdiction (AHJ). Some jurisdictions may require this protection be reviewed and approved by the AHJ before installation.

See Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks*, for information regarding design, operation and maintenance of safety instrumented systems.

2.2.2 Installation

2.2.2.1 General

2.2.2.1.1 Install relief devices in accordance with manufacturer’s recommendations.

2.2.2.1.2 To facilitate proper care and servicing, arrange pressure relief devices for easy access and removal.

2.2.2.1.3 Install pressure relief devices as close to the protected vessel as possible, so the device will be properly fed under flowing conditions. However, a more stable location may be advisable where rapid pressure fluctuations or strong vibrations are possible.

2.2.2.1.4 For guidance on piping, see Data Sheet 12-2, *Vessels and Piping* and ASME B31.3, *Process Piping*.

2.2.2.2 Pressure Relief Valves

2.2.2.2.1 Ensure the actions below are followed prior to installation of new and existing pressure relief valves. In addition, verify the valve and connections have been thoroughly cleaned and inspected to remove any foreign material that may affect their proper operation.

New Valves

A. Follow manufacture’s recommendations for proper handling and storage conditions.

Valves should be left in their original shipping containers with all the protectors in place until the valve is ready to be installed. Store them (preferably) indoors on a dry surface with a protective covering to prevent dirt and other forms of contamination from contacting the valve. PRVs should be handled carefully and never subjected to sharp impacts. They should not be struck, bumped or dropped. Rough handling may alter the pressure setting, deform valves parts and adversely affect seat tightness and valve performance.

B. Before installation verify that the valve's pressure setting, fluid type, service temperature and other specific requirements are according to design specifications.

C. Perform a detailed visual inspection of the PRVs conditions. If the shipping container is damaged and the valve shows indications of alterations or body damage, do not install it. Have the valve tested by a qualified person or shop to verify the PRV is undamaged and no changes in pressure settings have occurred.

Existing Valves

A. Review available history to identify evidence of chatter or any other condition that can result in valve failure. Perform a thorough evaluation to determine the cause and prevent reoccurrence. Any evidence of chatter should trigger a review of the PRV system design.

B. Ensure valves that were sent to a shop for maintenance or repair have been bench tested for proper settings and checked for leakage before installation.

2.2.2.2.2 Pressure relief valves installed in a vertical position are preferred to avoid induced misalignment of moving parts and accumulation of liquid in the device, which may interfere with valve operation.

2.2.2.3 Rupture Disks

2.2.2.3.1 Install rupture disks according to manufacturer's recommendations. Thoroughly inspect and clean the disk before installation. Ensure no physical damage or deformations are present that may affect the tightness of the disk.

2.2.2.3.2 Ensure that during installation, the disk and holder are properly oriented relative to the flow; and that the manufacturer's bolt torque and tightening procedures are followed.

2.2.2.3.3 Install rupture disks either in a vertical or horizontal position, ensuring the inlet and discharge piping is adequately supported and aligned.

2.2.2.3.4 Install rupture disks in series using specifically designed disk holders. Ensure a suitable tell-tale indicator is provided to monitor and prevent pressure buildup in the space between disks (Figure 2.2.2.3.4-1), which can affect proper activation of the primary upstream disk. Ensure a means for draining accumulated liquid from this area is provided. See Sections 2.2.2.4.3 and 2.3.1.2 for additional information and inspection frequencies.

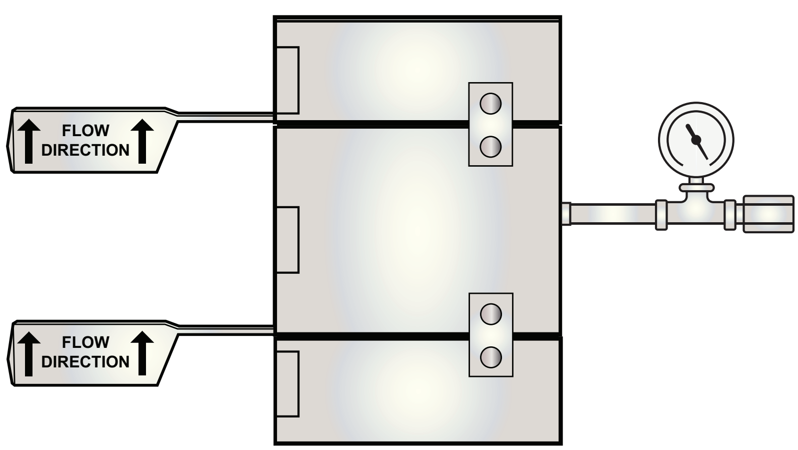

Fig. 2.2.2.3.4-1. Rupture disks mounted in series

2.2.2.4 Combined Pressure Relief Valves and Rupture Disks

2.2.2.4.1 For emergency relief systems using rupture disks under safety relief valves, ensure the rupture disk is of the non-fragmenting type; and that the specified burst pressure of the rupture disk and the set pressure of the PRV are of the same nominal value to have both close coupled.

2.2.2.4.2 For relief systems using rupture disks under safety relief valves (Figure 2.2.2.4.2-1), provide a tell-tale indicator in the space between the two devices. Doing so will allow discovery of a leak and subsequent pressure buildup that would change the operating point of the disk. Also provide means for draining accumulated liquid from this area.

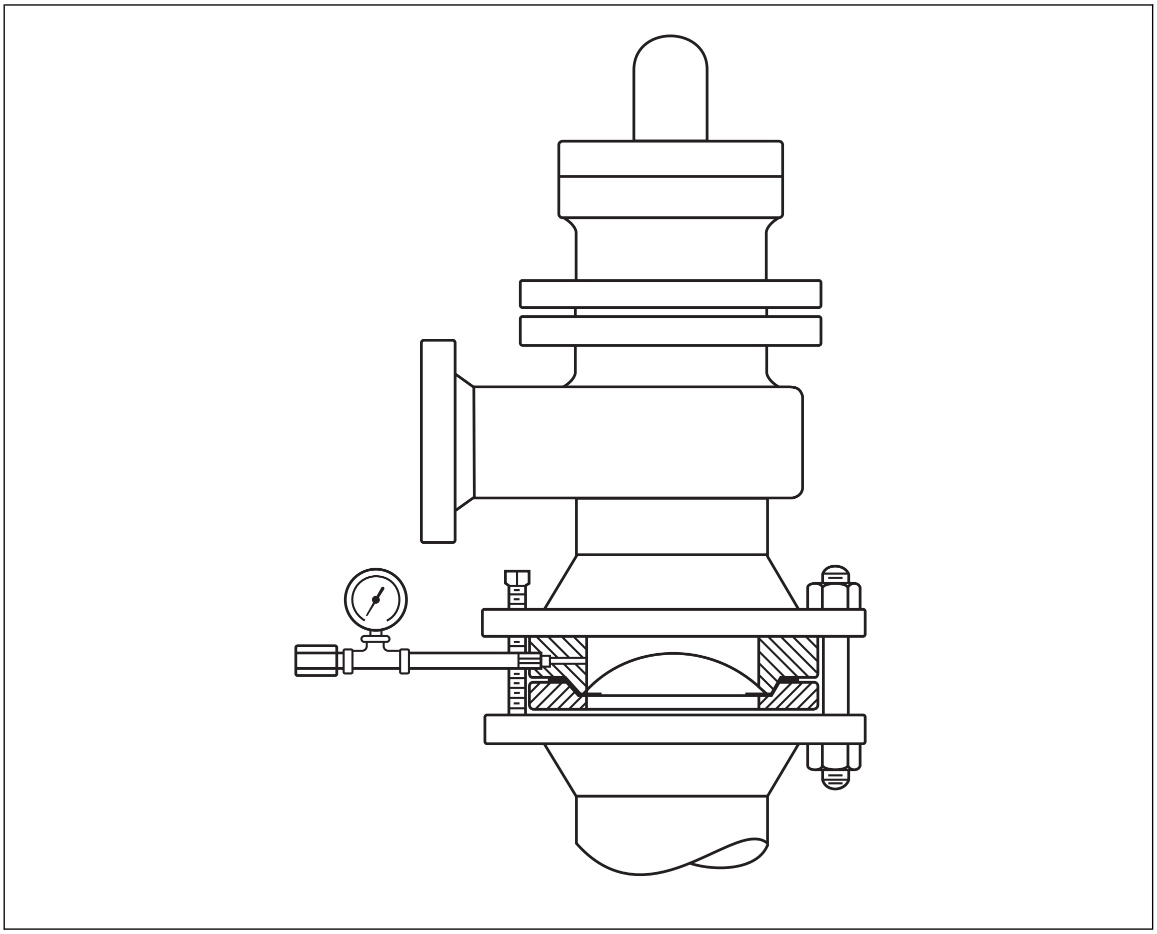

Fig. 2.2.2.4.2-1. Rupture disk mounted under a relief valve

2.2.2.4.3 The tell-tale indicator may be a simple pressure gauge as shown in Figure 2.2.2.4.2-1, or a pressure measurement can be sent to the control room with an alarm to indicate the presence of pressure in the space.

2.2.2.5 Inlet Piping

2.2.2.5.1 Avoid long horizontal runs or trapped sections of inlet pipe where foreign matter may accumulate and interfere with relief device operation or discharge flow.

2.2.2.6 Discharge Piping

2.2.2.6.1 General

2.2.2.6.1.1 Ensure the discharge piping on the outlet of the relief device is as short and straight as possible. Minimize changes in direction and number of elbow pipes.

2.2.2.6.1.2 Provide the discharge piping close to the relief device with a method to permit drainage of condensation or other accumulating liquids (Figure 2.2.2.6.1.3-1). If this method is direct atmospheric discharge via small holes that could result in impingement of potentially burning vapors on the vessel during an emergency, protect the surface from overheating by insulation, water spray or equivalent. Alternatively, a small elbow on the hole could be used to redirect the discharge.

2.2.2.6.1.3 Ensure discharge piping is designed, braced, or fastened to allow for the thrust loading and bending moments generated by the discharged fluid (Figure 2.2.2.6.1.3-1). Any flexible couplings should meet the same design criteria as the fixed relief lines.

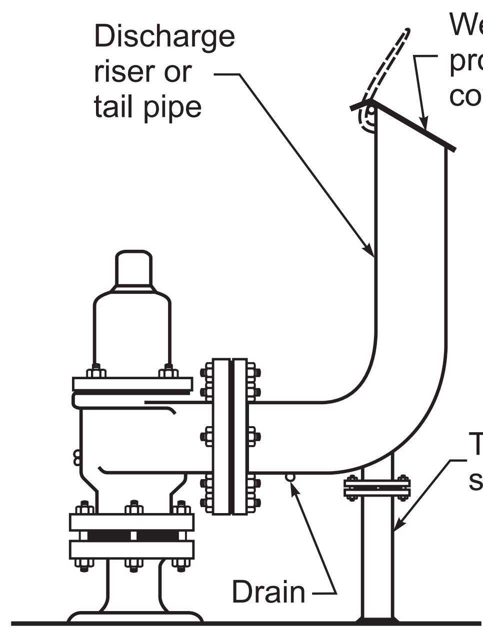

Fig. 2.2.2.6.1.3-1. Support for relief valve discharge piping

2.2.2.6.1.4 Assemble discharge piping in such a way that it can be easily disassembled for cleaning and inspection.

2.2.2.6.2 Direct Atmospheric Release

2.2.2.6.2.1 Ensure the tip of the discharge pipe faces straight up to improve vapor dispersion and is provided with a loose-fitting rain cover or other suitable method to prevent rain accumulation without restricting the vent opening. (Figure 2.2.2.6.1.3-1).

