2010 Annual Revision Cycle

Report on Proposals

A compilation of NFPA® Technical
Committee Reports on Proposals
for public review and comment

Public Comment Deadline: September 4, 2009

NOTE: The proposed NFPA documents addressed in this Report on Proposals (ROP) and in a follow-up Report on Comments (ROC) will only be presented for action when proper Amending Motions have been submitted to the NFPA by the deadline of April 9, 2010. The June 2010 NFPA Conference & Expo will be held June 7–10, 2010 at the Mandalay Bay Convention Center, Las Vegas, NV. During the meeting, the Association Technical Meeting (Tech Session) will be held June 9–10, 2010. Documents that receive no motions will not be presented at the meeting and instead will be forwarded directly to the Standards Council for action on issuance. For more information on the rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org) or contact NFPA Standards Administration.

National Fire Protection Association®

1 BATTERYMARCH PARK, QUINCY, MA 02169-7471

ISSN 1079-5332

Information on NFPA Codes and Standards Development

I. Applicable Regulations. The primary rules governing the processing of NFPA documents (codes, standards, recommended practices, and guides) are the NFPA *Regulations Governing Committee Projects (Regs)*. Other applicable rules include NFPA *Bylaws*, NFPA *Technical Meeting Convention Rules*, NFPA *Guide for the Conduct of Participants in the NFPA Standards Development Process*, and the NFPA *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council*. Most of these rules and regulations are contained in the *NFPA Directory*. For copies of the *Directory*, contact Codes and Standards Administration at NFPA Headquarters; all these documents are also available on the NFPA website at "www.nfpa.org."

The following is general information on the NFPA process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

II. Technical Committee Report. The Technical Committee Report is defined as "the Report of the Technical Committee and Technical Correlating Committee (if any) on a document. A Technical Committee Report consists of the Report on Proposals (ROP), as modified by the Report on Comments (ROC), published by the Association."

III. Step 1: Report on Proposals (ROP). The ROP is defined as "a report to the Association on the actions taken by Technical Committees and/or Technical Correlating Committees, accompanied by a ballot statement and one or more proposals on text for a new document or to amend an existing document." Any objection to an action in the ROP must be raised through the filing of an appropriate Comment for consideration in the ROC or the objection will be considered resolved.

IV. Step 2: Report on Comments (ROC). The ROC is defined as "a report to the Association on the actions taken by Technical Committees and/or Technical Correlating Committees accompanied by a ballot statement and one or more comments resulting from public review of the Report on Proposals (ROP)." The ROP and the ROC together constitute the Technical Committee Report. Any outstanding objection following the ROC must be raised through an appropriate Amending Motion at the Association Technical Meeting or the objection will be considered resolved.

V. Step 3a: Action at Association Technical Meeting. Following the publication of the ROC, there is a period during which those wishing to make proper Amending Motions on the Technical Committee Reports must signal their intention by submitting a Notice of Intent to Make a Motion. Documents that receive notice of proper Amending Motions (Certified Amending Motions) will be presented for action at the annual June Association Technical Meeting. At the meeting, the NFPA membership can consider and act on these Certified Amending Motions as well as Follow-up Amending Motions, that is, motions that become necessary as a result of a previous successful Amending Motion. (See 4.6.2 through 4.6.9 of *Regs* for a summary of the available Amending Motions and who may make them.) Any outstanding objection following action at an Association Technical Meeting (and any further Technical Committee consideration following successful Amending Motions, see *Regs* at 4.7) must be raised through an appeal to the Standards Council or it will be considered to be resolved.

VI. Step 3b: Documents Forwarded Directly to the Council. Where no Notice of Intent to Make a Motion (NITMAM) is received and certified in accordance with the Technical Meeting Convention Rules, the document is forwarded directly to the Standards Council for action on issuance. Objections are deemed to be resolved for these documents.

