PROSAF Inc.

ERS Design for Fire

Committee Presentation

April 29, 2003 Philadelphia Meeting

Insulation Considerations

- **Documents added to ERS Design for Fire Library from Pgh Corning Corp. showing Foamglas meets NFPA 30 guidelines for insulation environmental factor**
- **Minimum thickness required is 1” (that is the thinnest they make)**
- **Test results available showing acceptable conductance values at NFPA temperature**
- **Another committee member to comment on conductance values as function of time at temperature?**

Insulation Considerations

- **Normal insulation Installation techniques may not be adequate**
- **Pgh. Corning Spec #I-FP-1998, section 4.4:**
- **“in fire protection applications, it is necessary to install the insulation in multiple layers with the through joints staggered”**
- **sections 5.2,3,4:**
- **“single layer of insulation thickness is usually sufficient for process insulation requirements; however, a double layer must be specified for fire protection”**

Drainage required for fire credit?

- **Two Changes to NFPA 30**
- **Information source: NFPA website:**
- **NFPA.org**

Drainage required for fire credit?

- **CHANGE ONE: NO OR INADEQUATE INSULATION**
- **SUBMITTER: David C. Kirby, Union Carbide Corp./Rep. American Chemistry Council**
- **RECOMMENDATION: Revise text to read as follows:**
- **Paragraph 2.2.5.2.6(b) A reduction factor of 0.3 shall be allowed for tanks that are protected with an <u>automatically actuated</u> water spray system that meets the requirements of NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection.** **Delete "and that are provided with drainage that meets the requirements of 2.3.2.3.1"**

Drainage required for fire credit?

- **CHANGE ONE: NO OR INADEQUATE INSULATION**
- **SUBSTANTIATION: Add the requirement for automatic actuation. Tests show that bare steel vessels can fail within a few minutes of full fire exposure, making manually actuated water spray systems inappropriate protection. Drop the requirement for remote impounding. The emperically derived equations for heat input to tanks protected with water spray were based on pool fires, or fires simulating pool fires surrounding the tanks.**

Drainage required for fire credit?

- **CHANGE ONE: NO OR INADEQUATE INSULATION**
- **COMMITTTEE MEETING ACTION: Accept in Principle**
- **Add a new item (c) to read:**
- **"(c) A reduction factor of 0.3 shall be allowed for tanks that are protected with an automatically actuated water spray system that meets the requirements of NFPA 15, Standard for WaterSpray Fixed Systems for Fire Protection."**

Drainage required for fire credit?

- CHANGE ONE: NO OR INADEQUATE INSULATION
- COMMITTEE STATEMENT:
- By adding this as a new item instead of amending the existing one, the user can still opt to use manual water spray plus drainage.

Drainage required for fire credit?

- **CHANGE TWO: ADEQUATE INSULATION**
- **SUBMITTER: David C. Kirby, Union Carbide Corp./Rep. American Chemistry Council**
- **RECOMMENDATION: Revise text to read as follows:**
- **Paragraph 2.2.5.2.6(d) A reduction factor of 0.15 shall be allowed for tanks that are protected with a water spray system that meets the requirements of NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection and that have insulation that meets the requirements of 2.2.5.2.7.** **delete: "and that are provided with drainage that meets the requirements of 2.3.2.3.1"**

Drainage required for fire credit?

- **CHANGE TWO: ADEQUATE INSULATION**
- **SUBSTANTIATION: Drop the requirement for remote impounding. The emperically derived equations for heat input to tanks protected with water spray and insulation were based on pool fires, or fires simulating pool fires surrounding the tanks.**

PROSAF Inc.

Drainage required for fire credit?

- **CHANGE TWO: ADEQUATE INSULATION**
- **COMMITTTEE MEETING ACTION: Accept**
- **COMMITTEE STATEMENT:**

- **The Committee notes that this is now item (e), per action on Proposal 30-19 (Log #13).**

FAX MESSAGE FROM

PITTSBURGH CORNING CORPORATION

800 Presque Isle Drive
Pittsburgh, PA 15239-2799

TEL: 724-327-6100
FAX: 724-327-5890

Date: April 23, 2003

To: John Hauser

Phone: 724/942-3717

From: PCC / Ken Collier

Subject: Information

Pages: 1 of: 16

Dear Mr. Hauser:

Here is Energy Analysis Report number 13014 and the information that you had requested concerning the use of Pittsburgh Corning FOAMGLAS® Insulation on equipment for fire protection.

If you have any questions or if we can be of further assistance, please call me or your territory representative Mr. H. C. Mohr at 609/737-9609.

Sincerely,

Kenneth R. Collier
FOAMGLAS® Application Engineer

cc: C. Mohr
S. Oslica

These calculations provided to you at no charge conform to the design criteria which you provided. PCC does not guarantee the final design values indicated by such calculations nor represent that they are free of all errors and shall bear no liability for direct or indirect damages arising out of or in connection with your use of these calculations.

FOAMGLAS® INSULATION SPECIFICATION

PITTSBURGH CORNING CORPORATION
Technical Service & Systems Development
800 Presque Isle Drive
Pittsburgh, PA 15239
724-327-6100

SPECIFICATION GUIDELINES FOR FOAMGLAS® INSULATION USED IN FIRE PROTECTION APPLICATIONS FOR PIPING, TANKS AND VESSELS

1. SCOPE

1.1 These specification guidelines are general in nature and intended to be used as a tool in the design process, not as the ultimate design.

1.2 These specification guidelines offer application suggestions for the use of FOAMGLAS® insulation in fire protection applications for piping, tanks, and vessels. All accessory products and fabrication recommendations for FOAMGLAS® insulation within different temperature ranges are listed in the General Specification: I-H/C-89-02-01.