2.2.2.6.3 Manifold Discharge Piping Systems

2.2.2.6.3.1 Arrange manifold lines to ensure that actuation of one relief system does not affect other systems or devices connected to the same manifold line.

2.2.2.6.3.2 Provide vacuum supports or special back pressure supports for relief devices connected to a discharge piping manifold to prevent rupture of the disk by back pressure when another relieving device operates (Figure 2.2.2.6.3.2-1).

2.2.2.6.3.3 Where materials can solidify in the manifold line at ambient temperatures, ensure the line is heat traced in an appropriate manner.

2.2.2.7 Isolation Valves

2.2.2.7.1 Install isolation valves on the inlet and/or outlet of pressure relief devices only when allowed by the authority having jurisdiction (AHJ) or when required for process functionality. See Section 3.7 for additional information.

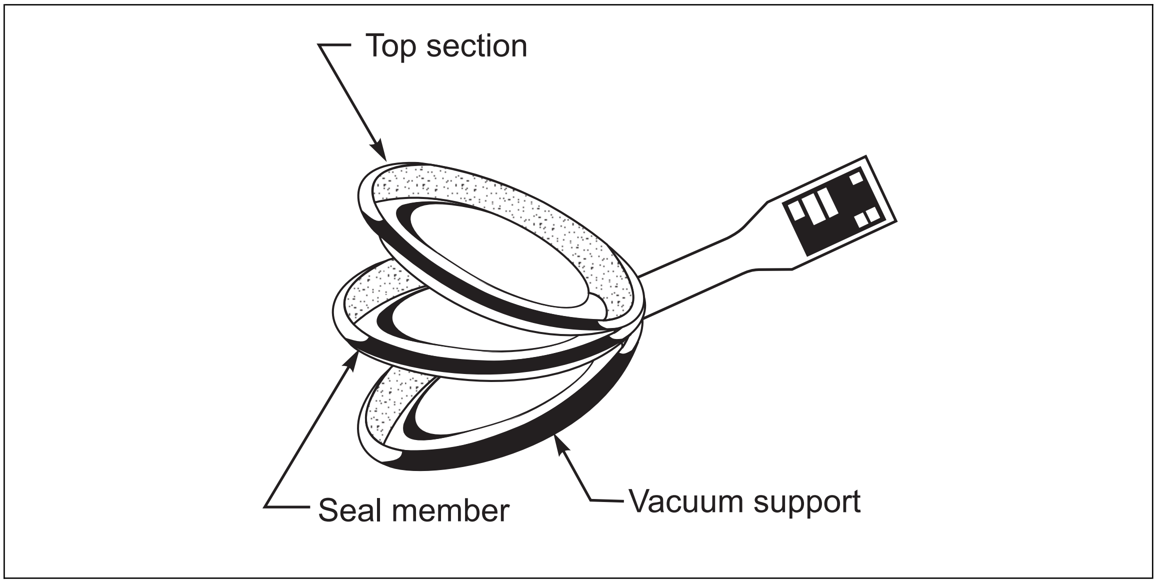

Fig. 2.2.2.6.3.2-1. Vacuum support for rupture disk

2.2.2.7.2 If a pressure relief device needs to be serviced while the protected equipment/system is operating, install redundant pressure relief devices and provide valve operation controls to ensure that isolation valves in the pressure relief path are in their proper position (open or closed). This could include:

A. A three-way switching valve (so that one device always remains in service). (See Figure 2.2.2.7.2-1).

B. Mechanical or instrumented interlocks designed to prevent valve operations that could result in blocking the pressure relief path before an alternate path is put into service.

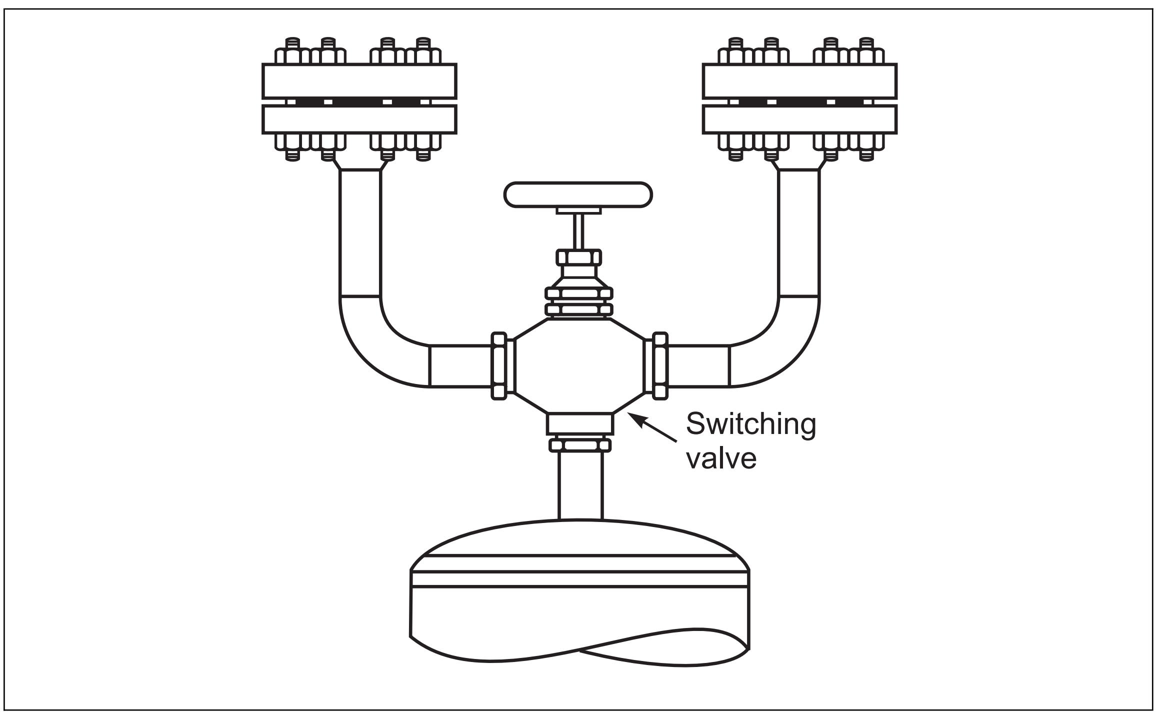

Fig. 2.2.2.7.2-1. Switching valve with rupture disks (or relief valves)

2.2.2.7.3 For the installation of multiple pressure relief devices in combination with isolation valves, use any of the following options:

A. Provide each device with a separate connection to the vessel and/or piping system, or a single connection supplying multiple devices; such that isolating one relief device will not reduce the venting capacity below that required by the vessel operation (e.g., three relief devices where any two can provide adequate relief capacity).

B. Provide interlocks or administrative controls (documented operating procedures) to prevent more than one relief device from being isolated during vessel operation.

2.2.2.7.4 Design each isolation valve to have a full-bore port larger than or equal in size to the inlet and/or discharge (as applicable) of the pressure relief device. Select a valve type with a minimal pressure loss.

2.2.2.7.5 Design and install any isolation valve for the service conditions and so that the valve position can be visually verified.

2.3 Inspection, Testing and Maintenance

2.3.1 General

2.3.1.1 Clean relief system piping and containment/disposal vessels after every actuation of the emergency relief system. Ensure a full incident investigation is conducted to determine the cause of valve activation, and establish any corrective actions needed to prevent recurrence.

2.3.1.2 For pressure gauges used as tell-tale indicators between pressure relief devices, conduct a visual recorded check prior to the start of each batch (or once a shift for continuous processes) and prior to any restart after a shutdown to verify no leakage or pressure buildup. If a batch takes more than one shift, conduct a visual check each shift.

2.3.1.2.1 For systems where pressure buildup is detected between devices, conduct a full investigation to determine the cause and prevent recurrence.

2.3.2 Pressure Relief Valves

2.3.2.1 Test pressure relief valves on vessels containing dirty, fouling, or highly corrosive materials or materials susceptible to polymerization fouling at least annually. For pressure relief valves in clean service, test at least every three years.

2.3.2.2 Ensure pressure relief valves are tested by qualified technicians or shops following recognized standards (i.e., API 576) and manufacturers recommendations. Maintain records and proper testing documentation.

2.3.3 Rupture Disks

2.3.3.1 Replace rupture disks based on the disk manufacturer's recommendations. Disks exposed to frequent pressure cycling, high operating temperature, or fouling/corrosive atmospheres may require annual replacement.

2.3.3.2 Visually inspect rupture disks whenever the vessel is inspected. If any cracking or material creep is discovered, replace the disk prior to putting the vessel back into service.

2.3.4 Isolation Valves

2.3.4.1 Include all isolation valves in a management system or program to ensure the valves are always open while in service. Include at a minimum:

A. Pre-plan and document procedures to isolate a pressure relief device from the vessel and/or piping system in order to minimize the time required to inspect, test, repair or replace the relief device.

B. A by-pass program to manage whenever any isolation valve is closed for inspection, testing, repair or replacement to ensure they are reopened promptly after completion of the activity. See also Section 2.3.4.2.

C. Locks or car seals to maintain isolation valves in an open position. Ensure the locks or car seals are suitable for the service conditions and installed so they must be open or broken to operate the isolation valve.

2.3.4.2 Where a single pressure relief device is provided, do not isolate the pressure relief device while the equipment is in service.

2.3.4.3 Perform monthly inspections to verify the isolation valve is open, and the lock or car seal has not been removed or broken. Maintain and review the records of the inspections as part of the site maintenance program.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

A pressure relief device is a safety device designed to protect a pressurized vessel or system by venting fluid and relieving pressure during an overpressure event that may cause pressure to increase beyond the specified design pressure or maximum allowable working pressure (MAWP).

Once a condition occurs that causes the pressure in a system or vessel to increase to a dangerous level, the pressure relief device may be the only remaining means to prevent a catastrophic failure. Therefore, reliability of these devices is paramount; they must be always capable of operating with the process fluid as the sole source of power for activation. Proper sizing, selection, installation and maintenance of pressure relief devices is critical to obtain adequate protection.

The size of relief devices is specified in many cases (mostly for non-reactive systems) by existing codes and standards. These include the American Society of Mechanical Engineers (ASME), American Petroleum Institute (API), National Fire Protection Association (NFPA) and Occupational Safety & Health Administration (OSHA) for ignitable liquids; the Compressed Gases Association (CGA) for gases; the Chlorine Institute for chlorine, as well as some specific international standards such as DIN ISO-4126-10. These codes are mostly based on single-phase system. However, basic guidance for reactive systems is also provided in some of these codes and standards.

3.2 Pressure Relief Devices - Types and Operation

Pressure relief devices are available in many types and sizes to cover a range of fluids and process conditions. In general, pressure relief devices can be classified as reclosing and non-reclosing devices. A reclosing type is designed to close after operation once normal conditions have been restored. These include devices such as pressure relief valves, safety valves, etc. Non-reclosing devices, once activated, cannot be resealed; they must be replaced. Types of non-reclosing devices include rupture disks and device pins.

