

NFPA® 87

Recommended Practice for Fluid Heaters

2015 Edition



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NFPA® 87

Recommended Practice for

Fluid Heaters

2015 Edition

This edition of NFPA 87, *Recommended Practice for Fluid Heaters*, was prepared by the Technical Committee on Fluid Heaters. It was issued by the Standards Council on April 29, 2014, with an effective date of May 19, 2014, and supersedes all previous editions.

This edition of NFPA 87 was approved as an American National Standard on May 19, 2014.

Origin and Development of NFPA 87

The 2011 edition of NFPA 87 was the first edition of the document. 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 over a number of years as NFPA received requests 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 excludes process heaters used in chemical and petroleum manufacture from coverage by NFPA 85, *Boiler and Combustion Systems Hazards Code*. NFPA 86 does not exclude process heaters, but the Technical Committee on Ovens and Furnaces recommended the development of a new document that recognizes that process heaters are fundamentally different from ovens and furnaces.

NFPA 87 incorporates many safety recommendations that are 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 have been added to NFPA 87 that address unique hazards associated with the combustible fluids being heated in these systems (e.g., pressure containment, flow and temperature monitoring, and mitigation of accidental fluid releases).

The 2015 edition of NFPA 87 includes several changes to Chapter 3 due to 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 intended to make the document consistent with NFPA 86 include ESOV requirements, emergency isolation valves, and overpressure protection. The Committee added procedures for placing equipment into service based on purging practices in NFPA 54 and the new NFPA 56. The Committee added a requirement prohibiting manifold vent lines from different pressure levels based on NFPA 85. As a result of introducing definitions for BMS and combustion safeguard, the Committee modified requirements for logic systems for both BMS logic and PLC systems. The Committee completely revised requirements for Class F heaters in Chapter 9 and added new content for Chapters 10 and 11 on Class G and H heaters, respectively.



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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: Proposed 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.



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NFPA 87

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in the recommendations sections of this document are given in Chapter 2 and those for extracts in the informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text should be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1* Scope.

1.1.1 This recommended practice covers Type F, Type G, and Type H fluid heaters and related equipment.

1.1.2 Within the scope of this recommended practice, 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 or gaseous fuel or an electrical source occurs within the unit.

1.1.3 This recommended practice does not apply to the following:

- (1) Boilers (which are covered by NFPA 85, *Boiler and Combustion Systems Hazards Code*, 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, *Standard for Ovens and Furnaces*)
- (3) Fired heaters in petroleum refineries and petrochemical facilities that are designed and installed in accordance with API 560, *Fired Heaters for General Refinery Services*; API RP 556, *Instrumentation and Control Systems for Fired Heaters and Steam Generators*; 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, *Liquefied Petroleum Gas Code*
- (7)*Coal or other solid fuel-firing systems
- (8) Listed equipment with a heating system(s) that supplies a total input not exceeding 150,000 Btu/hr (44 kW)

1.1.4 The following types of heaters are covered by this recommended practice:

- (1) Class F heaters, which have fluid inside the tubes with a relatively constant flow rate
- (2) Class G heaters, which have fluid inside the tubes with a modulated flow rate and firing rate
- (3) Class H heaters, which have a heat source (combustion or electricity) inside the tubes

1.2 Purpose. This recommended practice provides recommendations for fluid heaters to minimize the fire and explosion hazards that can endanger the fluid heater, the building, or personnel.

1.3 Application.

1.3.1* This recommended practice applies to new installations and to alterations or extensions of existing equipment.

1.3.2 Chapters 1 through 8 apply to equipment described in subsequent chapters except as modified by those chapters.

1.3.3 Chapter 7 applies to all operating fluid heaters.

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

1.4.1 Unless otherwise specified, the provisions of this recommended practice 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 recommended practice. Where specified, the provisions of this recommended practice 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 should be permitted to apply retroactively any portions of this recommended practice deemed appropriate.

1.4.3 The retroactive recommendations of this recommended practice should 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 recommended practice 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 recommended practice.