VII. Step 4a: Council Appeals. Anyone can appeal to the Standards Council concerning procedural or substantive matters related to the development, content, or issuance of any document of the Association or on matters within the purview of the authority of the Council, as established by the *Bylaws* and as determined by the Board of Directors. Such appeals must be in written form and filed with the Secretary of the Standards Council (see 1.6 of *Regs*). Time constraints for filing an appeal must be in accordance with 1.6.2 of the *Regs*. Objections are deemed to be resolved if not pursued at this level.

VIII. Step 4b: Document Issuance. The Standards Council is the issuer of all documents (see Article 8 of *Bylaws*). The Council acts on the issuance of a document presented for action at an Association Technical Meeting within 75 days from the date of the recommendation from the Association Technical Meeting, unless this period is extended by the Council (see 4.8 of *Regs*). For documents forwarded directly to the Standards Council, the Council acts on the issuance of the document at its next scheduled meeting, or at such other meeting as the Council may determine (see 4.5.6 and 4.8 of *Regs*).

IX. Petitions to the Board of Directors. The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the codes and standards development process and to protect the interests of the Association. The rules for petitioning the Board of Directors can be found in the *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council* and in 1.7 of the *Regs*.

X. For More Information. The program for the Association Technical Meeting (as well as the NFPA website as information becomes available) should be consulted for the date on which each report scheduled for consideration at the meeting will be presented. For copies of the ROP and ROC as well as more information on NFPA rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org) or contact NFPA Codes & Standards Administration at (617-984-7246).

2010 Annual Revision Cycle ROP Contents

by NFPA Numerical Designation

Note: Documents appear in numerical order.

TYPES OF ACTION

P Partial Revision **C** Complete Revision **N** New Document **R** Reconfirmation **W** Withdrawal

2010 Annual Revision Cycle ROP
Committees Reporting

COMMITTEE MEMBER CLASSIFICATIONS[1,2,3,4]

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M Manufacturer: A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.

2. U User: A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.

3. IM Installer/Maintainer: A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.

4. L Labor: A labor representative or employee concerned with safety in the workplace.

5. RT Applied Research/Testing Laboratory: A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.

6. E Enforcing Authority: A representative of an agency or an organization that promulgates and/or enforces standards.

7. I Insurance: A representative of an insurance company, broker, agent, bureau, or inspection agency.

8. C Consumer: A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).

9. SE Special Expert: A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: “Standard” connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of “Utilities” in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

FORM FOR COMMENT ON NFPA REPORT ON PROPOSALS
2010 ANNUAL REVISION CYCLE
FINAL DATE FOR RECEIPT OF COMMENTS: 5:00 pm EDST, September 4, 2009

For further information on the standards-making process, please contact the Codes and Standards Administration at 617-984-7249 or visit www.nfpa.org/codes.

For technical assistance, please call NFPA at 1-800-344-3555.

FOR OFFICE USE ONLY

Log #: ____________

Date Rec'd: ____________

Please indicate in which format you wish to receive your ROP/ROC ☐ **electronic** ☐ **paper** ☒ **download**

(Note: If choosing the download option, you must view the ROP/ROC from our website; no copy will be sent to you.)

Date 8/1/200X **Name** John B. Smith **Tel. No.** 253-555-1234

Company ____________ **Email** ____________

Street Address 9 Seattle St. **City** Tacoma **State** WA **Zip** 98402

******If you wish to receive a hard copy, a street address MUST be provided. Deliveries cannot be made to PO boxes.***

Please indicate organization represented (if any) Fire Marshals Assn. of North America

1. (a) NFPA Document Title National Fire Alarm Code **NFPA No. & Year** NFPA 72, 200X ed.

(b) Section/Paragraph 4.4.1.1

2. Comment on Proposal No. (from ROP): 72-7

3. Comment Recommends (check one): ☐ new text ☐ revised text ☒ deleted text

4. Comment (include proposed new or revised wording, or identification of wording to be deleted): [Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (<u>inserted wording</u>) and strike-through to denote wording to be deleted (~~deleted wording~~).]

Delete exception.

5. Statement of Problem and Substantiation for Comment: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Comment, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

A properly installed and maintained system should be free of ground faults. The occurrence of one or more ground faults should be required to cause a 'trouble' signal because it indicates a condition that could contribute to future malfunction of the system. Ground fault protection has been widely available on these systems for years and its cost is negligible. Requiring it on all systems will promote better installations, maintenance and reliability.