3.2.1 Pressure Relief Valves

Pressure relief valves are designed to open at a predetermined pressure (to relieve excess pressure and protect the vessel or other equipment from an overpressure condition or catastrophic failure) and close when the system pressure returns to a safe level. Pressure relief valves can be classified according to their construction features and operation with spring-loaded and pilot operated devices being the most common types. Spring-loaded pressure relief valves can also be found as conventional or balanced bellow types.

3.2.1.1 Spring-Loaded Pressure Relief Valves.

Spring loaded pressure relief valves (Figure 3.2.1.1-1) are referred to by different terms depending on the application, such as safety valves (gas/vapor services), relief valves (liquid services), and safety relief valves (multiservice applications). Spring-loaded pressure relief valves are self-actuating devices that remain closed during normal operation. Once the pressure reaches the valve set pressure, the valve will gradually open until full lift is reached. When a pressure relief valve begins to lift, the spring forces increases, requiring the system pressure to increase in order to obtain a full valve lift. For this reason, pressure relief valves are allowed an overpressure allowance to reach full lift. The valve closes when the inlet pressure has dropped sufficiently below the set pressure (better known as closing pressure). The difference between the set pressure and the closing pressure is called the blowdown, usually expressed as a percentage of the set pressure.

Pressure relief valves are reliable devices when properly sized, operated and maintained. However, these devices can be affected by back pressure and chatter if built-up back pressure is too high, which may be the case in closed discharge systems or when a long vent pipe is used.

Conventional pressure relief valves are one of the most common pressure relief devices used in the chemical industry. The working principle of a conventional valve is based on the balance of force, where the pressure force acts on a disc that is positioned against a seating surface by a spring. The compression of the spring can be adjusted using an adjusting screw so that the spring force is equal to the pressure force at the valve set pressure. An important consideration of these valves is that their operational characteristics (set pressure, closing pressure, and relieving capacity) are affected by back pressure (superimposed and built-up) from the discharge system or piping. These valves can also be prone to seat leakage, that may result in continuous loss of fluid with potential damage to the valve seating surface. The selection of an adequate seated material, considering fluid properties and temperature, is important to prevent valve damage and failures.

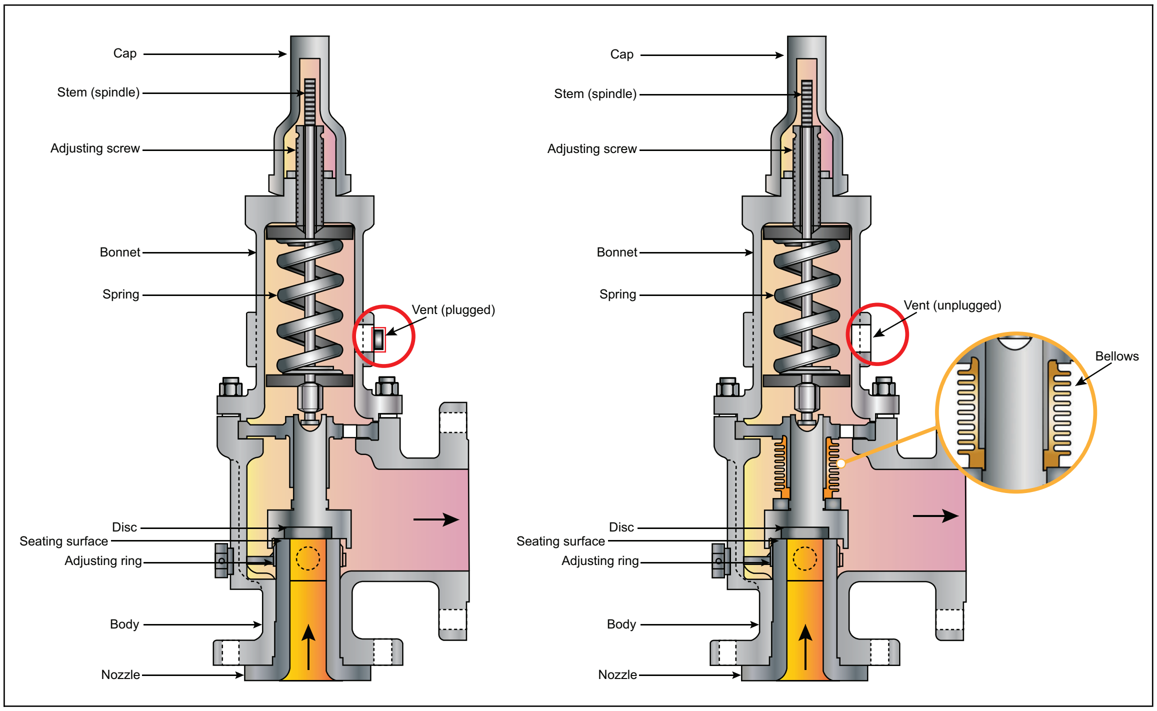

Fig. 3.2.1.1-1. Spring loaded pressure relief valves. Left: Conventional PRV. Right: Balanced-bellows PRV

The operational principle of a balanced bellows pressure relief valve, which is based on force balance, is similar to a conventional valve. However, the incorporation of a bellow seal can minimize the effects of back pressure on these valves. The bellows also prevent discharging fluid from entering the bonnet space; but in the event of bellows failure, fluid can enter the bonnet space and escape through the bonnet vent. It is important to inspect bellows integrity; balanced bellows valves will perform as a conventional valve if the bellows fail. This condition can represent a hazard, especially for systems that involve significant backpressure.

In vapor or gas service, the valve may simmer before it will pop. Liquid service valves do not pop in the same manner as vapor or gas service valves; they utilize reactive forces to achieve lift. These forces typically build very slowly during the first 2% to 4% of overpressure. Spring-loaded pressure relief valves designed for liquid and gas applications and balanced to minimize the effects of back pressure are recommended for two-phase applications.

3.2.1.2 Pilot Operated Pressure Relief Valves

A pilot operated pressure relief valve (Figure 3.2.1.2-1) is a device that uses process pressure to keep the valve closed until set pressure is reached. It consists of the main valve that relieves the required capacity of process fluid, a floating unbalanced piston or diaphragm and an external pilot that controls the pressure on the main valve. The valve operates once the set pressure is reached; and the pilot vents the pressure from the top of the piston, causing the piston to move upward to allow flow through the main valve. When the process pressure decreases to a safe level, the pilot will close, depressurizing the cavity above the piston and closing the main valve.

One important characteristic of pilot operated pressure relief valves is that the lift of the main piston or diaphragm is not affected by backpressure. These valves are commonly used in applications where the built up or superimposed backpressure is higher than that applied to conventional or balanced bellows valves. They are also used where a large relieving area at high set pressure is required or where the operating pressure is close to the set pressure. In fact, pilot operated valves are frequently chosen when operating pressures are within 5% of set pressures and a close tolerance valve is required. The main disadvantage of these valves is they are normally temperature limited by the elastomer or plastic piston seal materials and limited to noncorrosive and non-fouling services. The pilot control unit and its tubing can easily be blocked by dirty or fouling process materials.

Pilot-operated pressure relief valves can be classified based on the type of moving members (pistons or diaphragms), type of pilots and type of pilot flow.

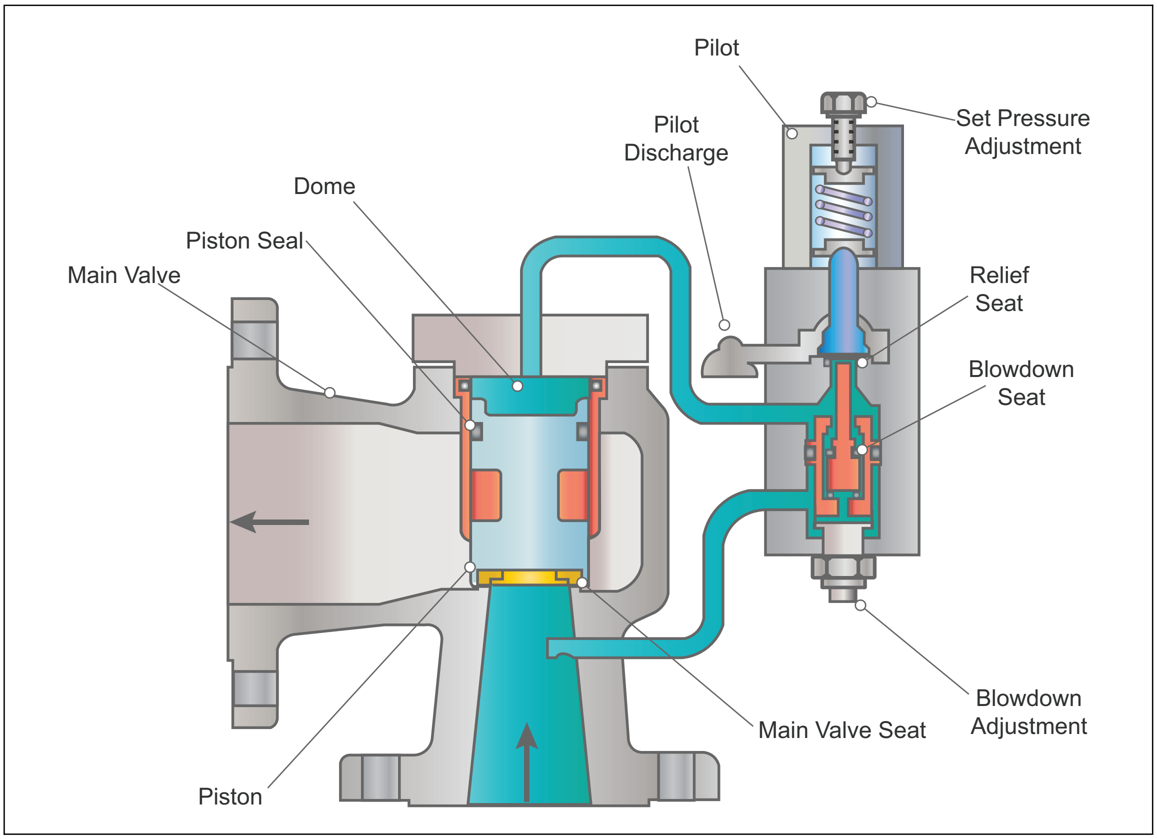

Fig. 3.2.1.2-1. Pop-action pilot operated valve (non-flowing pilot type)

3.2.2 Rupture Disks

Rupture disks are non-reclosing, pressure-relief devices designed to release pressure upon membrane disk rupture at a predetermined pressure difference between the inlet and outlet of the device. Rupture disks cannot be resealed once burst; they must be replaced. A rupture disk assembly consists of a thin, circular membrane usually made of metal, plastic or graphite that is firmly clamped in a disk holder (Figure 3.2.2-1).