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

1.5.2 The system, method, or device should 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 recommended practice 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 recommended practice is followed by an equivalent value in other units, the first stated value is the recommendation. 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 recommended practice and should be considered part of the recommendations 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*, 2013 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2010 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2011 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2013 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2012 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2013 edition.

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2013 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2014 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2011 edition.

NFPA 54, *National Fuel Gas Code*, 2015 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2014 edition.

NFPA 79, *Electrical Standard for Industrial Machinery*, 2015 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2011 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2015 edition.

2.3 Other Publications.

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

API 560, *Fired Heaters for General Refinery Services*, 2007.

API RP 556, *Instrumentation and Control Systems for Fired Heaters and Steam Generators*, 1997.

API RP 2001, *Fire Protection in Refineries*, 2005.

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

ANSI/ASME Boiler and Pressure Vessel Code, 2007.

ANSI/ASME B31.1, *Power Piping*, 2007.

ANSI/ASME B31.3, *Process Piping*, 2008.

ANSI/ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers*, 2006.

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

ASTM D 396, *Standard Specifications for Fuel Oils*, 2009.

2.3.4 IEC Publications. International Electrical Commission, 3 rue de Varembe, P.O. Box 131, CH - 1211, Geneva 20, Switzerland.

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

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

UL 795, *Standard for Commercial-Industrial Gas Heating Equipment*, 2011.

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

2.4 References for Extracts in Recommendation Sections.

NFPA 54, *National Fuel Gas Code*, 2015 edition.

NFPA 70®, *National Electrical Code®*, 2014 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2013 edition.

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*, 2012 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. Merriam-Webster's Collegiate Dictionary, 11th edition, is 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 evaluation 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. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which 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 *Manual of Style for NFPA Technical Committee Documents*.

3.3 General Definitions.

3.3.1 Automatic Fire Check. A flame arrester equipped with a check valve to shut off the fuel gas supply automatically if a backfire occurs. [86, 2015]

3.3.2 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, 2015]

3.3.3 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.

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

3.3.4* 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.

3.3.5 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, 2013]

3.3.6 Combustion Safeguard. A safety control directly responsive to flame properties that senses the presence or absence of flame and de-energizes the fuel safety shutoff valve in the event of flame failure.

3.3.7 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 recommended safety interlocks and the excess temperature limit controller(s).

3.3.8 Controller.

3.3.8.1 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 func-

tions to control, through digital or analog inputs and outputs, various types of machines or processes. [86, 2015]

3.3.8.2 Temperature Controller. A device that measures the temperature and automatically controls the input of heat into the fluid heater.

3.3.9 Emergency Shutoff Valve. A manual shutoff valve to allow the fuel to be turned off in an emergency.

3.3.10 Equipment Isolation Valve. A manual shutoff valve for shutoff of the fuel to each piece of equipment.

3.3.11 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).

3.3.12 Fluid Heater.

3.3.12.1 Class F Fluid Heater. A heater that has fluid inside the tubes with essentially constant fluid flow rate and where the outlet temperature of the fluid is controlled by modulating the heat input rate to the heater.

3.3.12.2 Class G Fluid Heater. A heater that has fluid inside the tubes with modulated fluid flow rate (e.g., by process demand) and where the outlet temperature of the fluid is controlled by modulating the heat input rate to the heater.

3.3.12.3 Class H Fluid Heater. A heater that has the heat source (combustion or electricity) inside the tube(s) with fluid surrounding the tube.

3.3.13 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, 2012]

3.3.14 Fuel Oil. Grades 2, 4, 5, or 6 fuel oils as defined in ASTM D 396, *Standard Specifications for Fuel Oils*.

3.3.15 Gas Analyzer. A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture. [86, 2015]

3.3.16 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: Article 100]

3.3.17* Hardwired. The method of interconnecting signals or interlocks to a logic system or between logic systems using a dedicated interconnection for each individual signal.

3.3.18 Interlock.

3.3.18.1 Excess Temperature Limit Interlock. A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point.

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

3.3.19 Lower Flammable Limit (LFL). See 3.3.11, *Flammable Limits*.

3.3.20 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.



