

# NFPA®

# 87

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Standard for  
Fluid Heaters

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## 2021



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## NFPA® 87

### Standard for

## Fluid Heaters

### 2021 Edition

This edition of NFPA 87, *Standard for Fluid Heaters*, was prepared by the Technical Committee on Fluid Heaters. It was issued by the Standards Council on October 5, 2020, with an effective date of October 25, 2020, and supersedes all previous editions.

This edition of NFPA 87 was approved as an American National Standard on October 25, 2020.

### Origin and Development of NFPA 87

In 2006, the Standards Council authorized the Technical Committee on Ovens and Furnaces to begin work on a new recommended practice on process heaters. The task force formed by the committee to develop the recommended practice comprised members of the Technical Committee on Ovens and Furnaces (NFPA 86, *Standard for Ovens and Furnaces*) and fire safety professionals from the community of fluid heater users and manufacturers.

The need for NFPA to develop a document on fluid heaters became apparent when NFPA received requests over a number of years for interpretation as to whether fluid heaters were covered by any existing NFPA codes and standards. The Technical Committee on Boiler and Combustion Systems specifically excluded process heaters used in chemical and petroleum manufacture from coverage by NFPA 85, *Boiler and Combustion Systems Hazards Code*. NFPA 86 did not exclude process heaters, but the Technical Committee on Ovens and Furnaces recommended the development of a new document that recognized that process heaters were fundamentally different from ovens and furnaces. The first (2011) edition of NFPA 87 was published in 2010.

The 2011 edition of NFPA 87 incorporated safety recommendations consistent with requirements in NFPA 86 and NFPA 85, especially those related to hazards associated with the combustion of gaseous and liquid fuels. Additional recommendations were added to NFPA 87 that addressed unique hazards associated with the heating of combustible fluids (e.g., pressure containment, flow and temperature monitoring, and mitigation of accidental fluid releases).

The 2015 edition of NFPA 87 included the addition of definitions for *burner management system (BMS)* and *emergency shutoff valve (ESOV)* and other updates to definitions for consistency with NFPA 86. Changes to Chapter 6 for consistency with NFPA 86 included ESOV recommendations, emergency isolation valves, and overpressure protection. The technical committee added procedures for placing equipment into service based on purging practices in NFPA 54 and NFPA 56. The committee added a recommendation against manifolded vent lines from different pressure levels based on NFPA 85. As a result of introducing definitions for BMS and combustion safeguard, the technical committee modified recommendations for logic systems for both BMS and PLC systems. The technical committee completely revised recommendations for Class F heaters in Chapter 9 and added new content for Chapters 10 and 11 on Class G and Class H heaters, respectively.

For the 2018 edition, NFPA 87 transitioned from a recommended practice to a standard. The committee added nine new definitions to Chapter 3 that were extracted from NFPA 86, including *self-piloted burner*, *line pressure regulator*, *monitoring pressure regulator*, *series pressure regulator*, *service pressure regulator*, *flame rod*, *flame detector*, *supervised flame*, and *flame failure response time (FFRT)*. A definition for authorized personnel from NFPA 1901 was modified, and qualified personnel from NFPA 70 was modified.

In addition, Class F, Class G, and Class H heaters were combined into one chapter due to the similarity of the requirements for all three classes of heaters. Fluid mixture changes were revised to be in accordance with heater manufacturers' recommendations, in accordance with fluid manufacturers' recommendations, or with a third-party approved by the AHJ. Fluid type changes

were also revised to be in accordance with heater manufacturers' recommendations or a third-party approved by the AHJ. Provisions in 8.2.9 required the use of two manual hardwired emergency switches — one located remotely and one located locally in reference to the fluid heater. Requirements in 8.5.2.5 addressed the issue of false flame signal for flame sensing technologies. The PLC software section was altered to refer to the PLC logic programming instead of the general term *software*.

Finally, interlock requirements that had been in Chapter 9 were moved to Chapter 8 with other system interlock requirements. Chapter 9 allowed secondary catch/storage tanks, and safety PLC requirements were aligned with NFPA 86. A requirement for blanket gas low-pressure proving devices was also added.

For the 2021 edition of NFPA 87, a new Chapter 10, Solid Fuel-Fired Heating Systems, provides requirements and guidance for manufacturers and users of solid-fuel-fired fluid heaters. With this chapter, new definitions have been added to Chapter 3 for terms such as *primary air*, *solid fuel backup burner*, *mechanical feeder*, and *flame arrestor*. For thermal fluid applications, annex language has been added that discourages the use of ball valves due to the risk of thermal expansion of trapped fluid. For Chapter 8, supplemental annex material adds context to the existing purge volume requirement and cautions when this requirement may not be conservative. Also, a new annex figure for Chapter 9 has been added that provides information on typical expansion tank instruments and appurtenances.

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**Committee Scope:** The committee shall have primary responsibility for documents covering fluid heaters where the release of energy inside the heater indirectly heats a process fluid that is flowing under pressure. The committee shall not have responsibility for boilers (which are covered by NFPA 85); ovens and furnaces (which are covered by NFPA 86); fired heaters in petroleum refineries and petrochemical facilities (which are covered by API Standards and Recommended Practices); units that heat air for occupiable space or comfort; and LP-gas vaporizers designed and installed in accordance with NFPA 58 and NFPA 59.