Rupture disks are available in a wide variety of types and designs, and they can be used in pressure or full vacuum systems. However, depending on the application, rupture disks are mainly classified as reverse- and forward-acting. Reverse-acting rupture disks (Figure 3.2.2-2) have the dome towards the process. The compression loaded designs are pressurized on the convex side of the dome, and the bursting or breaking

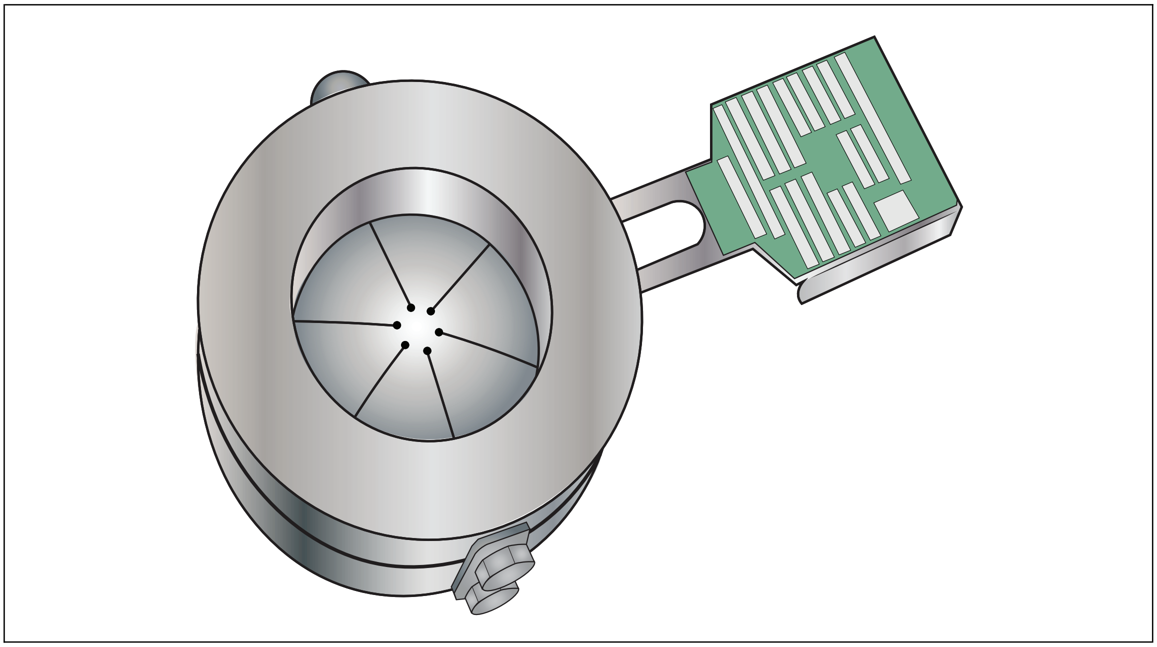

Fig. 3.2.2-1. Typical rupture disk assembly

elements are subjected primarily to compressive stress during the initial buckling of the disk. Domes are typically supported on the outlet side to prevent movement prior to reversal. Reverse acting rupture disks may be manufactured as non-fragmenting devices, making them more suitable for an upstream installation combined with a pressure relief valve.

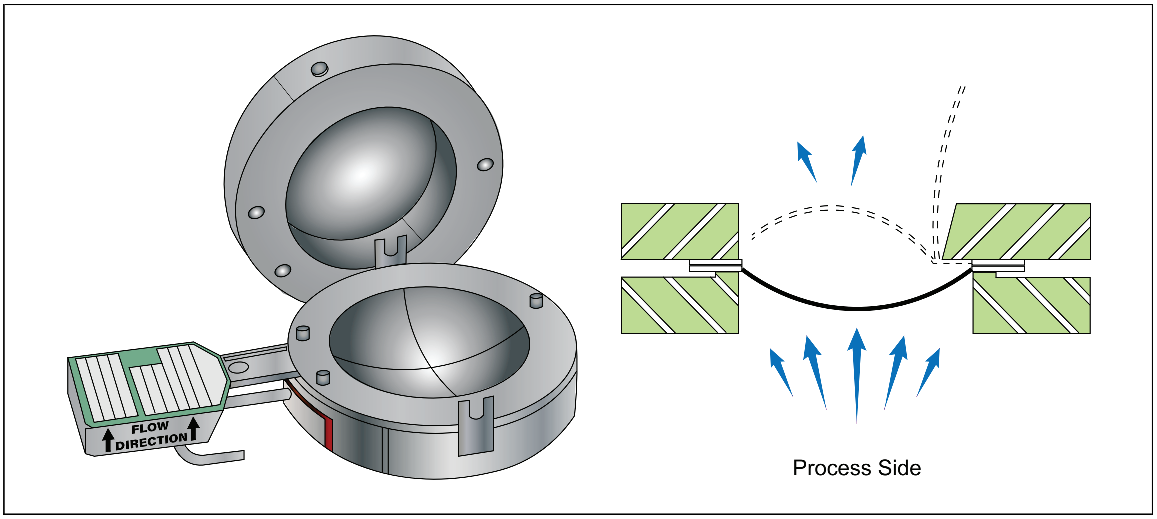

Fig. 3.2.2-2. Reverse acting rupture disk

Forward-acting rupture disks (Figure 3.2.2-3) have the dome away from the process. The tension loaded designs are pressurized on the concave side of the dome, and the bursting or breaking elements fails in the tension or a combination of bending and tension. These devices are normally not supported and are not recommended for use in combination with a relief valve; because the membrane of the disk will fragment when burst, potentially allowing pieces of the ruptured disk to enter the relief valve.

Rupture disks can be use in any application requiring overpressure protection where a non-reclosing device is suitable. Rupture disks are cheaper than relief valves and do not require as much routine maintenance or pressure testing. However, these devices need to be inspected on a periodic basis for corrosion or metal

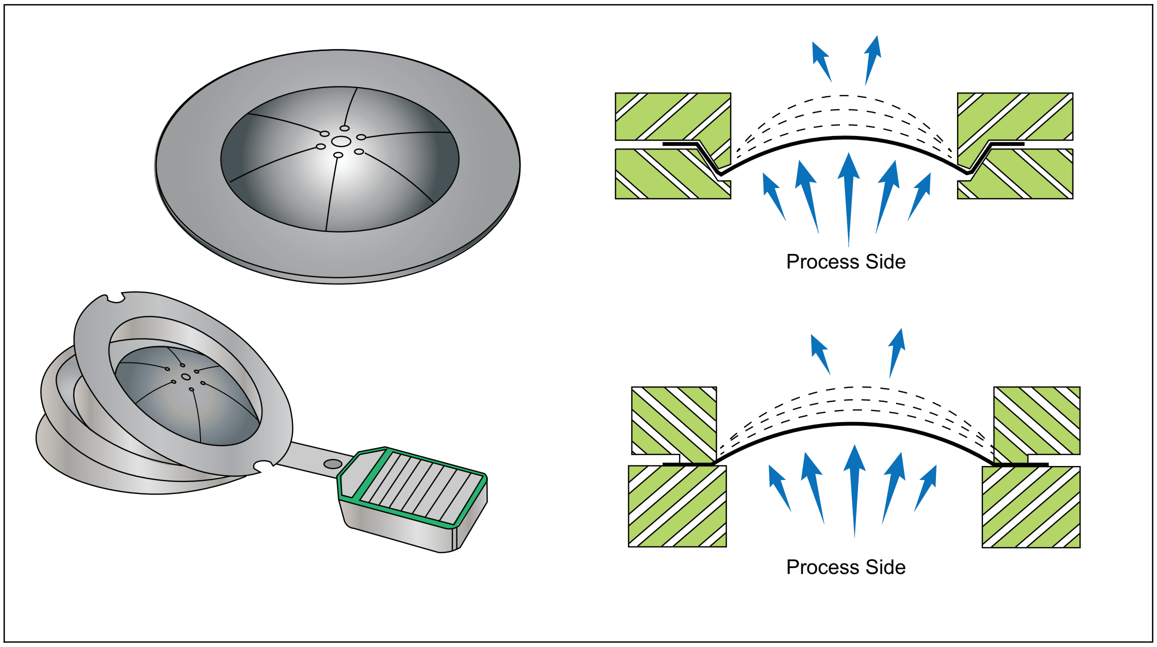

Fig. 3.2.2-3. Forward acting rupture disks

fatigue. Rupture disks are fast acting devices and represent a good option for cases where pressure relief valves may not respond quick enough to prevent catastrophic failures. Also, rupture disks can perform better than pressure relief valves in highly viscous systems.

Rupture disks can be installed alone, in combination with a pressure relief valve or in series. When installed with a pressure relief valve, rupture disks can be located at the inlet (upstream) or outlet (downstream) of the pressure relief valve, depending on purpose. For instance, rupture disks may be located upstream of the relief valve to ensure a positive seal of the system, to prevent plugging of the relief valve if the system contains solids or particles, to protect the pressure relief valve if the process materials are corrosive, etc. In this arrangement, the rupture disk and pressure relief valve should be close coupled, i.e., the specified burst pressure of the rupture disk and set pressure of the pressure relief valve are of the same nominal value.

Disk leakage due to corrosion or other causes is one of the main concerns when rupture disks are installed at the inlet of a pressure relief device. When leakage occurs, the disk may not burst in tolerance due to backpressure build up. Therefore, the space between disks has to be monitored and/or appropriately vented to ensure safe operation.

Rupture disks may be installed at the outlet of a pressure relief valve mainly to protect the valve from atmospheric or downstream fluids.

Rupture disks are installed in series mainly for highly corrosive applications to prevent any hazardous product release. If the first disk develops a leak due to corrosion, then the second disk will contain the fluid. Both rupture disks are typically specified at the same burst pressure and should be installed using a suitable telltale indicator, pressure gauge or free vent in the space between disks to ensure the required pressure difference is maintained.

Rupture disks are temperature-sensitive devices, and burst pressures can vary significantly with temperature changes. Thus, rupture disks need to be specified at the pressure and temperature that the disk is expected to burst. Also, an allowance between the operating pressure and set pressure is required to prevent premature disk fail due to pressure pulsations.

3.3 Design Considerations

When designing a pressure relief system, the goal is to determine the proper discharge area of the relief device and diameter of the associated inlet and outlet piping to provide an adequate equipment venting path that prevents the pressure in any piece of the protected system from exceeding the maximum allowable accumulated pressure, considering the worst credible scenario. The design process of pressure relief systems follows a series of steps that generally include the following:

- Definition of the protected system and desired relieving conditions: Set pressure of the relief device and MAWP of the system. Protected system may consist of one or more pieces of equipment and piping. For instance, a pressure relief device designed to protect a distillation column may also be used to protect the reboiler and condenser.
- Selection of every credible relief scenario that includes all physical, thermal and reactive properties at relief conditions.
- Calculation of the require relief flow rate, discharge area and relief conditions for each credible relief scenarios.
- Selection of the worst credible scenario that requires the largest discharge area.
- Selection of the appropriate type of relief device and associated piping to handle the relief flow rates and conditions.
- Design of inlet, outlet piping and containment systems, if needed.

3.3.1 Relief Scenarios

Evaluation of all potential overpressure process or equipment scenarios is the first step in the pressure relief design process. The pressure in systems or equipment will typically increase in the presence of conditions such as excess material flow, thermal expansion, or gas generation due to heat input or chemical reactions. Common tools (i.e., P&IDs, SOPs) or techniques that can assist in the evaluation of different scenarios include Failure Modes and Effects Analysis (FMEA), Hazard and Operability Studies (HAZOPS), Fault Tree Analysis, etc. See Data Sheet 7-43, *Process Safety*, for additional information on these or other available methodologies. When determining the list of potential scenarios, consider all modes of operation including normal, startup, shutdown, emergency, maintenance, idle and out of service conditions.

