TECH TIP

Evaluating Vessel Overpressure Scenarios During the PHA

Overpressure of vessels can lead to a loss of containment of process material which can result in significant safety hazards if the released material is hazardous (e.g., flammable, toxic, etc.). Hence, it is understandable why overpressure scenarios are some of the more commonly identified hazards across many Process Hazard Analyses (PHA). However, evaluating overpressure scenarios in the context of the PHA is not always simple.

The focus of a PHA is on developing the most-credible, worst-case consequences. In the case of overpressure scenarios, this could mean identifying the difference between a vessel flange leak or component failure versus vessel rupture (more catastrophic); to do so, PHA Teams rely on knowing the overpressure ratio.

Determining the Overpressure Ratio

For overpressure scenarios, the PHA Team should first identify: (1) the maximum possible pressure that can be reached within the localized system during the overpressure event (in the absence of relief valves or other safeguard controls), and (2) the equipment with the lowest design pressure or maximum allowable working pressure (MAWP) rating (design pressure and/or MAWP should be included within the documented process safety information). Knowing both the maximum possible pressure and the equipment design rating, the overpressure ratio can be calculated by dividing the maximum pressure by the equipment design pressure. This quantifies the extent of “overpressure” for the equipment in question.

Calibrating the Severity of the Overpressure Scenario

Ultimately, it is the overpressure ratio that provides the basis for the PHA Team to determine the worst-case severity of the overpressure scenario. **Table 7.13** in API 581 (*Risk-based Inspection Methodology*) contains guidance regarding potential consequences for varying levels of vessel overpressure [1]. **Table 7.13** is shown on the following page.

While the guidance outlined in **Table 7.13** is meant to be qualitative, it nonetheless provides a gauge for the PHA Team when thinking about overpressure cases. For example, it is not credible to say that all overpressure scenarios should be considered as vessel rupture cases leading to catastrophic releases; rather, if the overpressure ratio is low enough (i.e., less than 90% of MAWP), then the most credible consequence might be a vessel leak in which the release is smaller, and the severity is less pronounced.

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It is still up to the PHA Team to converge on the proper severity of the hazard after determining the type of overpressure scenario, but this sort of calibration helps the PHA Team to avoid overstating hazards. In fact, **Table 7.13** suggests that an increase in pressure up to or less than the hydrotest pressure of the vessel would not lead to a credible hazardous consequence. Thus, knowing the hydrotest pressure would be another key piece of process safety information that could justify the overpressure hazards identified by the PHA Team.

Table 7.13 – Potential Consequences of Pressure Vessel Overpressure

Accumulation (% over MAWP)	Significance	Potential Consequence
10%	ASME code allowable accumulation for process upset cases (non-fire) protected by a single relief device.	No expected consequence at this accumulation level.
16%	ASME code allowable accumulation for process upset cases protected by multiple relief device.	No expected consequence at this accumulation level.
21%	ASME code allowable accumulation for external fire relief cases regardless of the number of relief devices.	No expected consequence at this accumulation level.
50%	ASME standard hydrostatic test pressure (may be 30% on new designs).	Possible leaks in associated instrumentation, etc. Medium consequence.
90%	Minimum yield strength (dependent on materials of construction).	Catastrophic vessel rupture, remote possibility. Significant leaks probable. Failure of damaged vessel areas (corrosion, cracks, blisters, etc.) likely. High consequence.
300%	Ultimate tensile strength (dependent on materials of construction).	Catastrophic vessel rupture predicted. Highest consequence.

Resources

1. API Recommended Practice 581. (2016). *Risk-based Inspection Methodology* (3rd ed.). American Petroleum Institute.

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