6. Copyright Assignment

(a) ☒ **I am the author of the text or other material (such as illustrations, graphs) proposed in the Comment.**

(b) ☐ **Some or all of the text or other material proposed in this Comment was not authored by me. Its source is as follows:** (please identify which material and provide complete information on its source)

____

I hereby grant and assign to the NFPA all and full rights in copyright in this Comment and understand that I acquire no rights in any publication of NFPA in which this Comment in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Comment and that I have full power and authority to enter into this assignment.

Signature (Required) ____________

PLEASE USE SEPARATE FORM FOR EACH COMMENT

Mail to: Secretary, Standards Council · National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

5/27/2009

FORM FOR COMMENT ON NFPA REPORT ON PROPOSALS
2010 ANNUAL REVISION CYCLE
FINAL DATE FOR RECEIPT OF COMMENTS: 5:00 pm EDST, September 4, 2009

For further information on the standards-making process, please contact the Codes and Standards Administration at 617-984-7249 or visit www.nfpa.org/codes.

For technical assistance, please call NFPA at 1-800-344-3555.

FOR OFFICE USE ONLY

Log #: ________

Date Rec'd: ________

Please indicate in which format you wish to receive your ROP/ROC ☐ **electronic** ☐ **paper** ☒ **download**

(Note: If choosing the download option, you must view the ROP/ROC from our website; no copy will be sent to you.)

Date ________ **Name** ________ **Tel. No.** ________

Company ________ **Email** ________

Street Address ________ **City** ________ **State** ________ **Zip** ________

******If you wish to receive a hard copy, a street address MUST be provided. Deliveries cannot be made to PO boxes.***

Please indicate organization represented (if any) ________

1. (a) NFPA Document Title ________ **NFPA No. & Year** ________

(b) Section/Paragraph ________

2. Comment on Proposal No. (from ROP): ________

3. Comment Recommends (check one): ☐ new text ☒ revised text ☐ deleted text

4. Comment (include proposed new or revised wording, or identification of wording to be deleted): [Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

5. Statement of Problem and Substantiation for Comment: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Comment, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

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____

I hereby grant and assign to the NFPA all and full rights in copyright in this Comment and understand that I acquire no rights in any publication of NFPA in which this Comment in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Comment and that I have full power and authority to enter into this assignment.

Signature (Required) ________

PLEASE USE SEPARATE FORM FOR EACH COMMENT

Mail to: Secretary, Standards Council · National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

5/27/2009

Sequence of Events Leading to Issuance of an NFPA Committee Document

Step 1 Call for Proposals

▼ Proposed new document or new edition of an existing document is entered into one of two yearly revision cycles, and a Call for Proposals is published.

Step 2 Report on Proposals (ROP)

▼ Committee meets to act on Proposals, to develop its own Proposals, and to prepare its Report.

▼ Committee votes by written ballot on Proposals. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.

▼ Report on Proposals (ROP) is published for public review and comment.

Step 3 Report on Comments (ROC)

▼ Committee meets to act on Public Comments to develop its own Comments, and to prepare its report.

▼ Committee votes by written ballot on Comments. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.

▼ Report on Comments (ROC) is published for public review.

Step 4 Association Technical Meeting

▼ *"Notices of intent to make a motion"* are filed, are reviewed, and valid motions are certified for presentation at the Association Technical Meeting. ("Consent Documents" that have no certified motions bypass the Association Technical Meeting and proceed to the Standards Council for issuance.)

▼ NFPA membership meets each June at the Association Technical Meeting and acts on Technical Committee Reports (ROP and ROC) for documents with "certified amending motions."

▼ Committee(s) vote on any amendments to Report approved at NFPA Annual Membership Meeting.

Step 5 Standards Council Issuance

▼ Notification of intent to file an appeal to the Standards Council on Association action must be filed within 20 days of the NFPA Annual Membership Meeting.