Table 3.3.1-1 shown a list of common process conditions or scenarios that may require evaluation and overpressure protection. This is by no means a complete list. These conditions may not be the only causes of overpressure for the system under consideration, and any circumstance that reasonably constitutes a hazard should be considered in the design.

Table 3.3.1-1. Common Overpressure Process Conditions/Scenarios

Process Condition/ Scenario	*Description*
Exposure to External Fire	External fire scenarios involving equipment can result in overpressure due to vapor generation and/or fluid expansion. The classic fire hazard is an accumulation of ignitable liquid that may catch fire, resulting in an extended duration pool fire that exposes the process vessel or equipment. To determine this as a credible scenario, sufficient fuel need to be available to heat the contents of the equipment or vessel from its normal operating temperature to its bubble point temperature at relief pressure.
Flow Blockages	This scenario should be evaluated for cases where flow blockages can result in pressure that exceeds the MAWP of the vessel or equipment. Blocked outlets can be caused by control valve failure, inadvertent valve operation, instrument-air or power failure, etc.
Overfilling	An overfilling condition should be evaluated for process vessels and equipment (including columns and towers) that have a liquid level present during normal startup or shutdown operations, which may be overfilled under conditions where the source pressure of a liquid feed or supply line exceeds the relief device set pressure and/or the design pressure of the equipment.
Loss of Cooling/ Reflux	Loss of cooling is often related to the failure of electrical or mechanical equipment that provides cooling or condensation in process streams and can cause overpressure conditions. A few examples include loss of quench stream, air-cooled exchanger failure, loss of cold feed water, loss of reflux, etc.Overpressure scenarios caused by loss of reflux are commonly associated with pump, valve or instrument failures or the loss of cooling water. Loss of reflux will cause liquid condensate built-up in the equipment reflux drum (and eventually in the condensers) causing the loss of cooling.
Utility Failure (air, water, nitrogen, steam, refrigeration, power, etc.)	Utility service failures and consequences need to be carefully evaluated, whether for a complete or partial failure, to determine the overpressure effects to the processes and/or equipment and the reaction time involved. Utility failures may include: gen eral/partial power failure, loss of fuel oil/gas loss of inert gas, loss of instrument air, loss of cooling water, loss of steam, etc.
Instrument Failure	Instrument failure can be associated with electronic or mechanical signal failure, loss of instrument air or loss of power for systems that are electrically operated. This can result in overpressure if the specified failure positions of the valves are not selected to prevent overpressure conditions or if the system is not able to maintain process control upon instrument failure.
Loss of Heat	This scenario needs to be evaluated for cases where equipment in series (such as fractionation columns) can be affected by loss of heat input and create overpressure conditions to a downstream column by increasing the vapor load.
Abnormal Heat/ Vapor Input	Abnormal heat input needs to be evaluated for cases where: • The supply of heating medium, such as fuel oil/gas to a fired heater, can be increased. • Heat transfer occurs in a new and clean heat exchanger after revamp. • The control valve for the fuel supply fails fully open. • The supply pressure of the heating steam can be changed from normal range to maximum pressure. Abnormal vapor input is usually considered for cases where the upstream vapor control valve can fail fully open. An evaluation should also be considered for overpressure conditions created by systems with extra vapor generation that cannot be discharged, whether directly caused by an abnormal vapor input or not.
Exchanger Tube Failure	Heat exchangers and similar vessels may require protection with a relieving device of sufficient capacity to avoid overpressure in case of an internal failure such as a complete tube rupture or pinhole leak. Complete tube rupture, in which large quantity of high-pressure fluid will flow to the lower pressure side of the exchanger, is a remote but possible contingency. Minor leakage can seldom overpressure an exchanger during operation; however, such leakage occurring where the low-pressure side is closed in can result in overpressure conditions.
Thermal or Hydraulic Expansion	Thermal or hydraulic expansions are commonly considered for liquid systems. When liquids are blocked in a vessel or pipeline, external heat input can cause liquid temperature to increase and volume to rise. Examples include: • Liquid in a vessel or pipeline that is subject to heat, causing the liquid to expand and increasing pressure. • The cold side of a heat exchanger being filled while the hot side is flowing. • A vessel that is filled with liquid at ambient temperature that is also heated by direct solar radiation.
Chemical Reaction	Runaway reactions tend to accelerate with rising temperature; extremely high volumes of non-condensable with high energy can cause the internal pressure of a vessel or pipeline to rise rapidly.
Accumulation of Non-Condensable	Non-condensable accumulation can result from blocking of the normal vent, or accumulation in the pocket of a piping configuration or equipment. The accumulation of non-condensable can blanket a condenser and result in a loss of cooling.

Chemical reactions pose one of the most difficult challenges for designing relief systems. The reactive characteristics of the material should be well understood, including the potential for reacting with itself, decomposing, rearranging or reacting with contaminants such as water, air, rust and other materials that could be present in the system. All reactions that could occur should be identified, and the kinetics of these reactions should be determined either by experiment or through trusted literature sources. Numerous theoretical, computational and experimental reactivity screening tools are available. See Data Sheet 7-46, *Chemical Reactions and Reactors*, for additional information.

After the overpressure scenarios have been listed, the next step is to decide which scenarios are credible. This will involve breaking each scenario into the sequence of events that cause it and comparing them to an established credible criterion. Causes of overpressure can sometimes be related between scenarios, which needs verification. To determine design basis, the causes of overpressure must be unrelated or independent, meaning no process, mechanical or electrical linkages among them and sufficient time between occurrences to make their classification unrelated. The scenarios with unrelated causes are known as single jeopardy scenarios and are the ones commonly evaluated. While the design basis usually does not consider the simultaneous occurrence of two or more unrelated causes of overpressure (also known as double or multiple jeopardy), it can be considered adequate for cases with severe consequences. Examples of multiple jeopardy scenarios include but are not limited to simultaneous fire exposure with heat exchanger internal tube failure, simultaneous fire exposure with failure of administrative controls to drain and depressurize isolated equipment, or operator error that leads to a blocked outlet coincident with a power failure.

For each credible scenario, the required relief flow rate, discharge area and fluid relief conditions must be calculated, either by conventional methods or by a process simulation. Dynamic simulations are an alternative method that provide a better understanding of the conditions during relief, where variables are calculated as they change over time, and often have more accurate results than just conventional methods. For circumstances where the most dangerous part of the relief scenario is unclear, a dynamic simulation is usually recommended. However, inputs, dynamic calculation methods and results of the dynamic model should be validated to ensure the reliability of the pressure relief system.

3.3.1.1 External Fire Exposure

External fire exposure is a common cause of overpressure in pipes and vessels. Different formulas and assumptions are included in API (521/2000), NFPA-30, and OSHA 1910.106 that are used to calculate the heat input of a vessel exposed to an external fire. However, take careful consideration when selecting the correlation that better predicts the heat flux associated with the specific fire scenario. For some scenarios or materials, advance simulation techniques may be the most appropriate way to determine the heat flux and fire duration of an exposed vessel. Factors to be considered include type of fuel and inventories, drainage, curbing, dikes, firefighting capabilities, etc.

External fires can be characterized as pool fires, jet fires or three-dimensional fires. A pool fire typically results from an ignited liquid spill, while a jet fire results from an ignited pressurized leak. The heat flux from three dimensional and jet fires is very high, whereas the heat flux from pool fires is lower. The evaluation method for fire exposure in API 521 is based on an open pool fire. This method and the set of equations were empirically derived to size pressure relief devices involving hydrocarbons in a refinery environment and were validated by full-scale test data. However, alternative methods can be used when the assumptions for the empirical method are not adequate and more rigorous calculations or simulations are needed.

Under this standard, fire exposure evaluation for a pressure relief device is not required when the equipment is located at a height greater than 25 ft (7.6 m) above the source of the flame; because wetted surfaces above 25 ft (7.6 m) are not likely to be exposed to fire flames for long duration. Any portion of the vessel with a wetted surface located at a height less than 25 ft (7.6 m) above the base of the pool fire that is exposed and heated from the fire needs to be evaluated.

The empirical method in API 521, uses different equations for gases and liquids to calculate the heat absorbed by a vessel exposed to an open pool fire. For liquid service vessels, the heat absorbed can be significantly affected by the type of fire fuel, level of flame exposure according to vessel size and shape, environment factors, the presence of firefighting measures and adequate drainage.

Environment factors are related to the level of insulation provided, which is installed to limit the heat input to a vessel when exposed to a fire scenario. External insulation reduces the rise of the vessel wall temperature and the generation of vapor inside the vessel. Therefore, a capacity relief reduction can be given when insulation is installed to resist being dislodged by fire hose streams and is capable of withstanding an exposure temperature of approximately 1660°F (904°C) for up to two hours.

3.3.2 Device Selection

The selection of pressure relief devices should consider all the operating conditions most likely to be present during typical operations, including fluid properties and characteristics, relief rate, discharge conditions, etc. Figure 3.3.2-1 presents some general guidance for the selection of pressure relief devices and arrangements.

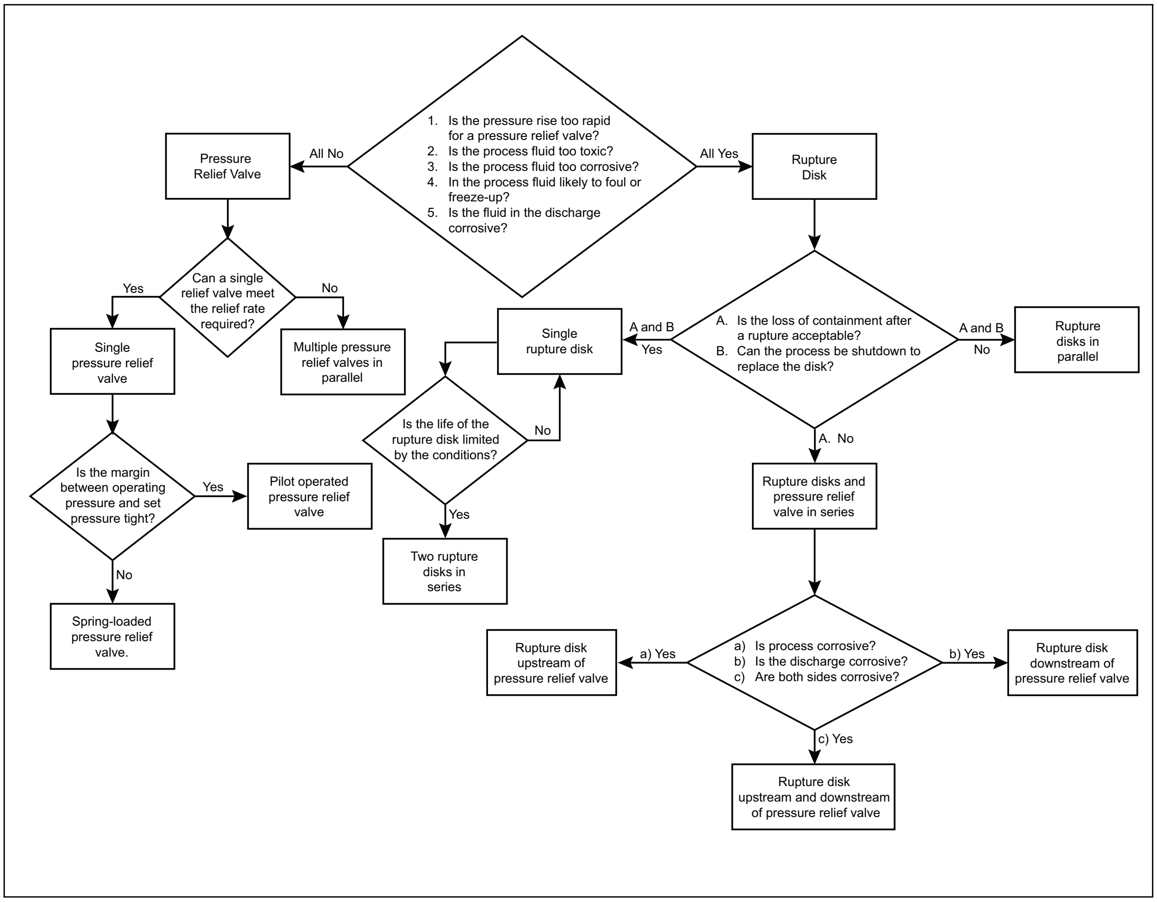

Fig. 3.3.2-1. Pressure relief device selection. Adapted from CCPS Guidelines for Pressure Relief and Effluent Handling System