3.3.21 Mixer.

3.3.21.1 Air–Fuel Gas Mixer. A mixer that combines air and fuel gas in the proper proportions for combustion. [86, 2015]

3.3.21.2 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, 2015]

3.3.22 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. Mixing machines operated at 10 in. w.c. (2.49 kPa) or less static pressure are considered mixing blowers. [86, 2015]

3.3.23 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, 2015]

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

3.3.25 Pilot. A flame that is used to light the main burner. [86, 2015]

3.3.25.1 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, 2015]

3.3.26 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]. [54, 2015]

3.3.27 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, 2015]

3.3.28 Resistance Heating System. A heating system in which heat is produced by current flow through a resistive conductor. [86, 2015]

3.3.29 Safe-Start Check. A checking circuit incorporated in a safety-control circuit that prevents light-off if the flame-sensing relay of the combustion safeguard is in the unsafe (flame-present) position due to component failure within the combustion safeguard or due to the presence of actual or simulated flame. [86, 2015]

3.3.30 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. [86, 2015]

3.3.31 Safety Relay. A relay listed for safety service. [86, 2015]

3.3.32 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.

3.3.33 Scf. One cubic foot of gas at 70°F (21°C) and 14.7 psia (an absolute pressure of 101 kPa). [86, 2015]

3.3.34 Switch.

3.3.34.1 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, 2015]

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

3.3.34.3 Flow Switch. A switch that is activated by the flow of a fluid in a duct or piping system. [86, 2015]

3.3.34.4 Pressure Switch.

3.3.34.4.1 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.

3.3.34.4.2 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, 2015]

3.3.34.4.3 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, 2015]

3.3.34.5* Proof-of-Closure Switch. Non-field-adjustable switch installed in a safety shutoff valve by the manufacturer that activates only after the valve is fully closed.

3.3.35 Tank.

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

3.3.36 Trial-for-Ignition Period (Flame-Establishing Period).

The interval of time during light-off that a safety control circuit allows the fuel safety shutoff valve to remain open before the combustion safeguard is required to supervise the flame. [86, 2015]

3.3.37* Valve Proving System. A system used to check the closure of safety shutoff valves by detecting leakage. [86, 2015]

3.3.38 Vent Limiter. A fixed orifice that limits the escape of gas from a vented device into the atmosphere. [86, 2015]

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 should be submitted for approval to the authority having jurisdiction.

4.1.1.1 Plans should 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 should be included.

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

4.1.2 Any deviation from this recommended practice should require special permission from the authority having jurisdiction.

4.1.3 Electrical.

4.1.3.1* All wiring should be in accordance with *NFPA 70, National Electrical Code*, *NFPA 79, Electrical Standard for Industrial Machinery*, and as described hereafter.

4.1.3.2 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 should be installed.

4.1.3.3 Wiring and equipment installed in hazardous (classified) locations should comply with the applicable requirements of *NFPA 70, National Electrical Code*.

4.1.3.4* The installation of a fluid heater in accordance with this recommended practice should not in and of itself require a change to the classification of the fluid heater location.

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 should be accessible to the operator.

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

4.2.3 The warning label should 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 should not be used unless such mixtures are in accordance with recommendations of the manufacturer of the fluids.

4.3.2* When a fluid is being changed from one fluid type to another, a study should be performed to determine that all aspects of the system are compatible with the new fluid.

Chapter 5 Location and Construction

5.1 Location.

5.1.1 General.

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

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

5.1.1.3 Fluid heaters should 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 should 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 should be located at or above grade and should 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 should consider the minimum pumpable viscosity of the fluid.

5.1.2 Structural Members of the Building.

5.1.2.1 Fluid heaters should 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 should 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 should be located so as to minimize exposure to power equipment, process equipment, and sprinkler risers.

5.1.3.2 Unrelated stock and combustible materials should 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 should be provided.

5.1.3.3.1 A minimum 1 in. (25 mm) clearance should 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) should be provided.

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

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

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

5.1.3.6 Equipment should 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 should be provided above and on all sides for inspection, maintenance, and operational purposes.