▼ Standards Council decides, based on all evidence, whether or not to issue document or to take other action, including hearing any appeals.

The Association Technical Meeting

The process of public input and review does not end with the publication of the ROP and ROC. Following the completion of the Proposal and Comment periods, there is yet a further opportunity for debate and discussion through the Association Technical Meeting that takes place at the NFPA Annual Meeting.

The Association Technical Meeting provides an opportunity for the final Technical Committee Report (i.e., the ROP and ROC) on each proposed new or revised code or standard to be presented to the NFPA membership for the debate and consideration of motions to amend the Report. The specific rules for the types of motions that can be made and who can make them are set forth in NFPA's rules, which should always be consulted by those wishing to bring an issue before the membership at an Association Technical Meeting. The following presents some of the main features of how a Report is handled.

The Filing of a Notice of Intent to Make a Motion. Before making an allowable motion at an Association Technical Meeting, the intended maker of the motion must file, in advance of the session, and within the published deadline, a Notice of Intent to Make a Motion. A Motions Committee appointed by the Standards Council then reviews all notices and certifies all amending motions that are proper. The Motions Committee can also, in consultation with the makers of the motions, clarify the intent of the motions and, in certain circumstances, combine motions that are dependent on each other together so that they can be made in one single motion. A Motions Committee report is then made available in advance of the meeting listing all certified motions. Only these Certified Amending Motions, together with certain allowable Follow-Up Motions (that is, motions that have become necessary as a result of previous successful amending motions) will be allowed at the Association Technical Meeting.

Consent Documents. Often there are codes and standards up for consideration by the membership that will be noncontroversial and no proper Notices of Intent to Make a Motion will be filed. These "Consent Documents" will bypass the Association Technical Meeting and head straight to the Standards Council for issuance. The remaining documents are then forwarded to the Association Technical Meeting for consideration of the NFPA membership.

What Amending Motions Are Allowed. The Technical Committee Reports contain many Proposals and Comments that the Technical Committee has rejected or revised in whole or in part. Actions of the Technical Committee published in the ROP may also eventually be rejected or revised by the Technical Committee during the development of its ROC. The motions allowed by NFPA rules provide the opportunity to propose amendments to the text of a proposed code or standard based on these published Proposals, Comments, and Committee actions. Thus, the list of allowable motions include motions to accept Proposals and Comments in whole or in part as submitted or as modified by a Technical Committee action. Motions are also available to reject an accepted Comment in whole or part. In addition, Motions can be made to return an entire Technical Committee Report or a portion of the Report to the Technical Committee for further study.

The NFPA Annual Meeting, also known as the NFPA Conference & Expo, takes place in June of each year. A second Fall membership meeting was discontinued in 2004, so the NFPA Technical Committee Report Session now runs once each year at the Annual Meeting in June.

Who Can Make Amending Motions. NFPA rules also define those authorized to make amending motions. In many cases, the maker of the motion is limited by NFPA rules to the original submitter of the Proposal or Comment or his or her duly authorized representative. In other cases, such as a Motion to Reject an accepted Comment, or to Return a Technical Committee Report or a portion of a Technical Committee Report for Further Study, anyone can make these motions. For a complete explanation, the NFPA Regs should be consulted.

Action on Motions at the Association Technical Meeting. In order to actually make a Certified Amending Motion at the Association Technical Meeting, the maker of the motion must sign in at least an hour before the session begins. In this way a final list of motions can be set in advance of the session. At the session, each proposed document up for consideration is presented by a motion to adopt the Technical Committee Report on the document. Following each such motion, the presiding officer in charge of the session opens the floor to motions on the document from the final list of Certified Amending Motions followed by any permissible Follow-Up Motions. Debate and voting on each motion proceeds in accordance with NFPA rules. NFPA membership is not required in order to make or speak to a motion, but voting is limited to NFPA members who have joined at least 180 days prior to the Association Technical Meeting and have registered for the meeting. At the close of debate on each motion, voting takes place, and the motion requires a majority vote to carry. In order to amend a Technical Committee Report, successful amending motions must be confirmed by the responsible Technical Committee, which conducts a written ballot on all successful amending motions following the meeting and prior to the document being forwarded to the Standards Council for issuance.