Pressure relief valves are mechanical devices with moving parts, so they are not suitable for situations that could result in a sudden pressure impulse or used in an environment that limits its functionality. The selection of a pressure relief valve should consider a variety of factors such as backpressure, type of service (gas or liquid), discharge capacity, inlet pressure losses, etc. Back pressure is an important factor when selecting the type of relief valve. Different backpressure tolerances are established according to the type of pressure relief valve and manufacturer. Conventional pressure relief valves should typically not be used when the built-up back pressure is greater than 10% of the set pressure at 10% overpressure. For balanced valves or other relief devices that function independent of back pressure, the resistance in the discharge line should be considered in the system design. However, the limits should be in accordance with manufacturer's guidelines.

Rupture disks consists of a thin membrane secured between two flange faces that rupture when a specified pressure is reached. Although not as precisely calibrated as pressure relief valves, they are more suitable in corrosive or fouling services. Rupture disks are fast acting. They do not reseat and must be replaced after they discharge. Even though the replacement cost of rupture disks is lower and they require less maintenance than pressure relief valves, they should be carefully handled and installed to avoid mechanical damage. Another important consideration for these devices is that rupture disks are temperature sensitive, and burst pressures can vary significantly with temperature changes. For this reason, a rupture disk needs to be specified at the pressure and temperature that the disk is expected to burst.

When selecting a rupture disk, different specifications need to be considered. However, consult the manufacturer's information. Each manufacturer has different technology and methods. Therefore, even similar models will vary between manufacturers. Disk specification include the following:

- Disc type and dimensions.
- Materials of construction.
- Recommended temperature limits.
- Seating configurations.
- Burst pressure. This is the value of the upstream static pressure minus the downstream static pressure just prior to disk bursts.
- Burst pressure tolerance. Refers to the accuracy of the rupture disk's performance, and indicates the variation around the marked burst pressure at the specified rupture disk burst temperature.
- Operating ratio. Defined as the relationship between operating pressure and the marked burst pressure, and usually is expressed as a percentage.
- Manufacturing range. This is the pressure range in which the rupture disk should be marked. It is usually a percentage of the specified burst pressure. The most common ranges are 0%, 5% and 10%; but other standard ranges are also available for specific rupture disk designs.

3.3.3 Inlet/Outlet Piping

Inlet/outlet piping arrangement plays a very important role for an adequate operation of pressure relief valves. For inlet piping, the nominal size and fittings must be the same or larger than the nominal size of the pressure relief valve inlet connection. The length of the inlet piping should be minimized to limit pressure losses to a tolerable level to ensure stable operation and no chatter or flutter. High inlet pressure losses may also result in relief device capacity reduction. The inlet piping system should also be free draining to prevent accumulation of liquid or foreign matter in the piping.

The discharge or outlet piping must be no smaller than the discharge opening of the relief device to prevent pressure development on the discharge side of the device during operation. Discharge piping should run directly as possible to the point of final release, which should be a safe disposal area. Short, direct routing to the atmosphere is the preferred method of handling relief valve discharge. However, environmental or other considerations may dictate discharge to a catch tank, scrubber, incinerator, etc. This could also result in manifolding more than one relief device into a single discharge line.

Reduction of the relieving capacity of a pressure relief device below the amount required to protect a vessel from overpressure due to backpressure (present or generated) is a concern that should be evaluated during design. Thus, the effect of superimposed or built-up backpressure on the operating characteristics of the valves should be carefully examined. For systems using conventional relief valves, back pressure in the discharge pipe could cause the valve to flutter or chatter. Conventional relief valves are used when the sum of the maximum superimposed backpressure plus the built-up backpressure is less than 10% of the set pressure.

The discharge of a relief device creates a reactive load on the relief system from the force of the flowing liquid, causing the piping and/or vessel to recoil. Transient effects of reaction forces on piping and the effects of thermal expansion or contraction should also be addressed in the evaluation. Therefore, supports for outlet piping should be designed to minimize the transference of pipe loads to the valve body and provide an allowance for piping expansion when fluids with high temperature are handled. Valve displacement due to thermal expansion may cause valve leakage or faulty operation. These loads could affect or prevent the proper operation of the device, including proper reclosure after operating.

Discharge piping must be provided with a drain to prevent the accumulation of liquids and covers or rain caps for atmospheric vents, to prevent the ingress of rain or animals. Cover components should not obstruct the free and full discharge of the pressure relief valve.

Flanged piping or mechanical couplings are preferred for relief systems because they are easy to disassemble and clean. However, the fittings should have pressure ratings similar to the piping. Welded piping in relief systems should be avoided since it is difficult to disassemble and clean, but it can be used when flanged connections are provided to permit disassembly.

ANSI/ASME Code B31.3, *Process Piping*, specifies the type of pipe and the corrosion resistance specifications that should be met for relief system piping. Schedule 40, carbon steel pipe is the material most commonly used in relief systems. However, alternative pipe materials may be used, provided they meet the above requirements or any equivalent international code

3.3.3.1 Direct Atmospheric Release

Direct atmospheric release is used for vapor venting when environmental regulations permit these discharges. Discharging flammable or hazardous vapors to the atmosphere requires careful evaluation to ensure the disposal does not create a potential hazard, such as the formation of flammable mixtures at grade level or on elevated structures, exposure of personnel to toxic/corrosive vapors, exposure of equipment to corrosive vapors, ignition of relief streams at the point of emission and air pollution.

When flammable vapors are discharged to the atmosphere from a venting system, a mixture within the flammable range will unavoidably occur downstream of the outlet; as the vapor mixes with air. If the vent discharge is located a safe distance from other facilities, the material may be safely diluted by mixing with air; or the mixture may be burned as a flare by providing a pilot ignition source. Where venting is conducted without a flare, the system is normally designed to discharge at a high flow rate to facilitate turbulence and rapid dilution of the vapor or gas with air.

However, if the vent discharge contains significant quantities of a volatile ignitable liquid or its vapors, the liquid can condense and accumulate at grade level, generating a cloud of flammable vapors in the area. This will normally result in a decision to direct the release to a catch tank or knockout drums to reduce the hazard.

3.3.3.2 Containment and Disposal

The purpose of a containment or disposal system is to guide the relieved effluent to a location where it can be safely treated, disposed or discharged. These systems are used when the direct atmospheric release is not allowed or requires supplemental treatment. The selection of the system depends primarily on the phase and hazards of the discharge. Vapors and gases are commonly discharged to elevated vent stacks or to a flare where combustion is used to convert flammable, toxic or corrosive vapors to less objectionable compounds. Collected liquid fractions and solids may be reused in the process or recovered for off-site treatment or disposal.

Containment systems are used to capture the relief effluent from a vessel to prevent direct atmospheric discharge. Containment vessels may be known as catch tanks, dump tanks, knock-out drums, etc., and can be found in a variety of sizes and designs. Hazardous or reacting chemicals can be discharged into these vessels to be neutralized, rendering them nonreactive or less hazardous. They can also be used to contain any vapor or liquid effluent for posterior treatment at a scrubber or flare.

All containment and disposal system components must be suitable in size to allow for the requirements of all credible release scenarios and phases, pressure ratings and materials for the intended service conditions.

3.4 Installation

The installation of pressure relief devices plays a very important role in the reliability and adequate performance of both pressure relief valves and rupture disks. The variety of devices currently available and the specific installation arrangements require this be performed by trained and qualified personnel following manufacturer’s recommendations.

Before installation, these devices must be thoroughly inspected and cleaned to detect any damage or foreign material that could affect the device performance. Also, check valves should not be installed in PRD inlet or outlet lines; since these devices are normally closed, and the check valve can become stuck in the closed position or fail in a manner, causing an obstruction in the PRD path.

3.4.1 Pressure Relief Valves

Many valves are damaged when first placed in service because of failure to clean the connections properly when installed. Both the valve inlet and the vessel and/or line on which the valve is mounted must be cleaned thoroughly of all dirt and foreign material before the pressure relief valve is installed. New systems, in particular, are prone to contain welding beads, pipe scale and other foreign materials that might inadvertently become trapped during construction and damage the seating surface when the valve opens. Therefore, the inlet and outlet cover should be left in place until the valve is installed.

Pressure relief valves needs to be mounted vertically in an upright position, either directly on a nozzle from the pressure vessel or on a short connection fitting that provides a direct, unobstructed flow between the vessel and the valve. Installing a pressure relief valve in other than a vertical upright position may affect its operation and create instability. Consult the valve’s manufacturer regarding any other mounting position, since it may cause a shift in the set pressure and a reduction in the degree of seat tightness.

Pressure relief valves have to be connected as direct and close as possible to the vessel in a location that facilitates access and maintenance. The weight of the discharge piping should be carried by a separate support and braced firmly against swaying or vibrations. Otherwise, it can weigh down and warp the valve, causing the valve not to seat properly, resulting in excessive leakage. The vibrations may cause leakage at the seat of a PRV, premature opening or premature fatigue of certain valve parts or piping.

Fittings or pipe having a smaller inside diameter than the valve outlet connections must not be used.

Install valves away from locations where excessive turbulence or pressure fluctuation on the vessel and/or the system are present, such as reducing stations, orifice plats/nozzles and other valves and fittings.

To prevent any damage to the valves during transportation, they should be transported in an upright position, avoiding excessive movement or shock; as this can result in considerable internal damage or misalignment. Pilot operated valves should be moved using the lifting eyes provided on the main valve body and never be lifted or handled using the tubing, piping, pilot or pilot brackets. In addition, protective valve packaging should be kept in place until actual installation.

Position the discharge piping close to the relief device with a method to permit drainage of condensation or other accumulating liquids. If discharge pipes are fitted with components to prevent ingress of rainwater or foreign bodies, the components should not obstruct the free and full discharge of the pressure relief valve.

