1. Chair’s welcome, call to order, and opening remarks at 9:00 a.m.
2. Self-Introduction of Committee Members and Guests
3. Approval of Minutes from the ROC Meetings held in September 2010 in Quincy, MA. See NFPA 59 Document Information page, www.nfpa.org/59, to review.
4. Staff Liaison Report
   A. Review of new NFPA process, software and timeline (Attachment A)
   B. Committee membership update (For the period Sept 1, 2010 – Aug 17, 2012)

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(Total Voting Members –21; U=33%; SE=24%; M=19%; E=10%, IM=10%; I=5%)

5. Old Business
   A. Extract Updates task group. Bill Young, chair, Jim Goodrich, and Dave Stainbrook. The task group will review text extracted from other NFPA documents, and make recommendations to update as required by NFPA Regulations Governing Committee Projects.
   B. Chapter 13, Fire Protection, Safety, and Security. Stanley Kastanis, Kevin Ritz, Mike Osmundson, and Bruce Swiecicki. No Chair was appointed. The task group will review the chapter to determine if part or all of the chapter should be retroactive to existing installations. The task group will report actions recommended, or identify sections where no action should be taken. Note: AGA has submitted two proposals related to this topic, Log #66 (PI-72) and Log #75 (PI-81).
   C. Vaporizer distances. The members are Randy Irvine (Chair), Bruce Swiecicki, Charlie McDaniel, Kevin Ritz, and James Goodchild.

6. New Business
   A. Review of public input (Attachment B)
   B. Review J. Stannard’s request to review pressure relief valve sizing calculations (Attachments C and D)

7. Other Items?

8. Date/Location of Next Meeting. (The Second Draft meeting must occur between May 3 and October 18, 2013.)

Attachment A: Revision Cycle Timeline
**2014 ANNUAL REVISION CYCLE**

*Public Input Dates may vary according to documents and schedules for Revision Cycles may change. Please check the NFPA Website for the most up-to-date information on Public Input Closing Dates and schedules at www.nfpa.org/document # (i.e. www.nfpa.org/101) and click on the Next Edition tab*  

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| Tech Session Association Meeting for Documents with CAMs | 6/9-12/2014 | 6/9-12/2014 |

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1.1.1 This code shall apply to the design, construction, location, installation, operation, and maintenance of refrigerated and nonrefrigerated utility gas plants including LP-gas containers, piping and associated process equipment and controls and fire protection as utility LP-gas plants are defined within this standard and associated Annex information (Figure A.111). Coverage of liquefied petroleum gas systems at utility gas plants begins at the point of LP-gas (liquid) delivery (first valve or transfer hose) and shall extend to the point where LP-Gas vapor or a mixture of LP-Gas vapor and air is introduced into the utility distribution system.

Substantiation: Proposal is offered to aid in the consistent and appropriate application by LP-gas facility owners/operators and regulatory authorities of the NFPA 59 standard vs that of the NFPA 58 standard. Additional clarification accompanies in a separate proposal following this paragraph listing facilities proposed to be titled "Nonapplication of Code" similar to format of NFPA 58.

1.1.2 When operations that involve the liquid transfer of LP-Gas from the utility gas plant storage into cylinders or portable tanks (as defined by NFPA 58, Liquefied Petroleum Gas Code) are carried out in the utility gas plant, these operations shall conform to NFPA 58, Liquefied Petroleum Gas Code.

Substantiation: Delete as the intent of this text was moved to proposed new 1.2 Nonapplication of Code section.

1.1.3 Installations that have an aggregate water capacity of 4000 gal (15.14 m³) or less shall conform to NFPA 58, Liquefied Petroleum Gas Code.

Substantiation: Delete as the intent of this text was moved to proposed new 1.2 section titled Nonapplication of Code.
1.2 Nonapplication of Code. This code shall not apply to the following:

(1) The design, construction, installation, and operation of marine terminals whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users.

(2) The design, construction, installation, and operation of pipeline terminals that receive LP-Gas from pipelines under the jurisdiction of the U.S. Department of Transportation (DOT) whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users. Coverage shall begin downstream of the last pipeline valve or tank manifold inlet.

(3) Operations that involve the liquid transfer of LP-Gas from the utility gas plant storage into cylinders or portable tanks (as defined by NFPA 58, Liquefied Petroleum Gas Code) are carried out in the utility gas plant, these operations shall conform to NFPA 58, Liquefied Petroleum Gas Code.

(4) Installations that have an aggregate water capacity of 4000 gal (15.14 m³) or less shall conform to NFPA 58, Liquefied Petroleum Gas Code.

(5) Containers, piping, and associated equipment, when delivering LP-Gas to a single building for use as a fuel gas shall conform to NFPA 58, Liquefied Petroleum Gas Code.

(6) Highway transportation of LP-Gas to the point of transfer at a NFPA 59 LP-Gas Utility Plant of a NFPA 58 LP-Gas facility as defined by NFPA 59 and NFPA 58 Standards under the jurisdiction of the Department of Transportation.

(7) LP-gas (liquids) pipelines to the point of transfer at a NFPA 59 LP-Gas Utility Plant or a NFPA 58 LP-Gas facility as defined by NFPA 59 and NFPA 58 Standards under the jurisdiction of the Department of Transportation, Pipeline & Hazardous Materials Administration (PHMSA) 49 CFR Part 195.

(8) The point downstream of where LP-Gas vapor or a mixture of LP-Gas vapor and air mixture is introduced into the utility distribution system serving:

(A) 10 or more customers located in a public place

(B) More than a (1) single customer no matter if the portion of the system is located entirely on the customers premises or in a public location are under the jurisdiction of the Department of Transportation, Pipeline & Hazardous Materials Administration (PHMSA) 49 CFR Part 192.

(9) Portions of LP-Gas systems covered by NFPA 54 (ANSI Z223.1), National Fuel Gas Code, where NFPA 54 (ANSI Z223.1) is adopted, used, or enforced

Substantiation: Rename currently reserved "Purpose" section as proposed with associated proposed text to further aid in the application of the NFPA 59 standard vs. the NFPA 58 standard the following is proposed to clarify facilities which are not applicable to the NFPA 59 standard. This approach aligns with the NFPA 58 standard which as both application and nonapplication descriptions.
Recommendation: Include an entry for NFPA 750, Standard on Water Mist Fire Protection Systems and re-number the balance of the list. Other forms of 'fire Protection water systems' are listed but not water mist. Water Mist systems have been approved and installed in many sprinkler applications globally for over 15 years. They have been listed by national and internationally recognized testing laboratories such as: UL (Ordinary Hazard Group 1), FM (Light Hazard occupancies, Computer Rooms, Subfloors, Special Hazard Machinery & spaces), City of New York (Light Hazard Occupancies, Combustion Turbines, Machinery Spaces), VdS Germany (Light Hazard, Ord Haz Grp I,II parking garages & III selected occupancies, Cable Tunnels), KfV Austria (Light Hazard, Ord Haz Grp I, Combustion Turbines) and other agencies. These listings and installations have demonstrated equivalent fire protection to the authority having jurisdiction (AHJ). The addition of the proposed text will provide the AHJ a clear option to accept water mist systems as an equivalent system to an approved automatic sprinkler system. NFPA 750 is a performance based standard enabling the engineering, design and installation of a water based system that will take into consideration the fire control problems in facilities covered by this standard. It should be included in the list.
Revise text to read as follows:

2.2 NFPA Publications.
National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.
NFPA 10, Standard for Portable Fire Extinguishers, 2010 edition
NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam, 2010 edition
NFPA 14, Standard for the Installation of Standpipe and Hose Systems, 2010 edition
NFPA 17, Standard for Dry Chemical Extinguishing Systems, 2009 edition
NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, 2009 edition
NFPA 70®, National Electrical Code®, 2011 edition
NFPA 72®, National Fire Alarm and Signaling Code, 2013 edition

Substantiation: Proposal recognized NFPA standard for fire extinguishing systems that can be utilized in LPG facilities which replaces Halon systems known as an agent that depletes ozone.

Revise text to read as follows:


Substantiation: In anticipation of the publishing of the latest edition of API 620 the 2012 edition is being proposed. If the 2012 edition is not published the inclusion of recent addendums to the 2008 edition in 2009 and 2010 should be recognized.
59- Log #9  Final Action:
(2.3.2)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
Substantiation: Proposal recognizes correct code number and recent supplement.

59- Log #10  Final Action:
(2.3.3)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:

59- Log #11  Final Action:
(2.3.4)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
Substantiation: Proposal recognize latest editions of both standards.

59- Log #12  Final Action:
(2.3.5)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
2.3.5 UL Publications.
Underwriter's Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.
Substantiation: The proposal addresses the need to acquire both the 2007 standard and the 2010 amendment as the 2010 amendment does not include the full standard text.
2.3.8 NACE Publications.
NACE International, 1440 South Creek Drive, Houston, TX 77084-4906.
NACE SP-0169, Control of External Corrosion of Underground or Submerged Metallic Piping Systems, 2007

Substantiation: The proposed new standard is necessary to implement the corrosion control requirements added to NFPA 59 2012 edition in Chapter 12, Maintenance. The added 2012 corrosion control requirements were added to clarify and align corrosion control expectations in 49 DFR Part 192 as part of a AGA lead effort to compare NFPA 59 to Part 192 requirements and identifying conflicts and omissions between the code and the standard.