Standards Council Issuance

One of the primary responsibilities of the NFPA Standards Council, as the overseer of the NFPA codes and standards development process, is to act as the official issuer of all NFPA codes and standards. When it convenes to issue NFPA documents, it also hears any appeals related to the document. Appeals are an important part of assuring that all NFPA rules have been followed and that due process and fairness have been upheld throughout the codes and standards development process. The Council considers appeals both in writing and through the conduct of hearings at which all interested parties can participate. It decides appeals based on the entire record of the process as well as all submissions on the appeal. After deciding all appeals related to a document before it, the Council, if appropriate, proceeds to issue the document as an official NFPA code or standard. Subject only to limited review by the NFPA Board of Directors, the decision of the Standards Council is final, and the new NFPA code or standard becomes effective twenty days after Standards Council issuance.

Report of the Committee on

Ovens and Furnaces

Richard A. Gallagher, *Chair*
Zurich Services Corporation, DE [I]

Richard J. Martin, *Secretary*
Exponent, Inc., CA [SE]

Gary S. Andress, Liberty Mutual Property, MA [I]
Randy P. Bal, Delphi Corporation, MI [U]
John J. Barron, Solar Atmospheres Manufacturing, Inc., PA [M]
David W. Collier, Eclipse, Inc., IL [M]
John Dauer, Siemens Building Technologies, IL [M]
James J. Garmaker, 3 M Company [U]
Thomas B. George, Visteon Corporation [U]
David D. Herron, CMI EFCO, Inc., OH [M]
John E. Higginbotham, Alcoa, Inc., TN [U]
Ted Jablkowski, Fives North American Combustion, Inc., CT [M]
Rep. Industrial Heating Equipment Association
Kai-Eric Jensen, Jensen Industries, Inc., MI [M]
Gary D. Keil, Caterpillar Incorporated, IL [U]
William M. Keough, AFC - Holcroft, MI [M]
Peter B. Matthews, Hartford Steam Boiler Inspection & Insurance Company, CT [I]
Raymond Ostrowski, Consultant-Industrial Safety, AZ [SE]
Michael C. Polagye, FM Global, MA [I]
John R. Puskar, CEC Combustion Safety, Inc., OH [SE]
Jeffrey T. Rafter, Honeywell/Maxon Corporation, IN [M]
Raymond E. Serafini, Jr., BOC Gases, PA [IM]
J. William Sheppard, General Motors Corporation, MI [U]
Rep. NFPA Industrial Fire Protection Section
Mark V. Stender, Surface Combustion, Inc., OH [M]
Franklin R. Switzer, Jr., S-afe, Inc., IN [SE]
Grant F. Tiefenbruck, 3M Company, MN [U]
Jay D. Tindall, Paragon Risk Engineering, PA [I]
Algirdas Underys, A. Finkl & Sons Inc., IL [U]
Rep. Forging Industry Association
Peter J. Willse, XL Global Asset Protection Services, CT [I]

Alternates

Bryan R. Baesel, CEC Combustion Safety, Inc., OH [SE]
(Alt. to John R. Puskar)
Kevin J. Carlisle, Karl Dungs Inc., MN [M]
(Alt. to Ted Jablkowski)
Erik W. Christiansen, Exponent, Inc., CA [SE]
(Alt. to Richard J. Martin)
Randall Conklen, Caterpillar Incorporated, IL [U]
(Alt. to Gary D. Keil)
Dan Curry, Eclipse, Inc., IL [M]
(Alt. to David W. Collier)
Robert Daley, Solar Atmospheres Manufacturing, Inc., PA [M]
(Alt. to John J. Barron)
James J. Garmaker, 3M Company, MN [U]
(Alt. to Grant F. Tiefenbruck)
Brent D. Hill, Liberty Mutual Property, TX [I]
(Alt. to Gary S. Andress)
Jeffrey M. Hunt, Alcoa, Inc., VA [U]
(Alt. to John E. Higginbotham)
Jerry D. Jablonski, Delphi Corporation, MI [U]
(Alt. to Randy P. Bal)
Glen R. Mortensen, Zurich Services Corporation, IL [I]
(Alt. to Richard A. Gallagher)
David S. Neff, Honeywell/Maxon Corporation, IN [M]
(Alt. to Jeffrey T. Rafter)
Lee M. Rebodos, Paragon Risk Engineering, TX [I]
(Alt. to Jay D. Tindall)
Glen N. Schwartz, General Motors Corporation, MI [U]
(Alt. to J. William Sheppard)
Dennis Szabo, XL Global Asset Protection Services, GA [I]
(Alt. to Peter J. Willse)