1.3 The product data sheets referenced in the text are listed at the end of the specification.

1.4 Metric conversions have been rounded to nearest inch-pound equivalent.

2. GENERAL

2.1 This specification is subject to revision without notice. Contact Pittsburgh Corning Corporation for current revision data before using. This specification is offered as a guide for the purpose described herein and should be employed at the discretion of the user. No warranty of procedures, either expressed or implied, is intended.

2.2 All surfaces to be insulated shall be cleaned of all scale, rust, oil, and foreign matter and shall be dry and free of frost prior to and during application of insulation.

2.3 Cleaning, such as sandblasting and priming of surfaces to be insulated, while recommended, is not part of this specification. If priming is specified, the primer must be thoroughly dry prior to the application of any insulation materials. The primer should also be compatible with any accessory materials recommended in this guide specification with which it may come in contact.

2.4 All un-insulated protrusions, such as stairs and railings, shall be cleaned, primed and painted prior to the application of any insulation materials.

2.5 It is recommended that all testing of piping, vessels, equipment, and tanks be completed prior to the application of any insulation materials.

2.6 All insulation and accessory materials shall be stored in an area that is dry and protected from the weather before and during insulation application.

3. MATERIALS

3.1 Insulation - shall be FOAMGLAS® cellular glass insulation manufactured in accordance with ASTM C 552, "Standard Specification for Cellular Glass Thermal Insulation," by Pittsburgh Corning Corporation, whose quality system for manufacturing, inspecting, and testing of FOAMGLAS® insulation is certified to meet the requirements of ISO 9002.

3.1.1 For pipes, FOAMGLAS® insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved sidewall segments are preferred. See Table 1 for fabrication guidelines.

3.1.2 For large diameter piping, vessels, kettles, and other large radius curved surfaces, insulation should be fabricated in curved sidewall segments or dished head segments wherever possible. See Table 1 for fabrication guidelines.

3.1.3 Fabricated head segments shall be used on all vessel heads that are 14" (356 mm) O.D. or larger. Heads smaller than 14" (356 mm) O.D. may be insulated with either fabricated head segments, or by extending the insulation for the body of the vessel out over the end of the vessel and cutting round sections of FOAMGLAS® insulation out of flat block. These round sections are plugs that can be used to fill the opening formed by the extended insulation.

3.2 Fabrication Adhesive - See Table 2 for fabrication adhesive recommendations. May be either:

3.2.1 Hydrocal® B-11 Powder, a gypsum cement, as manufactured by U.S. Gypsum, Inc.

3.2.2 Hot asphalt, ASTM D 312, Type III.

3.2.3 StrataFab® Adhesive for use with the FOAMGLAS® Insulation StrataFab® System only, as supplied by Pittsburgh Corning Corporation.

3.3 Insulation Securement:

3.3.1 Stainless steel is typically specified as a result of its demonstrated ability in fire exposure conditions. The material retains its integrity in instances of direct flame impingement, and secures the insulation material to resist dislodgment by a firehose stream. For the purposes of fire codes compliance, FOAMGLAS® insulation is recommended to be secured with stainless steel bands and jacketing.

3.3.2 Metal Jacket: 0.016" (0.4 mm) smooth stainless steel jacket. Contact jacketing manufacturer for recommendations.

3.3.3 Metal Bands: 0.5" x 0.015" (13 x 0.38 mm) stainless steel bands with matching seals.

3.3.4 Adhesive: PC® 88 Adhesive is a two-component adhesive manufactured by Pittsburgh Corning Corporation.

Note: For hydrocarbon fire conditions such as those described in UL 1709, maximum protection time in excess of one hour has been achieved by utilizing PC® 88 Adhesive as securement for both insulation layers in addition to stainless steel bands and the outer layer covered with stainless steel jacketing. This type of installation would be typical for tanks, vessels, and their support structures. For installation in this manner on stainless steel tanks, vessels and support structures, contact Pittsburgh Corning Corporation for recommendations.

For piping subjected to hydrocarbon fire conditions such as those described in UL 1709, protection time up to one hour has been achieved using Hydrocal® B11 as a bore coat, and stainless steel bands to secure both layers, the outer layer covered with stainless steel jacketing. For installation in this manner on stainless steel piping, contact Pittsburgh Corning Corporation for recommendations.

4. APPLICATION: Insulation Thickness Criteria

4.1 Insulation thickness selected for fire protection should be checked against the process thickness for the piping, tanks or vessels. In cases where the process thickness is less than that necessary for fire protection, the minimum required thickness for fire protection will govern. In cases where the process thickness is greater than that required for fire protection, the process thickness will govern.

4.2 FOAMGLAS® insulation thickness can be designed to provide fire protection for piping and equipment for specified amounts of time under given fire conditions. Credit may be taken for the insulation in sizing pressure relief valves, protecting the steel from over stressing, or protecting the contents of the vessel from overheating.

4.3 For the purpose of sizing the insulation thickness required for fire protection, the following characteristics of the application need to be determined:

a. Code requirements: For some codes, the desired outcome is an achieved length of protection time for the piping material, or tank and vessel contents. Other codes involve the calculation of a thermal credit gained from the insulation, for the purpose of sizing pressure relief valves. The criteria associated with each code is specific only to that code.

b. Thermal Criteria: For codes where the length of time is involved, the determining factor is the length of time the piping or vessel material will be protected until the metal temperature reaches the threshold of structural failure. For codes where the thermal credit for heat gain into the system is taken, the criteria involves the value of the thermal conductivity for the insulation at the mean temperature of the flame and the vessel contents at relieving conditions. The purpose of these calculations is to reduce the size of the pressure relief valve through the determination of an environmental credit factor. Different codes have different flame temperatures corresponding to various types of fires. See Section 6. Fire Protection Codes.

4.4 For the purpose of using FOAMGLAS® insulation in fire protection applications, it is necessary to install the insulation in multiple layers with the through joints staggered.

