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Pressure Relief Systems

This publication of the European community on Common Inspection Criteria is intended to share knowledge about technical measures and enforcement practices related to major hazard control and implementation of the Seveso Directive. The criteria have been developed by Seveso inspectors to aid in dissemination of good enforcement and risk management practices for the control of major industrial hazards in Europe and elsewhere.

This particular issue highlights a number of issues that are critical for successfully reducing risks through efficient and correct pressure relief systems. Poor design, inadequate maintenance and improper operation and training can all lead to the failure of pressure relief systems. Many major process accidents and incidents have been caused by relief system failures. Note that this document is not intended as a technical standard nor as a summary or replacement of any existing standards on the matter.

DEFINITION AND SCOPE

In this document, the term "Pressure Relief Systems" is defined as a combination of:

- One or more pressure relief devices (PRD)
- The inlet piping, i.e., the piping from the protected vessel to the inlet of the pressure relief device
- The outlet or discharge piping, i.e., the piping from the outlet of the pressure relief device to the atmospheric venting point, the flare, the blow down tank or any other system designed to handle the relief flow

Pressure relief devices protect a vessel against overpressure. A pressure relief device can be a pressure relief valve or a rupture disk.

A pressure relief valve is designed to automatically reclose and prevent the flow of fluid when pressure has dropped below the set pressure. There are various types of pressure relief valves: spring-loaded pressure relief valves, safety (relief) valves, balanced pressure relief valves, pilot-operated pressure relief valves. A description of these types of pressure relief valves is beyond the scope of this document and can be found in literature. The criteria in this bulletin apply to all types of pressure relief valves.

A rupture disk device is a non-reclosing differential pressure relief device actuated by inlet static pressure and designed to function by bursting the rupture disk that is installed in a rupture disk holder. The rupture disk device includes the rupture disk and rupture disk holder.

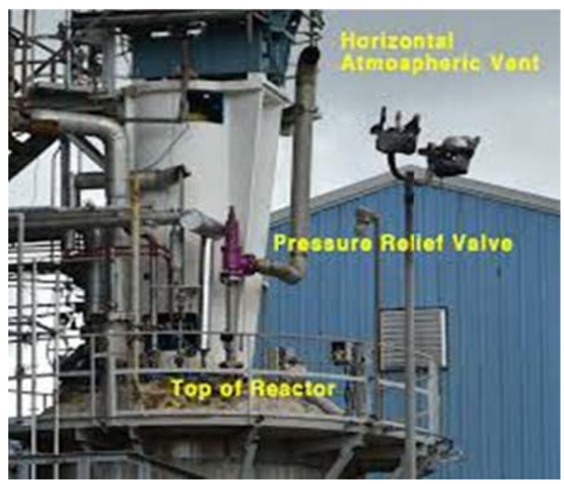

Figure 1. Reactor with a pressure relief system (U.S. Chemical Safety Board, 2018)

A pressure relief system may consist of only one pressure relief valve or rupture disk device, either with or without discharge pipe, on a single vessel or line. A more complex system may involve many pressure-relieving devices discharging into common headers to terminal disposal equipment.

Flare systems are not included as part of this CIC, even though they are normally regarded as a part of the pressure relief system.

THE PURPOSE OF PRESSURE RELIEF SYSTEMS

A pressure relief system is normally installed where it is necessary to avoid that the pressure in a plant, specific installations, or specific equipment exceeds limits for safe operation of the plant and affected equipment. The system prevents escalation of incidents by rapid pressure reduction and ensures that released substances are removed from the process in a safe manner without causing damage to personnel and equipment. Protection against overpressure is recognized as an important part of process design.

Overpressure can occur due to any number of conditions. Inadvertent valve opening, closed or blocked outlets on vessels, utility failure, excess heat, transient pressure surges, and fire are all examples of situations that may cause overpressure. Pressure relief valves are typically associated with boilers and pressure vessels and storage and transport tanks.

IDENTIFICATION & DOCUMENTATION

For each pressure relief valve or rupture disk device the operator should have a specification sheet.

Templates of these specification sheets can be found in literature and typically contain information such as:

- Identification of the components (item number)
- Identification of each relief position (e.g., the tag number on a P&ID)
- The service conditions (liquid, vapour, two phase flow, temperature, back pressure, …)
- Orifice area
- Operating pressures
- Design code
- Construction materials
- Type of pressure relief valve or rupture disk

EFFECTIVENESS, SIZE & CALIBRATION OF THE PRESSURE RELIEF SYSTEM

The operator should be able to demonstrate that design and dimensioning of the pressure relief system is based on a pressure relief analysis. This analysis should be appropriate for the expected fluid phase (liquid, vapour, or two-phase flow).

The overpressure scenarios for which the PRS serves as a risk reducing measure should be listed. For each scenario, the relief flow (to be discharged) should be calculated. The PRS should be sized for the scenario with the largest relief flow.

Using the largest relief flow, the minimal discharge area of the PRD is obtained. The PRD that are installed should have an orifice area equal or larger than the minimal area required (for the 'largest' scenario).

Calculation should take into account phenomena such as the pressure losses in the inlet and outlet piping and any backpressure present in the blow down system (if present).

RISKS INTRODUCED BY THE PRESSURE RELIEF SYSTEM

When a pressure relief system discharges to the atmosphere, a hazardous situation can occur, depending on the properties of the substances released. For instance, a toxic or explosive cloud can be formed. The operator should assess the risks involved with potential substance releases. The analysis typically involves dispersion calculations. If the risks are deemed unacceptable, measures should be taken to reduce the risks, such as, discharging into a blowdown vessel or to a flare, relocating the atmospheric venting point to a safer location, implementing additional measures to reduce the likelihood of the PRS being activated (e.g., via safety instrumented systems), etc.