Submitter: Nneka Assing, American Gas Association
Recommendation: Add new text to read as follows:

3.3.11 Filling Density. The percent ratio of the weight of the LP gas liquid in a container to the weight of water at 60°F (15.6°C) that the container will hold.

Substantiation: Clarifies the weight of LPG in liquid phase and not the gas phase.

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:

3.3.16.5 Slip Tube Gauge. A variable liquid level gauge in which a relatively small positive shutoff valve is located at the outside end of a straight tube, normally installed vertically, that communicates with the container interior and can be adjusted to find the liquid level surface.

Substantiation: Adds clarification to definition.

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:

3.3.32 Redundant Fail-Safe Product Control Measures (RFPCM). Specified product storage controls that are more stringent than the basic requirements of this standard. (RFPCM would be used to alleviate the requirement for special protection and to be a factor in reducing distance requirements.

Substantiation: Eliminate definition as section is no longer in NFPA 59.
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**Submitter:** Nneka Assing, American Gas Association

**Recommendation:** Revise text to read as follows:

3.3.40.2 Internal Valve. A container primary shutoff valve having the following features:

1. The seat and seat disc remain inside the container so that damage to parts exterior to the container or mating flange does not prevent effective sealing of the valve;
2. The valve is designed for the addition of a means for remote closure and is also designed for automatic shutoff when the flow through the valve exceeds its maximum rated flow capacity or when pump actuation differential pressure drops to a predetermined point.

**Substantiation:** Cleans up definition. Eliminates pump requirement as this is related to an application of an internal valve.

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**Submitter:** Nneka Assing, American Gas Association

**Recommendation:** Revise text to read as follows:

4.1 Qualifications of Personnel Training. Persons engaged in gas operating and emergency procedures and in the handling of LP-Gas liquefied petroleum gases shall be trained in the properties and safe handling of these gases and in emergency procedures. This training shall be repeated at least annually.

**Substantiation:** Section addresses employee training, not qualification, and utilizes the definition in 3.3.20.

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**Submitter:** Nneka Assing, American Gas Association

**Recommendation:** Revise text to read as follows:

4.3 Acceptance of Equipment. In systems with containers of over 2000 gal (7.6 m³) water capacity, each container valve, excess-flow valve, device, relief device directly connected on the liquified petroleum gas container, and direct-fired vaporizer shall be approved. (See 3.2.1, Approved.)

**Substantiation:** Clean-up of wording.

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**Submitter:** Nneka Assing, American Gas Association

**Recommendation:** Revise text to read as follows:

4.4 Damage from Vehicles. Where damage to liquefied petroleum gas systems from vehicular traffic is a possibility, precautions (such as warning signs, or devices, or barricades, or other devices) shall be taken against such damage. (See 5.8.2.)

**Substantiation:** Clean up poorly written text.
5.5.1.6 Vertical containers shall be designed to be self-supporting without the use of guy wires and shall take into account wind loading per 5.5.1.8, seismic forces (earthquake) per 5.5.1.9, and hydrostatic test loads. Adding this text creates a proper connection with other statements.

6.3.3.4 Gaskets used to retain LP-Gas in flanged connections in piping containing liquid LP-Gas and LP-Gas vapor shall be as follows:
1. Resistant to the action of LP-Gas
2. Made of metal or other material that is confined in metal that has a melting point over 1500°F (816°C) or protected against fire exposure
3. Replaced when a flange is opened
4. Nonmetallic or electrically insulating where electrical insulating fittings are required

Replace original verbiage to standardize requirement for gasket material.

6.3.3.6 When a flange is opened, the gasket shall be replaced. Delete 6.3.3.4, 6.3.3.5, and 6.3.3.6 and replace with 7.1.6.

Same as earlier justification.
6.5.8.3 The duration of the incident shall be the amount of time that automatic systems or plant personnel could effect emergency procedures and stop the leak. The subimpoundment basin shall be located as far away from the container as possible. [58.12.5.9.3]

**Substantiation:** Delete text as it is not a design feature of the impoundment system. This needs to be inserted at XXXX. This change should also be communicated to the 58 TC.

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7.1.1 Piping, valves, and equipment shall be suitable for LP-Gas service at the minimum design temperature and the maximum design pressure. 

**Clarification.**

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7.1.1.1 The design and fabrication of process piping systems shall be in accordance with ASME B31.3, Process Piping, except as specifically modified by the provisions of this chapter and any applicable federal pipeline regulations.

**Substantiation:** Clarify that ASME B31.3 is the design code unless a specific item is modified by such as specifically modifies the test pressure to 150%.

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7.1.1.5 Buried flammable liquid or gas piping shall be installed with a minimum of 30 inches of cover in normal soil and a minimum of 18 inches in consolidated rock.

**Substantiation:** This comment and associated revised text addresses identified gap as a result of an AGA Supplemental Gas Committee and NFPA 59 TC member Task force to perform a detailed comparison between Part 192 and NFPA 59. The intent of the comparison was to identify gaps and reach alignment with part 192 through the normal NFPA standards development process.
59- Log #30
(7.1.1.6 (New))

Submitter: Nneka Assing, American Gas Association
Recommendation: Add new text to read as follows:
7.1.1.6 Buried flammable liquid or gas piping shall be installed with a minimum of 12 inches clearance between the pipe and any other structure not associated with the pipe to allow for proper maintenance.

Substantiation: This comment and associated revised text addresses identified gap as a result of an AGA Supplemental Gas Committee and NFPA 59 TC member. Task force to perform a detailed comparison between Part 192 and NFPA 59. The intent of the comparison was to identify gaps and reach alignment with part 192 through the normal NFPA standards development process.

Final Action:

59- Log #31
(7.1.3.1 (New))

Submitter: Nneka Assing, American Gas Association
Recommendation: Add new text to read as follows:
7.1.3.1 Piping that carries LP-gas liquids, LP-gas vapors, and LP-gas/air mixtures used in utility LP-gas plants shall not be made of plastic.

Substantiation: Addresses potential fire safety risk as well as clarifying material allowed in Part 192 during Part 192 and NFPA 59 comparison submitted to PHMSA and present at AGA in Washington DC.

Final Action:

59- Log #32
(7.1.6(4))

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
(4) Nonmetallic or electrically insulating where electrical insulating fittings are required

Substantiation: Clarify the intent of [4].

Final Action:

59- Log #33
(7.1.10)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
7.1.10 Underground and submerged piping shall be protected and maintained to minimize corrosion as required in 12.2 of this standard.

Substantiation: Proposal leads user to corrosion control requirements in 12.2 added in the 2012 NFPA 59 edition.

Final Action:

59- Log #34
(7.8.1)

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
7.8.1 Refrigerated storage systems shall be provided with sufficient capacity to maintain all containers at a pressure not in excess of the operating pressure under all design ambient conditions where the tank is sited summer weather conditions and shall be provided with additional capacity for filling or standby service.

Substantiation: The proposed language is more specific engineering terminology.

Final Action:
8.2.2 Structure or Building Ventilation. The structure shall be ventilated to prevent an accumulation of flammable gas within the building using air inlets and outlets, the bottom of which shall be not more than 6 in. (150 mm) above the floor, and ventilation shall be provided in accordance with one of the following:

[1] Where mechanical ventilation is used, the rate of air circulation shall be at least 1 ft³/min.per ft² (0.3 m³/min.per m²) of floor area.
   a) The ventilation system can be in continuous operation
   or
   b) The ventilation system must be automatically activated upon detection of a flammable gas at the gas detection setting in 13.2.3.

Outlets shall discharge at least 5 ft (1.5 m) from any opening into the structure or any other structure.

[2] Where natural ventilation is used, each exterior wall shall be provided with one opening for each 20 ft (6.1 m) of length.

   [a] Each opening shall have a minimum size of 50 in.² (32,250 mm²), and the total of all openings shall be at least 1 in.²/ft² (6900 mm²/m²) of floor area.

[58:10.2.2] Substantiation: This clarifies the purpose, and activation of the ventilation system to prevent the accumulation of flammable gas in the building.

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9.3.1.1 All vaporizers, including atmospheric-type vaporizers that use heat from surrounding air or the ground, shall be equipped, at or near the discharge, with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 10.7.1. Fusible plug devices shall not be used.

Substantiation: Renumbering 9.3.1 to 9.3.5.7 are dependent on all proposals being coordinated together. This creates separate categories for the various types of LP-Gas vaporizers.
59- Log #38
(9.3.1.2 (New )

Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Move text from 9.3.2 to 9.3.1.2 as follows:

9.3.1.2 Vaporizer. The heat exchangers for LP-Gas shall be constructed in accordance with the ASME Boiler and Pressure Vessel Code for not less than an MAWP of 250 psig (1.7 MPag) and shall be permanently and legibly marked with the following:

[1] The marking required by the ASME Code
[2] The MAWP and temperature for which the heat exchanger is designed
[3] The name or symbol of the manufacturer
[4] The maximum vaporizing capacity in gallons per hour (L/h)
[5] The rated heat input in British thermal units per hour (Btu/hr) (mJ/hr)

Substantiation: Renumbering 9.3.1 to 9.3.5.7 are dependent on all proposals being coordinated together. This creates separate categories for the various types of LP-Gas vaporizers. "(4)" is misleading and meaningless, and would need to state operating conditions to accurately represent maximum vaporization capacity.

