VENT SIZING FOR FIRE

CONSIDERATIONS FOR

SPECIAL EQUIPMENT AND PIPING

Developed by the

DIERS USERS GROUP

ERS DESIGN FOR FIRE COMMITTEE

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Background

There are many types of pressure containing equipment items that are not generally considered to be vessels and for which ERS requirements in fire exposure cases are not addressed in a clear manner by codes such as Section VIII of the ASME Boiler and Pressure Vessel Code. This group of equipment, which is referred to here as special equipment, includes heat exchangers, reactor jackets (annular, dimpled and half-pipe), filters, centrifuges, etc. For the most part these are designed, constructed and stamped according to Section VIII of the ASME Code, hereafter referred to as ASME Code or "Code". Also, there are "vessels" constructed of piping components which may be designed according to the ASME Code, but are generally not code-stamped. Finally, piping itself may be designed to an applicable piping code (such as ANSI B31.3), but is not given a code stamp, ASME or otherwise.

Issue

When should overpressure protection on special equipment and piping be provided for the fire exposure case and what should be considered in its design? The DIERS Users Group, ERS Design for Fire Committee, offers the following guidelines on handling this question. These guidelines are intended to cover those pressure containing equipment items designed and/or stamped per the ASME Code ($\geq$ 15 psig). These guidelines should be considered as minimum requirements. More conservative overpressure protection designs should be used where required by government regulation or where indicated by local engineering judgement.

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Guidelines

1. For the following categories of special equipment, overpressure protection should be provided for external fire exposure, and the exposed equipment surface should be included in determining the relief rate:

    A. Equipment which has an ASME Code stamp or
    B. Equipment which is constructed of piping components of a size and pressure rating which fall within the ASME Code and are Code stamped.
    C. Equipment which has been designed to the ASME Code, but is not Code stamped.
    D. Piping which, in the judgement of the designer, presents a special hazard if not protected by a fire-sized relief system.

2. A fire-sized pressure relief device need not always be installed on every equipment item. Pressure relief for fire exposure may be provided by a "Single Pressure Relief Device Protecting Several Components in a Process System" as defined by API RP 520, Part I, Appendix B. All of the constraints in Appendix B must be met. Also, the pressure relief device must be sized for the total relieving rate, which includes contributions from all exposed equipment in the process system (in a given fire-risk area). (See API RP 521, Section 5.2.2 for more details.)

3. The following guidelines should be used to calculate relieving rates due to fire and to subsequently size the relief device and associated piping:

   A. API RP 520
   B. API RP 521
   C. NFPA 30

4. If the fluids in the process and nearby (up to 50 feet) processes and piping will not support a fire, then there is no need to consider fire exposure in sizing the pressure relief devices. In establishing such a non-fire-risk area, there must be no flammable/combustible materials present. Also, non-fire risk areas shall be protected against the accumulation of flammables from adjacent fire-risk areas by suitable fire walls, dikes, slopes and drainage, etc. The design of diking and drainage facilities should follow the guidelines presented in NFPA 30, sections 2-2.3.2 and 2-2.3.3.

   When designing vents for equipment in non-fire risk areas, consider the impact of external heat flux from a fire in any nearby fire-risk area. In this case, reduced heat input loads will have to be calculated.

5. Consider that high liquid levels or unusual geometries in these equipment items may hinder vapor-liquid disengagement. If so, it may be necessary to size the relief device for multiphase flow.

The following points apply generally to all pressure vessels, as well as the special equipment items and piping mentioned above.

6. If the materials within the process are hazardous or flammable, efforts should be made to slope the ground to avoid fire directly under the equipment, and to provide adequate fire protection such as water sprays, monitors, insulation, fire proofing, etc. (See NFPA 15 and NFPA 30 and API 2218, 2510 and 2510A .)

   These extra protection methods are recommended because pressure relief only protects vessels cooled by internal boiling. Fire exposure to unwetted portions of vessels, or fire exposure to vessels without a liquid inventory has been shown to cause rapid failure of the vessel wall. (1)

7. If the contents of vessels or piping components are especially toxic or dangerous, then note that there are other, more stringent codes that may apply. For example, there are specific, fire case, overpressure protection requirements in the following codes:

A. applicable OSHA regulations
B. codes for LPG
C. Codes for toxic compounds such as those produced by the Chlorine Institute
D. Compressed Gas Association guidelines

For these services, there is additional useful information in the CCPS books, Guidelines for Vapor Release Mitigation, by Richard W. Prugh and Robert W. Johnson, 1988, and Guidelines for Safe Storage and Handling of High Toxic Hazard Materials, by Arthur D. Little, Inc. and Richard LeVine, Ph.D., 1988.