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

5.1.4.3* Fluid heaters should 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 should be provided with a noncombustible, nonporous surface to prevent floors from becoming soaked with oil.



5.1.4.5 Means should 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 should be located to allow access for removal of tubes.

5.2* Fluid Heater Design.

5.2.1 Fluid heaters and related equipment should 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 should be constructed of non-combustible material.

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

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

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

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

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

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

5.2.7 Radiation shields, refractory material, and insulation should 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) should 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 should be located or guarded to prevent injury to personnel.

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

5.2.9 Observation ports or other visual means for observing the operation of individual burners should be provided and should 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 should be equipped with pressure relief.

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

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

5.2.10.3.1 Vent piping should 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 should be sloped so that liquid does not accumulate.

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

5.2.11 The metal frames of fluid heaters should be electrically grounded.

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

5.2.13 Heater components should be designed to allow for thermal expansion.

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

5.2.15 Fluid heater tube materials should 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) should be stamped as 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 should be utilized.

5.2.18 Tubing within the heat transfer area should have welded connections. Tubing or piping outside the heat transfer area should have either flanged or welded connections. Threaded connections can be used outside the heat transfer area for instrument connections and pressure relief valve connections of 1¼ in. (32 mm) and smaller diameter only.

5.2.19 Low point drains and high point vents should be accessible outside the heater.

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

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

5.2.22 Burners should be designed to prevent flame impingement on tubes and tube supports when operating at maximum heat release.

5.2.23 Fluid heaters should be designed to accommodate a specific range of fluid volume and mass and should not be operated outside those ranges.

5.2.24 Fluid heaters should be designed for a specific range of fluid viscosities, densities, and velocities and should not be operated outside those ranges.

5.3* Explosion Mitigation. Explosion hazards should 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 should be admitted to fluid heater rooms and buildings to provide the air volume required for fluid heater safety ventilation and combustion air.

5.4.2 Fans and Motors.

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

5.4.2.2 Fluid heater recirculating and exhaust fans should be designed for the maximum heating system temperature.

5.4.3 Ductwork.

5.4.3.1 Ventilating and exhaust systems, where applicable, should be installed in accordance with NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, or NFPA 54, *National Fuel Gas Code*, unless otherwise noted in this recommended practice.

5.4.3.2 Wherever fluid heater exhaust ducts or stacks pass through combustible walls, floors, or roofs, noncombustible insulation, clearance, or both should 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 should be sealed with noncombustible material to maintain the fire-resistance rating of the barrier.

5.4.3.4 Ducts should be constructed entirely of sheet steel or other noncombustible material capable of meeting the intended installation and conditions of service, and the installation should be protected where subject to physical damage.

5.4.3.5* No portions of the building should be used as an integral part of the duct.

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

5.4.3.7 All ducts should be braced where required and should be supported by metal hangers or brackets.

5.4.3.8 Stacks should be properly braced and should not be supported with guy wires.

5.4.3.9 Hand holes for inspection or other purposes should be equipped with tight-fitting doors or covers.

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

5.4.3.11 Exhaust ducts should 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 should 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 should 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 should be welded.

5.5.1.3.1 Flange connections should be limited to pump, valve, boundary limit, spool, and equipment connections.

5.5.1.3.2 Threaded connections should be limited to instruments and other miscellaneous connections less than 1 in. (25 mm).

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

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

5.5.1.6 The system design should accommodate the thermal expansion of the pipe.

5.5.1.7* The system should be pneumatically tested with dry air prior to being filled with fluid.

5.5.1.8 Thermal insulation used on pipes and equipment should 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 should be nonabsorbent.

5.5.1.8.2 Flanges, pumps, and equipment requiring routine maintenance should not be insulated.

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

5.5.1.8.4 Insulation should be applied only after a full heating cycle.

5.5.1.9 It is recommended that shielding be provided against hot fluid sprays in the event that a gasket or seal fails.

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

5.5.3 Fluid heater systems should 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 should 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 should be suitable for the specified range of design conditions.