59- Log #39
(9.3.1.2.1 (New )

Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Move text from 9.3.2.1 to 9.3.1.2.1 as follows:

9.3.1.2.1 Heat exchangers for vaporizers that have an inside diameter of 6 in. (150 mm) or less are exempt from the ASME Code and shall not be required to be marked.

Substantiation: Moved per substantiation in 9.3.1.2.

59- Log #41
(9.3.1.3 (New )

Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Move text from 9.3.3 to new 9.3.1.3 as follows:

9.3.1.3 All vaporizers shall be provided with a suitable automatic means to prevent liquid from passing through the vaporizer to the vapor discharge piping. This means shall be permitted to be integral with the vaporizer or otherwise provided in the external piping.

Substantiation: Moved per substantiation in 9.3.2.

59- Log #40
(9.3.1.3.1 (New )

Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Move text from 9.3.3.1 to 9.3.1.3.1 as follows:

9.3.1.3.1 A means for manually turning off the gas to the main burner and pilot shall be provided.

Substantiation: Moved per substantiation in 9.3.2.
59- Log #42
(9.3.1.4 (New))

Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Move text from 9.3.3.2 to 9.3.1.4 as follows:
9.3.1.4 Gas Direct-fired vaporizers shall be equipped with an automatic safety device to shut off the flow of gas to the main burner if the pilot light is extinguished. If the pilot flow exceeds 2000 Btu/hr (2 mJ/hr), the safety device also shall shut off the flow of gas to the pilot.
[moved from 9.3.3.2]
Substantiation: Identifies requirement is appropriate for all gas-fired units, not just “direct-fired” and renumbered as 9.3.4.

59- Log #43
(9.3.1.5 (New))

Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Move text from 9.3.5.6 to 9.3.1.5 as follows:
9.3.1.5 Gas-fired immersion heaters with an input of 400,000 Btu/hr (422 MJ/hr) or more shall be equipped with an electronic flame safeguard that performs the following functions:
[1] Prepurges the combustion chamber prior to ignition
[2] Proves the presence of a pilot before the main burner valve opens
[3] Shuts down the main gas valve and pilot upon failure of the burner flame
[moved from 9.3.5.6]
Substantiation: Added text for presence of pilot to clarify intent of (2) Renumbered to the general vaporizer section.

59- Log #44
(9.3.2)

Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Add new text to read as follows:
9.3.2 Direct-fired Vaporizers.
Substantiation: Create section for Direct-fired vaporizer requirements.

59- Log #45
(9.3.3)

Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Move text from 9.3.5 to 9.3.3 as follows:
9.3.3 Waterbath vaporizers shall comply with 9.3.5.1 through 9.3.5.7 9.3.3.
[moved from 9.3.5]
Substantiation: Moved from 9.3.5 to clarify requirements only for Waterbath LP-Gas vaporizers.
Submitter: Nneka Assing, American Gas Association
Recommendation:  Moved text from 9.3.5.2 to 9.3.3.1 as follows:
9.3.3.1 Waterbath sections of waterbath vaporizers shall be protected from overpressure conditions and shall be designed to withstand the pressures to which they will be subjected.
[move from 9.3.5.2]
Substantiation:  Moved from 9.3.5.2 into new designated section for Waterbath vaporizers.

Submitter: Nneka Assing, American Gas Association
Recommendation:  Move text from 9.3.5.3 to 9.3.3.2 as follows:
9.3.3.2 The immersion heater that provides heat to the waterbath shall be installed so as not to contact the LP-Gas heat exchanger.
[move from 9.3.5.3]
Substantiation:  Clarification of intent and moved from 9.3.5.3 to waterbath section.

Submitter: Nneka Assing, American Gas Association
Recommendation:  Move text from 9.3.5.4 to 9.3.3.3 as follows:
9.3.3.3 A control to limit the temperature of the waterbath shall be provided. [58:5.21.6.7]
[move from 9.3.5.4]
Substantiation:  Relocates 9.3.5.4 text in Waterbath section.

Submitter: Nneka Assing, American Gas Association
Recommendation:  Move text from 9.3.5.5 to 9.3.3.4 as follows:
9.3.3.4 Gas-fired immersion heaters shall be equipped with an automatic safety device to shut off the flow of gas to the main burner and pilot in the event of flame failure. [58:5.21.6.8]
[move from 9.3.5.5]
Substantiation:  Moved from 9.3.5.5 to consolidate text in waterbath vaporizer section.

Submitter: Nneka Assing, American Gas Association
Recommendation:  Move text from 9.3.5.7 to 9.3.3.5 as follows:
9.3.3.5 The heat source shall be shut off if the level of the heat transfer medium falls below the top of the fire tube or the electric heating coil or element unless the vaporizer is designed for such an occurrence.
[move from 9.3.5.7]
Substantiation:  Moved from 9.3.5.7 to Waterbath section to improve clarity.
9.3.4 Design and construction of direct-fired vaporizers shall be in accordance with the applicable requirements of the ASME Code for the working conditions to which the vaporizer will be subjected, and the vaporizer shall be permanently and legibly marked with the following:

1. Markings required by the ASME Code
2. Maximum vaporizing capacity in gallons per hour
3. Rated heat input in British thermal units per hour (Btu/hr)
4. Name or symbol of the manufacturer

Substantiation: Delete per substantiation in 9.3.2.

9.3.5 Waterbath vaporizers shall comply with 9.3.3.1 through 9.3.3.7.

Substantiation: Moved from 9.3.5 to clarify requirements only for Waterbath LP-Gas vaporizers.

9.3.5.1 The vaporizing chamber, tubing, pipe coils, or other heat exchange surface containing the LP-Gas to be vaporized, hereinafter referred to as the heat exchanger, shall be constructed in accordance with the applicable provisions of the ASME Code for a MAWP of 250 psig (1.7 MPag) and shall be permanently and legibly marked with the following:

1. Marking required by the ASME Code
2. MAWP and temperature for which the heat exchanger is designed
3. Name or symbol of the manufacturer

Substantiation: Delete per substantiation in 9.3.2.

9.3.5.2 Waterbath sections of waterbath vaporizers shall be protected from overpressure conditions and shall be designed to withstand the pressures to which they will be subjected.

Substantiation: Moved from 9.3.5.2 into new designated section for Waterbath vaporizers.
59- Log #56
(9.3.5.3) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:
9.3.5.3 The immersion heater that provides heat to the waterbath shall be installed so as not to contact the LP-Gas heat exchanger.
[moved to 9.3.3.2]
Substantiation: Clarification of intent and moved from 9.3.5.3 to waterbath section.

59- Log #57
(9.3.5.4) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:
9.3.5.4 A control to limit the temperature of the waterbath shall be provided. [58:5.21.6.7]
[moved to 9.3.3.3]
Substantiation: Relocates 9.3.5.4 text in Waterbath section.

59- Log #58
(9.3.5.5) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:
9.3.5.5 Gas-fired immersion heaters shall be equipped with an automatic safety device to shut off the flow of gas to the main burner and pilot in the event of flame failure. [58:5.21.6.6]
[moved to 9.3.3.4]
Substantiation: Moved from 9.3.5.5 to consolidate text in waterbath vaporizer section.

59- Log #59
(9.3.5.6) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:
9.3.5.6 Gas-fired immersion heaters with an input of 400,000 Btu/hr (422 MJ/hr) or more shall be equipped with an electronic flame safeguard that performs the following functions:
[1] Prepurses the combustion chamber prior to ignition
[2] Proves the presence of a pilot before the main burner valve opens
[3] Shuts down the main gas valve and pilot upon failure of the burner flame
[moved to 9.3.1.5]
Substantiation: Added text for presence of pilot to clarify intent of (2) Renumbered to the general vaporizer section.
59- Log #60 (9.3.5.7) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:

9.3.5.7 The heat source shall be shut off if the level of the heat transfer medium falls below the top of the fire tube or the electric heating coil or element unless the vaporizer is designed for such an occurrence.

[moved to 9.3.3.5]

Substantiation: Moved from 9.3.5.7 to Waterbath section to improve clarity.

59- Log #61 (9.4.4) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:

9.4.4 Where it is possible for condensation to take place between the vaporizer and the LP-Gas-air mixer, a separator or other means shall be provided to prevent LP-Gas liquid from entering the LP-Gas-air mixer.

Substantiation: No reason to specify a separator as a means to prevent liquid from entering the blender.

59- Log #62 (11.2.5.3) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:

11.2.5.3 At least one qualified person shall remain in attendance during the entire period of transfer from the time connections are made until the transfer is completed, shutoff valves are closed, and lines are disconnected.

Substantiation: Proposed deleted text is redundant with 11.2.1.3 and does not need repeating.

59- Log #63 (11.2.6.2) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Delete the following text:

11.2.6.2 At least one qualified person shall remain in attendance during the entire period of transfer from the time connections are made until the transfer is completed, shutoff valves are closed, and lines are disconnected.

Substantiation: Proposed deleted text is redundant with text in 11.2.1.3.

