VENT SIZING FOR FIRE

CONSIDERATIONS FOR

JACKETED VESSELS

Developed by the

DIERS USERS GROUP

ERS DESIGN FOR FIRE COMMITTEE

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DISCLAIMER

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Background

The methods for calculating heat flux to a vessel exposed to fire are well documented. API RP 520, 521, Standard 2000 and NFPA 30 are basic industry guidelines providing correlations to calculate this heat flux. Other guidelines are available for less general cases. Given the heat flux, a relieving rate can be calculated to prevent vessel damage due to over pressure. Considering height and geometry variables, the heat flux is calculated based on exposed vessel wall area which is wetted by internal liquids. Some add a contribution due to heat flux through unwetted surfaces. Finally, a credit (environmental factor) is sometimes taken when the vessel is protected by an adequate insulation or other heat transfer mitigation system.

Issue

How to determine the wetted surface area, heat flux and therefore relieving rates for jacketed vessels exposed to fire? In most cases the jacket is also considered a pressure vessel. Over pressure protection for the jacket itself must therefore be provided for the fire case. Relieving rate for the jacket vent is based on the jacket area. Heat flux into the jacket may be reduced by an environmental factor assuming an acceptable insulation system exists. This document assumes that the appropriate jacket relieving system has been designed and installed. Given that, the question remains on how to calculate the vessel relieving rate for the external fire case. This document provides guidance on whether or not the jacket itself performs as a form of thermal insulation for the vessel.

Contents

Guidelines

1. All of these guidelines apply to vent sizing for the external fire case. As always, there may be additional over pressure scenarios that may apply. If one of the alternate scenarios requires a larger vent than the fire case, then the larger vent should be installed. If this is done, the fire case and its relieving rate should still be documented.

2. Refer to the document, "Vent Sizing for Fire Considerations for Special Equipment and Piping" for additional guidelines that may apply to the case of small or unusually shaped equipment exposed to fire.

3. The jacket vent should be sized for fire with heat flux based on jacket outside area. Jacket vent sizing is normally done assuming homogeneous flow in the jacket. For additional information on sizing jacket vents for the fire case, refer to:

   a. Schiappa, C.A. and Winegardner, D.K. of the Dow Chemical Company, "Design of Pressure Relief Systems for Vessel Jackets Exposed to Fire", Presented at the AIChE Summer National Meeting, Denver, CO, 15 August, 1994.
   b. Schiappa, C.A. and Winegardner, D.K. of the Dow Chemical Company, "Pressure Relief System Alternatives for Vessel Jackets", Journal of Loss Prevention in the Process Industries, 1994, Volume 7, Number 1.
   c. Forrest, H.S., "Emergency Relief System Design for Fire Exposure with Consideration of Multiphase Flow", Proceedings of the International Symposium on Runaway Reactions and Pressure Relief Design, August, 1995, Boston, MA.

4. Since the jacket volume is small, assume that any liquid contents are quickly vented. That is, when sizing the vessel vent, assume the jacket has no liquid remaining.

5. The position presented by this paper is the result of theoretical heat transfer calculations, engineering experience, engineering judgement, several drafts and re-drafts and technical discussion. There are no (to our knowledge) test data. Consequently, it has become necessary to take a conservative approach. Three styles of jacket construction were examined: half-pipe, dimple and annular. In the first two cases, there was inadequate support for taking a heat flux reduction credit due to the presence of the empty jacket. On the other hand, for certain annular jackets, there is theoretical support for taking some heat flux reduction credit due to the presence of the jacket. More details are provided in 5.B below.

A. Half pipe and dimpled jackets. These jacket types have a lot of jacket metal to vessel metal contact. With these heat conduction paths plus heat transfer through the jacket space by radiation, the committee has concluded that there is little theoretical justification for expecting the jacket to provide significant heat transfer resistance.

B. Annular jackets. It is expected that, under fire conditions, the primary means of heat transfer will be radiation and the establishment of convection currents in the annular space. Consequently, there may be certain geometries (inner diameter, outer diameter and vessel height or length) where these convection currents will be negligible. While theoretical calculations may support taking heat transfer resistance credit for some geometry range, there will still be the question of test data support. As noted above, this committee is unaware of any test data on this subject.

   However, for vessels with annular jackets constructed according to the German DIN 28136, the following environmental credits are suggested:

   1. Use a jacket environmental factor of 0.7.
   2. Calculate the vessel effective area as "Wetted area not under jacket + 0.7*wetted area under jacket.
   3. Then apply an insulation environmental factor of 0.3 to the effective area (if properly insulated).
   4. These credits are only suggested for vessels with unbaffled jackets such as those built according to the German DIN 28136.

6. In conclusion, when sizing vessel vents for the external fire case for almost all vessels, this committee recommends taking no heat transfer resistance credit for the presence of a vessel jacket. Therefore, when determining heat flux for most jacketed vessels, calculate exposed area as though the jacket is not present.

7. As usual, heat flux to the vessel may still be reduced by an appropriate environmental factor if there is an acceptable insulation system covering the jacketed vessel. The environmental factor chosen may come from API RP 520, NFPA 30 or elsewhere. The value of the environmental factor used is also outside the scope of this document.

Additional References.

1. American Petroleum Institute "Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries", API Recommended Practice 520 Fifth Edition, July 1990.

2. American Petroleum Institute "Guide for Pressure-Relieving and Depressuring Systems", API Recommended Practice 521 Third Edition, Nov. 1990.

3. American Petroleum Institute "Venting Atmospheric and Low-Pressure Storage Tanks", API Standard 2000 Fourth Edition, January 1992.

4. National Fire Protection Association, "ANSI/NFPA 30, Flammable and Combustible Liquids Code", 1996 Edition.

5. 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.

6. F.P. Nichols, "Fire Relief of Jacketed Vessels", Report to the DIERS Users Group, October 1998 (attached).

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