Another risk typically associated with PRS discharges to the atmosphere may be caused by reaction forces imposed on outlet piping. The calculation of these forces should be a part of the sizing calculations. The operator should be able to demonstrate that the outlet piping (and more specifically, its supports) can withstand the reaction forces.

Discharging gases under high pressure or liquefied gases can lead to a considerable drop in temperature and hence, to brittle fracture in the outlet piping and blow down system. The calculation of the pressure drop should be part of the sizing calculation. The operator should be able to demonstrate that the materials used for the outlet piping and the blowdown system are suited to handle these low temperatures.

PREVENTION OF DAMAGE TO THE PRESSURE RELIEF SYSTEM

The pressure relief system also should be protected from potential damage during normal operations. For example, many process materials often build up and solidify on internal surfaces. This can create a problem for pressure relief systems such that they may become partially or completely blocked.

Corrosion can also compromise the proper operation of safety valve, causing the disk to stick at the seat or causing leaks between disk and seat.

The operator should have evaluated whether such harsh operation conditions are present and should have taken the appropriate measures in place to guarantee the reliable operation of the pressure relief device, such as:

- installing heating or tracing systems) to prevent freezing or solidification
- protection of a pressure relief valve by a rupture disk
- installation of pressure relief devices directly on a vessel (eliminating the need for inlet piping)
- Increasing the inspection and maintenance intervals

PRESSURE BUILD UP BETWEEN THE PRESSURE RELIEF VALVE AND RUPTURE DISK

When a pressure relief valve and a rupture disk are installed in sequence, an enclosed space is formed between the (outlet of the) bursting disk and (the inlet of the) pressure relief valve. Small leaks (pin holes, cracks) in the rupture disk can lead to a pressure build up in this enclosed space. The backpressure in this space will render the bursting disk (that is still largely closed) nonoperational. The bursting disk is activated by the pressure differential over the rupture disk. Due to the backpressure, the pressure differential at which the rupture disk should burst will not be attained when the maximum allowable pressure in the vessel safeguarded by the PRS is reached.

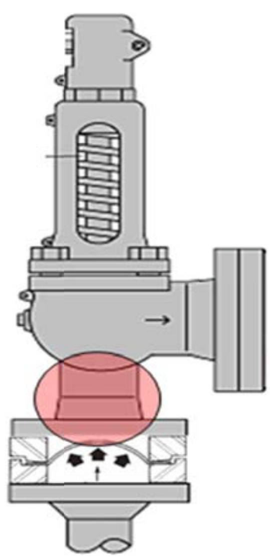

Figure 2. Diagramme showing the enclosed space between the bursting disk and the pressure relief valve

This phenomenon requires installation of a pressure indicator that monitors the space between the rupture disk and the pressure relief valve. The pressure indicator should preferably give an alarm when backpressure is detected. If not, the indicator should be regularly inspected (each shift). Operators must be aware that a high pressure reading requires urgent action.

DEACTIVATION OF THE PRS

A vessel or pipe that is protected by a PRS should never be disconnected from the PRS while it is in operation (and the risk of overpressure is present).

To allow maintenance and inspection of PRD some pressure systems are equipped with two or more (redundant) PRD. This configuration allows one PRD to remain in service (connected to the pressure system) while the other PRD can be shut off by a hand valve or 3-way valve.

A system should be in place to guarantee the right position of the valve in the inlet or outlet piping, making sure that at least one PRD is always lined up with the pressure system under protection.

INSPECTION AND MAINTENANCE

The operator should establish a periodic inspection and maintenance system with all activity documented. Each pressure relief valve should undergo:

- a periodic inspection and maintenance (testing and recalibration) of each pressure relief valve
- a visual on-stream inspection

Periodic maintenance of a safety valve involves removing it from the installation and transporting it to a maintenance shop. It is strongly recommended to test the pressure relief devices in the maintenance shop before disassembly. In this way, it can be tested whether the pressure relief valve opens at the set pressure. (This is sometime referred to as the ‘pretest’ or the ‘as received pop test’.) If a pressure relief valve fails to open at a pressure level above the set pressure (e. g., at 110% of the set pressure), the pressure relief valve is considered to have failed the test. An inquiry to the possible causes then should be executed. If the pressure relief valve fails the test repeatedly, it is a strong indication of a structural problem (e. g., corrosion, sticking, etc.).

After maintenance and reassembly of the pressure safety valve, the pressure safety valve is tested in order to verify:

- The opening pressure (the pop test)
- The tightness of the seat of the safety valve (to make sure it does not leak while in service).

Visual on-stream inspection (while the safety relief valve is in service) should ensure that:

- The relief device does not leak
- Bellows vents are open and clear
- Upstream and downstream block valves are sealed, or chained and locked, in the proper position
- Discharge piping is properly supported to avoid breakage or leakage
- Valve body drains and vent stack drains are open
- Any heat tracing or insulation critical to the proper operation of the relief system is intact and operating properly
- Any rupture disk is properly oriented

The pressure indicators and alarms monitoring the space between the rupture disk and the safety valve should also be periodically inspected.

Other publications in the Common Inspection Criteria Series

Process Safety Performance Monitoring

Management of Change

Emergency Isolation Systems

Process Hazard Analysis

Internal Auditing Procedures

The Permit-to-Work System

Safety Instrumented Systems

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About the bulletin

This bulletin is a product of the EU Technical Working Group on Seveso Inspections. For more information related to this bulletin and other similar products, visit http://minerva.jrc.ec.europa.eu

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