5.6.2 Internal electrical insulation material should 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 should be designed to minimize warpage due to expansion and contraction.

5.7.2 To prevent fluid heater damage, baffles, reflectors, and internal component supports should 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 should 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 should be grounded.

6.1.3 Pilot burners should be considered burners, and all provisions of Section 6.2 or Section 6.3 should 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, should 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 should provide a supply of clean 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 should not be mixed with the combustion air supply.

6.2.3.3 The recommendation of 6.2.3.2 should not exclude the use of flue gas recirculation systems specifically designed to accommodate such recirculation.

6.2.3.4* Where combustion air is provided by a fan or blower, combustion airflow or fan discharge pressure and damper position should 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.

6.2.3.5 Where a burner register air adjustment is provided, adjustment should 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 should be provided that meets the following requirements:

- (1) It should 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 should be readily accessible.
- (3) It should have permanently affixed visual indication of the valve position.
- (4) A removable handle should be permitted provided all the following requirements are satisfied:
 - (a) The valve position is clearly indicated whether the handle is attached or detached.
 - (b) The valve handle is 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 should 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 should comply with NFPA 58, *Liquefied Petroleum Gas Code*.

6.2.4.3 Piping from the point of delivery to the equipment isolation valve should comply with NFPA 54, *National Fuel Gas Code*. (See 6.2.5.2.)

6.2.4.4 An equipment isolation valve should be provided.

6.2.5 Equipment Fuel Gas Piping.

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

- (1) They should be provided for each piece of equipment.
- (2) They should have permanently affixed visual indication of the valve position.
- (3) They should be quarter-turn valves with stops.
- (4) Wrenches or handles should remain affixed to valves and should be oriented with respect to the valve port to indicate the following:
 - (a) An open valve when the handle is parallel to the pipe
 - (b) A closed valve when the handle is perpendicular to the pipe
- (5) They should be readily accessible.
- (6) Valves with removable wrenches should not allow the wrench handle to be installed perpendicular to the fuel gas line when the valve is open.
- (7) They should 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 should be in accordance with NFPA 54, *National Fuel Gas Code*.

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

6.2.6 Control of Contaminants.

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

6.2.6.2 Sediment traps should 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 6.2.6.2.

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

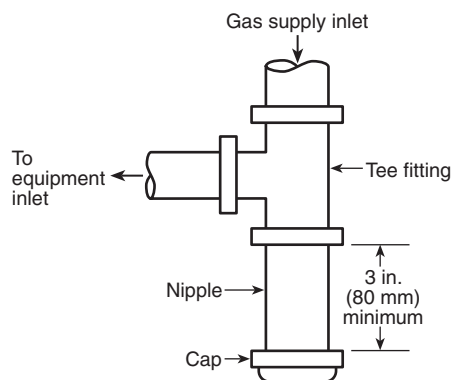


FIGURE 6.2.6.2 Method of Installing a Tee-Fitting Sediment Trap.

6.2.7 Pressure Regulators, Pressure Relief Valves, and Pressure Switches.

6.2.7.1 A pressure regulator should 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 6.2.7.2.

6.2.7.2 An automatic flow control valve is permitted to meet the recommendation of 6.2.7.1, provided that it can compensate for the full range of expected source pressure variations.

6.2.7.3* Regulators, relief valves, and switches should be vented to an approved location, and the following criteria also should be met:

- (1) Heavier-than-air flammable gases should 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 should be designed to prevent the entry of water and insects without restricting the flow capacity of the vent.

6.2.7.4* Fuel gas regulators, ratio regulators, and zero governors are not 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

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

6.2.7.6 Vent lines from multiple fluid heaters should not be manifolded together.

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

6.2.7.7.1 Vents from systems operating at different pressure control levels should not be manifolded together.

6.2.7.7.2 Vents from systems using different fuel sources should not be manifolded together.

6.2.7.8 The cross-sectional area of the manifold line should 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

6.2.7.9* A vent between safety shutoff valves, where installed:

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

6.2.8 Overpressure Protection.

6.2.8.1 Overpressure protection should 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 single upstream line regulator or service pressure regulator results in a supply pressure exceeding the pressure rating of any downstream component

6.2.8.2 Overpressure protection should 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

6.2.8.3* When a relief valve is used to comply with 8.7.1.10, the relief valve should be a full-capacity relief type.