## Contents

|                                                                                        |        |                                                                               |        |
|----------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------|--------|
| <b>Chapter 1 Administration</b> .....                                                  | 87- 5  | 8.2 General. ....                                                             | 87- 21 |
| 1.1 Scope. ....                                                                        | 87- 5  | 8.3 Burner Management System Logic. ....                                      | 87- 22 |
| 1.2 Purpose. ....                                                                      | 87- 5  | 8.4 Programmable Logic Controller Systems. ....                               | 87- 22 |
| 1.3 Application. ....                                                                  | 87- 5  | 8.5 Safety Control Application for Fuel-Fired Heating Systems. [86:8.5] ..... | 87- 22 |
| 1.4 Retroactivity. ....                                                                | 87- 5  | 8.6 Combustion Air Safety Devices. ....                                       | 87- 24 |
| 1.5 Equivalency. ....                                                                  | 87- 5  | 8.7 Safety Shutoff Valves (Fuel Gas or Liquid Fuel). ..                       | 87- 24 |
| 1.6 Units and Formulas. ....                                                           | 87- 5  | 8.8 Fuel Pressure Switches (Gas or Liquid Fuel). ....                         | 87- 24 |
| <b>Chapter 2 Referenced Publications</b> .....                                         | 87- 6  | 8.9 Flame Supervision. ....                                                   | 87- 25 |
| 2.1 General. ....                                                                      | 87- 6  | 8.10 Liquid Fuel Atomization (Other than Mechanical Atomization). ....        | 87- 25 |
| 2.2 NFPA Publications. ....                                                            | 87- 6  | 8.11 Liquid Fuel Temperature Limit Devices. ....                              | 87- 25 |
| 2.3 Other Publications. ....                                                           | 87- 6  | 8.12 Multiple Fuel Systems. ....                                              | 87- 25 |
| 2.4 References for Extracts in Mandatory Sections. ...                                 | 87- 7  | 8.13 Air-Fuel Gas Mixing Machines. ....                                       | 87- 25 |
| <b>Chapter 3 Definitions</b> .....                                                     | 87- 7  | 8.14 Ignition of Main Burners — Fuel Gas or Liquid Fuel. ....                 | 87- 25 |
| 3.1 General. ....                                                                      | 87- 7  | 8.15 Stack Excess Temperature Limit Interlock. ....                           | 87- 25 |
| 3.2 NFPA Official Definitions. ....                                                    | 87- 7  | 8.16 Fluid Excess Temperature Limit Interlock. ....                           | 87- 25 |
| 3.3 General Definitions. ....                                                          | 87- 7  | 8.17 Electrical Heating Systems. ....                                         | 87- 26 |
| <b>Chapter 4 General</b> .....                                                         | 87- 10 | 8.18 Additional Interlocks. ....                                              | 87- 26 |
| 4.1 Approvals, Plans, and Specifications. ....                                         | 87- 10 | <b>Chapter 9 Heaters</b> .....                                                | 87- 27 |
| 4.2 Safety Labeling. ....                                                              | 87- 10 | 9.1 General. ....                                                             | 87- 27 |
| 4.3 Thermal Fluids and Process Fluids. ....                                            | 87- 10 | 9.2 Auxiliary Equipment. ....                                                 | 87- 27 |
| <b>Chapter 5 Location and Construction</b> .....                                       | 87- 10 | <b>Chapter 10 Solid Fuel-Fired Heating Systems</b> .....                      | 87- 28 |
| 5.1 Location. ....                                                                     | 87- 10 | 10.1 Scope. ....                                                              | 87- 28 |
| 5.2 Fluid Heater Design. ....                                                          | 87- 11 | 10.2 Air System Safeguards. ....                                              | 87- 28 |
| 5.3 Explosion Mitigation. ....                                                         | 87- 12 | 10.3 Solid Fuel Supply System Safeguards. ....                                | 87- 28 |
| 5.4 Ventilation and Exhaust System. ....                                               | 87- 12 | 10.4 Solid Fuel Combustion Safeguards. ....                                   | 87- 29 |
| 5.5 Mountings and Auxiliary Equipment. ....                                            | 87- 12 | 10.5 Heat Transfer System Safeguards. ....                                    | 87- 30 |
| 5.6 Heating Elements and Insulation. ....                                              | 87- 13 | 10.6 Exhaust Gas System Safeguards. ....                                      | 87- 30 |
| 5.7 Heat Baffles and Reflectors. ....                                                  | 87- 13 | 10.7 Ash-Handling System Safeguards. ....                                     | 87- 30 |
| <b>Chapter 6 Heating Systems</b> .....                                                 | 87- 13 | 10.8 Fire Protection for Solid Fuel-Fired Fluid Heaters. ....                 | 87- 30 |
| 6.1 General. ....                                                                      | 87- 13 | 10.9 Other Safeguards for Solid Fuel-Fired Fluid Heaters. ....                | 87- 31 |
| 6.2 Fuel Gas-Fired Units. ....                                                         | 87- 13 | <b>Chapter 11 Fire Protection</b> .....                                       | 87- 31 |
| 6.3 Liquid Fuel-Fired Units. ....                                                      | 87- 18 | 11.1 General. ....                                                            | 87- 31 |
| 6.4 Oxygen Enhanced Fuel-Fired Units. ....                                             | 87- 19 | 11.2 Types of Fire Protection Systems. ....                                   | 87- 31 |
| 6.5 Flue Product Venting. ....                                                         | 87- 19 | 11.3 Inspection, Testing, and Maintenance of Fire Protection Equipment. ....  | 87- 31 |
| 6.6 Electrically Heated Units. ....                                                    | 87- 19 | <b>Annex A Explanatory Material</b> .....                                     | 87- 32 |
| <b>Chapter 7 Commissioning, Operations, Maintenance, Inspection, and Testing</b> ..... | 87- 19 | <b>Annex B Example Maintenance Checklist</b> .....                            | 87- 52 |
| 7.1 Scope. ....                                                                        | 87- 19 | <b>Annex C Steam Extinguishing Systems</b> .....                              | 87- 53 |
| 7.2 Commissioning. ....                                                                | 87- 20 | <b>Annex D Informational References</b> .....                                 | 87- 54 |
| 7.3 Training. ....                                                                     | 87- 20 | <b>Index</b> .....                                                            | 87- 56 |
| 7.4 Operations. ....                                                                   | 87- 20 |                                                                               |        |
| 7.5 Inspection, Testing, and Maintenance. ....                                         | 87- 20 |                                                                               |        |
| 7.6 Record Retention. ....                                                             | 87- 21 |                                                                               |        |
| 7.7 Procedures. ....                                                                   | 87- 21 |                                                                               |        |
| <b>Chapter 8 Heating System Safety Equipment and Application</b> .....                 | 87- 21 |                                                                               |        |
| 8.1 Scope. ....                                                                        | 87- 21 |                                                                               |        |

**NFPA 87**  
**Standard for**  
**Fluid Heaters**

2021 Edition

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Information on referenced and extracted publications can be found in Chapter 2 and Annex D.

## Chapter 1 Administration

### 1.1\* Scope.

**1.1.1** This standard covers fluid heaters and related equipment.

**1.1.2** Within the scope of this standard, a fluid heater is considered to be any thermal fluid heater or process fluid heater with the following features:

- (1) Fluid is flowing under pressure.
- (2) Fluid is indirectly heated.
- (3) Release of energy from combustion of a liquid, solid, or gaseous fuel or an electrical source occurs within the unit.

▲ **1.1.3** This standard does not apply to the following:

- (1) Boilers (which are covered by NFPA 85 or ANSI/ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers*)
- (2) Class A, B, C, or D ovens and furnaces (which are covered by NFPA 86)

- (3) Fired heaters in petroleum refineries and petrochemical facilities that are designed and installed in accordance with API STD 560, *Fired Heaters for General Refinery Service*; API RP 556, *Instrumentation, Control, and Protective Systems for Gas Fired Heaters*; and API RP 2001, *Fire Protection in Refineries*
- (4) Fired heaters commonly called reformer furnaces or cracking furnaces in the petrochemical and chemical industries
- (5) Units that heat air for occupiable space or comfort
- (6) LP-Gas vaporizers designed and installed in accordance with NFPA 58
- (7)\* Coal-fired systems
- (8) Listed equipment with a heating system(s) that supplies a total input not exceeding 150,000 Btu/hr (44 kW)
- (9) Quiescent bath fire-tube heaters

**1.2 Purpose.** This standard provides requirements for fluid heaters to minimize the fire and explosion hazards that can endanger the fluid heater, the building, or personnel.

**1.3\* Application.** This standard applies to new installations and to alterations or extensions of existing equipment.

**1.4 Retroactivity.** The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

**1.4.1** Unless otherwise specified, the provisions of this standard do not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard are retroactive.

**1.4.2** In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

**1.4.3** The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction and only where it is clearly evident that a reasonable degree of safety is provided.

**1.5\* Equivalency.** Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those recommended by this standard.

**1.5.1** Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

**1.5.2** The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

### 1.6 Units and Formulas.

**1.6.1 SI Units.** Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

**1.6.2 Primary and Equivalent Values.** If a value for a measurement as given in this standard is followed by an equivalent value in other units, the first stated value is the requirement. A given equivalent value might be approximate.

**1.6.3 Conversion Procedure.** SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

## Chapter 2 Referenced Publications

**2.1 General.** The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

### 2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2021 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2021 edition.

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2021 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2020 edition.

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 79, *Electrical Standard for Industrial Machinery*, 2021 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2019 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2020 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2020 edition.

NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2020 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

### 2.3 Other Publications.

#### 2.3.1 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

API STD 560, *Fired Heaters for General Refinery Service*, 2016.

API RP 556, *Instrumentation, Control, and Protective Systems for Gas Fired Heaters*, 2011.

API RP 2001, *Fire Protection in Refineries*, 2012.

#### 2.3.2 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose, Inch*, 2013.

ANSI/ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*, 2015.

ANSI/ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard*, 2017.

ANSI/ASME B16.20, *Metallic Gaskets for Pipe Flanges*, 2017.

ANSI/ASME B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*, 2016.

ANSI/ASME B16.24, *Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500*, 2016.

ANSI/ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300*, 2016.

ANSI/ASME B16.47, *Large Diameter Steel Flanges: NPS 26 through NPS 60 Metric/Inch Standard*, 2017.

ANSI/ASME B31.1, *Power Piping*, 2018.

ANSI/ASME B31.3, *Process Piping*, 2016.

ANSI/ASME B36.10M, *Welded and Seamless Wrought Steel Pipe*, 2018.

ANSI/ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers*, 2018.

*Boiler and Pressure Vessel Code*, 2019.

#### 2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2018.

ASTM A106/A106M, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*, 2019.

ASTM A254/A254M, *Standard Specification for Copper-Brazed Steel Tubing*, 2012, reapproved 2019.

ASTM A268/A268M, *Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service*, 2020.

ASTM A269/A269M, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*, 2015a, reapproved 2019.

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*, 2019.

ASTM B88, *Standard Specification for Seamless Copper Water Tube*, 2020.

ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, 2020.

ASTM D396, *Standard Specification for Fuel Oils*, 2019a.

#### 2.3.4 CSA Group Publications. CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada, [www.csagroup.org](http://www.csagroup.org).

ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*, 2018.

ANSI LC 4/CSA 6.32, *Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems*, 2016.

**2.3.5 IEC Publications.** International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 61508, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems*, 2010.

**2.3.6 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 795, *Standard for Commercial-Industrial Gas Heating Equipment*, 2016.

### 2.3.7 Other Publications.

*Merriam-Webster's Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

## 2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2019 edition.

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*, 2020 edition.