59- Log #64 (12.x (New)) Final Action:

Submitter: Nneka Assing, American Gas Association
Recommendation: Insert after existing 12.3

Add header Maintenance of Foundations and Supports. Each operating company shall perform periodic inspections of foundations and piping supports of equipment and piping containing flammable liquids/gases to visually evaluate their structural integrity. Where structural integrity appears compromised, the support/foundation shall be further evaluated and repaired as required.

Substantiation: Proposed additional text provides improved facility safety by ensuring the structural integrity of the facility is maintained.
59- Log #65 (13.1.1) Final Action:

Submitter: Nneka Assing, American Gas Association


13.1.1*
13.1.1.1*


59- Log #66 (13.1.1.3) Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Revise text to read as follows:

13.1.1.3 The requirement of 13.1.1.1 shall be conducted for all new facilities, shall be reviewed every 3 years, and shall be revised when necessary.

Substantiation: Remove reference to "new" facilities to meet the intent of the original technical Committee developed language adopted in the previous revision cycle.

59- Log #67 (13.1.3.1(6) (New)) Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Add text to read as follows:

6) Analyzing accidents or failures for the purpose of determining the cause of the failure and minimizing the possibility of recurrence.

Substantiation: This comment and associated revised text addresses identified gap as a result of an AGA Supplemental Gas Committee and NFPA 59 TC member Task force to perform a detailed comparison between Part 192 and NFPA 59. The intent of the comparison was to identify gaps and reach alignment with part 192 through the normal NFPA standards development process.

59- Log #68 (13.2.1) Final Action:

Submitter: Nneka Assing, American Gas Association

Recommendation: Revise text to read as follows:

13.2.1* Those areas, including enclosed buildings, that have a potential for flammable gas concentrations and fire shall be monitored as determined by the evaluation required in 13.1.1.

Substantiation: Added asterisk to indicate annex material proposed. See proposal for A.13.2.1.
13.2.1.1 A primary consideration when conducting the evaluation in 13.1.1.1 and 13.1.1.2 in any such product release prevention and incident preparedness review shall be an evaluation of the total product control system, including emergency shutoff and internal valves equipped for remote closure and automatic shutoff using thermal (fire) actuation pull-away protection.

Substantiation: This subject matter is addressed in 13.1.1.1 and 13.1.1.2, as well as A.13.1.1.

13.2.1.2 Where a written product release prevention and incident preparedness review exists, fire safety analysis shall not be required.

Substantiation: Text is not necessary as consideration for product control is part of 13.1.1.1 and 13.1.1.2 evaluation.

13.2.1.3 If it is determined in the preparation of the fire protection evaluation identified in 13.1.1.1 and 13.1.1.2 that a hazard to adjacent structures exists that exceeds the protection provided by the provisions of this code, special protection shall be provided in accordance with 13.4.3.

Substantiation: Proposed change identifies requirement to address results of the fire protection evaluation that identify opportunities to further protect adjacent structures per 13.4.3.
Submitter: Scott J. Harrison, Marioff Inc.
Recommendation: Revise to read:
(7) NFPA 750, Standard on Water Mist Fire Protection Systems
(8) NFPA 1961, Standard on Fire Hose
(9) NFPA 1962, Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose
(10) NFPA 1963, Standard for Fire Hose Connections
Substantiation: Include an entry for NFPA 750, Standard on Water Mist Fire Protection Systems and re-number the balance of the list. Other forms of "fire Protection water systems" are listed but not water mist. Water Mist systems have been approved and installed in many sprinkler applications globally for over 15 years. They have been listed by national and internationally recognized testing laboratories such as: UL (Ordinary Hazard Group 1), FM (Light Hazard occupancies, Computer Rooms, Subfloors, Special Hazard Machinery & spaces), City of New York (Light Hazard Occupancies, Combustion Turbines, Machinery Spaces), VdS Germany (Light Hazard, Ord Haz Grp I,II parking garages & III selected occupancies, Cable Tunnels), KfV Austria (Light Hazard, Ord Haz Grp I, Combustion Turbines) and other agencies. These listings and installations have demonstrated equivalent fire protection to the authority having jurisdiction (AHJ). The addition of the proposed text will provide the AHJ a clear option to accept water mist systems as an equivalent system to an approved automatic sprinkler system. NFPA 750 is a performance based standard enabling the engineering, design and installation of a water based system that will take into consideration the fire control problems in facilities covered by this standard. It should be included in the list.

Submitter: Nneka Assing, American Gas Association
Recommendation: Revise text to read as follows:
13.5.2 Allow extinguishers for special circumstances. The minimum size portable dry chemical extinguisher for gas fires shall be 18 lb (8.2 kg) with a B:C rating. Firehainers for other types of fires shall be sized and located as determined in accordance with 13.1.1, within the facility.
Substantiation: Specialty extinguishers such as Halon for electrical fires are not allowed. This would allow specialty extinguishers where determined by fire study to be used.

Submitter: Nneka Assing, American Gas Association
Recommendation: Add new text to read as follows:
(8) NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems
Substantiation: Proposal identifies standard for systems replacing ozone depleting agents such as Halon. NFPA 2001 was also proposed for IBR in Chapter 2.
### A.3.3.15 Gas-Air Mixer

A gas-air mixtures produced by Utility Gas Plants covered by this standard are used to supplement or substitute gas distribution systems and are also normally used in industrial or commercial facilities, and by fuel gas distributors, as a substitute for another fuel gas. [58: A.3.3.26] **Substantiation:** Broadens the explanatory material to include fuel gas distribution companies which is the intended reader of this standard.

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### A.3.3.39 Utility Gas Plant

1. In the United States, utility gas plants as defined within this standard and gas distribution systems are subject to but not limited to the following regulatory requirements:
   - 49 CFR Part 191 - Transportation of Natural Gas and Other Gases by Pipeline; Annual Reports, Incident reports, and Safety Related Condition Reports (latest revision)
   - 49 CFR Part 192 “Pipeline Safety Law” - Transportation of Natural Gas and Other Gases by Pipeline; Minimum Federal Safety Standards (latest revision)
     - Part 192.11 identifies NFPA 59 2004 by incorporation by reference at the time of this NFPA 59 editions publication.
     - The NFPA 59 2012 edition and this edition have been aligned to include applicable regulatory requirements listed in Part 192 into the NFPA 59 standard.
     - As such, the scope of 49 CFR Part 192 within an NFPA 59 Utility Gas Plant begins the gas-air mixer with respect to 49 CFR Part 192, Subpart "N" Qualification of Pipeline Personnel as the gas-air mixers operation and maintenance can affect the integrity of the distribution system piping downstream of the utility gas plant. NFPA 59 requirements for the gas-air mixer is jointly applicable with Part 192 requirements as stated above.
       - Portions of the NFPA 59 Utility Gas Plant prior to the gas-air mixer must meet the requirements listed in the version of NFPA 59 as described below in the NFPA 59 applicability.
   - 49 CFR Part 199 - Drug and Alcohol Testing (latest revision)
   - NFPA 59 Utility LP-Gas Plant Code
     - Original facility design, construction, modifications, operations, maintenance, and fire/safety and security prior to August 1970 when the 49 CFR Part 192 regulations were promulgated are to have complied with the edition of NFPA 59 published at the time of the design/construction.
     - Original facility design, construction, post original design and construction modifications, operations, maintenance, fire, safety, and security after August 1970 and the promulgation of 49 CFR Part 192 regulations are to have complied with the edition of NFPA 59 incorporated by reference by 49 CFR Part 192 at the time of the facility design, construction, post original design and construction modifications, operations, maintenance, fire, safety, and security.
   - Chapter 11 (Operations), Chapter 12 (Maintenance), and much of Chapter 13 (Fire Protection, Safety, and Security) are applied retroactively to the facility. The 2012 edition of NFPA clarifies this retroactive application.

**Substantiation:** Clarification of this annex material aligns with recent NFPA 59 Technical Committee and AGA Supplemental Gas Committee efforts to improve alignment between NFPA 59 and 49 CFR Part 192 which was presented to PHMSA at AGA in Washington D.C. in 2010.
Submitters: Nneka Assing, American Gas Association

Recommendation: Delete text as follows:
A.3.3.4.0.2 Internal Valve. An internal valve has provision for the addition of a means of remote closure. An internal valve closes when flow through the valve exceeds its rated excess flow capacity or when pump actuation differential pressure drops to a predetermined point.

Substantiation: Eliminate from appendix as it adds nothing to what is in section 3.3.40.2.

Submitters: Nneka Assing, American Gas Association

Recommendation: Add "3" in column for distance from Underground LP-Gas container to an aboveground LP-Gas container. Add "25" in column for distance from Underground LP-Gas container to Point of Transfer. per 5.8.2(2). Add "50" in column for distance of Vehicles to Aboveground LP-Gas container, and also to flammable liquids tank. per 4.5.4. Add "c" footnote to "75" dimension of line for vehicles to point of transfer. per 5.8.1 delete all references to superscript "b" as 5.9.3 and 5.9.4 do not exist.

Substantiation: This will complete the table for A 5.4.