8. Some systems exhibit a foaming tendency or otherwise exhibit a resistance to vapor-liquid disengagement at relief conditions even though they may not be foamy at normal conditions. For such a relieving fluid, it will be necessary to size the relief device for a multiphase release, which in general will result in a larger vent size than required for single-phase flow. For conservatism, the DIERS (2) homogeneous vessel model may be used, which assumes no vapor-liquid disengagement. However, if experience or test results show that partial disengagement can be expected, a less conservative model can be used which, depending on the specific conditions, will predict either partial or complete vapor-liquid disengagement. Such models include the DIERS bubbly, churn-turbulent, wall-heated and nonboiling height vessel flow models for vapor-liquid disengagement in a vessel. Note that there are ways to minimize this difficult (or expensive) vent sizing requirement. For example, steps (such as insulation or water sprays) can be taken to reduce heat flux to the vessel. (Be sure that any heat flux credit taken is consistent with applicable codes and guidelines.) This decreases the boiling rate and therefore, the venting requirement. Decreasing the boiling rate may also improve vapor-liquid disengagement, even with mixtures of appreciable viscosity or a slight foaming tendency that might be best characterized by the DIERS bubbly flow model.

On the other hand, be very careful about taking large credits (low Environment Factor, F) for heat flux reduction due to insulation. Even though API RP 521 allows taking credit for thick insulation in the form of very low Environment Factors, pipe branches, thermowells and insulation damage, etc. all act as major heat transfer paths. This makes it very difficult, practically, to achieve very low overall conductivities in the field.

9. When vessels or piping components contain appreciable solids, (such as catalyst beds, packing, etc) there are special considerations when sizing and locating the pressure relief device, associated piping and downstream containment. As the solids, vapors and liquids pass through the relief device the solids may block the device and discharge lines, especially when the line contains one or more 90 degree elbows. Packing hold down screens and similar devices have been known to present little resistance to solids

being entrained and entering the relief device during an upset. There is no known open literature publication which gives guidance, but some suggested means of dealing with this problem include:

A. Locate the relief device on the vessel, piping or process system so as to minimize the chances of solids entering the relief device during a release.

B. Expand the discharge line just after the relief device.

C. Minimize flow direction changes, especially 90 degree turns.

D. Route the discharge as directly as possible to a separator vessel or if possible to atmosphere.

E. Provide a second relief device in parallel with the primary relief device. The secondary relief device should be set to open at a higher pressure to prevent unnecessary opening of it. Also, the unrestricted flow path of a rupture disk provides an incentive to choose a disk as the secondary device.

F. It is advisable to conduct appropriate pilot or commercial size tests.

10. The normal basis for sizing relief devices for the fire case assumes the vessel to be blocked in. This may not always be conservative. Consider the case where the vessel in question is connected to lower design pressure equipment. When designing overpressure protection for the lower design pressure vessel, it may be necessary to consider that the upstream vessel, exposed to fire, is not blocked in. In this case, the relief system on the low pressure vessel must be capable of handling the incoming fluid due to a fire around the higher design pressure vessel. This applies regardless of whether the low pressure vessel is in a fire-risk area or not. If the low pressure vessel is in a fire-risk area, its relief system must also be designed for fire exposure to itself.

11. The above guidelines should also be used in the design of overpressure protection for low pressure storage tanks designed for $<$ 15 psig, for which the following industry guidelines apply:

A. NFPA 30
B. API Standard 2000

12. In all cases, document the design. This is especially important when a non-fire-risk area is concluded as in point 4.

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References.

1. Self, F.Jr., and Remsen, C.H., "Unsteady-State Heat Transfer to a Vessel Subject to External Fire", Proceedings of the 1992 Process Plant Safety Symposium in Houston, TX, AIChE, February 1992.

2. H.G. Fisher, H.S. Forrest, S.S. Grossel, J.E. Huff, A.R. Muller, J.A. Noronha, D.A. Shaw, B.J. Tilley, "Emergency Relief System Design Using DIERS Technology (The Design Institute for Emergency Relief Systems (DIERS) Project Manual), The Design Institute for Emergency Relief Systems of the American Institute of Chemical Engineers, 1992.