## Chapter 3 Definitions

**3.1 General.** The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

### 3.2 NFPA Official Definitions.

**3.2.1\* Approved.** Acceptable to the authority having jurisdiction.

**3.2.2\* Authority Having Jurisdiction (AHJ).** An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

**3.2.3 Labeled.** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

**3.2.4\* Listed.** Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evalua-

tion of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

**3.2.5 Recommended Practice.** A document that is similar in content and structure to a code or standard but that contains only nonmandatory provisions using the word “should” to indicate recommendations in the body of the text.

**3.2.6 Shall.** Indicates a mandatory requirement.

**3.2.7 Should.** Indicates a recommendation or that which is advised but not required.

**3.2.8 Standard.** An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

## 3.3 General Definitions.

**3.3.1 Authorized Personnel.** Those approved or assigned to perform specific types of duties or be at specific locations at a job site.

**3.3.2 Automatic Fire Check.** A flame arrester equipped with a check valve to shut off the fuel gas supply automatically if a backfire occurs. [86, 2019]

**3.3.3 Auxiliary Burner.** A burner fueled by gaseous liquid or solid wood fuel in suspension that provides auxiliary heat input and operates in conjunction with a stoker or grate.

**3.3.4 Backfire Arrester.** A flame arrester installed in fully premixed air-fuel gas distribution piping to terminate flame propagation therein, shut off fuel supply, and relieve pressure resulting from a backfire. [86, 2019]

**3.3.5 Backup Burner.** A burner fueled by gaseous liquid or solid wood fuel in suspension that provides backup heat and operates without a stoker or grate.

**3.3.6 Blanket Gas.** A dry nonoxidizing gas introduced above a liquid phase to prevent contamination or oxidation of the liquid, reduce hazard of detonation, or exert pressure on the liquid.

**3.3.7 Burner.** A device or group of devices used for the introduction of fuel and air into a fluid heater at the required velocities, turbulence, and concentration to maintain ignition and combustion of fuel.

**3.3.7.1 Burner System.** One or more burners operated as a unit by a common safety shutoff valve(s).

**3.3.7.2 Dual-Fuel Burner.** A burner designed to burn either fuel gas or liquid fuel but not to burn both simultaneously.

**3.3.7.3 Fluidized Bed Burner.** A solid fuel combustion system where a bed of granular particles is maintained in a mobile suspension by the velocity of an upward flow of air or gas.

- N 3.3.7.4 Grate Burner.** A solid fuel combustion system where the fuel is in a particle layer that rests on a grate, which permits air to flow upward through openings.
- N 3.3.7.5 Pile Burner.** A solid fuel combustion system where the fuel remains relatively stationary on the floor of the combustion chamber and oxygen diffuses toward it to accomplish the combustion.
- 3.3.7.6 Self-Piloted Burner.** A burner in which the pilot fuel is issued from the same ports as the main flame or merges with the main flame to form a common flame envelope with a common flame base. [86, 2019]
- N 3.3.7.7 Suspension Burner.** A solid fuel combustion system where the fuel is finely divided and is conveyed pneumatically to the combustion chamber, where it combusts in a suspended flame envelope.
- 3.3.8\* Burner Management System.** The field devices, logic system, and final control elements dedicated to combustion safety and operator assistance in the starting and stopping of fuel preparation and burning equipment and for preventing misoperation of and damage to fuel preparation and burning equipment.
- N 3.3.9 Combustible Liquid.** Any liquid that has a closed-cup flash point at or above 100°F (37.8°C), as determined by the test procedures and apparatus set forth in Section 4.4 of NFPA 30. Combustible liquids are classified according to Section 4.3 of NFPA 30. [30, 2018]
- 3.3.10 Combustion Air.** The air necessary to provide for the complete combustion of fuel and usually consisting of primary air, secondary air, and excess air. [211, 2019]
- 3.3.11 Combustion Safeguard.** A safety device or system that responds to the presence or absence of flame properties using one or more flame detectors and provides safe start-up, operation, and shutdown of a burner under normal and abnormal conditions.
- 3.3.12 Combustion Safety Circuitry.** That portion of the fluid heater control circuitry that contains the contacts, arranged in series ahead of the safety shutoff valve(s) holding medium, for the required safety interlocks and the excess temperature limit controller(s).
- 3.3.13 Controller.**
- 3.3.13.1 Programmable Controller.** A digital electronic system designed for use in an industrial environment that uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions to control, through digital or analog inputs and outputs, various types of machines or processes. [86, 2019]
- 3.3.13.2 Temperature Controller.** A device that measures the temperature and automatically controls the input of heat into the fluid heater.
- 3.3.14 Emergency Shutoff Valve.** A manual shutoff valve to allow the fuel to be turned off in an emergency.
- 3.3.15 Equipment Isolation Valve.** A manual shutoff valve for shutoff of the fuel to each piece of equipment.
- N 3.3.16 Feeder, Mechanical.** A solid fuel combustion system component where fuel is transferred from a storage bin to the combustion chamber.
- N 3.3.17 Flame Arrester.** A device that prevents the transmission of a flame through a flammable gas/air mixture by quenching the flame on the surfaces of an array of small passages through which the flame must pass. [69, 2019]
- 3.3.18 Flame Detector.** A safety device directly responsive to flame properties that senses the presence or absence of flame using flame sensors. [86, 2019]
- 3.3.19 Flame Failure Response Time (FFRT).** The period of time that starts with the loss of flame and ends with the deenergizing of the safety shutoff valve(s). [86, 2019]
- 3.3.20\* Flame Rod.** A sensor that employs an electrically insulated rod of temperature-resistant material that extends into the flame being supervised, with a voltage impressed between the rod and a ground connected to the nozzle or burner. [86, 2019]
- 3.3.21 Flammable Limit.** The range of concentration of a flammable gas in air within which a flame can be propagated, with the lowest flammable concentration known as the lower flammable limit (LFL), and the highest flammable concentration known as the upper flammable limit (UFL).
- N 3.3.22 Flammable Liquid.** Any liquid that has a closed-cup flash point below 100°F (37.8°C), as determined by the test procedures and apparatus set forth in NFPA 30.
- 3.3.23 Fluid Heater.** A fluid heater is considered to be any thermal fluid heater or process fluid heater with the following features: (1) fluid is flowing under pressure, (2) fluid is indirectly heated, and (3) release of energy from combustion of a liquid or gaseous fuel or an electrical source occurs within the unit.
- N 3.3.23.1\* Combination Fluid Heater.** A heater with a combustion system where the products of combustion serve multiple heat users in parallel, at least one of which is a fluid heat exchanger.
- 3.3.24 Fuel Gas.** A gas used as a fuel source, including natural gas, manufactured gas, sludge gas, liquefied petroleum gas–air mixtures, liquefied petroleum gas in the vapor phase, and mixtures of these gases. [820, 2020]
- 3.3.25 Fuel Oil.** Grades 2, 4, 5, or 6 fuel oils as defined in ASTM D396, *Standard Specification for Fuel Oils*.
- 3.3.26 Gas Analyzer.** A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture. [86, 2019]
- Δ 3.3.27 Guarded.** Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. [70:100]
- 3.3.28\* Hardwired.** The method of interconnecting signals or interlocks to a logic system or between logic systems using a dedicated interconnection for each individual signal.
- 3.3.29 Interlock.**
- 3.3.29.1 Excess Temperature Limit Interlock.** A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point.

**3.3.29.2 Safety Interlock.** A device required to ensure safe start-up and safe operation and to cause safe equipment shutdown.

**3.3.30 Lower Flammable Limit (LFL).** See 3.3.21, Flammable Limit.

**3.3.31 Manufacturer.** The entity that directs and controls any of the following: product design, product manufacturing, or product quality assurance; or the entity that assumes the liability for the product or provides the warranty for the product.

**3.3.32 Mixer.**

**3.3.32.1 Air–Fuel Gas Mixer.** A mixer that combines air and fuel gas in specific proportions for use in combustion. [86, 2019]

**3.3.32.2 Proportional Mixer.** A mixer comprising an inspirator that, when supplied with air, draws all the fuel gas necessary for combustion into the airstream, and a governor, zero regulator, or ratio valve that reduces incoming fuel gas pressure to approximately atmospheric. [86, 2019]

**3.3.33 Mixing Blower.** A motor-driven blower to supply air–fuel gas mixtures for combustion through one or more fuel burners or nozzles on a single-zone industrial heating appliance or on each control zone of a multizone installation. [86, 2019]

**3.3.34 Mixing Machine.** An externally powered mechanical device that mixes fuel and air and compresses the resultant mixture to a pressure suitable for delivery to its point of use. [86, 2019]

**3.3.35 Operator.** An individual trained and responsible for the start-up, operation, shutdown, and emergency handling of the fluid heater and associated equipment.