Submitters: Nneka Assing, American Gas Association

Recommendation: Add new text to read as follows:
A.13.2.1 Gas Detection Near Combustion Fired Equipment. In addition to areas such as enclosed buildings which have a potential for flammable gas concentrations, operators conducting the evaluation required in 13.1.1.1 and 13.1.1.2 should also consider installation of fixed gas detection near the location of the combustion air intakes of fired process equipment. When installed, gas detection equipment at the fired equipment can be installed such that if the detector senses the presence of flammable gas at some determined safe level below (25-50%) the LEL, activates an interlock so that the fired equipment is immediately shut down minimizing the risk that the flammable gas finds an ignition source.

Substantiation: The proposed annex material raises awareness of operators during the fire protection evaluation exercise of additional considerations to further minimize the risk of leaking flammable gases finding and active ignition source. Several refineries and LNG facilities outside the US have experienced incidents which could have been minimized or avoided if gas detection was located near fired combustion equipment and actions were taken to shutdown the fired equipment.
A.13.2.1.1 In recent years the concept of total product control systems has been developed. Facilities that have redundant automatic product control systems provide a high level of confidence that propane will not be released during an emergency. Therefore, not only would the storage be protected from a fire that could lead to container rupture, but major fires at the facility would be prevented. The public would be protected, fire-fighting operations would be safer, and applications of large quantities of water would not be needed to prevent tank failure. An incident prevention review should include the following:

1. The effectiveness of product control measures
2. An analysis of local conditions of hazard within the container site
3. Exposure to or from other properties, population density, and congestion within the site
4. The probable effectiveness of plant personnel or local fire departments based on available water supply, response time, resources, and training.

In the preparation of the incident prevention review, the owner/operator of the installation should cooperate with the local emergency response agencies in the preparation of their own preplanning and emergency response plans. To the extent practical, the owner/operator should promote pre-incident visits to the installation by members of the responding agencies.

Substantiation: This subject matter is addressed in 13.1.1.1 and 13.1.1.2, as well as A.13.1.1. If some of this text is needed, then add it to A.13.1.1. This does not add clarity to the standard.
Attachment C:
J. Stannard
Relief Valve
Sizing Proposal
August 16, 2012

Secretary, Standards Council
National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

Dear Ms Cronin;

Recently, I wrote a letter to the Standards Council that was accompanied by proposals to amend both NFPA 58 and NFPA 59 with respect to relief valve sizing. It was my hope that those changes could be made in the next editions of both documents. The next ROC meeting of NFPA 58 will be September 24 and 25 of this year and that will be immediately followed by the ROP meeting of the 59 committee. Recognizing that the NFPA rules are such that the proposed changes in NFPA 58 and NFPA 59 can only be accomplished through a TIA, I am writing this letter as a request for a TIA for both NFPA 58 and NFPA 59.

Neither my letter of July 19, 2012 nor the accompanying "Public Input Form" implicitly addressed the emergency nature of the proposals. The "Emergency Nature of the proposal" has been added to both proposals.

Sincerely,

James H. Stannard

Cc/w attachments:
Denise Beach
Frank Mortimer
TSS&S
RELIEF VALVE SIZING

James H. Stannard, Jr.

The generally accepted requirement for the sizing of relief valves on ASME tanks used for the storage or transport of liquefied gases is that the valve be adequate to prevent the pressure rising above \( P_{\text{max}} \) which is 120% of the Maximum Allowable Working Pressure (MAWP) for any foreseeable event (i.e., fire exposure, uncontrollable flow into the tank, etc.). Relief valves are tested with air at \( P_{\text{max}} \) and 60 °F rather than with the medium that they are designed for. Relief valves are marked with their rated air capacity. It then becomes necessary to determine the equivalent sizing for the particular tank and its exposure.

The 1953 edition of the National Fire Protection Association’s (NFPA) pamphlet NFPA 58 (which was then titled “Storage and Handling Liquefied Petroleum Gases 1953”) adopted an air equivalent value for tank relief valve sizing of:

\[
CFM_{\text{air}} = 53.632A^{0.82}
\]

When, \( A \) equals the total surface area of the tank in square feet. That formula was based, in part, upon the report of John H. Fetterly dated November 27, 1928.\(^1\) Prior to that time; NFPA 58, beginning in the 1932 edition, based relief valve size upon the Diameter (D) times the length (U) of the vessel.

The 1953 calculation, which is still in effect in the most recent edition of NFPA 58 “Liquefied Petroleum Gas Code, 2011” is based upon a total heat input \( Q \):

\[
Q = 34,500A^{0.82} \text{ Btu/ hr.}
\]

The heat flux value of 34,500 \( \text{Btu/ft}^2\cdot\text{hr.} \) is also adopted in several NFPA and API\(^2\) codes and standards with some modification for larger vessels.

The calculations that led to the adoption of “\( CFM_{\text{air}} = 53.632A^{0.82} \)” in the 1953 edition were apparently based is upon a single value for the “latent heat of vaporization” \( (\Delta h) \) regardless of either pressure or composition (i.e., butane or propane) and may have miscalculated the variation in sonic velocity of both air and the propane or butane.\(^3\) It is also possible that reliable thermodynamic property data was unavailable at that time. It should also be noted that the propane or butane vented by a relief valve is a saturated vapor while the air used for testing can be considered to be a perfect gas, which may have not been considered in those calculations.

\(^1\) Campbell’s Tariff No.8
\(^2\) American Petroleum Institute
\(^3\) Letter from L. I. Wissmiller to Sidney V. James, dated January 2, 1951
The inlet versus outlet pressure of a relief valve in LP-Gas service far exceeds the 2:1 critical ratio. Therefore the flow through the valve will be limited to sonic velocity. The sonic velocity of a \textit{perfect gas} (such as air) is:

\[
V_s = \sqrt{\frac{g k \times RT}{M}}
\]

Where:
- \(g\) = the acceleration due to gravity = 32.2 ft/sec\(^2\)
- \(k\) = the ratio of specific heats = \(c_p/c_v\)
- \(R\) = the \textit{universal gas constant} = 1545 ft-lb/°R·lb-mole
- \(T\) = absolute temperature, °R
- \(M\) = molecular weight of gas

The Molecular weight of air is 28.9586 and the ratio of specific heats is 1.4. Therefore the sonic velocity \((V_{air})\) for air at 60 °F (520 °R) is 1,118.33 ft/sec

The \(p-v-T\) relationship for a \textit{perfect gas} is:

\[
pv = \frac{RT}{M}
\]

Where:
- \(p\) = absolute pressure, lb/ft\(^2\) (psf)
- \(v\) = \textit{specific volume}, ft\(^3\)/lb

In the case of a \textit{non-perfect gas}, such as a saturated vapor, it would seem reasonable to substitute \(\frac{pv}{M}\) for \(\frac{RT}{M}\) using the value for \textit{specific volume} \((v)\) from the published thermodynamic properties of the fluid when calculating sonic velocity, resulting in:

\[
V_{gas} = \sqrt{g k \times pv}.
\]

The weight or mass flow \((W)\) of vapor generated that requires venting by the relief valve is

\[
W = \frac{34,500}{\Delta h} \text{ lb/hr} \quad \text{or} \quad W' = \frac{34,500}{3,600 \times \Delta h} \text{ lb/sec}
\]

The volumetric flow \((\varphi_{gas})\), at flowing pressure and temperature is

\[
\varphi_{gas} = W' v \text{ ft}^3/\text{sec}.
\]

When \((v)\) equals the specific volume of the gas at flowing pressure and temperature.

The effective orifice \((\alpha)\) necessary to accommodate the volumetric flow \((\varphi)\) is:

\[
\alpha = \frac{\varphi_{gas}}{V_{gas}} \text{ ft}^2
\]
The volumetric flow of air ($\varphi_{air}$) through that same effective orifice will be:

$$\varphi_{air} = \frac{a}{v_{air}} \text{ ft}^3/\text{sec}$$

The mass flow ($W'_{air}$) of air will be:

$$W'_{air} = \frac{a v_{air}}{v_{air}} \text{ lb/sec}$$

When $v_{air}$ is the specific volume of air at $P_{max}$ and at 60 °F.

The test value ($CFM_{air}$) will be:

$$CFM_{air} = W'_{air} \times v_{std} \times 60$$

When $v_{std}$ is the specific volume of a standard cubic foot (scf) of air at 14.696 psia and at 60 °F which is 13.11 ft$^3$/lb.