6.2.8.4 Token relief valves and internal token relief valves should not be permitted to be used as the only overpressure protection device.

6.2.9 Flow Control Valves. Where the minimum or maximum flow of combustion air or fuel gas is critical to the operation of the burner, flow valves should be equipped with limiting means and with a locking device to prevent an unintentional change in the setting.

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

6.2.10.1 Proportional Mixing.

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

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

(C) Fixed orifices are permitted for purposes of balancing.

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



(E) Where a mixing blower is used, safety shutoff valves should be installed in the fuel gas supply and should 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 should 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) should be considered mixing machines.

6.2.10.2 Mixing Machines.

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

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

(C) A separate, manually operated gas valve should 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 should 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 should be located upstream of the inlets of the automatic fire checks.

(E)* A backfire arrester with a safety blowout device should 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 should be installed in the fuel gas supply and should 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 should 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 should 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 should be maintained within design ranges throughout the firing cycle.

6.2.11.4 Burners should 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 should have a transition from pilot flame to main flame.

(B) Burners that cannot be ignited at all firing rates should have provision to reduce the burner firing rates during light-off to a lower level, which ensures ignition of the main flame without flashback or blowoff.

6.2.12 Fuel Ignition.

6.2.12.1* The ignition source (e.g., electric spark, hot wire, pilot burner, handheld torch) should be applied at the design location with the designed intensity to ignite the air-fuel mixture.

6.2.12.2 Fixed ignition sources should be mounted to prevent unintentional changes in location and in direction with respect to the main flame.

6.2.12.3 Pilot burners should be considered burners, and all provisions of Section 6.2 should apply.

6.2.13 **Dual-Fuel and Combination Burners.** Where fuel gas and liquid fuel are to be fired individually (dual-fuel) or simultaneously (combination), the provisions of Sections 6.2, 6.3, and 8.12 apply equally to the respective fuels.

6.3 Liquid Fuel-Fired Units.

6.3.1* **Scope.** Section 6.3 applies to the following:

- (1) Fluid heating systems fired with liquid fuels such as the following:
 - (a) No. 2 fuel oil (as specified by ASTM D 396, *Standard Specifications for Fuel Oils*)
 - (b) No. 4 fuel oil (as specified by ASTM D 396)
 - (c) No. 5 fuel oil (as specified by ASTM D 396)
 - (d) No. 6 fuel oil (as specified by ASTM D 396)
 - (e) Ethanol
- (2) Liquid fuel-burning portions of dual-fuel or combination burners

6.3.2 **General.** Burners, along with associated valving, safety controls, and other auxiliary components, should be selected for the type and pressure of the liquid fuel to be used and for the temperatures to which they are subjected.

6.3.3* Combustion Air.

6.3.3.1 The fuel-burning system design should provide for a supply of clean combustion air delivered in the amounts prescribed by the fluid heater designer or burner manufacturer across the full range of burner operation.

6.3.3.2 Products of combustion should not be mixed with the combustion air supply.

6.3.3.3 The recommendation of 6.3.3.2 should not exclude the use of flue gas recirculation systems specifically designed to accommodate such recirculation.

6.3.3.4 Where combustion air is provided by a fan or blower, combustion airflow or fan discharge pressure and damper position should be proven and interlocked with the safety shutoff valves so that the fuel cannot be admitted prior to establishment of combustion air and so that the fuel is shut off in the event of combustion air failure.

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

6.3.4 Fuel Supply Piping.

6.3.4.1 The liquid fuel supply to a fluid heater should be capable of being shut off at a location remote from the fluid heater so that fire or explosion at the fluid heater does not prevent access to the liquid fuel shutoff.