**3.3.36 Pilot.** A flame that is used to light the main burner. [86, 2019]

**3.3.36.1 Interrupted Pilot.** A pilot that is ignited and burns during light-off and is automatically shut off at the end of the trial-for-ignition period of the main burner(s). [86, 2019]

**3.3.37 Pressure Regulator.** Equipment placed in a gas line for reducing, controlling, and maintaining the pressure in that portion of the piping system downstream of the device.

**3.3.37.1 Line Pressure Regulator.** A pressure regulator placed in a gas line between the service regulator and the appliance (equipment) regulator. [86, 2019]

**3.3.37.2 Monitoring Pressure Regulator.** A pressure regulator in a nonregulated state and set in series with another pressure regulator for the purpose of automatically taking over, in an emergency, control of the pressure downstream of the regulator in cases where pressure exceeds a set maximum. [86, 2019]

**3.3.37.3 Series Pressure Regulator.** A pressure regulator in series with one service or line pressure regulator. [86, 2019]

**3.3.37.4 Service Pressure Regulator.** A pressure regulator installed by the serving gas supplier to reduce and limit the service line gas pressure to delivery pressure. [86, 2019]

**3.3.37.5 Pump.**

**3.3.37.5.1 Primary Pump.** A pump that provides a flow of fluid through the heater during normal operating conditions.

**3.3.37.5.2 Emergency Pump.** A pump that, during an emergency, provides a flow of fluid through the heater that is sufficient to prevent damage to either the fluid or the heat transfer tubes or both.

**3.3.38 Primary Air.** The air supplied through the burner that initiates or sustains combustion.

**3.3.39 Purge.** The replacement of a flammable, indeterminate, or high-oxygen-bearing atmosphere with another gas that, when complete, results in a nonflammable final state. [86, 2019]

**3.3.40 Qualified Personnel.** Those who have skills and knowledge related to the construction and operation of a fluid heating system, including installation, and have received safety training to recognize and avoid the hazards involved.

**3.3.41 Resistance Heating System.** A heating system in which heat is produced by current flow through a resistive conductor. [86, 2019]

**3.3.42\* Safe-Start Check.** A test incorporated in a combustion safeguard that prevents start-up if a flame-detected condition exists due to component failure within the combustion safeguard or flame detector(s) due to the presence of actual or simulated flame. [86, 2019]

**3.3.43 Safety Device.** An instrument, a control, or other equipment that acts, or initiates action, to cause the fluid heater to revert to a safe condition in the event of equipment failure or other hazardous event.

**3.3.44 Safety Relay.** A relay listed for safety service. [86, 2019]

**3.3.45\* Safety Shutdown.** Stopping operations by means of a safety control or interlock that shuts off all fuel and ignition energy in a manner necessitating a manual restart. [86, 2019]

**3.3.46 Safety Shutoff Valve.** A normally closed valve installed in the piping that closes automatically to shut off the fuel in the event of abnormal conditions or during shutdown.

**3.3.47 Scf.** One cubic foot of gas at 70°F (21°C) and 14.7 psia (an absolute pressure of 101 kPa). [86, 2019]

**3.3.48 Secondary Air.** The combustion air supplied to the burner or combustion chamber in excess of primary air intended to complete the combustion process.

**3.3.49 Solid Fuel.** Wood, coal, and other similar organic materials and any combination of them. [211, 2019]

**3.3.50 Supervised Flame.** A flame whose presence or absence is detected by a flame detector. [86, 2019]

**3.3.51 Switch.**

**3.3.51.1 Closed Position Indicator Switch.** A switch that indicates when a valve is within 0.040 in. (1 mm) of its closed position but does not indicate proof of closure. [86, 2019]

**3.3.51.2 Differential Pressure Switch.** A switch that is activated by a differential pressure that is detected by comparing the pressure at two different points.

**3.3.51.3 Flow Switch.** A switch that is activated by the flow of a fluid in a duct or piping system. [86, 2019]

**3.3.51.4 Pressure Switch.**

**3.3.51.4.1 Atomizing Medium Pressure Switch.** A pressure-activated switch arranged to effect a safety shutdown or to prevent the liquid fuel burner system from being actuated in the event of inadequate atomizing medium pressure.

**3.3.51.4.2 High Fuel Pressure Switch.** A pressure-activated switch arranged to effect a safety shutdown of the burner system in the event of abnormally high fuel pressure. [86, 2019]

**3.3.51.4.3 Low Fuel Pressure Switch.** A pressure-activated switch arranged to effect a safety shutdown of the burner system in the event of abnormally low fuel pressure. [86, 2019]

**3.3.51.5\* Proof-of-Closure Switch.** A switch installed in a safety shutoff valve by the manufacturer that activates only after the valve is fully closed. [86, 2019]

**3.3.52 Tank.**

**3.3.52.1 Expansion Tank.** A reservoir that allows expansion of a liquid to occur as the liquid is heated.

**3.3.53 Trial-for-Ignition Period (Flame-Establishing Period).** The interval of time during light-off that a combustion safeguard allows the fuel safety shutoff valve to remain open before the flame detector is required to supervise the flame. [86, 2019]

**3.3.54\* Valve Proving System.** A system used to check the closure of safety shutoff valves by detecting leakage. [86, 2019]

**3.3.55 Vent Limiter.** A fixed orifice that limits the escape of gas from a vented device into the atmosphere. [86, 2019]

## Chapter 4 General

### 4.1 Approvals, Plans, and Specifications.

**4.1.1** Before new equipment is installed or existing equipment is remodeled, complete plans, sequence of operations, and specifications shall be submitted for approval to the authority having jurisdiction.

**4.1.1.1** Plans shall be drawn that show all essential details with regard to location, construction, ventilation, piping, and electrical safety equipment. A list of all combustion, control, and safety equipment giving manufacturer, type, and number shall be included.

**4.1.1.2\*** Wiring diagrams and sequence of operations for all safety controls shall be provided.

**4.1.2** Any deviation from this standard shall require special permission from the authority having jurisdiction.

#### 4.1.3 Electrical.

**4.1.3.1\*** All wiring shall be in accordance with *NFPA 70*, *NFPA 79*, and as described hereafter.

**4.1.3.2\*** The installation of a fluid heater in accordance with this standard shall not in and of itself require a change to the classification of the fluid heater location.

**4.1.3.3** Where seal leakage or diaphragm failure in a device can result in flammable gas or flammable liquid flow through a conduit or cable to an electrical ignition source, a conduit seal or a cable type that is sealed shall be installed.

### 4.2 Safety Labeling.

**4.2.1** A safety design data form or nameplate that states the operating conditions for which the fluid heater was designed, built, altered, or extended shall be accessible to the operator.

**4.2.2** A warning label stating that the equipment shall be operated and maintained according to instructions shall be provided.

**4.2.3** The warning label shall be affixed to the fluid heater or control panel.

### 4.3 Thermal Fluids and Process Fluids.

**4.3.1\*** Mixtures of thermal or process fluids shall not be used unless such mixtures are in accordance with recommendations of the manufacturer of the heater or the fluid(s), or are third-party approved by the authority having jurisdiction.

**4.3.2\*** Changes to the fluid type shall be in accordance with recommendations of the manufacturer of the heater, or third-party approved by the authority having jurisdiction.

## Chapter 5 Location and Construction

### 5.1 Location.

#### 5.1.1 General.

**5.1.1.1\*** Fluid heaters and related equipment shall be located so as to protect personnel and buildings from fire or explosion hazards.

**5.1.1.2** Fluid heaters shall be located so as to be protected from damage by external heat, vibration, and mechanical hazards.

**5.1.1.3** Fluid heaters shall be located so as to make maximum use of natural ventilation, to minimize restrictions to adequate explosion relief, and to provide sufficient air supply for personnel.

**5.1.1.4\*** Where fluid heaters are located in basements or enclosed areas, sufficient ventilation shall be supplied so as to provide required combustion air and to prevent the hazardous accumulation of vapors.

**5.1.1.5** Fluid heaters designed for use with fuel gas having a specific gravity greater than air shall be located at or above grade and shall be located so as to prevent the escape of the fuel gas from accumulating in basements, pits, or other areas below the fluid heater.

**5.1.1.6\*** Location of the fluid heater, piping, and related equipment shall consider the minimum pumpable viscosity of the fluid.

#### 5.1.2 Structural Members of the Building.

**5.1.2.1** Fluid heaters shall be located and erected so that the building structural members are not affected adversely by the maximum anticipated temperatures (*see 5.1.4.3*) or by the additional loading caused by the fluid heater.