The following calculations are based upon:

- Air  Molecular weight = 28.9586  $k = 1.4$
- Propane  Molecular weight = 44.026  $k = 1.13$
- n-Butane  Molecular weight = 58.122  $k = 1.09$

Combining, yields:

$$CFM = \frac{7,538.25 \times v_g}{\Delta h \times v_{air}} \times \frac{V_a}{V_{sg}} A^{0.82}$$
### PROPANE

<table>
<thead>
<tr>
<th>MAWP</th>
<th>$P_{\text{max}}$</th>
<th>$T , ^{\circ}\text{R}$</th>
<th>$v_v$</th>
<th>$\Delta h$</th>
<th>$V_g$</th>
<th>$v_{\text{air}}$</th>
<th>$\text{CFM}_{\text{air}} A^{0.82}$</th>
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### nBUTANE

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<td>76.55</td>
<td>627.1</td>
<td>0.4954</td>
<td>70.90</td>
</tr>
</tbody>
</table>
5.3.2 The container marking shall contain the following information:
(1) Name and address of the container supplier or the trade name of the container
(2) Water capacity of the container in pounds or U.S. gallons
(3) Design pressure in pounds per square inch (psi)
(4) The wording “This container shall not contain a product having a vapor pressure in excess of ___ psi at 100°F” (see Table 5.2.1)
(5) Outside surface area in square feet
(6) Wetted surface area in square feet, based upon a filling density of 80% by volume.
(7) Year of manufacture
(8) Shell thickness and head thickness
(9) OL (overall length), OD (outside diameter), HD (head design)
(10) Manufacturer’s serial number
(11) ASME Boiler and Pressure Vessel Code symbol
(12) Minimum design metal temperature ___°F at MAWP ___ psi
(13) Type of construction “W”
(14) Degree of radiography “RT-___”

Chapter 10 Relief Devices
10.1* General.
10.1.1 Relief devices on containers shall be arranged so that the possibility of tampering is minimized.
10.1.2 If the pressure setting or adjustment is external, the relief devices shall be provided with an approved means for sealing the adjustment.
10.1.3 Each container relief device shall be marked with the pressure in pounds per square inch at which the device is set to start to discharge, with the actual rate of discharge in cubic feet per minute of air at 60°F (16°C) and 14.7 psia (an absolute pressure of 0.101 MPa).
10.1.4 Testing Relief Devices. All relief devices required by this code, other than hydrostatic relief valves, shall be tested for proper operation at intervals not exceeding 5 calendar years.
10.2 Nonrefrigerated Container Relief Devices.
10.2.1 ASME containers shall be equipped with one or more pressure relief valves that are designed to relieve vapor. [58:5.7.2.1]
10.2.2 ASME containers for LP-Gas shall be equipped with direct spring-loaded pressure relief valves conforming with the applicable requirements of ANSI/UL 132, Standard for Safety Relief Valves for Anhydrous Ammonia and LP-Gas, or other equivalent pressure relief valve standards. [58:5.7.2.5]
10.2.2.1 The start-to-leak setting of the pressure relief valves specified in 10.2.2, in relation to the pressure rating of the container, shall be in accordance with Table 10.2.2.1.
10.2.2.2 Containers of 40,000 gal (151 m3) or more water capacity shall be equipped with either a spring-loaded pressure relief valve or a pilot-operated pressure relief valve, as follows:
The pilot-operated relief valve shall be combined with, and controlled by, a self-actuated, direct, spring-loaded pilot valve that complies with Table 10.2.2.1.

The use of a pilot-operated pressure relief valve shall be approved.

Pilot-operated pressure relief valves shall be inspected and maintained by persons with training and experience, and shall be tested for operation at intervals not exceeding 5 years.

The minimum rate of discharge of pressure relief valves installed in ASME containers shall be in accordance with Table 5.7.2.6 or shall be calculated using the following value for heat flux:

\[ F = 53.632 A^{0.82} \]

\[ Q = 34,500 A^{0.82} \text{ Btu/hr} \]

where:
- \( F \) = flow rate (SCFM air)
- \( Q \) = heat input resulting in vaporization of contents
- \( A \) = total outside wetted surface area of container (ft²)

Relief valves for aboveground ASME containers shall relieve at not less than the flow rate specified in 10.2.3 before the pressure exceeds 120 percent of the minimum permitted start-to-leak pressure setting of the device, excluding the 10 percent tolerance in Table 10.2.2.1.

Determination of the required flow rate shall be based upon the latent heat of vaporization \( (h_v) \) of the contents (propane or butane) at \( P_{\text{max}} \), the specific volume at saturation of the content's vapor at \( P_{\text{max}} \) and the sonic velocity of the contents at \( P_{\text{max}} \). See Appendix D for calculation procedure and determination of equivalent relieving capacity in SCFM air.

If there is liquid product exceeding 10% by volume placed in containers while they are not buried, the pressure relief valve sizing shall be that of aboveground containers.

The flow capacity of pressure relief valves installed on underground or mounded containers shall be a minimum of 30 10 percent of the flow specified in Table 10.2.3

Annex D Relief Device Sizing
This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Nonrefrigerated Containers. Table D.1 should be used to size pressure relief valves.
Surface area equals the total outside surface area of the container in square feet. Where the surface area is not stamped on the nameplate or where the marking is not legible, the area can be calculated by using one of the following formulas:

1. Cylindrical container with hemispherical heads:
   Area = Overall length \(\times\) outside diameter \(\times\) 3.1416

2. Cylindrical container with other than hemispherical heads:
   Area = (Overall length + 0.3 outside diameter) \(\times\) outside diameter \(\times\) 3.1416

3. Spherical container:
   Area = Outside diameter squared \(\times\) 3.1416

Flow rate of air (ft³/min) = required flow capacity in cubic feet per minute of air at standard conditions, 60°F (15.6°C), and atmospheric pressure [14.7 psia (101 kPa)].
The rate of discharge can be interpolated for intermediate values of surface area. For containers with a total outside surface area that is greater than 2000 ft² (186 m²), the required flow rate can be calculated using the following formula:

\[
\text{Flow rate of air} = 3.634 \times 10^{-3} \times A^{0.82}
\]

where \( A \) = total outside surface area of the container (ft²) (0.4719 L/s)

D.2 Spring-Loaded Pressure Relief Valves for Aboveground and Cargo ASME Containers.

The requirement for the sizing of relief valves on ASME tanks used for the storage of liquefied gases is that the valve be adequate to prevent the pressure rising above \( P_{\text{max}} \) which is 120% of the Maximum Allowable Working Pressure (MAWP). Relief valves are tested with air at \( P_{\text{max}} \) and 60 °F rather than with the medium that they are designed for. Relief valves shall be marked with their rated air capacity. It then becomes necessary to determine the equivalent sizing for the particular tank and its exposure.

The inlet versus outlet pressure of a relief valve in LP-Gas service far exceeds the 2:1 critical pressure ratio. Therefore the flow through the valve will be limited to sonic velocity. The sonic velocity of a perfect gas (such as air) is:

\[
V_s = \sqrt{\frac{gk \times RT}{M}}
\]

Where:
- \( g = \) the acceleration due to gravity = 32.2 ft/sec²
- \( k = \) the ratio of specific heats = \( c_p/c_v \)
- \( R = \) the universal gas constant = 1545 ft-lb/°R·lb-mole
- \( T = \) absolute temperature, °R
- \( M = \) molecular weight of gas

The Molecular weight of air is 28.9586 and the ratio of specific heats is 1.4. Therefore the sonic velocity \( V_{\text{air}} \) for air at 60 °F (520 °R) is 1,118.33 ft/sec

The p-v-T relationship for a perfect gas is:

\[
pv = \frac{RT}{M}
\]

Where:
- \( p = \) absolute pressure, lb/ft² (psf)
- \( v = \) specific volume, ft³/lb

In the case of a non-perfect gas, such as a saturated vapor, substitute “\( pv \)” for “\( \frac{RT}{M} \)” using the value for specific volume (\( v \)) for the saturated vapor at \( P_{\text{max}} \) from the published physical properties (equation of state) of the fluid when calculating sonic velocity, resulting in:
\[ V_{gas} = \sqrt{gk \times pv} \]

The weight or mass flow \((W)\) of vapor generated that requires venting by the relief valve is
\[ W = \frac{34,500}{\Delta h} \text{ lb/hr} \quad \text{or} \quad W' = \frac{34,500}{3,600 \times \Delta h} \text{ lb/sec} \]

The volumetric flow \((\varphi_{gas})\), at flowing pressure and temperature is
\[ \varphi_{gas} = W'v \text{ ft}^3/\text{sec}. \]

where:
\((v)\) equals the specific volume of the gas at flowing pressure and temperature.

The effective orifice \((\alpha)\) necessary to accommodate the volumetric flow \((\varphi)\) is:
\[ \alpha = \frac{\varphi_{gas}}{V_{gas}} \text{ ft}^2 \]

The volumetric flow of air \((\varphi_{air})\) through that same effective orifice will be:
\[ \varphi_{air} = \frac{\alpha}{V_{air}} \text{ ft}^3/\text{sec} \]

The mass flow \((W'_{air})\) of air will be:
\[ W'_{air} = \frac{\alpha v_{air}}{V_{air}} \text{ lb/sec} \]

When \(v_{air}\) is the specific volume of air at \(P_{max}\) and at 60 °F.

The test value \((\text{CFM air})\) will be:
\[ \text{CFM}_{air} = W'_{air} \times v_{std} \times 60 \]

where:
\(v_{std}\) is the specific volume of a standard cubic foot (scf) of air at 14.696 psia and at 60 °F which is 13.11 ft³/lb.

The following calculations are based upon:

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<tr>
<th>Gas</th>
<th>Molecular weight</th>
<th>(k)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1.4</td>
</tr>
<tr>
<td>Propane</td>
<td>44.026</td>
<td>1.13</td>
</tr>
<tr>
<td>n-Butane</td>
<td>58.122</td>
<td>1.09</td>
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</table>

Combining, yields:
\[ CFM = \frac{7,538.25 \times v_g}{\Delta h \times v_{air}} \times \frac{V_{sa}}{V_{sg}} A^{0.82} \]

### PROPANE

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### Statement of Problem and Substantiation for Proposal

The 1953 edition of the National Fire Protection Association’s (NFPA) pamphlet NFPA 58 (which was then titled “Storage and Handling Liquefied Petroleum Gases 1953”) adopted an air equivalent value for tank relief valve sizing of:

\[ CFM_{air} = 53.632A^{0.82} \]

When, \( A \) equals the total surface area of the tank in square feet. That formula was based, in part, upon the report of John H. Fetterly dated November 27, 1928.\(^1\) Prior to that time; NFPA 58, beginning in the 1932 edition, based relief valve size upon the Diameter (D) times the length (U) of the vessel.