3.4.2 Rupture Disks

Rupture disk devices can be installed vertically or horizontally. Inlet and discharge piping need to be adequately supported and aligned to prevent excessive loads due to the weight of piping components or applied moments. All rupture disk devices should be thoroughly inspected before installation. The seating surfaces of the rupture disk holder shall be clean, smooth and undamaged. Any damage to the disk will affect the burst pressure and may create an unsafe installation and/or cause significantly reduced service life. A damaged disk should never be installed.

Before installation, confirm the rupture disk specifications for burst pressure, operating temperature and application. Also confirm the disk is compatible with the selected rupture disk holder, which should have a proper flange rating to effectively self-center the disk between the studs as shown in Figure 3.4.2-1. The companion flanges or pipe flanges need to be properly spaced and aligned to ensure the piping scheme will not affect the performance of the rupture disk through piping stress or clamping forces.

Also important is the orientation of the rupture disk during installation. Incorrect flow direction can decrease or increase the bursting pressure of the disk. Therefore, it should be installed with the flow arrows on the holder tags or name plates pointing in the same direction as the desired flow.

Gaskets are not commonly used between the rupture disk and the rupture disk holder. However, when used, they must have clean surfaces, be compatible with the process and ensure that the forces or bolt torque required for installation do not exceed the companion flange bolt torque specified by the rupture disk manufacturer. The intent is to have a positive system seal without overloading the rupture disk, which may result from disk burst pressure changes, leakage, premature activation, etc. Used gaskets need to be replaced whenever the disk device is disassembled during field service.

For rupture disks installed with holders, the alignment between the disk and the holder is crucial to prevent blockages of the discharge port that can ultimately lead to disk fatigue. No modifications should be made

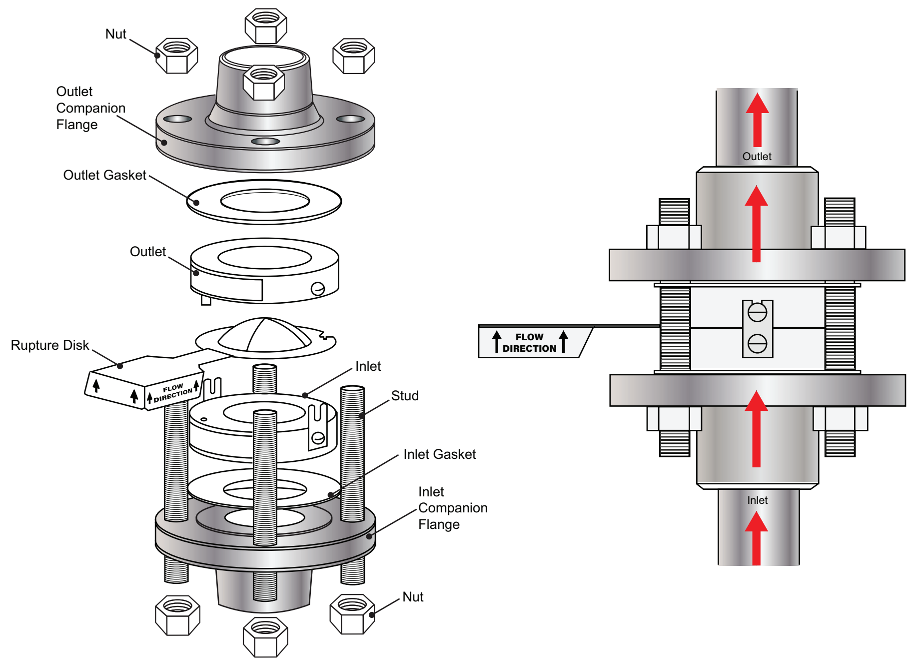

Fig. 3.4.2-1. Typical configuration of a rupture disk assembly

to a rupture disk holder, except by its manufacturer. Most manufacturers will evaluate holders for serviceability. In some cases, they can re-machine critical dimensions damaged through improper installation, excessively aggressive cleaning and/or superficial corrosion and return to the user for continued service.

Similar to safety relief valve installations, inlet and outlet pipes should be well supported. Incorrect piping and piping-support design can lead to the transfer of excessive piping loads to the rupture disk, affecting its burst pressure and life. The leading causes of rupture disk failures are tall or long discharge, and horizontal pipe runs, along with misaligned pipe flanges.

3.4.3 Installation of Pressure Relief Devices in Series, Parallel or Combined Arrangements

Different process situations and applications may require the emergency pressure relief devices to be installed using one or more devices to protect equipment or systems. (See Figure 3.3.2-1) Pressure relief valves and/or rupture disks can be used individually or installed in series, parallel, or combined arrangements.

Configurations in series are used to install multiple rupture disks or combined arrangements of a pressure relief valve and rupture disks. When rupture disks are used in series, depending on the application, the rupture disks may be installed in a double disk holder assembly or using two separate disk holders separated by a spool piece. The double disk holder assembly is commonly manufactured from three pieces, the inlet section of the rupture disk holder, the mid-flange and the outlet portion of the device.

Combined arrangements of pressure relief valve and rupture disks require both devices be close coupled, which limits shock loading on the relief valve during activation. Depending on the application, rupture disks can be installed upstream, downstream or on both sides of the pressure relief valve. Only non-fragmenting rupture disk devices should be used on the inlet side of a pressure-relief valve.

Configurations in series have the potential to build up pressure between devices usually the result of leakage or damage to the rupture disk that affects its seal. Therefore, the space between them, whatever the distance, should be fitted with a vent to prevent buildup pressure or provided with a suitable telltale indicator.

Pressure relief valves are commonly installed in parallel when a single valve cannot handle a very high relief load. To meet the total demand, several devices need to be installed. For this arrangement, at least one of the relief valves should be set at or below the MAWP of the vessel. The additional pressure relief valves may be set to open at higher pressures, but never at a pressure higher than 105% of the MAWP. Multiple pressure relief valves arranged in series reduce the possibility of chattering by not opening all the devices simultaneously.

3.5 Overpressure Protection by System Design

ASME Boiler & Pressure Vessel Code, Section XIII, Part 13 (2021 Ed.), determined that system design rather than pressure relief devices could be an alternate method of protecting a vessel against overpressure for cases where:

A. The pressure is self-limiting, such that the pressure is less than or equal to the MAWP; for example, the maximum discharge pressure of a pump or compressor feeding the vessel is less than MAWP.

B. The pressure is not self-limiting, where a series of conditions need to be met to prevent the pressurized equipment under normal operation from exceeding the MAWP at the coincident pressure. In this case, the pressurized equipment can be protected only by system design or by a combination of system design and pressure relief devices.

In general, mechanical overpressure devices are preferred for overpressure protection of vessels and equipment. However, for circumstances where the use of mechanical pressure relief devices is impractical, a safety instrumented system (SIS) is needed. When using safety instrumented systems in lieu of overpressure protection, avoid overpressure events by removing the source of overpressure or by reducing the probability of an overpressure event to such a low level it is no longer considered to be a credible case. The response time for this system must be evaluated to ensure it is fast enough to prevent the overpressure condition. Other considerations include the time needed to sense the overpressure process condition, the data processing time for the logic solver and the scan rate and closure time of the final element. If properly designed, the SIS can achieve or exceed the level of availability/reliability of a mechanical relief device. In this design approach, consider the system specifications for maintenance, testing and inspection procedures throughout its operational life to ensure system reliability.

3.6 Inspection, Testing and Maintenance

Efforts and capital spent designing and installing an emergency relief system to give adequate protection are of little value if the system is not kept in working order. Therefore, a well-documented and thorough inspection and preventive maintenance program should be considered a necessity. Inspection of safety relief valves is needed to ensure the valve is in proper working order.

Inspections of pressure relief valves are performed to determine the physical and operating conditions of the devices necessary to ensure reliable and adequate operating performance. These inspections are commonly known as shop inspections/overhauls that may include pretesting or as-received pop tests, and post-testing activities after inspection completion.

Shop inspections/overhauls refer to activities that involve removal, testing, disassembling and inspection of the pressure relief valve. Field inspections of internal inlet and outlet piping should be included after valve removal to detect the presence of any internal deposits that could restrict the flow or cause corrosion. If necessary, piping should be radiographed or dismantled for internal inspection and cleaning. A visual inspection of the valve should be performed as soon as it has been removed from the system to determine the presence of fouling or deposits. When these materials are present, collection samples for testing and to record deposit locations and appearances is recommended. Any obstructions in the valve should be recorded and removed.

Proper handling and transportation of pressure relief valves from the system to the valve shop is always recommended. Improper handling may result in inaccurate, as-received set pressure tests, which may cause improper adjustments to relief device inspection intervals. Proper handling and transportation are also recommended for valve transportation from the shop to the system to prevent valve damages and ensure the set pressure is maintained. Before any inspection is performed, the operating history of pressure relief valves should be obtained to determine any specific operating conditions.

Whenever possible, as-received pop testing should be conducted prior to valve cleaning. This test may not be performed if the pressure relief valve is received in extremely fouled and dirty condition. The as-received test results will help to create the valve history and establish the appropriate inspection and servicing frequencies, as well as any corrective action that may be needed. For instance, if during the as-received pop test the valve was found to be stuck shut due to corrosion, a corrective action may be to install a rupture disk at the inlet/outlet of the valve or change the valve construction material. Establish the pass/fail criteria of the as-received pop test according to the valve service and operation conditions to better understand root cause failures and determine the necessary corrective actions.

Generally, for this pop test, the pressure relief valve is mounted on the test bench; and the inlet pressure is slowly increased. The pressure at which the valve relieves is recorded as the as-received pop pressure. If the initial pop is at a pressure higher than the original set pressure, the valve needs to be tested a second time. If during the second test, the valve pops at a pressure, close to the original set pressure, it may be an indication of deposits. If during the second test, the valve does not open within the allowed tolerances, settings may be incorrect or may have been changed during operation. If the valve does not open within 150% of the set pressure, it should be considered stuck shut. On the other hand, if the valve opens below the set pressure; the valve may be damaged or the settings wrong/changed.

Testing with sufficient volume to allow the relief valve to pop should eliminate possible misalignment of moving parts and reduce the probability of damaging the valve seat.

Dismantling of the pressure relief valve may be needed if the result of the as-received pop test was not satisfactory or if valve restoration is required to restore it to “as good as new” condition. Valves should always be carefully dismantled following manufacturer’s recommendations. At each stage in the dismantling process, the various parts of the valve should be visually inspected for evidence of wear and corrosion. The valve spindle, guide, disc, and nozzle require visual inspection. The bellows in balanced valves should be checked for cracks or other failures that may affect performance.

After the valve has been inspected, cleaned and repaired, reassemble following manufacturer’s instructions, and adjust to ensure the valve will relieve at the required pressure conditions. After the valve has been adjusted, it should be actuated at least once to prove the accuracy of the setting. Some manufacturers recommend the valve be actuated at least two or three times after setting to ensure the deviation from set pressure is no more than 2 psi (15 kPa) for valves with set pressure equal or less than 70 psi (500 kPa) or 3% for valves with set pressure higher than 70 psi (500 kPa). However, these tolerances should be reviewed, considering the specific type of valve and operating conditions.