Contact Pittsburgh Corning Corporation's Energy Analysis Group for assistance in selecting an insulation thickness based on one or more of the above criteria.

5. APPLICATION: Process Consideration

5.1 Cryogenic Process: (-60°F to -450°F) / (-51°C to -268°C)

The requirements of the process insulation thickness from an allowable heat gain standard must be met initially. In cold service, limiting heat gain to a predetermined acceptable value may be based on process control, energy conservation, or limiting product boil-off (this value is frequently in the range of 8 - 12 Btu/hr ft^2 or (22 to 32 kcal/hr m^2). Insulation in this temperature range will be installed in multiple layers. The critical factor in determining the number and thickness of each layer is the interface temperature of the outer layer of insulation. This interface temperature must be within the service temperature range of the joint sealant.

From a fire protection standpoint, the amount of joint sealant for a finished installation is not expected to contribute as a material that would propagate the fire.

5.2 Below Ambient Process: (-60°F to 45°F) / (-51°C to 7°C)

For chilled water, glycol, brine and some refrigerants, although a single layer of insulation thickness is usually sufficient for process insulation requirements, a double layer must be specified for fire protection. The thickness for fire protection is selected based on the applicable code and the desired length of protection time. Insulation joints are sealed with the appropriate sealant within this temperature range.

5.3 Ambient and Above Ambient Process: (45°F to 400°F) / (7°C to 205°C)

Insulation joints are not sealed within this temperature range. As with the below ambient process, a single layer of insulation thickness is usually sufficient for process insulation requirements; however, a double layer must be specified for fire protection. The thickness for fire protection is selected based on the applicable code and the desired length of protection time.

5.4 High Temperature (Above 400°F / 205°C)

Insulation joints are not sealed within this temperature range. Fabrication options allow for the use of a single layer with the specification of the StrataFab® System; however, a double layer must be specified for fire protection. This may be a double layer of standard fabrication, or a combination of StrataFab® System and conventional fabrication.

6. FIRE PROTECTION CODES

The following is a list of related codes, and a brief description of how the information contained in the codes relates to the use of FOAMGLAS® insulation.

NFPA 58: Liquified Petroleum Gas Code 1998 Edition	Insulation must be capable of limiting container temperature to not over 800°F (427°C) for a minimum of 50 minutes as determined by test with insulation applied to a steel plate and subjected to a test flame. Insulation system should also be capable of resisting a concurrent hose stream of 10 minutes duration. Test parameters. (Appendix H)
NFPA 59: Standard for the Storage and Handling of Liquified Petroleum Gases at Utility Gas Plants 1995 Edition	Insulation must be capable of limiting container temperature to not over 800°F (427°C) for a minimum of 50 minutes as determined by test with insulation applied to a steel plate and subjected to a test flame. Insulation system should also be capable of resisting a concurrent hose stream of 10 minutes duration. Test parameters. (Appendix D)
NFPA 59A: Production, Storage and Handling of Liquified Natural Gas (LNG) 1996 Edition	Insulation must be noncombustible with a flame spread rating not greater than 25.
API 520: Sizing, Selection, and Installation of Pressure Relieving Devices and Refineries Sixth Edition Part 1 March 1993 Fourth Edition Part 2	Contains information as stated in API 52. (Appendix D) API 52, Fourth Edition, has most recent update of this material

API 521: Guide for Pressure Relieving and Depressuring Systems Fourth Edition March 1997	Contains equations for thermal credit taken for insulation restricting heat absorption by the vessel. Thermal credit in form of environmental factor is used in equation to determine vent capacity for pressure relief valve. Flame temperature used is 1660°F (904°C). The value of thermal conductivity of insulation is taken at mean temperature of flame and vessel contents at relieving conditions.
API 2000: Venting Atmospheric and Low Pressure Storage Tanks / Refrigerated and Nonrefrigerated	Contains equations for thermal credit taken for insulation restricting heat absorption by the vessel.

Fourth Edition October 1992	Thermal credit in form of environmental factor is used in equation to determine vent capacity for pressure relief valve. Carries statement that insulation shall be noncombustible, and shall not decompose at temperatures up to 1000°F (537°C).
API 2510: Design and Construction of Liquified Petroleum Gas (LPG) Installations Seventh Edition	States insulation should be fire retardant. Refers to NFPA 58 for fireproofing requirements relative to direct flame impingement and hose stream dislodgment. Refers to API 2000 for relief valve venting capacity requirements. Refers to UL 1709 for fireproofing of vessel structural and adjacent piping supports.
API 2510A: Fire Protection Considerations for the Design and Operation of Liquified Petroleum Gas (LPG) Storage Facilities Second Edition	Refers to API 2510.

7. FIRE PROTECTION PERFORMANCE TEST METHODS

The following is a list of test methods utilized to assess the performance of FOAMGLAS® insulation under various fire conditions.

ASTM E119: Standard Test Methods for Fire Tests of Building Construction and Materials	Test standard provides for the measurement of the transmission of heat, transmission of hot gasses, effect of fire endurance, hose stream test, and a standard time vs. temperature curve.
ASTM E 136: Behavior of Materials in a Vertical Tube Furnace at 750°C (1382°F)	This test considers the combustion and heat generating characteristics of building materials. FOAMGLAS® insulation has achieved a rating of noncombustible.
ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials	Information reported from this test contains the observations of burning characteristics, and values for flame spread index and smoke developed index. Gas test flame with cut-off at 980°F (527°C).
UL 1709: Fire Resistance Test for Petrochemical Facility Structural Elements	This test recreates conditions for a petrochemical plant fire and measures the hourly protection afforded steel during a rapid temperature rise that reaches 2000°F (1093°C) within 5 minutes. Performance is based on the insulation materials' ability to limit the temperatures measured on a steel member in a furnace environment to an average value of 1000°F (538°C).

