Minimal Requirements for Relief Systems Documentation

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This short summary lists the requirements for relief system related PSI and how other PSM elements tie into relief systems documentation. This short paper is meant to provide insight into how Smith & Burgess LLC approach relief systems documentation work. We satisfy the listed regulatory requirements; while leaving a system, which can be maintained by a knowledgeable process engineer.

OSHA Documents and Clarifications

These requirements listed here are based on the OSHA documentation below. All of the referenced documentation is currently stored on the OSHA web site (www.osha.gov).

1. *PSM Standard* (29 CFR 1910.119)
2. *Compliance guidelines and enforcement procedures* (CPL 02-02.45A CH-1)
3. *Process Safety Management* Booklet (OSHA 3132)
4. Preambles to Final Rules for the Process Safety Management Standard (Section 3 - III. Summary and Explanation of the Final Rule

Documentation requirements

To support safe design and operation OSHA requires relief systems documentation to contain at least the following information. The items below are requirements and assumed to be developed based on applicable industry and company standards. The following is a summary list of what documentation is required to satisfy the PSM requirements (1910.119(d)(3)(i)(D)):

1. Identification and description of the relief device including set pressure and valve type
2. Listing of all equipment and design pressures that the relief device protects
3. Listing of all the overpressure sources considered.
4. Identification of the design case
5. Thermal dynamic conditions and properties of the relief stream
6. Administrative control of relief system and flare system isolation valves
7. Documentation ensuring safe atmospheric releases (toxicity and radiation)

Note that in the new version of API STD 521, there is a comprehensive list of the requirements for relief systems documentation. Section 4.4 Recommended minimum relief system design content.

Findings

There is little doubt that a complete analysis of an existing system will generate a list of concerns that are deviations from industry and company standards. The following are the requirements from OSHA on how to handle the findings.

1. Enter the valid findings into the system used to resolve PSM related action items, recommendations, findings, etc.
2. Assure that the findings are resolved in a timely manner (generally considered to be between 1 and 2 years).
3. Document the resolution of the finding
4. Develop a written schedule of when corrective action is to be taken
5. Communicate the resolution to affected employees

6. Ensure means are taken to assure safe operation until the final corrective action is taken

Relief Systems Design Basis and Documentation Guidelines

Required for Compliance with OSHAs PSM Standard (29 CFR 1910.119)

Relief systems design and design basis PSI requirements 1910.119(d)(3)(i)(D)

The codes and standards used for the relief systems design and design bases are as follows, and this document is a clarification to these standards. The purpose of this document is to direct the analysis of the relief systems and flare systems such that the mentioned codes and standards are followed, and to ensure a consistent calculation methodology is applied across all of the systems studied.

American Petroleum Institute (API)

API Specification 12D Specification for Field Welded Tanks for Storage of Production Liquids
API Specification 12F Specification for Shop Welded Tanks for Storage of Production Liquids
API RP 520 Part I: Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries; Part I – Sizing and Selection
API RP 520 Part II: Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries Part II – Installation
API STD 521 Guide for Pressure-relieving and Depressuring Systems
API STD 620 Design and Construction of Large, Welded, Low-Pressure Storage Tanks
API STD 650 Welded Storage Tanks for Petroleum Storage
API STD 2000 Venting Atmospheric and Low-Pressure Storage Tanks
API RP 2350 Overfill Protection for Petroleum Storage Tanks
API STD 2510 Design and Construction of Liquefied Petroleum Gas (LPG) Installations
API RP 571 Damage Mechanisms Affecting Fixed Equipment in the Refining Industry
API RP 579 Fitness-for-Service
API RP 941 Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants

Am. Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE)

ASHRAE 3738 New Design Guide For Cool Thermal Storage

American Society of Mechanical Engineers (ASME)

ASME SEC I PT PG Part PG General Requirements for All Methods of Construction
ASME SEC II D SB PT 1 Subpart 1 Stress Tables
ASME SEC II D SB PT 3 Subpart 3 Charts and Tables for Determining Shell Thickness of Components Under External Pressure
ASME SEC VIII D1 A PT UG Part UG General Requirements for All Methods of Construction and All Materials
ASME SEC VIII D1 C PT UCS Part UCS Requirements for Pressure Vessels Constructed of Carbon and Low Alloy Steels
ASME SEC VIII D1 NMA APP M Appendix M Installation and Operation
ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.3 Process Piping (ASME Code for Process Piping)

Instrument Society of America (ISA)

ISA S.84.01 Application of Safety Instrumented Systems for the Process Industries

National Electrical Manufacturers Association (NEMA)

NEMA SM 23 Steam Turbines for Mechanical Drive Service

National Fire Protection Association (NFPA)

NFPA 30 Flammable and Combustible Liquid Code

Example Project Guidelines and Clarifications

The organization of the clarifications to the previously listed industry standards is done by equipment type, followed by general concerns that apply across the entire section of the facility. As no single document can completely encompass the complete body of knowledge in this area, all assumptions or deviations from these guidelines will be documented within the calculations and brought to the attention of the Company.

