Pressure relief to atmosphere – Is it safe?

BACKGROUND - The Chemical Industry is required by law to prevent or limit the consequences of major accidents. The release of hazardous substances can pose fire or explosion risks if ignited or toxicity or asphyxiation hazards. Equipment and pipework are designed to prevent the loss of containment of hazardous substances. Overpressure due to external fire, maloperation, equipment failure, change in ambient conditions or chemical reaction are common causes of loss of containment.

Pressure relief devices (e.g., relief valve, bursting disc) are typically considered as the last line of defence against overpressure which could result in failure of equipment and pipework. The relief device is usually set to operate at the design pressure of the system it is protecting. Best practice requires the vent from a relief device to discharge to a 'safe location'.

Industry evidence suggests that the discharge from a relief valve, if not properly handled, can escalate the initial incident, or create a new hazard. Examples include when vented substances from a relief valve have been ignited downwind and flashed back to the source. This has led to fires and explosions that have damaged nearby equipment and structures. A recent example occurred at Kuraray Pasadena, Texas in May 2018. The incident occurred during the startup of a chemical reactor associated with the ethylene and vinyl alcohol co-polymer plant when the PSV vented ethylene vapor horizontally into a congested process area with surrounding equipment, structures, and occupied work platforms. High-pressure conditions developed inside the reactor that activated the reactor's emergency pressure relief system, discharging flammable ethylene vapor horizontally into the local atmosphere that was ignited. The incident resulted in a total of 30 workers harmed with 2 suffering serious injuries. The relief system functioned as designed, however no consideration was given to the discharge location of the relief valve tailpipe.

This begs the question as to what is a safe location? In this discussion, we highlight a set of questions that must be answered before deciding on relief device tailpipe length, elevation of discharge and orientation.

Relief System Design

Several design codes and standards are available that provide guidance for the sizing of relief devices including API 521, API 526, API 2000, ISO 4126 etc. UK HSE provides guidance for sizing relief and vent systems Relief systems / vent systems (hse.gov.uk). The discharge from a relief device can be designed to vent into a closed system, scrubber, flare or vent to atmosphere. This design process has its pit falls but this commentary is focused on the relief valve discharging to atmosphere.

Care must be taken when venting to ensure the safety of personnel and the surrounding systems. The following questions should be asked as a minimum:-

- What are the properties of the substance? Flammable, toxic, asphyxiant?
- What are the prevailing wind conditions? Adverse conditions, day or night?
- What is the discharge velocity and exit gas temperature? Hot or cryogenic temperatures?
- What is around the vent? Roads, equipment, structure or personnel?
- What is the relative molecular mass and quantity of the exit gas? Buoyant or dense?
- What is the discharge elevation? Towards personnel or work platform?
- Is noise level acceptable?

Dispersion Analysis

Although API 521 Section 5.8.2.2 provides guidance for deciding whether a dispersion analysis is required, caution should be applied to ensure that all possible scenarios are considered during design. Dispersion analysis allows for more detailed analysis of flammable and toxic discharges to decide on the minimum tailpipe height and discharge elevation. This will give an indication of the distance to the lower flammability limit (LFL) and confirm the restricted zone (personnel, ignition sources, vulnerable equipment or structures) around the relief discharge. It also helps the designer decide on the most appropriate route for the tailpipe that avoids downwind ignition sources. The tailpipe should be earthed to minimise potential for ignition by lightning strike.

The analysis should also consider both the worst-case release scenario and reduced flow because relief devices can leak and lead to flammable and toxic atmosphere within the tailpipe. If ignited, this can escalate the incident.

Oyinda Gunn BSc (Hons), MSc
Principal Process Safety Engineer

To find out more how Axiom can support you with relief device design verification, flare system design and consequence modelling using PHAST, please visit https://www.axiomengineeringassociates.com or contact Oyinda Gunn at oyinda.gunn@ax-ea.co.uk