8. INSPECTION

Inspect all insulation and accessory materials to be certain they are applied in conformance with the specification recommendations. Joints should be tight, sealing and flashing should be thorough and watertight, and finishes should be uniform and free of defects.

9. QUALITY ASSURANCE

The insulation manufacturer's quality system, including its implementation, shall meet the requirements of ISO 9002.

10. CERTIFICATES

The manufacturer will furnish evidence of compliance with the quality system requirements of ISO 9002.

Product Data Sheets

1. Hydrocal® B-11 Powder: FI-169
2. Fire Performance Data Sheet: FI-239

Code/ Test Method References

1. NFPA: National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101 Quincy, MA 02269-9101
2. API: American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005-4070
3. UL: Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL, 60062-2096
4. ASTM: American Society Testing Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428

TABLE 1
RECOMMENDED FABRICATION CONSIDERATION

DIAMETER in./ft (mm/m)	HALF-SECTIONS (min. thickness) in (mm)	CURVED SIDEWALL SEGMENTS	BEVELED LAGS	FLAT BLOCKS (max. size)
< 6" O.D. (152 mm)	1" (25 mm)			
6" to 12" (152 to 305 mm)	1 - 1 1/2" (25 to 38 mm)			
12" to 20" (305 to 508 mm)	2" (51 mm)			
20" to 24" (508 to 610 mm)	2 - 2 1/2" (51 to 64 mm)	X		
24" to 6' (610 mm to 1.8 m)		X		
6' to 13' (1.8 m to 4 m)		X	X	6" (152 mm)
14' to 23'(4.3 to 7 m)		X	X	9" (229 mm)
24' to 53' (7.3 to 16 m)				12" (305 mm)
54' to 150' (16.2 to 45 m)				18" (457 mm)
over 150' (over 45 m)				18" (457 mm)

TABLE 2
FABRICATION ADHESIVE GUIDELINES

OPERATING TEMPERATURE °F (°C)	HOT ASPHALT	HYDROCAL® B-11	StrataFab ® System
-450 to -290 (-268 to -179)		X[1]	
-289 to -101 (-178 to -74)	X	X	
-100 to 250 (-73 to 121)	X	X	
250 to 400 (121 to 204)	X[2]	X	X
401 to 500 (205 to 260)		X	X
501 to 900 (261 to 482)		X	X[3]

Notes: Tables 1 and 2

1. Hydrocal® B-11 is an inorganic gypsum based cement product. For applications where the process temperature may result in the presence of liquid oxygen, inorganic materials are always preferred. For stainless steel piping, tanks and vessels where stress corrosion cracking is a concern, contact Pittsburgh Corning Corporation for alternative gypsum cement product.

2. In this temperature range, only use asphalt if it is above ground and outdoors because of potential odor and melting concerns.

3. If the StrataFab® System is being used indoors in this temperature range, make certain that there is ample ventilation during heat-up, and for the first day after startup, to purge any potentially noxious fumes from the air.

PREPARED FOR JOHN HAUSER
BY PITTSBURGH CORNING CORPORATION

23-APR-03 13:30:02

THERMAL CONDUCTIVITY AS A FUNCTION OF MEAN TEMPERATURE FOR FOAMGLAS**

ENGLISH UNITS		METRIC UNITS		SI UNITS	
FOAMGLAS** INSULATION AT UNIFORM TEMPERATURE DEGREES F	FOAMGLAS** INSULATION THERMAL CONDUCTIVITY BTU IN/HR SQFT DEG F	FOAMGLAS** INSULATION AT UNIFORM TEMPERATURE DEGREES C	FOAMGLAS** INSULATION THERMAL CONDUCTIVITY KCAL/HR M DEG C	FOAMGLAS** INSULATION AT UNIFORM TEMPERATURE DEGREES K	FOAMGLAS** INSULATION THERMAL CONDUCTIVITY W/M DEG K
0.0	0.251	-17.8	0.0311	255.4	0.0362
50.0	0.278	10.0	0.0345	283.1	0.0400
100.0	0.307	37.8	0.0381	310.9	0.0443
150.0	0.339	65.6	0.0420	338.7	0.0489
200.0	0.374	93.3	0.0464	366.5	0.0539
250.0	0.412	121.1	0.0511	394.3	0.0594
300.0	0.454	148.9	0.0563	422.0	0.0654
350.0	0.500	176.7	0.0620	449.8	0.0720
400.0	0.549	204.4	0.0681	477.6	0.0792
450.0	0.604	232.2	0.0749	505.4	0.0871
500.0	0.664	260.0	0.0824	533.2	0.0957
550.0	0.730	287.8	0.0905	560.9	0.1052
600.0	0.803	315.6	0.0995	588.7	0.1157
650.0	0.883	343.3	0.1095	616.5	0.1272
700.0	0.971	371.1	0.1205	644.3	0.1400
750.0	1.070	398.9	0.1326	672.0	0.1542
800.0	1.178	426.7	0.1461	699.8	0.1698
850.0	1.299	454.4	0.1611	727.6	0.1872
900.0	1.433	482.2	0.1777	755.4	0.2065
950.0	1.582	510.0	0.1962	783.2	0.2280
1000.0	1.747	537.8	0.2167	810.9	0.2518
1050.0	1.931	565.6	0.2395	838.7	0.2784
1100.0	2.136	593.3	0.2649	866.5	0.3078
1150.0	2.363	621.1	0.2930	894.3	0.3406
1200.0	2.615	648.9	0.3243	922.0	0.3769
1250.0	2.895	676.7	0.3590	949.8	0.4172
1300.0	3.205	704.4	0.3975	977.6	0.4619
1350.0	3.548	732.2	0.4400	1005.4	0.5114
1400.0	3.928	760.0	0.4871	1033.2	0.5662

THE VALUES OF THE THERMAL CONDUCTIVITY OF THE INSULATION SHOWN ABOVE WERE DETERMINED BY EVALUATING A POLYNOMIAL AT THE INSULATION MEAN TEMPERATURE. THIS POLYNOMIAL, GIVING THE THERMAL CONDUCTIVITY IN BTU IN/HR SQFT DEG F AS A FUNCTION OF MEAN TEMPERATURE IN DEGREES F, IS:

$$K(T) = 0.2511 + 0.0005094\,T + 0.00000048040\,T^{2} + 0.00000000020180\,T^{3} + 0.00000000000011054\,T^{4} + 0.000000000000000019410\,T^{5}.$$

THIS CURVE IS BASED UPON AN INSULATION DENSITY OF 7.50 LBS/CUFT AND MAY BE SUBJECT TO DECREASING RELIABILITY OUTSIDE THE TEMPERATURE RANGE FROM -265.0 TO 850.0 DEGREES F.