**5.1.2.2** Structural building members shall not pass through or be enclosed within a fluid heater.

**5.1.3 Location in Regard to Stock, Processes, and Personnel.**

**5.1.3.1** Fluid heaters shall be located so as to minimize exposure to power equipment, process equipment, and sprinkler risers.

**5.1.3.2** Unrelated stock and combustible materials shall be located at a distance from a fluid heater, its heating system, or ductwork so that the combustible materials will not be ignited, with a minimum separation distance of 2.5 ft (0.8 m).

**5.1.3.3** Adequate clearance between heat transfer fluid piping and wood or other combustible construction materials shall be provided.

**5.1.3.3.1** A minimum 1 in. (25 mm) clearance shall be provided for insulated piping with surface temperature below 200°F (93°C).

**5.1.3.3.2** For insulated pipe whose surface temperature exceeds 200°F (93°C), suitable clearance to keep the surface temperature of nearby combustible construction materials below 160°F (71°C) shall be provided.

**5.1.3.3.3** A minimum 18 in. (450 mm) clearance for uninsulated piping shall be provided.

**5.1.3.4** Fluid heaters shall be located so as to minimize exposure of people to possible injury from fire, explosion, asphyxiation, and hazardous materials and shall not obstruct personnel travel to exitways.

**5.1.3.5\*** Fluid heaters shall be designed or located so as to prevent an ignition source to nearby flammable vapors, gases, dusts, and mists.

**5.1.3.6** Equipment shall be protected from corrosive external processes and environments, including fumes or materials from adjacent processes or equipment that produce corrosive conditions when introduced into the fluid heater environment.

**5.1.4 Floors and Clearances.**

**5.1.4.1** Space shall be provided above and on all sides for inspection, maintenance, and operational purposes.

**5.1.4.2** In addition to the requirement in 5.1.4.1, where applicable, adequate space shall be provided for the installation of extinguishing systems and for the functioning of explosion venting.

**5.1.4.3\*** Fluid heaters shall be constructed **and** located to keep temperatures at combustible floors, ceilings, and walls less than 160°F (71°C).

**5.1.4.4** Floors in the area of mechanical pumps, liquid fuel burners, or other equipment using oil shall be provided with a noncombustible, nonporous surface to prevent floors from becoming soaked with oil.

**5.1.4.5** Means shall be provided to prevent released fluid from flowing into adjacent areas or floors below.

**5.1.5 Manifolds and External Piping.** Manifolds and external piping shall be located to allow access for removal of tubes.

**5.2\* Fluid Heater Design.**

**5.2.1** Fluid heaters and related equipment shall be designed to minimize the fire hazard inherent in equipment operating at elevated temperatures.

**5.2.2** Fluid heater components exposed simultaneously to elevated temperatures and air shall be constructed of noncombustible material.

**5.2.3\*** Fluid heater structural members shall be designed to support the maximum loads of the fluid heater throughout the anticipated range of operating conditions.

**5.2.4\*** Fluid heaters shall withstand the strains imposed by expansion and contraction, as well as static and dynamic mechanical loads and seismic, wind, and precipitation loads as applicable.

**5.2.5** Provision shall be made for draining the fluid heater for maintenance and emergency conditions.

**5.2.6** Fluid heaters and related equipment shall be designed and located to provide access for recommended inspection and maintenance.

**5.2.6.1\*** Ladders, walkways, or access facilities shall be provided so that equipment can be operated or accessed for testing and maintenance.

**5.2.6.2** Means shall be provided for recommended internal inspection by maintenance and other personnel.

**5.2.7** Radiation shields, refractory material, and insulation shall be retained or supported so they do not fall out of place under designed use and maintenance.

**5.2.8** External parts of fluid heaters that operate at temperatures in excess of 160°F (71°C) shall be guarded by location, guard rails, shields, or insulation to prevent accidental contact by personnel.

**5.2.8.1** Openings or other parts of the fluid heater from which flames, hot gases, or fluids could be discharged shall be located or guarded to prevent injury to personnel.

**5.2.8.2** Where it is impractical to provide adequate shields or guards required by 5.2.8, warning signs or permanent floor markings visible to personnel entering the area shall be provided.

**5.2.9** Observation ports or other visual means for observing the operation of individual burners shall be provided and shall be protected from damage by radiant heat.

**5.2.10 Pressure Relief Devices.**

**5.2.10.1** Each section of the fluid flow path that can exceed the design pressure shall be equipped with pressure relief.

**5.2.10.2** Pressure relief shall be provided for fluid piping and tanks that can be isolated.

**5.2.10.3** Fluid vented from a pressure relief device shall be directed to an approved location.

**5.2.10.3.1** Vent piping shall be sized for the anticipated flow of vented fluid, which can be a two-phase mixture.

**5.2.10.3.2** Horizontal piping in the vent line shall be sloped so that liquid does not accumulate.

**5.2.10.3.3** Heat tracing of the vent line shall be considered for fluids having a minimum pour point above expected ambient temperatures.

**5.2.11** The metal frames of fluid heaters shall be electrically grounded.

**5.2.12** Fluid heaters shall be designed for relatively uniform heat flux to all heat transfer surfaces.

**5.2.13** Heater components shall be designed to allow for thermal expansion.

**5.2.14** Refractory and insulation shall be adequately supported by materials that are fit for the conditions.

**5.2.15** Fluid heater tube materials shall be selected to accommodate the chosen fluid at the desired operating temperature, with sufficient protection against corrosion and erosion.

**5.2.16** Heater pressure vessels operating at pressures greater than 15 psi (100 kPa) shall be stamped and protected with overpressure protection in accordance with ASME *Boiler and Pressure Vessel Code*, Section I or ASME Section VIII, Division 1 vessels.

**5.2.17** For combustible fluids, seamless tubes and fittings shall be utilized.

**5.2.18** Tubing within the heat transfer area shall have welded connections.

**5.2.19** Tubing or piping outside the heat transfer area shall have either flanged or welded connections.

**5.2.20** Threaded connections shall be permitted to be used outside the heat transfer area for instrument connections and pressure relief valve connections of 1¼ in. (32 mm) and smaller diameter only.

**5.2.21** Low point drains and high point vents shall be accessible outside the heater.

**5.2.22** The maximum unsupported length of tubes shall be such that tube stress does not exceed one-half of the stress to produce 1 percent creep in 10,000 hours.

**5.2.23** Tube hangers that cannot be easily inspected and replaced shall be designed such that their stress does not exceed one-half of the stress to produce 1 percent creep in 10,000 hours.

**5.2.24** Burners shall be designed to prevent flame impingement on tubes and tube supports when operating.

**5.2.25** Fluid heaters shall be designed for a specific range of fluid viscosities, densities, flow rates, and velocities.

**5.2.26** Fluid heaters shall not be operated outside the ranges specified in 5.2.25.

**5.3\* Explosion Mitigation.** Explosion hazards shall be mitigated through one of the following methods:

- (1) Containment
- (2) Explosion relief
- (3) Location
- (4) Explosion suppression
- (5) Damage limiting construction

## **5.4\* Ventilation and Exhaust System.**

**5.4.1\* Building Makeup Air.** A quantity of makeup air shall be admitted to fluid heater rooms and buildings to provide the air volume required for fluid heater combustion air.

### **5.4.2 Fans and Motors.**

**5.4.2.1** Electric motors that drive exhaust or recirculating fans shall not be located inside the fluid heater or ductwork.

**5.4.2.2** Fluid heater fans shall be designed for the maximum anticipated temperature that they will be exposed to.

### **5.4.3 Ductwork.**

**5.4.3.1** Ventilating and exhaust systems, where applicable, shall be installed in accordance with NFPA 31 or NFPA 54, unless otherwise noted in this standard.

**5.4.3.2** Wherever fluid heater exhaust ducts or stacks pass through combustible walls, floors, or roofs, noncombustible insulation, clearance, or both shall be provided to prevent combustible surface temperatures from exceeding 160°F (71°C).

**5.4.3.3\*** Where ducts pass through fire resistance-rated or noncombustible walls, floors, or partitions, the space around the duct shall be sealed with noncombustible material to maintain the fire-resistance rating of the barrier.

**5.4.3.4** Ducts shall be constructed entirely of sheet steel or other noncombustible material capable of meeting the intended installation and conditions of service.

**5.4.3.5** The duct installation shall be protected where subject to physical damage.

**5.4.3.6\*** No portions of the building shall be used as an integral part of the duct.

**5.4.3.7\*** All ducts shall be made tight throughout and have no openings other than those required for the operation and maintenance of the system.

