THINGS PLANT ENGINEERS SHOULD KNOW ABOUT REVIEWING RELIEF VALVE & FLARE ACTION ITEMS

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Introduction - The purpose of this paper is to help the Plant Engineer review the concerns as part of a relief systems audit. Most companies review the relief systems and flare systems design bases to ensure compliance with Recognized and Generally Accepted Good Engineering Practices, referred to as RAGAGEP.

Definitions:

- **Plant engineer** - The facility or owner's engineer that is responsible for reviewing the concerns and determining if facility modifications should be implemented.
- **Process designer** - The individual that is responsible for analyzing the relief device and overpressure protection system and develops the concerns.

Prior to implementing costly field modifications/upgrades, a Plant Engineer should consider how the following items affect the concerns generated:

1. Relief systems review methodology
2. Relief systems review priorities (are rear-ends being covered or exposed)
3. The Process Designer's familiarity with the process and/or plant when concerns are being reviewed
4. The Plant Engineer's understanding of the differences between compliance and best-in-class

Reviewing the Relief System Study Details - The following information helps the Plant Engineer understand the details used to generate the relief systems design basis documentation. A plant engineer must ensure that:

- The Process Designers understood the process
- The scenario, which is the basis of the concern, is credible
- The basis for the required relief rate is sound
- The concern is not based on missing data
- The concern is not based on contractor scope or execution guidelines

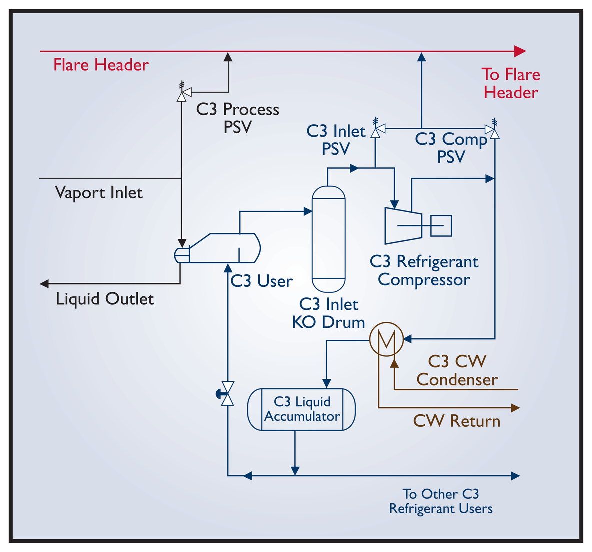
The Plant Engineer should confirm that the concern is a legitimate deviation from RAGAGEP and not just a result of the project execution process.

Flare Systems Review Methodology - This section is to help the Plant Engineer understand how: the individual relief systems' loads are developed, then used to create an overall set of global scenarios, which is then used to verify that the flare system and associated equipment are adequately designed.

- Global Load Considerations
  - Credibility of the Scenario:
    - Scenario is based on a real failure (e.g. not a general power failure)
    - Scenario considers the side effects of the failure (e.g. depressuring valves) Scenario logic is internally consistent
  - Credibility of the Rates:
    - Not overly conservative
    - Internally consistent
    - Consideration of limitations of equipment during upsets (See Fractionator Example)