TECHNICAL/GENERAL INFORMATION LETTER

Pittsburgh Corning Corporation
800 Presque Isle Drive, Pittsburgh, PA 15239
Phone (412) 327-6100

NO: TD-243

DATE: February 8, 1993

TO: FOAMGLAS® Insulation Sales Representatives and Sales Supervisors

SUBJECT: NFPA 30, Flammable and Combustible Liquids Code, 1990 Edition and API 2000, Venting Atmospheric and Low-pressure Storage Tanks

A. NFPA[1] 30

Chapter 2 of NFPA 30 applies to "aboveground, underground, and inside storage of liquids in fixed tanks ..."

Paragraph 2-3.5, "Emergency Relief Venting for Fire Exposure for Aboveground Tanks", discusses requirements for the relief of excessive internal pressure caused by exposure of the tank to fires.

If the tank is insulated, the capacity of the venting device may be reduced by an appropriate factor, as long as the insulation system meets the requirements spelled out in subparagraph 2-3.5.7(a). (Copies of pertinent paragraphs from the code are attached.)

> To meet the insulation system requirements of subparagraph 2-3.5.7(a) of the code, Pittsburgh Corning Corporation's fire resistance specifications recommend that FOAMGLAS® insulation be banded with stainless steel bands and covered with an outside jacket of stainless steel secured with stainless steel bands. When thus banded and jacketed, the insulation system will remain in place under fire exposure conditions.
>
> The FOAMGLAS® insulation will not be dislodged by the hose stream if the stainless steel jacketing and bands remain in place during fire exposure.
>
> The FOAMGLAS® insulation system will maintain a conductance below 4.0 Btu/hr/sq ft/°F when the outer insulation jacket is at a temperature of 1660°F and when the mean temperature of the insulation is 1000°F.

[1] National Fire Protection Association

B. API[1] 2000

Section 2.3 "Emergency Venting for Fire Exposure" of API 2000 discusses the requirements for sizing pressure relief valves on refrigerated tanks covered by API 2000. Copies of this section are attached.

If the tank is insulated, the capacity of the venting device may be reduced by an appropriate factor F, as long as the insulation system meets the requirements spelled out in section 2.3.2. (Copies of pertinent paragraphs from the standard are attached.)

> To meet the insulation system requirements of footnote a of table 4 of the standard, Pittsburgh Corning Corporation's fire resistance specifications recommend that FOAMGLAS® insulation be banded with stainless steel bands and covered with an outside jacket of stainless steel secured with stainless steel bands. When thus banded and jacketed, the insulation system will remain in place under fire exposure conditions.
>
> The noncombustible FOAMGLAS® insulation will not be dislodged by the hose stream if the stainless steel jacketing and bands remain in place during fire exposure.
>
> The FOAMGLAS® insulation system will maintain an arbitrary thermal conductivity below 4.0 Btu in/hr sq ft °F when there is a temperature differential of 1600F and a heat input of 21,000 Btu/hr ft^2.

[1]American Petroleum Institute

If there are any questions, please call.

Sincerely,

Robert M. McMarlin

Robert M. McMarlin
Manager, Product/Systems Services

RMM:jac

cc: T. Bovard, S. Bowser, M. L. Bruce, W. Carroll, L. Clair, J. P. Collet, K. Collier, R. DeGusipe, A. Dickey, C. Francik, R. Gerrish, D. Goss, L. Harris, J. Kirkpatrick, A. Parrillo, H. Patrick, T. Pirosko, K. Posteraro, G. Vandenbulcke, L. Wolosencuk

2-3.4.3 Low-pressure tanks and pressure vessels shall be adequately vented to prevent development of pressure or vacuum, as a result of filling or emptying and atmospheric temperature changes, from exceeding the design pressure of the tank or vessel. Protection shall also be provided to prevent overpressure from any pump discharging into the tank or vessel when the pump discharge pressure can exceed the design pressure of the tank or vessel.

2-3.4.4 If any tank or pressure vessel has more than one fill or withdrawal connection and simultaneous filling or withdrawal can be made, the vent size shall be based on the maximum anticipated simultaneous flow.

2-3.4.5 The outlet of all vents and vent drains on tanks equipped with venting to permit pressures exceeding 2.5 psig (17.2 kPa) shall be arranged to discharge in such a way as to prevent localized overheating of, or flame impingement on, any part of the tank, in the event vapors from such vents are ignited.

2-3.4.6 Tanks and pressure vessels storing Class IA liquids shall be equipped with venting devices that shall be normally closed except when venting to pressure or vacuum conditions. Tanks and pressure vessels storing Class IB and IC liquids shall be equipped with venting devices that shall be normally closed except when venting under pressure or vacuum conditions, or with listed flame arrestors. Tanks of 3,000 bbl (476 910 L) capacity or less containing crude petroleum in crude-producing areas, and outside aboveground atmospheric tanks under 23.8 bbl (3785 L) capacity containing other than Class IA liquids may have open vents. (*See 2-3.6.2.*)

2-3.4.7 Flame arrestors or venting devices required in 2-3.4.6 may be omitted for IB and IC liquids where conditions are such that their use may, in case of obstruction, result in tank damage. Liquid properties justifying the omission of such devices include, but are not limited to, condensation, corrosiveness, crystallization, polymerization, freezing, or plugging. When any of these conditions exist, consideration may be given to heating, use of devices employing special materials of construction, the use of liquid seals, or inerting (*see NFPA 69, Standard on Explosion Prevention Systems*).