The 1953 calculation, which is still in effect in the most recent editions of both NFPA 58 “Liquefied Petroleum Gas Code, 2011” and NFPA 59 Utility “LP-Gas Plant Code, 2012” is based upon a total heat input \( Q \):

\[ Q = 34,500A^{0.82} \text{ Btu/hr.} \]

\(^1\) Campbell’s Tariff No.8
The heat flux value of 34,500 \textit{Btu/ft}^2 \textit{hr.} is also adopted in several NFPA codes and standards with some modification for larger vessels.

The calculations that led to the adoption of "\textit{CFM air} = 53.632A^{0.82}\" in the 1953 edition were apparently based is upon a single value for the \textit{latent heat of vaporization} \((\Delta h)\) regardless of either pressure or composition (\textit{i.e.,} butane or propane) and may have miscalculated the variation in sonic velocity of both air and the propane or butane. It is also possible that reliable thermodynamic property data was unavailable at that time. It should also be noted that the propane or butane vented by a relief valve is a \textit{saturated vapor} while the air used for testing can be considered to be a \textit{perfect gas}, which may have not been considered in those calculations.

This proposal up-dates the original calculations for relief valve capacity by incorporating the specific physical properties of both propane and butane and by basing the calculations upon the sonic velocity of both the protected medium and air.

In addition, this proposal would revise the rate of heat input from "total surface area" to the more realistic "wetted surface area." This would make NFPA 59 consistent with NFPA 30 (see 22.7.3.3).

The revision of 10.2.5 provides a reasonable and safe alternative to the complete evacuation of buried or mounded tanks when it becomes necessary to expose the tank for inspection or repair.

In addition, this proposal would reduce the required relieving capacity of mounded tanks to a more realistic value of 10\% of that required for aboveground tanks, because they are not subject to fire exposure, and therefore do not need relief valves to relieve overpressure due to fire exposure.

The proposed changes incorporated within this proposal will not affect any existing ASME containers but it will, in some cases, result in a reduced relief valve size for some large and higher pressure containers, while making the sizing procedures technically correct. Other minor changes have been proposed to either clarify the meaning or to match the wording in NFPA 58.

\textbf{Emergency Nature of Proposal}

The paper \textquote{Relief Valve Sizing}, which is attached, has shown that the relief valve sizing criteria of \textquote{\textit{CFM air} = 53.632A^{0.82}}\ could be considered to be inadequate by the revised calculations for many existing LP-Gas containers. This could prove to be very onerous for many of the very large containers (\textit{i.e.,} 20,000 gallons or more) because the present container entries would have to either enlarged or increased in number, both of which would require taking the container out of service and
subsequently prequalifying the container under ASME rules. In addition, larger relief valves to meet the requirements are not currently available.

The proposal would change the definition of “A” in sizing criteria from “total surface area of the container” to “wetted surface area of the container.” This change makes perfect sense because it is only the wetted surface that provides heat to the contained product during fire exposure. Such a change is consistent with NFPA 30 as well as API’s “Recommended Practice 521” and it does not denigrate the safety of LP-Gas containers, while it provides a safe and reasonable solution to the potential dilemma presented by the revised calculation procedures for relief valve sizing.
Attachment D:
NFPA Standards Council
Relief Valve Sizing Methods
Task Group Report
And Correspondence
I. Attendance

J. A. Davenport, Industrial Risk Insurers
(Rep. TC on Flammable & Combustible Liquids)
D. Dockray, Southern California Gas Co.
(Rep. TCs on Vehicular Alternative Fuel Systems)
D. E. Dressel, Monsanto Co.
(Rep. TCC on Boiler Combustion System Hazards)
P. E. Duus, CBI Technical Services Co.
(Rep. TCs on Liquefied Natural Gas and Liquefied Petroleum Gases)
H. Forrest, ABB Lummus Construction, Inc.
R. S. Kraus, Petroleum Safety Consultants
(Rep. American Petroleum Institute)
E. E. Linder, Watsonville, CA
(Rep. TC on Liquefied Petroleum Gases)
J. Nelson, A T & T, CHAIR
(Rep. NFPA Standards Council)
A. M. Ordile, Loss Control Associates
(Rep. TC on Flammable & Combustible Liquids)
W. Sheppard, General Motors Corp.
(Rep. TC on Ovens and Furnaces)
F. Smist, Sherwood, Div. of Harsco
(Rep. National Propane Gas Association)
R. P. Stanley, ARCO Products Co.
(Rep. American Petroleum Institute)
(Rep. TC on Liquefied Natural Gas)

R. P. Benedetti, NFPA STAFF LIAISON

II. MINUTES

The Meeting was called to order at 2:25 on May 20th.
2. Attendees introduced themselves and signed the attendance roster.

3. Ms. Nelson reviewed the reason for the meeting: i.e., the alleged discrepancy between the required emergency vent capacities that are set forth in NFPA 30, Flammable and Combustible Liquids Code, and NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases. NFPA 30 uses the same emergency vent criteria as API 2000. NFPA 58 uses API 520.

Mr. Stannard also pointed out that, in his opinion, neither document adequately relate to refrigerated tanks, which typically have thinner walls.

4. Those present agreed that, after review of the information at hand (circulated to attendees on May 1, 1997), a 1963 joint effort between the American Petroleum Institute and NFPA had also discussed this same topic with no resolution. The two groups basically “agreed to disagree”.

5. Mr. Duus presented examples, shown in Attachment #1, of the various equations used by several different codes. He also reduced each equation to its basic source equation to show that most originated from the same source. He also presented examples of the how these different equations predicted heat absorption versus tank size.

6. Mr. Sheppard and Mr. Dressel expressed their opinion that this issue had no impact at all on either NFPA 86, Standard for Ovens and Furnaces, or any of the Boiler/Furnace standards. They stated that this issue is strictly related to storage tanks.

7. One basic difference involves how the equations apply. NFPA 30 only considers the first 30 feet above grade of the height of the tank shell. NFPA 58 uses the entire height of the tank shell.

8. Those present agreed that each Technical Committee would draft a brief white paper to justify the respective equations and their use. Then, an inter-committee task group will be selected to work out differences, with a goal of developing a consistent set of emergency vent sizing criteria.

This issue will be reported to the Technical Correlating Committee on Flammable and Combustible Liquids, the Technical Committee on Liquefied Natural Gas, and the Technical Committee on Liquefied Petroleum Gases at their next meetings.
CODE

NFPA 30

SCFH = 1107 \ A^{0.82}

NFPA 59

Q = \frac{633,000 \ F \ A^{0.82}}{L \ C} \sqrt{\frac{Z \ T}{M}}

NFPA 59A

H = 1560 \ C, \ A^{0.82} + H_n
H = (34,500 - 360C_2) \ A^{0.82} + H_n

NFPA 58

SCFM = 53.632 \ A^{0.82}

ANSI K61.1

W = \frac{34,500 \ F \ A^{0.82}}{L}

SOURCE EQUATION

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

Q = 34,500 \ F \ A^{0.82}

Q = 34,500 \ F \ A^{0.82}

Q = 34,500 \ F \ A^{0.82}

Q = 34,500 \ F \ A^{0.82}
CODE

**NFPA 30**
\[ SCFH = 1107 \ A^{0.82} \]

**NFPA 59**
\[ Q = \frac{633,000 \ F \ A^{0.82}}{L \ C} \sqrt{\frac{Z^T}{M}} \]

**NFPA 59A**
\[ H = 1560 \ C_i \ A^{0.82} + H_n \]
\[ H = (34,500 - 360C_2) \ A^{0.82} + H_n \]

**NFPA 58**
\[ SCFM = 53.632 \ A^{0.82} \]

**ANSI K61.1**
\[ W = \frac{34,500 \ F \ A^{0.82}}{L} \]

SOURCE EQUATION

**Q = 21,000 \ F \ A^{0.82}**

**Q = 34,500 \ F \ A^{0.82}**

**Q = 34,500 \ F \ A^{0.82}**

**Q = 34,500 \ F \ A^{0.82}**
EQUATION

CODE

API 520
Q = 21,000 \ F \ A^{0.82}
Q = 34,500 \ F \ A^{0.82}

API 2000
Q = 20,000 \ F \ A
Q = 199,300 \ F \ A^{0.566}
Q = 963,400 \ F \ A^{0.338}
Q = 21,000 \ F \ A^{0.82}

API 2000
SCFH = 3.091 \ \frac{F \ Q}{L} \ \frac{T}{\sqrt{M}}

SOURCE EQUATION

This is the original source.

Modifies the original source equation to provide more venting capacity for small tanks.