**5.4.3.8** All ducts shall be braced and supported by metal hangers or brackets where required.

**5.4.3.9** Stacks shall be properly braced and supported.

**5.4.3.10** Hand holes for inspection or other purposes shall be equipped with tight-fitting doors or covers.

**5.4.3.11** Exposed hot fan casings, fluid piping, and hot ducts [temperatures exceeding 160°F (71°C)] shall be guarded by location, guardrails, shields, or insulation to prevent injury to personnel.

**5.4.3.12\*** Exhaust ducts shall not discharge near openings or other air intakes where effluents can be entrained and directed to locations creating a hazard.

## **5.5 Mountings and Auxiliary Equipment.**

### **5.5.1 Fluid Piping System.**

**5.5.1.1** Piping and fittings shall be compatible with the fluid being used and with the system operating temperatures and pressures.

**5.5.1.2** For fluid piping systems that operate above 15 psig (100 kPa), piping materials shall be in accordance with ANSI/ASME B31.1, *Power Piping*, or ANSI/ASME B31.3, *Process Piping*.

**5.5.1.3\*** In applications where fluid leakage creates a hazard, all pipe connections shall be welded except as permitted in 5.5.1.3.1 and 5.5.1.3.2.

**5.5.1.3.1\*** Flange connections shall be limited to pump, valve, boundary limit, spool, and equipment connections.

**5.5.1.3.2** Threaded connections shall be limited to instruments and other miscellaneous connections less than or equal to 1.25 in. (32 mm).

**5.5.1.4** Thread sealant shall be compatible with the fluid used and with the maximum operating temperature.

**5.5.1.5** Seal and gasket materials shall be compatible with the fluid and with the operating temperature and pressure.

**5.5.1.6** The system design shall accommodate the thermal expansion of the pipe.

**5.5.1.7\*** The system shall be tested in accordance with the applicable piping code.

**5.5.1.8** Thermal insulation used on pipes and equipment shall be selected for the intended purpose and for compatibility with the fluid.

**5.5.1.8.1** Where there is a potential for fluid system leaks, the thermal insulation selected shall be nonabsorbent.

**5.5.1.8.2** Insulation applied to system piping and equipment shall be applied only after a leakage or pressure test of the plant has been conducted.

**5.5.1.8.3** Insulation shall be applied only after a full heating cycle.

**5.5.1.9** Shielding shall be provided against hot fluid sprays in the event that a gasket or seal fails.

**5.5.2** Pipes, valves, and manifolds shall be mounted so as to provide protection against damage by heat, vibration, and mechanical hazard.

**5.5.3** Fluid heater systems shall have provisions such as motion stops, lockout devices, or other safety mechanisms to prevent injury to personnel during maintenance or inspection.

**5.5.4** Instrumentation and control equipment shall meet the following criteria:

- (1) Be located for ease of observation, adjustment, and maintenance
- (2) Be protected from physical and thermal damage and other hazards

## 5.6 Heating Elements and Insulation.

**5.6.1** Material for electric heating elements shall be suitable for the specified range of design conditions.

**5.6.2** Internal electrical insulation material shall be suitable for the specified range of design conditions.

## 5.7 Heat Baffles and Reflectors.

**5.7.1** To prevent fluid heater damage, baffles, reflectors, and internal component supports shall be designed to minimize warpage due to expansion and contraction.

**5.7.2** To prevent fluid heater damage, baffles, reflectors, and internal component supports shall be of heat-resistant material

that minimizes sag, rupture, or cracking under normal operating limits specified by the manufacturer.

**5.7.3** Baffles and reflectors shall be accessible and removable for the purpose of cleaning and repairing.

## Chapter 6 Heating Systems

### 6.1 General.

**6.1.1** For the purposes of this chapter, the term *heating system* includes the heating source, the associated piping and wiring used to heat the enclosure, and the process fluid therein.

**6.1.2** All components of the heating system and control cabinet shall be grounded.

**6.1.3** Pilot burners shall be considered burners, and all provisions of Section 6.2 or Section 6.3 shall apply.

### 6.2\* Fuel Gas-Fired Units.

**6.2.1 Scope.** Section 6.2 applies to the following:

- (1) Fluid heating systems fired with fuel gases such as the following:
  - (a) Natural gas
  - (b) Mixed gas
  - (c) Manufactured gas
  - (d) Liquefied petroleum gas (LP-Gas) in the vapor phase
  - (e) LP-Gas-air systems
- (2) Gas-burning portions of dual-fuel or combination burners

**6.2.2 General.** Burners, along with associated mixing, valving, and safety controls and other auxiliary components, shall be selected for the intended application, type, and pressure of the fuel gases to be used and temperatures to which they are subjected.

### 6.2.3 Combustion Air.

**6.2.3.1** The fuel-burning system design shall provide a supply of suitable combustion air delivered in amounts prescribed by the fluid heater designer or burner manufacturer across the full range of burner operation.

**6.2.3.2** Products of combustion shall not be mixed with the combustion air supply.

**6.2.3.2.1** The requirement of 6.2.3.2 shall not prohibit the use of flue gas recirculation systems specifically designed to accommodate such recirculation.

**6.2.3.3\*** Where primary or secondary combustion air is provided mechanically, combustion air flow or pressure shall be proven and interlocked with the safety shutoff valves so that fuel gas cannot be admitted prior to establishment of combustion air and so that the gas is shut off in the event of combustion air failure.

**6.2.3.4** Where a burner register air adjustment is provided, adjustment shall include a locking device to prevent an unintentional change in setting.

### 6.2.4 Fuel Gas Supply Piping.

**6.2.4.1\*** An emergency shutoff valve shall be provided that meets the following requirements:

- (1) It shall be remotely located away from the fluid heater so that fire or explosion at a fluid heater does not prevent access to the valve.
- (2) It shall be readily accessible.
- (3) It shall have permanently affixed visual indication of the valve position.
- (4) A removable handle shall be permitted, provided all the following requirements are satisfied:
  - (a) The valve position shall be clearly indicated whether the handle is attached or detached.
  - (b) The valve handle shall be tethered to the gas main no more than 3 ft (1 m) from the valve in a manner that does not cause personnel safety issues and that allows trouble-free reattachment of the handle and operation of the valve without untethering the handle.
- (5) It shall be able to be operated from full open to full close and return without the use of tools.

**6.2.4.2** Installation of LP-Gas storage and handling systems shall comply with NFPA 58.

**6.2.4.3** Piping from the point of delivery to the equipment isolation valve shall comply with NFPA 54. (See 6.2.5.2.)

**6.2.4.4** An equipment isolation valve shall be provided.

#### **6.2.5 Equipment Fuel Gas Piping.**

**6.2.5.1 Equipment Isolation Valves.** Equipment isolation valves shall meet the following requirements:

- (1) They shall be provided for each piece of equipment.
- (2) They shall have permanently affixed visual indication of the valve position.
- (3) They shall be quarter-turn valves with stops.
- (4) Wrenches or handles shall remain affixed to valves and shall be oriented with respect to the valve port to indicate the following:
  - (a) When the handle is parallel to the pipe, it shall indicate an open valve.
  - (b) When the handle is perpendicular to the pipe, it shall indicate a closed valve.
- (5) They shall be readily accessible.
- (6) Valves with removable wrenches shall not allow the wrench handle to be installed perpendicular to the fuel gas line when the valve is open.
- (7) They shall be able to be operated from full open to full close and return without the use of tools.

**6.2.5.2\*** Fuel gas piping materials shall be in accordance with 6.2.6.

**6.2.5.3** Fuel gas piping shall be sized to provide flow rates and pressures that maintain a stable flame over the burner operating range.

#### **N 6.2.6\* Piping Materials and Joining Methods.**

##### **N 6.2.6.1 General.**

**N 6.2.6.1.1 Acceptable Materials.** Materials used for piping systems shall either comply with the requirements of this chapter or be acceptable to the authority having jurisdiction. [54:5.5.1.1]

**N 6.2.6.1.2 Used Materials.** Pipe, fittings, valves, or other materials shall not be used again unless they are free of foreign

materials and have been ascertained to be adequate for the service intended. [54:5.5.1.2]

##### **N 6.2.6.2 Metallic Pipe.**

**N 6.2.6.2.1 Cast Iron.** Cast-iron pipe shall not be used. [54:5.5.2.1]

**N 6.2.6.2.2 Steel, Stainless Steel, and Wrought Iron.** Steel, stainless steel, and wrought-iron pipe shall be at least Schedule 40 and shall comply with the dimensional standards of ANSI/ASME B36.10M, *Welded and Seamless Wrought Steel Pipe*, and one of the following:

- (1) ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*.
- (2) ASTM A106/A106M, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*.
- (3) ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*.