Pressure Vessels:

1. For external fire cases, the following hierarchy will be used to determine the liquid level for vessels operating with liquid:
    a. The liquid level will be taken as the normal operating level or a high average based on plant operating data (typically DCS data).
    b. The liquid level will be taken as the level for the High Level Alarm or High Level Shutdown.
    c. If no level indication is available, the liquid level will be based on 90% of the level taps, or 75% of the total height/diameter (whichever is less).
    d. For spherical vessels, the level will be taken as 25 feet from grade or the maximum diameter (whichever is greater).
    e. For vessels that are normally drained manually by operations (e.g. Fuel Gas KO Drums), the liquid level will be taken as 20%.
2. Credit for fireproof insulation will only be taken based on direction from the Company, for both the presence of and the environmental factor associated with the insulation.
3. Per ASME Section VIII, fire loads for vessels less than 6" (ID, width, height or diagonal cross-section) will not be considered.
4. Heat absorption calculations will be based on adequate drainage and firefighting for process units and will be based on the higher heat input factor for off-site areas.
5. Per ASME Section VIII, Appendix M 5.8, vessels were a relief path is normally present for an external fire case, but has intermitted block valves between the vessel and the relief valve will be calculated based on the assumption that operating procedures exist to drain and vent the vessel upon removing from service. Smith & Burgess LLC will bring these items to the attention of the Company.
6. Vessel overfilling will be considered for all vessels handling liquid unless one of the following conditions is met:
    a. The vessel has a high-level shutdown system with an overall SIL-3 performance.
    b. The vessel level control system is compliant with API STD 2350 or 2510.
    c. The vessel is outfitted with a redundant level alarm that is monitored in the DCS and it takes more than 30 minutes from the LAH level to overfill the vessel.
7. Per API STD 521 §3.10.3, all control valves, regardless of fail position, will be analyzed based on the potential to fail full open.
8. For cases where the control valve has a bypass valve that is not car-sealed or locked closed, the analysis will be based on 150% of the control valve capacity assuming that the bypass is partially open for additional unit capacity.
9. Opening of normally closed manual valves will be considered based on the normal pressure upstream of the valve.

10. Instances where opening or closing of car-sealed or locked valves will be brought to the attention of the Company if the upstream pressure source is in excess of the downstream vessels hydrotest pressure.

Column Systems:

1. All instances not covered in this section are covered under process vessels.
2. A single point failure resulting in a loss of reflux or cooling will be considered.
3. Abnormal heat input to the column system will be considered.
4. Simultaneous fire will be identified for all equipment associated with the system.
5. Global scenarios to be identified, will include but are not limited to:
    - Total power failure
    - Partial power failures
    - Cooling tower failure
    - Instrument air failure
    - Steam failure

Pumps, Compressors, and Blowers:

1. For reciprocating equipment, blocked outlet will be considered
2. For centrifugal equipment, the blocked outlet case will be considered based on one of the following:
    - Maximum upstream suction pressure simultaneously with the maximum discharge head
    - Maximum upstream suction pressure simultaneously with the normal discharge head
    - Normal upstream suction pressure simultaneously with the maximum discharge head

Heat Exchangers:

1. All instances not covered in this section are covered under process vessels.
2. The relief loads in the event of an external fire will be quantified for both sides of a heat exchanger.
3. The relief load in the event of an external fire will not be considered for aerial coolers in gas or condensing service.
4. The relief load for external fire for air-cooled exchangers located directly above pipe racks are not normally included in fire risk areas and per API Std 521 §5.15.7.1 will not be quantified.
5. For air-cooled exchangers in liquid service the wetted area will be based on the guidance provided in API STD 521§5.15.7.4
    a. Wetted are shall be the bare tube area within 25 feet of grade (Not the finned tube area as the fins are assumed to fail in the event of a fire)
    b. For tubes greater than 25 feet above grade or not in the fire risk area the wetted surface will be taken as zero.