2-3.5 Emergency Relief Venting for Fire Exposure for Aboveground Tanks.

2-3.5.1 Except as provided in 2-3.5.2, every aboveground storage tank shall have some form of construction or device that will relieve excessive internal pressure caused by exposure fires.

2-3.5.2 Tanks larger than 285 bbl (45 306 L) capacity storing Class IIIB liquids and not within the diked area or the drainage path of Class I or Class II liquids do not require emergency relief venting.

2-3.5.3 In a vertical tank, the construction referred to in 2-3.5.1 may take the form of a floating roof, lifter roof, a weak roof-to-shell seam, or other approved pressure-relieving construction. The weak roof-to-shell seam shall be constructed to fail preferential to any other seam. Design methods that will provide a weak roof-to-shell seam construction are contained in API 650, *Welded Steel Tanks for Oil Storage*, and UL 142, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*.

2-3.5.4 Where entire dependence for emergency relief is placed upon pressure-relieving devices, the total venting capacity of both normal and emergency vents shall be enough to prevent rupture of the shell or bottom of the tank if vertical, or of the shell or heads if horizontal. If unstable liquids are stored, the effects of heat or gas resulting from polymerization, decomposition, condensation, or self-reactivity shall be taken into account. The total capacity of both normal and emergency venting devices shall be not less than that derived from Table 2-8 except as provided in 2-3.5.6 or 2-3.5.7. Such device may be a self-closing manhole cover, or one using long bolts that permit the cover to lift under internal pressure, or an additional or larger relief valve or valves. The wetted area of the tank shall be calculated on the basis of 55 percent of the total exposed area of a sphere or spheroid, 75 percent of the total exposed area of a horizontal tank, and the first 30 ft (9 m) above grade of the exposed shell area of a vertical tank. (*See Appendix B for the square footage of typical tank sizes.*)

Table 2-8 Wetted Area versus Cubic Feet Free Air per Hour* (14.7 psia and 60°F) (101.3 kPa and 15.6°C)

Sq Ft	CFH	Sq Ft	CFH	Sq Ft	CFH
20	21,100	200	211,000	1,000	524,000
30	31,600	250	239,000	1,200	557,000
40	42,100	300	265,000	1,400	587,000
50	52,700	350	288,000	1,600	614,000
60	63,200	400	312,000	1,800	639,000
70	73,700	500	354,000	2,000	662,000
80	84,200	600	392,000	2,400	704,000
90	94,800	700	428,000	2,800	742,000
100	105,000	800	462,000	and over	
120	126,000	900	493,000		
140	147,000	1,000	524,000		
160	168,000				
180	190,000				
200	211,000				

SI Units: 10 ft^2 = 0.93 m^2; 36 ft^3 = 1.0 m^3
*Interpolate for intermediate values.

2-3.5.5 For tanks and storage vessels designed for pressures over 1 psig (6.9 kPa), the total rate of venting shall be determined in accordance with Table 2-8, except that when the exposed wetted area of the surface is greater than 2,800 sq ft (260 m^2), the total rate of venting shall be in accordance with Table 2-9 or calculated by the following formula:

$$CFH = 1{,}107\ A^{0.82}$$

Where:

CFH = venting requirement, in cubic feet of free air per hour

A = exposed wetted surface, in square feet

The foregoing formula is based on $Q = 21{,}000\ A^{0.82}$

Table 2-9 Wetted Area Over 2,800 sq ft and Pressures Over 1 psig

Sq Ft	CFH	Sq Ft	CFH
2,800	742,000	9,000	1,930,000
3,000	786,000	10,000	2,110,000
3,500	892,000	15,000	2,940,000
4,000	995,000	20,000	3,720,000
4,500	1,100,000	25,000	4,470,000
5,000	1,250,000	30,000	5,190,000
6,000	1,390,000	35,000	5,900,000
7,000	1,570,000	40,000	6,570,000
8,000	1,760,000		

SI Units: 10 ft^2 = 0.93 m^2; 36 ft^3 = 1.0 m^3

2-3.5.6 The total emergency relief venting capacity for any specific stable liquid can be determined by the following formula:

$$\text{Cubic feet of free air per hour} = V \frac{1{,}337}{L\sqrt{M}}$$

V = cubic feet of free air per hour from Table 2-8
L = latent heat of vaporization of specific liquid in Btu per pound
M = molecular weight of specific liquids

2-3.5.7 For tanks containing stable liquids, the required airflow rate of 2-3.5.4 or 2-3.5.6 may be multiplied by the appropriate factor listed in the following schedule when protection is provided as indicated. Only one factor shall be used for any one tank.

0.5 for drainage in accordance with 2-3.3.2 for tanks over 200 sq ft (18.6 m^2) of wetted area

0.3 for water spray in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, and drainage in accordance with 2-3.3.2

0.3 for insulation in accordance with 2-3.5.7(a)

0.15 for water spray with insulation in accordance with 2-3.5.7(a) and drainage in accordance with 2-3.3.2 (*see Appendix B*)

(a) Insulation systems for which credit is taken shall meet the following performance criteria:

1. Remain in place under fire exposure conditions.
2. Withstand dislodgment when subjected to hose stream impingement during fire exposure. This requirement may be waived where use of solid hose streams is not contemplated or would not be practical.
3. Maintain a maximum conductance value of 4.0 Btu per hour per square foot per degree Fahrenheit (Btu/hr/sq ft/°F) when the outer insulation jacket or cover is at a temperature of 1,660°F (904.4°C) and when the mean temperature of the insulation is 1,000°F (537.8°C).