Can be derived from equations in the Crane handbook "Flow of Fluids"
CODE

API 520

EQUATION

\[ Q = 21,000 \ F \ A^{0.82} \]
\[ Q = 34,500 \ F_0 \ A^{0.82} \]

API 2000

EQUATION

\[ Q = 20,000 \ F \ A \]
\[ Q = 199,300 \ F_0 \ A^{0.566} \]
\[ Q = 963,400 \ F_0 \ A^{0.338} \]
\[ Q = 21,000 \ F_0 \ A^{0.82} \]

API 2000

SCFH = 3.091 \ \frac{F \ Q}{L} \ \sqrt{\frac{T}{M}}

SOURCE EQUATION

This is the original source.

Modifies the original source equation to provide more venting capacity for small tanks.

Can be derived from equations in the Crane handbook "Flow of Fluids"
MEMORANDUM

TO: R.P. Benedetti
FROM: L.A. Nisbet
DATE: August 15, 1997
SUBJECT: Standards Council Action

This is to notify you that at its meeting on July 22-23, 1997, the Standards Council reviewed an interim report of a Task Group established to address the various models used to establish emergency relief valve size and capacity, and voted to defer action pending the circulation of the minutes to the respective task group members, and to request a clarification as to whether or not the affected documents can have differences. (Item No. 8).

c: SC TG on Emergency Relief Venting
   C.C. Grant

96-88
(7/97)
Comparison of Basic Safety Relief Valve Sizing Equations

Prepared by Per Duus

Chicago Bridge and Iron

Presented to the NFPA Committee on Storage and Handling of Liquefied Petroleum Gas (NFPA 58)

Committee Meeting

Portsmouth, New Hampshire

August, 1998
# BASIC EQUATIONS

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>EQUATION</th>
</tr>
</thead>
</table>
| **API RP 520/521** | 1) $Q = 21,000 \ F A^{.82}$ (Btu/hr)  
2) $Q = 34,500 \ F A^{.82}$ (Btu/hr) |
| **API 2000**   | $SCFH = 1107 \ F A^{.82}$ (Air)                                          |
|               | Note 1) Based on $Q = 21,000 \ A^{.82}$  
Note 2) Applies to Design Pressure in Excess of 1 psig and Wetted 
Surface in Excess of 2800 Ft$^2$  
Note 3) No specific equation for double wall tanks |
| **NFPA 30**    | $CFH = 1107 \ A^{.82}$ (Air)                                              |
|               | Note: Same Basis as API 2000                                             |
| **NFPA 58**    | $SCFM = 58.632 \ A^{.82}$ (Air)                                           |
|               | Note 1) Based on $Q = 34,500 \ A^{.82}$  
Note 2) No Specific Requirement in Chapter 9 for Refrigerated 
Storage |
| **NFPA 59**    | Refrigerated Containers: $Q_a = \frac{633,000 \ FA^{.82}}{LC} \sqrt{\frac{ZT}{M}}$ (SCFM AIR) |
|               | Note 1) Based on $Q = 34,500 \ A^{.82}$  
Note 2) For Non Refrigerated Container Same as NFPA 58  
Note 3) No Specific Equation for Double Wall Tanks |
| **NFPA 59A**   | $H = 1560 C_1 A^{.82} + H_n$ (Btu/hr)  
$H = 34,500 - 360 C_2 A^{.82} = H_n$ (Btu/hr) |

---

**ATTACHMENT**
### SURFACE AREA

#### STANDARD | SURFACE AREA AND LIMITATIONS
--- | ---
API RP 520/521 | - A. Equal Total Wetted Surface  
- Limited to 25 ft Above Source of Flame  
- Spheres and Spheroids: Up to the Maximum Horizontal Diameter or Up to a Height of 25 Feet, Whichever is Greater  
- Allows Using Reduced Area For Vessels Normally Operated Partially Full

#### API 2000 |  
- A. Equal Wetted Surface Area  
- Limited to:  
  - Vertical Tanks: Area of Shell up to 30 ft Above Grade  
  - Spheres or Spheroids: 55 percent of total surface area or the surface up to 30 ft above grade, whichever is greater  
  - Horizontal Tanks: 75 percent of Total surface area or the surface area to a height of 30 ft, whichever is greater

#### NFPA 30 |  
- A. Equal Exposed Wetted Surface  
- Limited to: Same as API 2000

#### NFPA 58 |  
- A. Equal Total Outside Surface Area of Container  
- No Limitations on Height

#### NFPA 59 |  
- Refrigerated Containers:  
  - A. Equal Total Exposed Wetted Surface  
  - Limited To:  
    - Vertical Tanks: Area of Shell up to 30 Ft Above Ground  
    - Spheres and Spheroids: To The Elevation of Maximum Horizontal Diameter

- Non Refrigerated Containers: Same as NFPA 58

#### NFPA 59A |  
- A. Equal Total Exposed Wetted Surface  
- No Limitations on Height
RECOMMENDATIONS

1. Use one equation, one format

HEAT INPUT, \( Q = 34,500 \text{ F} A^{0.82} \) (Btu/hr)

RELIEVING RATE, \( W = \frac{Q}{L} \) (#/hr)

EQUATION (A) \( W = \frac{34,500 \text{ F} A^{0.82}}{L} \) (#/hr)

2. Equivalent air flow:

\[
\text{SCFM}_{\text{air}} = \frac{1100 \ W}{60 \ C} \sqrt{\frac{2T}{M}}
\]

Substituting:

\[
\text{SCFM}_{\text{air}} = \frac{1100 \times 34,500 \ A^{0.82}}{60 \ C \times L} \sqrt{\frac{2T}{M}}
\]

\[
= \frac{633,000 \text{ F} A^{0.82}}{LC} \sqrt{\frac{2T}{M}}
\]
Recommendations

3. Insulated (double wall) vessels:

\[ F = \frac{K(1660 - T_f)}{34,500 \, t} \]

Substituting:

\[ Q = 34,500 \frac{K(1660 - T_f)}{34,500 \, t} \cdot 0.82 \]

\[ Q = \frac{K}{t} (1660 - T_f) \cdot 0.82 \]

**Example for LNG:**

\[ T_f = -260^\circ F \quad C_1 = \frac{K}{t} \]

\[ Q = 1920 \, C_1 \cdot 0.82 \]

**PLUS THE NORMAL HEAT LEAK THRU SURFACES NOT EXPOSED TO FIRE**

**NOTE:** NFPA 59A ADDS NORMAL HEAT LEAK THRU SURFACES EXPOSED TO FIRE SO INSTEAD OF \([1660 - (-260)]\) IT IS \([1660 - 100] + (100 - (-260)]\)

\[ 1560 + 360 = 1920 \]
RECOMMENDATIONS

NFPA 59: 1) USE EQUATION A
2) USE F FACTOR FOR INSULATION FOR DOUBLE WALL TANKS
3) ADD NOTE FROM API 2000 RE DW TANKS
4) ELIMINATE TABLE E-1 REVISE TABLE E-2B PER API 2000

NFPA 58: 1) USE EQUATION A
2) RESOLVE WHETHER OR NOT TO CONTINUE USING A = TOTAL OUTSIDE SURFACE OF CONTAINER OR TO USE WEPTED AREA PLUS HEIGHT LIMITATIONS AS IN NFPA 59
3) USE F FACTOR FOR INSULATION
4) OUGHT TO BE IDENTICAL TO 59

NFPA 59A: 1) USE EQUATION A
2) USE F FACTOR
3) DELIGHTS EQUATION FOR PARTIAL LOSS OF INSULATION
4) ADD API 2000 NOTE RE DW TANKS

NFPA 30: 1) MAKE IDENTICAL TO API 2000
(2) REVIEW CREDIT (DISCOUNT) FOR F - FACTORS
EXAMPLE

10 FT. DIAMETER X 40 FT. SHELL LENGTH PROPANE PRESSURE VESSEL
(Aprox. Capacity = 25,000 Gallons)

Vessel outside surface area = 1551 ft²

Design pressure (MAWP) = 250 psi
Relief pressure (120%) = 300 psi

Assume pure propane properties @ 300 psig
Temperature, \( T = 143°F \) (60.3°C)
Latent heat, \( L = 110 \text{ Btu}/\text{lb} \)
Molecular weight, \( M = 44 \)

Compressibility, \( Z = 0.67 \)

\[ \frac{C_p}{C_v} = 1.12 \]
Constant, \( C = 329 \)

NFPA 58: \( SCFM = 53.632 \times (1551)^{0.82} = 22,168 \) (Air)

NFPA 59: \( SCFM = \frac{633,000 \times (1551)^{0.82}}{110 \times 329 \sqrt{0.67 \times 603}} = 21,907 \) (Air)
SAME VESSEL BUT:

\[
\text{MANP} = 450 \text{ psig}
\]
\[
120^\circ = 540 \text{ psig}
\]
\[
T = 196^\circ \text{F} = 68^\circ \text{C}
\]
\[
L = 56
\]
\[
F = 0.46
\]
\[
K = 1.11
\]
\[
C = 328
\]

NFPA 58°: SCFM = 53.632 (1551)^{-0.82} = 22,168 (Air)

NFPA 59°: SCFM = \left( \frac{63,000 \times 1551}{56 \times 328} \right)^{-0.82} \sqrt{\frac{460}{0.46 \times 168}} = 37,303 (Air)