6. For external fire cases, the following hierarchy will be used to determine the liquid level for heat exchangers operating with liquid:
    a. The liquid level will be taken as the normal operating level or a high average based on plant operating data (typically DCS data) for kettle type exchangers. If the level information is not available the liquid level will be based on either the weir height or level tap location.
    b. Heat exchangers that are in condensing service and are free draining, will be assumed to have a liquid level 30% of the diameter, per API STD 521 5.20.2.3.C referencing a contained vapor volume of 80%.
    c. Steam exchangers that are fitted with steam traps will be assumed to contain no liquids.
7. For exchangers where the cold side can be isolated, the scenario will be based on hydraulic expansion cases when the temperature of hot side fluid is less than the cold side fluids bubble point temperature at relief pressure. Hydraulic expansion relief rates will not be quantified, as a relief valve with a ¾" or larger inlet will be considered adequate. When the temperature of the hot side fluid exceeds the bubble point temperature of the cold side fluid at relief conditions, the calculation will be based on a boil-up of the exchanger contentsusing the heat input based on the reduced LMTD and overall heat transfer rate of 20% of the design rate due to the "blocked-in" state of the exchanger cold side.
8. For cooling water exchangers with no means of automatic isolation, procedures will be assumed adequate to prevent overpressure from hydraulic expansion. These cases will be summarized on the concern list for verification.
9. For all cases where heat input is used to quantify a relief requirement for a global scenario, Smith & Burgess LLC will base the heat input on the reduced LMTD.
10. A single complete tube failure will be considered for cases where the high side operating pressure exceeds the low side hydrotest pressure. For instances where the heat exchanger is part of a system, the limiting hydrotest pressure of the low-side system will be used.
11. Instances where tube rupture is identified as a credible case, and liquid or two-phase fluid could be injected into a liquid packed system, will be brought to the attention of the Company.
12. Per API STD 521 §5.19.6, if heat exchanger internals are made of process piping, failure need not be considered as a source of overpressure. Hairpin exchangers and pipe exchangers using tubing internally, will be analyzed for heat exchanger tube failure.

Global Scenarios for closed disposal systems:

1. Global fire will be based on fire circles of 2,500 ft^2, and will be identified separately from the simultaneous fire scenarios identified on the column systems.
2. Total power failure
3. Partial power failures will be evaluated to ensure that "double dipping" does not occur when including multiple column systems.
4. Cooling tower failures
5. Instrument air failure
6. Steam failure
7. Other single triggering events may be identified that would cause multiple relief valves to discharge simultaneously.

Pressure Relief Valves

1. To prevent the need for changes in analysis based on the brand of valve or disk manufacturer, stand flow coefficients will be used:
    a. 0.975 = K_d for vapor sizing
    b. 0.85 = K_d for saturated liquids and two-phase releases
    c. 0.65 = K_d for liquids and fluids that flash in the outlet piping
    d. 0.9 combination capacity factor for rupture disks/relief valve combinations
2. API STD 526 relief devices will be sized based on the API equations; all other valves will be based on the ASME Section VIII equations.
3. Inlet/outlet pressure drops will be based on the requirements in API STD 521 and API STD 520.
4. For outlet piping, the pressure drop will be assumed negligible once the outlet piping exceeds 2 normal pipe sizes greater than the relief device outlet flange.
5. All flare system valves not indicated as car-sealed or locked open will be identified.
6. For instances where the orifice size of a relief device is not available, the smallest API standard orifice area for the relief valve inlet and outlet nozzles will be assumed.
7. For initial analysis, the back pressure correction factor (K_b) will be evaluated using the API curves, and manufacturer specific values will be used if deficiencies are identified.

General Concerns

1. Check valves will not be considered a positive means to prevent backflow.
2. Low pressure and atmospheric tanks will be assumed to have a nominal pressure rating of 1.5 inches of water, and a vacuum rating of 0.8 inches of water (when no other information is available).
3. Flare equipment rating (tips, drums, headers) will be based on the guidance of API STD 521.
4. Fire on vapor filled systems, gas-like supercritical systems, and those where the bubble point temperature at relief pressure exceeds 1,000 °F, will not be quantified but will be brought to the Company's attention.
5. Blocked outlet scenarios where the maximum upstream pressure is limited to 116% of the vessel MAWP will be considered acceptable, as is, per ASME Section VIII, as long as all the provisions of Appendix M 5.7 are met.
6. For atmospheric valves, releases with the potential for toxicity and radiation concerns will be brought to the Company's attention.