6.3.4.2 The liquid fuel shutoff should be by either of the following:

- (1) Emergency shutoff valve that meets the following requirements:
 - (a) It should be remotely located away from the fluid heater so that fire or explosion at a fluid heater does not prevent access to this valve.
 - (b) It should be readily accessible.
 - (c) It should have permanently affixed visual indication of the valve position.
 - (d) A removable handle should be permitted provided all the following requirements are satisfied:
 - i. The valve position is clearly indicated whether the handle is attached or detached.
 - ii. The valve handle is 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.
- (2) Means for removing power to the positive displacement liquid fuel pump

6.3.4.3 Where a shutoff is installed in the discharge line of a fuel pump that is not an integral part of a burner, a pressure relief valve should be connected to the discharge line between the pump and the shutoff valve and arranged to return surplus fuel to the supply tank or to bypass it around the pump, unless the pump includes an internal bypass.

6.3.4.4* All air from the supply and return piping should be purged initially, and air entrainment in the fuel should be minimized.

6.3.4.5 Suction, supply, and return piping should be sized with respect to fuel pump capacity.

6.3.4.6* Where a section of fuel piping can be shut off at both ends, relief valves or expansion chambers should be installed to release the pressure caused by thermal expansion of the fuel.

6.3.4.7 An equipment isolation valve should be provided.

6.3.5 Equipment Fuel Piping.

6.3.5.1 Manual shutoff valves should comply with the following:

- (1) Individual manual shutoff valves for equipment isolation should be provided for shutoff of the fuel to each piece of equipment.
- (2) Manual shutoff valves should be installed to avoid fuel spillage during servicing of supply piping and associated components.
- (3) Manual shutoff valves should display a visual indication of the valve position.
- (4) Quarter-turn valves with removable wrenches should not allow the wrench handle to be installed perpendicular to the liquid fuel line when the valve is open.
- (5) The user should keep separate wrenches (handles) affixed to valves and keep the wrenches oriented with respect to the valve port to indicate the following:
 - (a) An open valve when the handle is parallel to the pipe
 - (b) A closed valve when the handle is perpendicular to the pipe

(6)*Valves should be maintained in accordance with the manufacturer's instructions.

(7) Lubricated valves should be lubricated and subsequently leak tested for valve closure at least annually.

6.3.5.2 Liquid fuel piping materials should be in accordance with NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

6.3.5.3 Liquid fuel piping should be sized to provide flow rates and pressure to maintain a stable flame over the burner operating range.

6.3.5.4* Filters and Strainers. A filter or strainer should meet the following criteria:

- (1) Be selected for the maximum operating pressure and temperature anticipated
- (2) Be selected to filter particles larger than the most critical clearance in the liquid fuel system
- (3) Be installed in the liquid fuel piping system downstream of the equipment isolation valve and upstream of all other liquid fuel piping system components

6.3.5.5 Pressure Regulation. Where the fuel pressure exceeds that required for burner operation or where the fuel pressure is subject to fluctuations, either a pressure regulator or an automatic flow control valve that can compensate for the full range of expected source pressure variations should be installed.

6.3.5.6* Pressure Gauges. Pressure gauges should be isolated or protected from pulsation damage during operation of the burner system.

6.3.6 Flow Control Valves. Where the minimum or maximum flow of combustion air or the liquid fuel is critical to the operation of the burner, flow valves should be equipped with a limiting means and with a locking device to prevent an unintentional change in the setting.

6.3.7 Fuel Atomization.

6.3.7.1* Fuel should be atomized to droplet sizes required for combustion throughout the firing range.

6.3.7.2 The atomizing device should be accessible for inspection, cleaning, repair, replacement, and other maintenance, as required.

6.3.8 Liquid Fuel Burners.

6.3.8.1 All burners should 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.

6.3.8.2 All pressures required for the operation of the combustion system should be maintained within design ranges throughout the firing cycle.

6.3.8.3 All burners should be supplied with liquid fuel of the type and grade for which they have been designed and with liquid fuel that has been preconditioned, where necessary, to the viscosity required by the burner design. Burners should be used only with the fuels for which they are designed.

6.3.8.4 Burners should 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.