2-3.5.8 The outlet of all vents and vent drains on tanks equipped with emergency venting to permit pressures exceeding 2.5 psig (17.2 kPa) shall be arranged to discharge in such a way as to prevent localized overheating of or flame impingement on any part of the tank, in the event vapors from such vents are ignited.

2-3.5.9 Each commercial tank venting device shall have stamped on it the opening pressure, the pressure at which the valve reaches the full open position, and the flow capacity at the latter pressure. If the start to open pressure is less than 2.5 psig (17.2 kPa) and the pressure at full open position is greater than 2.5 psig (17.2 kPa), the flow capacity at 2.5 psig (17.2 kPa) shall also be stamped on the venting device. The flow capacity shall be expressed in cubic feet per hour of air at 60°F (15.6°C) and 14.7 psia (760 mm Hg).

(a) The flow capacity of tank venting devices under 8 in. (20 cm) in nominal pipe size shall be determined by actual test of each type and size of vent. These flow tests may be conducted by the manufacturer if certified by a qualified, impartial observer or may be conducted by a qualified, impartial outside agency. The flow capacity of tank venting devices 8 in. (20 cm) nominal pipe size and larger, including manhole covers with long bolts or equivalent, may be calculated provided that the opening pressure is actually measured, the rating pressure and corresponding free orifice area are stated, the word "calculated" appears on the nameplate, and the computation is based on a flow coefficient of 0.5 applied to the rated orifice area.

(b) A suitable formula for this calculation is:

$$CFH = 1{,}667\, C_f A\sqrt{P_t - P_a}$$

where CFH = venting requirement in cubic feet of free air per hour
C_f = 0.5 [the flow coefficient]
A = the orifice area in sq in.
P_t = the absolute pressure inside the tank in inches of water
P_a = the absolute atmospheric pressure outside the tank in inches of water

2-3.6 Vent Piping for Aboveground Tanks.

2-3.6.1 Vent piping shall be constructed in accordance with Chapter 3.

2-3.6.2 Where vent pipe outlets for tanks storing Class I liquids are adjacent to buildings or public ways, they shall be located so that the vapors are released at a safe point outside of buildings and not less than 12 ft (3.6 m) above the adjacent ground level. In order to aid their dispersion, vapors shall be discharged upward or horizontally away from closely adjacent walls. Vent outlets shall be located so that flammable vapors will not be trapped by eaves or other obstructions and shall be at least 5 ft (1.5 m) from building openings.

2-3.6.3 The manifolding of tank vent piping shall be avoided except where required for special purposes such as vapor recovery, vapor conservation, or air pollution control. When tank vent piping is manifolded, pipe sizes shall be such as to discharge, within the pressure limitations of the system, the vapors they may be required to handle when manifolded tanks are subject to the same fire exposure.

2-3.6.4 Vent piping for tanks storing Class I liquids shall not be manifolded with vent piping for tanks storing Class II or Class III liquids unless positive means are provided to prevent the vapors from Class I liquids from entering tanks storing Class II or Class III liquids, to prevent contamination (*see 1-1.2*) and possible change in classification of the less volatile liquid.

Table 3—Total Rate of Emergency Venting Required for Fire Exposure Versus Wetted Surface Area (Refrigerated Aboveground and Belowground Tanks)

Wetted Area[a] (square feet)	Venting Requirement (cubic feet of free air[b] per hour)	Wetted Area[a] (square feet)	Venting Requirement (cubic feet of free air[b] per hour)
20	21,100	350	288,000
30	31,600	400	312,000
40	42,100	500	354,000
50	52,700	600	392,000
60	63,200	700	428,000
70	73,700	800	462,000
80	84,200	900	493,000
90	94,800	1000	524,000
100	105,000	1200	557,000
120	126,000	1400	587,000
140	147,000	1600	614,000
160	168,000	1800	639,000
180	190,000	2000	662,000
200	211,000	2400	704,000
250	239,000	2800	742,000
300	265,000	>2800[c]	—

NOTE: Interpolate for intermediate values. The total surface area does not include the area of ground plates but does include roof areas less than 30 feet above grade.
[a]The wetted area of the tank or storage vessel shall be calculated as follows: For spheres and spheroids, the wetted area is equal to 55 percent of the total surface area or the surface area to a height of 30 feet (9.14 meters), whichever is greater. For horizontal tanks, the wetted area is equal to 75 percent of the total surface area. For vertical tanks, the wetted area is equal to the total surface area of the shell within a maximum height of 30 feet (9.14 meters) above grade.
[b]At 14.7 pounds per square inch absolute (1.014 bar) and 60 F (15.56 C).
[c]For wetted surfaces larger than 2800 square feet (260.1 square meters), see 2.3.2.

4. Vapor displacement during filling.
5. A drop in barometric pressure.
6. Rupture of an internal coil.

2.2.2 VACUUM

A vacuum relief device shall be installed to permit the entry of air, or another gas or vapor, to avoid excessive vacuum that may result from the following:[5]

1. Withdrawal of the stored liquid at the maximum rate (see 1.2.1.1).
2. Withdrawal of vapor from the tank at the maximum compressor suction rate.
3. A rise in barometric pressure.
4. A reduction in vapor pressure resulting from the introduction of subcooled product into the vapor space.

The vacuum relief device shall be suitable to relieve the flow capacity determined for but not limited by the largest single contingency listed above or any reasonable and probable combination of the contingencies. It is permissible to reduce the requirement for vacuum relief capacity by the rate of vaporization that results from minimum normal heat gain to the contents. A gas-repressuring line with a suitable control and source of gas may be provided to avoid drawing air into the tank. The use of a gas-repressuring system shall not obviate the use of vacuum relief valves.