Once the valve is set to pop at its required set pressure, the next step is to check for valve leakage. This test verifies seat tightness and is performed on the test bench by increasing the pressure on the valve up to the manufacturer’s specified simmer pressure (oftentimes this is 90% of the set pressure) and observing the discharge side of the valve for evidence of leakage. Manual lift testing of relief valves is not recommended. A lift test can lead to a misalignment of the valve’s operating mechanism and damage the valve seat, which can result in leakage.

Bench testing is the preferred method for testing relief valves due to the controlled environment. However, if a valve is difficult or impossible to remove, it can be tested inline, providing an adequate, mobile, test apparatus is used; and the relief system is set up for this testing.

3.6.1 Causes of Improper Valves Performance

Improper performance or failure of pressure relief valves can be attributed to inadequate system design, incorrect valve installation, poor maintenance practices or a combination of these factors. A pressure relief valve is a single component of a larger system. Therefore, valves, piping, connections, disposal or containment systems and the operating vessel must be working properly for the pressure relief valve to function according to specifications. An improper performance of a pressure relief valve may not be caused by the valve itself. In some cases, leaks, chatter and valve body degradation may be caused by problems with other elements of the system. Some common issues that can be observed with pressure relief valves include:

- Corrosion damage.
- Failed springs.
- Leakage of the valve (can result from contaminants, misalignment and/or vibration, seating surface damages, etc.).
- Contaminants within the valve body/piping, such as corrosive material, dirt, lint, rust or sludge.
- Misalignment of the valve (can cause the pressure relief valve to stick).
- Vibration of the valve.

- Inlet/outlet piping blockage (creating excessive back pressure).
- Inlet/outlet piping cracking due to mechanical stresses/vibration.
- Opening below set pressure with low back seat pressure (typically indicates valve internals malfunctioning).

3.7 Isolation Valves Around Pressure Relief Devices

The use of isolation valves (stop valves, intervening valves, shutoff valves) on either side of pressure relief devices is not generally considered an accepted or good practice. However, isolation valves are sometimes installed for process functionality at the inlet and/or discharge of pressure relief devices for inspection, testing, repair or replacement purposes. When this is done, additional precautions are needed to minimize the likelihood of unintended closure during equipment operation. (See Section 2.3.4.)

The best option on the inlet side of pressure relief devices is a three-way switching valve (Figure 2.2.2.7.1-1). A three-way switching valve has an adequate inlet internal cross-sectional area for pressure relief and is designed to prevent a flow path from being blocked without another path being simultaneously open. No intermediate position allows both pressure relief devices to be isolated from the protected vessel and/or piping system at the same time.

Another example of the use of isolation valves is multiple pressure relief devices installed with connection to the vessel and/or piping system (e.g., three relief devices where any two can provide adequate relief capacity) and having mechanical or instrumented interlocks to prevent all devices from being isolated simultaneously.

Butterfly and globe valves should not be used as isolation valves. These valves are not full area and typically are not designed for tight shut-off. In addition, butterfly valves have the potential for internal failure that may cause obstructions in the PRD inlet line. Installation of a bleed valve between the isolation valve and the PRD is also recommended to enable safe depressurization of the system prior to maintenance activities. This bleed valve can also be used to prevent pressure buildup between the PRD and the closed outlet isolation valve.

The ASME Boiler & Pressure Vessel Code, Section XIII, Part 12 and Appendix B (2021 Ed.) provide criteria for the use of isolation valves.

4.0 REFERENCES

4.1 FM

Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks*
Data Sheet 7-46, *Chemical Reactions and Reactors*
Data Sheet 12-2, *Vessels and Piping*

4.2 Others

ASME B31.3-2020, *Process Piping*

American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code Section XIII*, (2021 Ed.)

API 520, *Sizing, Selection, and Installation of Pressure-Relieving Devices - Part I, Sizing and Selection,* (10th Edition, 2020)

API 520, *Sizing, Selection, and Installation of Pressure-Relieving Devices - Part II, Installation,* (7th Edition, 2020)

API 521, *Pressure-Relieving and Depressuring Systems,* (7th Edition, 2020)

API 537, *Flare Details for Petroleum, Petrochemical, and Natural Gas Industries,* (3rd Edition, 2020)

API RP 576, *Inspection of Pressure-Relieving Devices,* (4th Edition, 2017)

EN ISO 4126, *Safety Devices for Protection Against Excessive Pressure*

EN 764-7. *Pressure Equipment*, Part 7.

APPENDIX A GLOSSARY OF TERMS

Accumulation: The increase in pressure over the maximum allowable working pressure of the vessel during discharge through the pressure relief device, expressed in pressure units or as a percentage. Maximum allowable accumulations are established by applicable codes for operating and fire contingencies. (See also Overpressure.)

Backpressure: The pressure at the outlet of a pressure relief device that results from superimposed and built-up backpressures in the system.

Blowdown: The difference between the set pressure and the closing pressure of a pressure relief valve, usually expressed as a percentage of the set pressure or in pressure units.

Built-up Backpressure: The increase in pressure at the outlet of a pressure relief device that develops as a result of flow after the pressure relief device opens.

Burst Pressure: The value of inlet static pressure at which a rupture disk device will burst.

Chatter or Flutter: Chatter refers to the motion that causes the disk to contact the seat and damage the valve and associated piping. Flutter refers to the abnormally rapid reciprocating motion of the movable parts of a pressure relief valve during which the disk does not contact the seat.

Critical Flow: The flow rate of compressible fluid through an orifice that is unaffected by further reduction in downstream pressure. This flow rate is reached at the critical pressure ratio, the ratio of downstream absolute pressure to upstream absolute pressure. This ratio is typically between 0.5 and 0.6 and is a function of the fluid's specific heat.

Ignitable Liquid: Any liquid or liquid mixture that is capable of fueling a fire, including flammable liquids, combustible liquids, inflammable liquids or any other reference to a liquid that will burn. An ignitable liquid must have a fire point.

Overpressure: The increase in pressure over the set pressure of the relieving device, expressed either in pressure units or as a percentage. It is the same as accumulation if the relieving device is set at the maximum allowable working pressure of the vessel.

Maximum Allowable Working Pressure (MAWP): The maximum pressure permissible at the top of a vessel in its normal operating position at the designated coincident temperature specified for that pressure. This factor measures the greatest amount of pressure that the weakest part of the vessel can handle at specific operating temperatures.

Maximum Allowable Accumulated Pressure: The maximum allowable working pressure plus the accumulation.

Maximum Operating Pressure: The maximum pressure expected during normal system operation.

Pressure Relief Device (PRD): A device actuated by inlet static pressure and designed to open during emergency or abnormal conditions to prevent a rise of internal fluid pressure in excess of a specified design value. The device also may be designed to prevent excessive internal vacuum. The device may be a pressure relief valve, a non-reclosing pressure relief device or a vacuum relief valve.

Relief system: The components of the overpressure protection system, including inlet and outlet piping, the relief device(s) and any containment or disposal devices.

Relief Valve: An automatic pressure relief device actuated by the static pressure upstream of the valve, which opens further with an increase in pressure over the opening pressure. It is primarily used for liquid service.

Safety Relief Valve: An automatic pressure relief device suitable for use either as a safety valve or relief valve, depending on the application.

Safety Valve: An automatic pressure relief device actuated by the static pressure upstream of the valve and characterized by full opening pop action. It is used for steam, gas or vapor service.

Set Pressure: The inlet gauge pressure at which the pressure relief device is set to open under service conditions.

Simmer: The audible or visible escape of fluid between the seat and disk of a pressure relief valve that may occur at an inlet static pressure below the set pressure prior to opening. Simmer applies to safety valves or safety relief valves for compressible fluid service.

Superimposed Backpressure: The static pressure that exists at the outlet of a pressure relief device at the time the device is required to operate. It is the result of pressure in the discharge system from other sources and may be constant or variable.

Supplemental Device: Devices that provides additional relieving capacity for hazards such as exposure to fire or other unexpected sources of external heat.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

July 2023. This document has been completely revised. The following significant changes were made:

A. Reorganized the document to provide a format that is consistent with other data sheets.

B. Relocated guidance on design cases for pressure relief devices involving runaway chemical reactions and reactive systems to Data Sheet 7-46.

C. Removed equations, tables and charts for calculation of effective discharge area and mass flow through pressure relief devices for non-reactive systems.

D. Reviewed guidance for fire exposure scenarios.

E. Added new recommendations and guidance for rupture disks.

F. Relocated guidance for Safety Instrumented Systems (SIS) used in lieu of overpressure protection from Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks (SCAI)* into Section 2.2.1.6 of this data sheet.

G. Added new guidance for types and operation of pressure relief devices.

January 2016. Interim revision.

Section 2.1.2.1.10 was modified and Section 2.1.2.1.11 was added to recognize the use of manual stop valves on the inlet and/or outlet of pressure relief device with limitation comparable to what is permitted under The ASME Boiler & Pressure Vessel Code, Section VIII Division I, UG-135 and Appendix M, Section M-5 (2015), or National Board Inspection Code NB 23, Part 1 (2015). Section 3.1.5 was similarly updated.

October 2013. Section 2.1.2 on the various ASME-related guidance for relief device operating limits has been clarified. Text and recommendations were modified to deemphasize DIERS as the only acceptable method for sizing vents for reactive systems, and Section C.1 was updated with respect to software solutions for two-phase venting.

January 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards. A new Section 3.1.5 has been added with some comments regarding the use of manual shutoff valves in emergency vent systems and reference to ASME guidance for this situation.

April 2011. Added Sections 2.1.4 and 3.1.4 to address implementation of former *ASME Boiler and Pressure Vessel Code Case 2211 within ASME Section VIII*.

September 2000. This revision of the document has been reorganized to provide a consistent format.

June 1993. Major update to implement technology of DIERS. The following changes were included:

1. Guidance is given for sizing overpressure protection for various types of equipment by cross-referencing to the appropriate existing data sheets.

2. Guidance on calculation procedures for heat absorbed (and therefore vapor discharged) by a vessel from fire exposure is changed to adopt NFPA 30 criteria, as represented by Figures 1a and 1b. The previous edition of this data sheet used criteria from API 520. API 520 *automatically* includes a 50% reduction of heat absorbed based on ‘‘good drainage.'' On a similar ‘‘good drainage'' basis, the two criteria are very close up

to 1000 ft^2 (93 m^3) wetted surface (approximately 25,000 gal [6.6 m^3] horizontal tank). OSHA regulations and API 2000 also follow the NFPA 30 guidelines.

3. Guidance for designing overpressure protection for reactive systems, which was developed in relation to the AIChE DIERS project is incorporated mostly by reference. Some limited information on DIERS methods is included as Appendix material. Design of DIERS based venting systems is complex and best left to specialists in that field.

4. Reference is made to the importance of proper determination of the worst credible case as the design basis for the vent system, and some factors that should be considered for the scenario.

5. Some key criteria on the design of overpressure relief system components, e.g., piping, containment and disposal, manifolding and maintenance, have been included.

6. Emphasis is given to the need to communicate the overpressure protection system design criteria within the user's organization, to effectively manage change where process modifications are required.

7. Guidance is provided for the comparison of risk vs. consequences for reactive systems where relief venting (existing or proposed) is inadequate.

8. Guidance is provided for the evaluation of existing facilities.

9. Information is provided on the various test procedures that can be used to develop data for vent sizing via calculation or simulation and scale up.

January 1977. Original document issued.