Staff Liaison: **Theodore C. Lemoff**

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding against fire and explosion hazards associated with industrial ovens, furnaces, and related equipment that are used in the processing of combustible or non-combustible materials in the presence of air, vacuum, or other special atmospheres and are heated by electricity, fossil fuels, or other heating sources.

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the front of this book.

The Technical Committee on **Ovens and Furnaces** is presenting Two Reports for adoption, as follows:

Report I: The Technical Committee proposes for adoption, amendments to NFPA 86, **Standard for Ovens and Furnaces**, 2007 edition. NFPA 86-2007 is published in Volume 6 of the 2009 National Fire Codes and in separate pamphlet form.

The report on NFPA 86 has been submitted to letter ballot of the **Technical Committee on Ovens and Furnaces**, which consists of 27 voting members. The results of the balloting, after circulation of any negative votes, can be found in the report.

Report II: The Technical Committee proposes for adoption, a new document to NFPA 87, **Recommended Practice for Fluid Heaters**, 2011 edition

The report on NFPA 87 has been submitted to letter ballot of the **Technical Committee on Ovens and Furnaces**, which consists of 27 voting members. The results of the balloting, after circulation of any negative votes, can be found in the report.

87-1 Log #CP1 **Final Action: Accept**
(Entire Document)

Submitter: Technical Committee on Ovens and Furnaces,
Recommendation: Add as follows:

The Technical Committee on Ovens and Furnaces proposes a new document, NFPA 87, *Recommended Practice for Fluid Heaters* as shown at the end of this report.

Substantiation: Currently, there is no single document that addresses fluid heaters, and designers and installers have used both NFPA 85, *Boiler and Combustion Systems Hazards Code*, and NFPA 86, *Standard for Ovens and Furnaces*, for fluid heaters. The committee has developed this recommended practice based on existing material from general industry practices. This document will provide the minimum fire protection requirements for fired heaters.

Committee Meeting Action: Accept

Number Eligible to Vote: 26

Ballot Results: Affirmative: 17

Ballot Not Returned: 9 Andress, G., Barron, J., Dauer, J., Herron, D., Jablkowski, T., Keough, W., Ostrowski, R., Serafini, Jr., R., Tindall, J.

Comment on Affirmative:

MARTIN, R.: **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.

COMMENT: Annex Material should be included that mentions State Pressure Vessel Inspector as one possible AHJ, in addition to Insurer and/or Fire Department.

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.

COMMENT: Create new Annex material with a sample of the required data form.

5.2.16 Heater pressure vessels operating at pressures greater than l5 psig should be stamped as ASME Code Section I or ASME Section VIII Division 1 vessels.

COMMENT: Current guidance fails to designate which stamp (“U”, “H”, or “S”) is required. Need to check Uniform Mechanical Code to address possible conflict.

9.2.5.12 Pressurized expansion tanks should have a low inert gas pressure alarm set at a value determined by the fluid supplier.

COMMENT: Are listed switches commercially available for this environment?

5.2.18 Joints. Tubing within the heater should have welded connections. Tubing or piping outside the heater should have either flanged or welded connections. Threaded connections should never be used inside the heater.

COMMENT: Current wording is misleading - tubing inside is first required to be “welded” then it is seemingly permitted to be anything but threaded. Some manufacturers use threaded connections for gauges and instruments outside the combustion chamber. Also, since the combustion chamber is sometimes only partially enclosed (e.g., insulated sheet metal covers with open bottom), the terms “inside” and “outside” may be unclear.