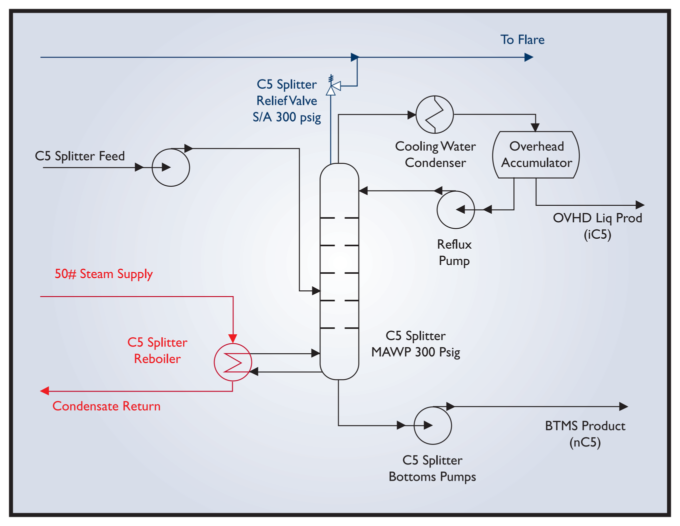
Example: Refrigeration Loop

- Assume:
  - Power failure results in loss of the compressor
  - Blocked outlet applies to both sides of the exchanger "C3 User"
- Release occurs from:
  - The "C3 Inlet PSV"
  - Or the "C3 Process PSV"



Example: iC5/nC5 Splitter?

- No Vapor Release from this tower
  - 50# steam cannot boil i-pentane at 300 psig
- Consider
  - 50# Steam Saturation Temperature ~ 300°F
  - iC5 Saturation Temperature @ 300 psig ~ 315°F

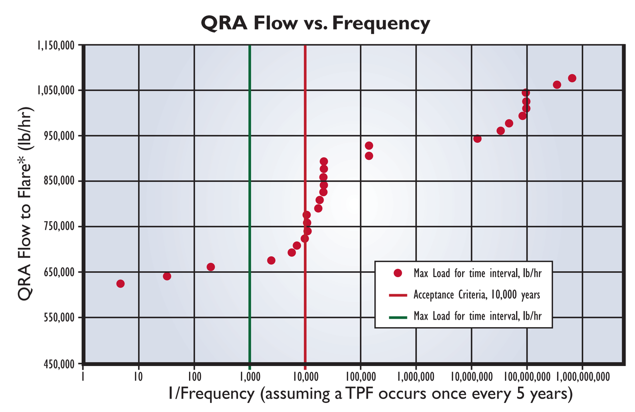


The following are examples of advanced flare techniques that are used to get more flare system designs that are more realistic to operational history.

Flare Quantitative Risk Assessment

In a presentation to the 6th Global Conference on Process Safety, D. Smith reported on a method to estimate the flare loading probability. [7] This method determines the likelihood of loads to the flare system and can be used to target instrumented responses and piping modifications. This method demonstrates that by analyzing the effects of safeguards and the Probability of Failure on Demand (PFD) of these safeguards can be used to develop the system loading as a function of probability/frequency.

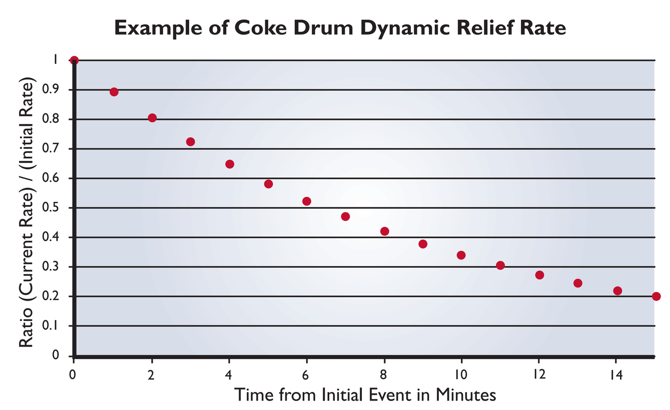
Recently the authors of this paper reviewed a refinery where the likelihood of a "worst case" load if a total power failure occurred was approximately 1/100,000,000. The design load for a 1/100,000 years was a fraction of the total load and more consistent with the complexity of the plant and the DCS programing and the safety instrumented functions and interlocks recently installed.



Flare Load Dynamic Simulations

Offering and requesting dynamic flare system designs is becoming increasingly common. Like the other advanced flare analysis techniques, this one increases the complexity of the analysis; thus, requiring the facility to increase their understanding of the effects of assumptions on the final answer. [10] The basic premise of dynamic simulation is that by combining the effects of staged timing of releases and the dynamic pressurization of the flare system, the peak loads and backpressures on system components are reduced.