**N 6.2.6.2.3\* Copper and Copper Alloy.** Copper and copper alloy pipe shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L). [54:5.5.2.3]

**N 6.2.6.2.4 Threaded Copper and Copper Alloy.** Threaded copper and copper alloy pipe shall not be used with gases corrosive to such material.

##### **N 6.2.6.3 Metallic Tubing.**

**N 6.2.6.3.1** Tubing shall not be used with gases corrosive to the tubing material. [54:5.5.3.1]

**N 6.2.6.3.2 Steel.** Steel tubing shall comply with ASTM A254/A254M, *Standard Specification for Copper-Braced Steel Tubing*. [54:5.5.3.2]

**N 6.2.6.3.3 Stainless Steel.** Stainless steel tubing shall comply with one of the following:

- (1) ASTM A268/A268M, *Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service*
  - (2) ASTM A269/A269M, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
- [54:5.5.3.3]

**N 6.2.6.3.4\* Copper and Copper Alloy.** Copper and copper alloy tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L). Copper tubing shall comply with standard Type K or Type L of ASTM B88, *Standard Specification for Seamless Copper Water Tube*, or ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*. [54:5.5.3.4]

**N 6.2.6.3.5 Corrugated Stainless Steel.** Corrugated stainless steel tubing shall be listed in accordance with ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*. [54:5.5.3.6]

**N 6.2.6.4 Workmanship and Defects.** Gas pipe, tubing, and fittings shall be clear and free from cutting burrs and defects in structure or threading and shall be thoroughly brushed and chip and scale blown. Defects in pipe, tubing, and fittings shall not be repaired. Defective pipe, tubing, and fittings shall be replaced. [54:5.5.5]

**N 6.2.6.5 Metallic Pipe Threads.**

**N 6.2.6.5.1 Specifications for Pipe Threads.** Metallic pipe and fitting threads shall be taper pipe threads and shall comply with ANSI/ASME B1.20.1, *Pipe Threads, General Purpose, Inch*. [54:5.5.6.1]

**N 6.2.6.5.2 Damaged Threads.** Pipe with threads that are stripped, chipped, corroded, or otherwise damaged shall not be used. Where a weld opens during the operation of cutting or threading, that portion of the pipe shall not be used. [54:5.5.6.2]

**N 6.2.6.5.3 Number of Threads.** Field threading of metallic pipe shall be in accordance with Table 6.2.6.5.3. [54:5.5.6.3]

**N 6.2.6.5.4\* Thread Joint Sealing.**

**N 6.2.6.5.4.1** Threaded joints shall be made using a thread joint sealing material. [54: 5.5.6.4.1]

**N 6.2.6.5.4.2** Thread joint sealing materials shall be compatible with the pipe and fitting material on which the compounds are used. [54: 5.5.6.4.2]

**N 6.2.6.5.4.3** Thread joint sealing materials shall be non-hardening and shall be resistant to the chemical constituents of the gases to be conducted through the piping. [54:5.5.6.4.3]

**N 6.2.6.6 Metallic Piping Joints and Fittings.** The type of piping joint used shall be suitable for the pressure and temperature conditions and shall be selected giving consideration to joint tightness and mechanical strength under the service conditions. The joint shall be able to sustain the maximum end force due to the internal pressure and any additional forces due to temperature expansion or contraction, vibration, fatigue, or the weight of the pipe and its contents. [54:5.5.7]

**N 6.2.6.6.1\* Pipe Joints.** Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded, or assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32, *Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems*. [54:5.5.7.1]

**N (A)** Pipe lighter than Schedule 40 shall be connected using press-connect fittings, flanges, brazing, or welding. [54:5.5.7.1(A)]

**N (B)** Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C). [54:5.5.7.1(B)]

**N (C)** Brazing alloys shall not contain more than 0.05 percent phosphorus. [54:5.5.7.1(C)]

**N 6.2.6.6.2 Copper Tubing Joints.** Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32, *Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems*. Brazing alloys shall not contain more than 0.05 percent phosphorus. [54:5.5.7.2]

**N 6.2.6.6.3 Stainless Steel Tubing Joints.** Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32, *Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems*. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [54:5.5.7.3]

**N 6.2.6.6.4 Flared Joints.** Flared joints shall be used only in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is suitable for the conditions and where provisions are made in the design to prevent separation of the joints. [54:5.5.7.4]

**N 6.2.6.6.5 Metallic Pipe Fittings.** Metallic fittings shall comply with the following: [54:5.5.7.5]

- (1) Threaded fittings in sizes larger than 4 in. (100 mm) shall not be used. [54:5.5.7.5(1)]
- (2) Fittings used with steel, stainless steel, or wrought-iron pipe shall be steel, stainless steel, copper alloy, malleable iron, or cast iron. [54:5.5.7.5(2)]
- (3) Fittings used with copper or copper alloy pipe shall be copper or copper alloy. [54:5.5.7.5(3)]
- (4) *Cast-Iron Fittings.* Cast-iron fittings shall comply with the following:
  - (a) Flanges shall be permitted.
  - (b) Bushings shall not be used.
  - (c) Fittings shall not be used in systems containing flammable gas-air mixtures.
  - (d) Fittings in sizes 4 in. (100 mm) and larger shall not be used indoors unless approved by the authority having jurisdiction.
  - (e) Fittings in sizes 6 in. (150 mm) and larger shall not be used unless approved by the authority having jurisdiction. [54:5.5.7.5(5)]
- (5) *Special Fittings.* Fittings such as couplings, proprietary-type joints, saddle tees, gland-type compression fittings, and flared, flareless, or compression-type tubing fittings shall be as follows:
  - (a) Used within the fitting manufacturer's pressure-temperature recommendations
  - (b) Used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion, or contraction
  - (c) Acceptable to the authority having jurisdiction [54:5.5.7.5(8)]
- (6) Pipe fittings shall not be drilled and tapped in the field.

**N Table 6.2.6.5.3 Specifications for Threading Metallic Pipe**

| Iron Pipe<br>Size<br>(in.) | Approximate<br>Length of<br>Threaded Portion<br>(in.) | Approximate<br>No. of Threads<br>to Be Cut |
|----------------------------|-------------------------------------------------------|--------------------------------------------|
| 1/2                        | 3/4                                                   | 10                                         |
| 3/4                        | 3/4                                                   | 10                                         |
| 1                          | 7/8                                                   | 10                                         |
| 1 1/4                      | 1                                                     | 11                                         |
| 1 1/2                      | 1                                                     | 11                                         |
| 2                          | 1                                                     | 11                                         |
| 2 1/2                      | 1 1/2                                                 | 12                                         |
| 3                          | 1 1/2                                                 | 12                                         |
| 4                          | 1 3/8                                                 | 13                                         |

For SI units, 1 in. = 25.4 mm.  
[54:Table 5.5.6.3]

Shaded text = Revisions. **N** = Text deletions and figure/table revisions.

• = Section deletions.

**N** = New material



**6.2.6.7 Flanges.****6.2.6.7.1 Flange Specifications.**

**6.2.6.7.1.1** Cast iron flanges shall be in accordance with ANSI/ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*. [54:5.5.9.1.1]

**6.2.6.7.1.2** Steel flanges shall be in accordance with the following: ANSI/ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard*, or ANSI/ASME B16.47, *Large Diameter Steel Flanges: NPS 26 through NPS 60 Metric/Inch Standard*. [54:5.5.9.1.2]

**6.2.6.7.1.3** Non-ferrous flanges shall be in accordance with ANSI/ASME B16.24, *Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500*. [54:5.5.9.1.3]

**6.2.6.7.1.4** Ductile iron flanges shall be in accordance with ANSI/ASME B16.42, *Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300*. [54:5.5.9.1.4]

**6.2.6.7.2 Dissimilar Flange Connections.** Raised-face flanges shall not be joined to flat-faced cast iron, ductile iron or nonferrous material flanges. [54:5.5.9.2]

**6.2.6.7.3 Flange Facings.** Standard facings shall be permitted for use under this standard. Where 150 psi (1034 kPa) steel flanges are bolted to Class 125 cast-iron flanges, the raised face on the steel flange shall be removed. [54:5.5.9.3]

**6.2.6.7.4 Lapped Flanges.** Lapped flanges shall be used only aboveground or in exposed locations accessible for inspection. [54:5.5.9.4]