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

COMMENT: Baffles and reflectors should be accessible ~~and~~ or removable...

8.7.2.2* Where the main or pilot fuel gas burner system capacity exceeds 400,000 Btu/hr (1 17 kW), at least one of the safety shutoff valves between each burner and the fuel supply should be proved closed and interlocked with the preignition purge interval.

(A) A proved closed condition is accomplished by either of the following means:

(l) A proof-of-closure switch

(2) A valve proving system

(B) Auxiliary and closed position indicator switches do not satisfy the proved closed recommendation of 8.7.2.2(A).

COMMENT: Review and address whether this requirement is consistent with UL 795
and ASME CSD-I. Question - is the hazard associated with gas leakage in a medium-sized fluid heater more consistent with boiler hazards or oven/furnace hazards.

8.3.2.2* Electrical power for safety control circuits should be DC or single-phase AC, 250 volt
maximum, one-side grounded, with all breaking contacts in the ungrounded, fuse-protected, or circuit breaker-protected line.

COMMENT: NFPA 86 and NFPA 87 should review the maximum voltage for control circuits. The maximum voltage permitted in CSD-I (Section CE-l l0) is 150 V.

A.8.3.2.2 This control circuit and its non-furnace-mounted or furnace-mounted control and safety components should be housed in a dust-tight panel or cabinet, protected by partitions or secondary barriers, or separated by sufficient spacing from electrical controls employed in the higher voltage furnace power system. Related instruments might or might not be installed in the same control cabinet. The door providing access to this control enclosure might include means for mechanical interlock with the main disconnect device required in the furnace power supply circuit. Temperatures within this control enclosure should be limited to 125°F (52°C) for suitable operation of plastic components, thermal elements, fuses, and various mechanisms that are employed in the control circuit.

COMMENT: Many controls are rated to 140°F. Should the 125°F be increased?

8.4.1.2 Natural Draft Purging. When no combustion air blower or exhaust blower is provided, a natural draft purge is permissible provided all of the following conditions are satisfied:

(A)* A permanently installed, interlocked combustible gas analyzer is provided that samples the firebox atmosphere in a location selected to account for the characteristics of the heater and the fuel(s) used; and

(B) Means are provided for proving that inlet air registers and outlet dampers are in the fully-open position to admit air

COMMENT: This may not be consistent with UL 795 and CSD-1.

8.7.1.11 Local visual position indication should be provided at each safety shutoff valve to burners or pilots in excess of 150,000 Btu/hr (44 kW).

COMMENT: This was taken from NFPA 86, but it may not be consistent with UL 795.

NFPA 87

Recommended Practice for Fluid Heaters

2011 Edition

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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 mandatory sections of the document are given in Chapter 2 and those for extracts in 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 Types F, G, and 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 or ASME CSD-1)
(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 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
1.1.4 This recommended practice does not apply to the following:
(1)* Coal or other solid fuel-firing systems
(2) Listed equipment with a heating system(s) that supplies a total input not exceeding 150,000 Btu/hr (44 kW)
1.1.5 The following types of heaters are covered by this standard:
(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 or to alterations or extensions to 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 should 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 should be 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 requirements 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 prescribed 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 this document.
2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2007 edition.
NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2005 edition.
NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2005 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2007 edition.
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2007 edition.
NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2002 edition.
NFPA 17A, *Standard for Wet Chemical Extinguishing Systems,* 2002 edition.
NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.
NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.
NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2006 edition.
NFPA 54, *National Fuel Gas Code,* 2006 edition.
NFPA 58, *Liquefied Petroleum Gas Code,* 2004 edition.
NFPA 70, *National Electrical Code®,* 2005 edition.
NFPA 79, *Electrical Standard for Industrial Machinery,* 2007 edition.
NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.
NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2006 edition.