There are other methods to analyze flare systems that are proprietary to operating companies. All of these methods are designed to account for the probability that either operator intervention or instrumentation will operate or fail to operate as desired.



Reviewing the Relief System Study Assumptions - During a typical execution of a project, consistent assumptions help ensure that the relief systems design basis is conservative and compliant with RAGAGEP. To ensure that field modifications are for items that really need to be addressed, these assumptions may need to be challenged when concerns are raised.

- Standard and generally conservative assumptions are specified to ensure consistency and efficiency. For example:
  - Liquid levels for equipment
  - Control valve flow coefficients and or trim sizes
  - Utility pressures (e.g. steam, nitrogen, cooling water, etc.)
  - Heat exchanger or pump capacities

To ensure the best possible analysis, the assumptions associated with each concern should be reviewed and, if possible, refined to be specific for that system.

- "Conservative" or Simplifying Assumptions - The following are examples of "conservative assumptions"
  - Normal flow rate was used instead of a reduced estimate
  - Column tray one or overhead flow rate was used instead of performing a simulation
  - Multiple unrelated failures occur simultaneously

The design and analysis of relief systems are an art and much of the analysis is based on the assumptions. Mathematical errors are rarely the cause of an incorrect analysis; usually, the cause is almost always a problem with the basis.

Example

In the past, the authors reviewed a Fractionator that had the normal feed vapor rate specified as the relief rate for a power failure relief load (conservatively assumed). When the capacity of the Feed Furnace was confirmed, the Feed Furnaces could barely vaporize the normal amount at the normal production rate and Fractionator pressure. This particular power failure scenario specified the loss of the pump-arounds, which resulted in the loss of ~80% of the crude preheat train duty. With the increase in pressure and cooler-than-normal feed temperature to Feed Furnace, the maximum vaporization would be around 50% of the normal vapor rate. The argument for keeping the feed preheat was it was conservative as the heat input may not be lost. If this was the case, then pump-arounds would have continued, leading to a significantly different outcome. Assumptions need to at least be internally consistent for each scenario. If the pump-around cooling is lost, then so is the feed preheat or visa-versa.

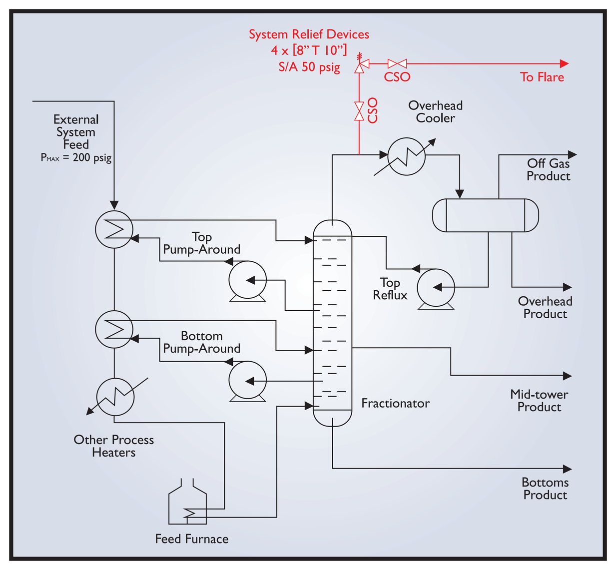


Figure 1 – Example Fractionator

Conclusion

When reviewing concerns generated from either the relief system or flare design and documentation process, the Plant Engineer must ensure that each concern is valid and any resolution requiring physical changes are a proper investment of a facilities capital. To properly perform this task, it is recommended that a Plant Engineer understand how a Process Designer performs the study and review the concerns prior to making physical changes in the facility.

When properly reviewed, upgrades to the flare and relief system from a relief systems analysis can improve the safety of an operating facility.

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