**6.2.6.8 Flange Gaskets.** The material for gaskets shall be capable of withstanding the design temperature and pressure of the piping system and the chemical constituents of the gas being conducted without change to its chemical and physical properties. The effects of fire exposure to the joint shall be considered in choosing the material. [54:5.5.10]

**6.2.6.8.1** Acceptable materials shall include the following:

- (1) Metal (plain or corrugated)
  - (2) Composition
  - (3) Aluminum "O" rings
  - (4) Spiral-wound metal gaskets
  - (5) Rubber-faced phenolic
  - (6) Elastomeric
- [54:5.5.10.1]

**6.2.6.8.2 Gasket Specifications.**

**6.2.6.8.2.1** Metallic flange gaskets shall be in accordance with ANSI/ASME B16.20, *Metallic Gaskets for Pipe Flanges*. [54:5.5.10.2.1]

**6.2.6.8.2.2** Non-metallic flange gaskets shall be in accordance with ANSI/ASME B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*. [54:5.5.10.2.2]

**6.2.6.8.3** Full-face flange gaskets shall be used with all non-steel flanges. [54:5.5.10.3]

**6.2.7 Control of Contaminants.**

**6.2.7.1** A sediment trap or other acceptable means of removing contaminants shall be installed downstream of the equipment isolation valve and upstream of all other fuel-gas system components.

**6.2.7.2** Sediment traps shall have a vertical leg with a minimum length of three pipe diameters [minimum of 3 in. (80 mm)] of the same size as the supply pipe, as shown in Figure 6.2.7.2.

**6.2.7.3\*** A gas filter or strainer shall be installed in the fuel gas piping and shall be located downstream of the equipment isolation valve and sediment trap and upstream of all other fuel gas system components.

**6.2.8 Pressure Regulators, Pressure Relief Valves, and Pressure Switches.**

**6.2.8.1** A pressure regulator shall be furnished wherever the plant supply pressure exceeds the burner operating parameters or the design parameters or wherever the plant supply pressure is subject to fluctuations, unless otherwise permitted by 6.2.8.2.

**6.2.8.2** An automatic flow control valve shall be permitted to meet the requirement of 6.2.8.1, provided that it can compensate for the full range of expected source pressure variations.

**6.2.8.3\*** Regulators, relief valves, and switches shall be vented to an approved location, and the following criteria also shall be met:

- (1) Heavier-than-air flammable gases shall be vented outside the building to a location where the gas is diluted below its lower flammable limit (LFL) before coming in contact with sources of ignition or re-entering the building.
- (2) Vents shall be designed to prevent the entry of water and insects without restricting the flow capacity of the vent.

**6.2.8.4\*** Fuel gas regulators, ratio regulators, and zero governors shall not be required to be vented to an approved location in the following situations:

- (1) Where backloaded from combustion air lines, air-gas mixture lines, or combustion chambers, provided that gas leakage through the backload connection does not create a hazard
- (2) Where a listed regulator-vent limiter combination is used
- (3) Where a regulator system is listed for use without vent piping

**6.2.8.5\*** A pressure switch shall not be required to be vented if it employs a vent limiter rated for the service intended.

**6.2.8.6** Vent lines from multiple fluid heaters shall not be manifolded together.

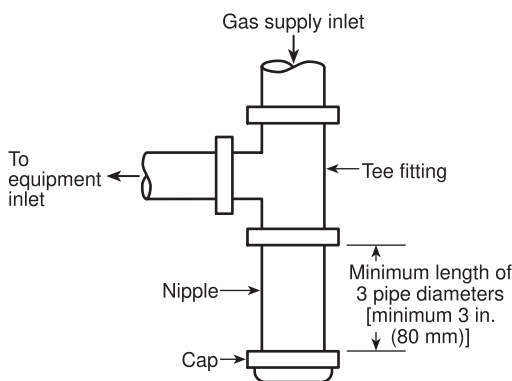


**FIGURE 6.2.7.2 Method of Installing a Tee-Fitting Sediment Trap.**

**6.2.8.7** Vent lines from multiple regulators and switches of a single fluid heater, where manifolded together, shall be piped in such a manner that diaphragm rupture of one vent line does not backload the others.

**6.2.8.7.1** Vents from systems operating at different pressure control levels shall not be manifolded together.

**6.2.8.7.2** Vents from systems using different fuel sources shall not be manifolded together.

**6.2.8.8** The cross-sectional area of the manifold line shall not be less than the greater of the following:

- (1) The cross-sectional area of the largest vent plus 50 percent of the sum of the cross-sectional areas of the additional vent lines
- (2) The sum of the cross-sectional areas of the two largest vent lines

**6.2.8.9\*** A vent between safety shutoff valves, where installed, shall conform to the following requirements:

- (1) It shall not be combined with other vents.
- (2) It shall terminate to an approved location.

### **6.2.9 Overpressure Protection.**

**6.2.9.1** Overpressure protection shall be provided in either of the following cases:

- (1) When the supply pressure exceeds the pressure rating of any downstream component
- (2) When the failure of a single upstream line regulator or service pressure regulator results in a supply pressure exceeding the pressure rating of any downstream component

**6.2.9.2** Overpressure protection shall be provided by any one of the following:

- (1) A series regulator in combination with a line regulator or service pressure regulator
- (2) A monitoring regulator installed in combination with a line regulator or service pressure regulator
- (3) A full-capacity pressure relief valve
- (4) An overpressure cutoff device, such as a slam-shut valve or a high pressure switch in combination with an adequately rated shutoff valve

**6.2.9.3\*** When a relief valve is used to comply with 8.7.1.9, the relief valve shall be a full-capacity relief type.

**6.2.9.4** Token relief valves and internal token relief valves shall not be permitted to be used as the only overpressure protection device.

**6.2.10\* Air-Fuel Gas Mixers.** Subsection 6.2.10 shall apply only to mixtures of fuel gas with air.

#### **6.2.10.1 Proportional Mixing.**

(A) Piping shall be designed to provide a uniform mixture flow of pressure and velocity needed for stable burner operation.

(B) Valves or other obstructions shall not be installed between a proportional mixer and burners, unless otherwise permitted by 6.2.10.2(C).

(C) Fixed orifices shall be permitted for purposes of balancing.

(D) Any field-adjustable device built into a proportional mixer (e.g., gas orifice, air orifice, ratio valve) shall incorporate a device to prevent unintentional changes in the setting.

(E) Where a mixing blower is used, safety shutoff valves shall be installed in the fuel gas supply and shall interrupt the fuel gas supply automatically when the mixing blower is not in operation or in the event of a fuel gas supply failure.

(F) Mixing blowers shall not be used with fuel gases containing more than 10 percent free hydrogen ( $H_2$ ).

(G) Mixing blowers having a static delivery pressure of more than 10 in. w.c. (2.49 kPa) shall be considered mixing machines.

#### **6.2.10.2 Mixing Machines.**

(A)\* Automatic fire checks shall be provided in piping systems that distribute flammable air-fuel gas mixtures from a mixing machine.

(B) The automatic fire check shall be installed at the burner inlet(s), and the manufacturer's installation guidelines shall be followed.

(C) A separate, manually operated gas valve shall be provided at each automatic fire check for shutting off the flow of an air-fuel mixture through the fire check after a flashback has occurred.

**CAUTION:** These valves shall not be reopened after a flashback has occurred until the fire check has cooled sufficiently to prevent re-ignition of the flammable mixture and has been properly reset.

(D) The valves recommended by 6.2.10.2(C) shall be located upstream of the inlets of the automatic fire checks.

(E)\* A backfire arrester with a safety blowout device shall be installed in accordance with the manufacturer's instructions near the outlet of each mixing machine that produces a flammable air-fuel gas mixture.

(F) Where a mixing machine is used, safety shutoff valves shall be installed in the fuel gas supply and shall interrupt the fuel gas supply automatically when the mixing machine is not in operation or in the event of an air or fuel gas supply failure.

#### **6.2.11 Fuel Gas Burners.**

**6.2.11.1** All burners shall maintain both the stability of the designed flame shape over the entire range of turndown encountered during operation where supplied with combustion air and the designed fuels in the designed proportions and in the designed pressure ranges.

**6.2.11.2** Burners shall be used only with the fuels for which they are designed.

**6.2.11.3** All pressures required for the operation of the combustion system shall be maintained within design ranges throughout the firing cycle.

**6.2.11.4** Burners shall have the ignition source sized and located in a position that provides ignition of the pilot or main flame within the design trial-for-ignition period.

(A) Self-piloted burners shall have a transition from pilot flame to main flame.