2.3 Emergency Venting for Fire Exposure

The capacity of the pressure relief devices for fire exposure shall be determined in accordance with the procedures specified in 2.3.1 through 2.3.3 and based on the factors contained in Tables 3 and 4.

2.3.1 For refrigerated tanks, the total rate of venting shall be determined in accordance with Table 3, multiplied by the environmental factor, F, selected from Table 4.

2.3.2 When the wetted area of the surface is larger than 2800 square feet (260.1 square meters), the total rate of venting shall be calculated from the following formula:

$$CFH = 1107\, F A^{0.82}$$

Where:

CFH = venting requirement, in cubic feet of free air per hour (at 14.7 pounds per square inch absolute and 60 F).

[5]However, the required capacity may be reduced for products whose volatility is such that vapor generation or condensation, within the permissible operating range of vessel pressure, will provide all or part of the venting requirements. In cases in which noncondensables are present, this should be taken into account.

Table 4—Environmental Factors

Datum	*F* Factor
Bare metal vessel	1.0
Insulation thickness[a]	
6 inches (152 millimeters)	0.05[b]
8 inches (203 millimeters)	0.037[b]
10 inches (254 millimeters)	0.03[b]
12 inches (305 millimeters) or more[c]	0.025[b]
Concrete thickness	[d]
Water-application facilities[e]	1.0
Depressuring and emptying facilities[f]	1.0
Underground storage	0
Earth-covered storage above grade	0.03

[a]To take credit for reduced heat input, the insulation shall resist dislodgment by a fire-hose stream, shall be noncombustible, and shall not decompose at temperatures up to 1000 F. If the insulation does not meet these criteria, the *F* factor for a bare vessel shall be used.
[b]These *F* factors are based on an arbitrary thermal conductivity of 4 British thermal units per hour per square foot per (degree F per inch of thickness) and a temperature differential of 1600 F when using a heat input value of 21,000 British thermal units per hour per square foot in accordance with the conditions assumed in API Recommended Practice 520. When these conditions do not exist, engineering judgment should be exercised either in selecting a higher *F* factor or in providing other means of protecting the tank from fire exposure.
[c]The insulation credit is arbitrarily limited to the *F* factor shown for 12 inches of insulation, even though greater thicknesses may be used. More credit, if taken, would result in a relieving device that would be impractically small but that might be used if warranted by design considerations.
[d]Twice the *F* factor for an equivalent thickness of insulation.
[e]Under ideal conditions, water films covering the metal surfaces can absorb substantially all incident radiation. However, the reliability of effective water application depends on many factors. Freezing temperatures, high winds, system clogging, unreliability of the water supply, and adverse tank surface conditions are a few factors that may prevent adequate or uniform water coverage. Because of these uncertainties, the use of an *F* factor other than 1.0 for water application is generally discouraged.
[f]Depressuring devices may be used, but no credit for their use shall be allowed in sizing safety valves for fire exposure.

F = environmental factor from Table 4.
A = wetted surface area, in square feet (see Table 3, Footnote a).

NOTE: The formula above is based on

$$Q = 21{,}000\,A^{0.82}$$

as given in API Recommended Practice 520. The total heat absorbed, Q, is in British thermal units per hour. The constant 1107 is derived by converting the heat input value of 21,000 British thermal units per hour per square foot to standard cubic feet of free air by using the latent heat of vaporization at 60 F and the molecular weight of hexane. When the molecular weight, latent heat of vaporization, and temperature of relief conditions for refrigerated hydrocarbons are substituted in the formula based on hexane, the venting requirements are about equal to the values for hexane. Hexane has therefore been used as a basis for simplification and standardization (see Appendix B for additional information about the derivation of the formula).

2.3.3 If the normal vent capacity is inadequate, additional emergency venting devices shall be provided so that the total venting capacity is at least equivalent to that required by 2.3.1 or 2.3.2.

2.4 Marking and Test Requirements

Each pressure and vacuum relief device shall be marked in accordance with 1.6. The capacity of the device shall be established in accordance with 1.5.

2.5 Installation of Pressure and Vacuum Relief Devices

Pressure and vacuum relief devices shall be installed to:

1. Provide direct communication with the vapor space and not be sealed off by the liquid contents of the tank.
2. Prevent plugging of the inlet by insulation during relieving conditions.
3. Minimize the possibility of tampering with the adjustment mechanism, which, if external, may be provided with a seal.
4. Protect the tank from the closure of a block valve or valves installed between the tank and the pressure or vacuum relief device or between the pressure or vacuum relief device and the outlet of its discharge vent. This may be done by locking or sealing the block valves open without installing excess relief capacity or by providing excess pressure or vacuum relief capacity with multiple-way valves, interlocked valves, or sealed block valves arranged so that isolating one pressure or vacuum relief device will not reduce the remaining relief capacity below the required relief capacity.
5. Ensure that the inlet and outlet assemblies, including any block valves, will permit the safety relief device to provide the required flow capacity.
6. Have the inlet connection sufficiently long and uninsulated so that the devices remain at atmospheric temperature under no-flow conditions.

NOTE: Inlet pressure losses developed during relief conditions must be taken into account when sizing the pressure and vacuum relief.

2.6 Discharge Vents

2.6.1 Discharge vents from the safety relief devices or common discharge headers shall be installed to:

1. Lead to a safe location.
2. Be protected against mechanical injury.
3. Exclude or remove atmospheric moisture and condensate from the relief devices and associated piping. This may be done by the use of loose-fitting rain caps or drains. Drains shall be installed to prevent possible flame impingement on the tanks, piping, equipment, and structures.
4. Discharge in areas that (a) will prevent flame impingement on personnel, tanks, piping, equipment, and structures and (b) will prevent vapor entry into enclosed spaces.