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

ANSI/ASME *Boiler and Pressure Vessel Code,* 2004.
ANSI/ASME B31.1, *Power Piping,* 2004.
ANSI/ASME B31.3, *Process Piping,* 2002.
ANSI/ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers,* 2006.

2.3.2 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.

2.3.3 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,* 2005.

2.3.4 Other Publications.

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

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 Shall. Indicates a mandatory requirement.
3.2.6 Should. Indicates a recommendation or that which is advised but not required.
3.2.7 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 shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.
3.2.8 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.
3.3 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**, 2007]
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. [86-2007]
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. [**86**, 2007]
3.3.4 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,** 2006]
3.3.5 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. [**86**, 2007]
3.3.6 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).
3.3.7 Controller.
3.3.7.1 ***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**, 2007]
3.3.7.2 ***Temperature Controller.*** A device that measures the temperature and automatically controls the input of heat into the fluid heater.
3.3.8 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,** 2003]
3.3.9 Fuel Oil. Grades 2, 4, 5, or 6 fuel oils as defined in ASTM D 396, *Standard Specifications for Fuel Oils*. [**86**, 2007]
3.3.10 Fluid Heater.
3.3.10.1 ***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.
3.3.10.2 ***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.
3.3.10.3 ***Class H Fluid Heater.*** A heater that has the heat source (combustion or electricity) inside the tube(s) with fluid surrounding the tube.
3.3.11 Explosive Range. 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 explosive limit (LEL), and the highest flammable concentration known as the upper explosive limit (UEL). [**86,** 2007]
3.3.12 Gas Analyzer. A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture. [**86,** 2007]
3.3.13 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,** 2005]
3.3.14 Interlock.
3.3.14.1 ***Excess Temperature Limit Interlock.*** A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point.
3.3.14.2 ***Safety Interlock.*** A device required to ensure safe start-up and safe operation and to cause safe equipment shutdown.
3.3.15 Lower Explosive Limit (LEL). See 3.3.11, Explosive Range.
3.3.16 Mixer.
3.3.16.1 ***Air–Fuel Gas Mixer.*** A mixer that combines air and fuel gas in the proper proportion for combustion. [**86**, 2007]
3.3.16.2 ***Proportional Mixer.*** A mixer comprised of 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**, 2007]
3.3.17 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**, 2007]
3.3.18 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**, 2007]
3.3.19 Operator. An individual trained and responsible for the start-up, operation, shutdown, and emergency handling of the fluid heater and associated equipment. [**86**, 2007]
3.3.20 Pilot. A flame that is used to light the main burner. [**86**, 2007]
3.3.20.1 ***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**, 2007]
3.3.21 Pressure Regulator. A device placed in a gas line for reducing, controlling, and maintaining the pressure in that portion of the piping system downstream of the device. [**54,** 2006]
3.3.22 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**, 2007]
3.3.23 Resistance Heating System. A heating system in which heat is produced by current flow through a resistive conductor. [**86**, 2007]
3.3.24 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**, 2007]
3.3.25 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**, 2007]
3.3.26 Safety Relay. A relay listed for safety service. [**86**, 2007]
3.3.27 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.
3.3.28 Scf. One cubic foot of gas at 70°F (21°C) and 14.7 psia (an absolute pressure of 101 kPa). [**86**, 2007]
3.3.29 Switch.
3.3.29.1 ***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**, 2007]
3.3.29.2 ***Differential Pressure Switch.*** A switch that is activated by a differential pressure that is detected by comparing the pressure at two different points.
3.3.29.3 ***Flow Switch.*** A switch that is activated by the flow of a fluid in a duct or piping system. [**86**, 2007]
3.3.29.4 ***Pressure Switch.***
3.3.29.4.1 ***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. [**86**, 2007]
3.3.29.4.2 ***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**, 2007]
3.3.29.4.3 ***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**, 2007]
3.3.29.5* ***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. [**86**, 2007]
3.3.30 Tank.
3.3.30.1 ***Catch Tank.*** A tank used to capture liquid from drains, relief valves, vents, and overflows.
3.3.30.2 ***Expansion Tank.*** A reservoir that allows expansion of a liquid to occur as the liquid is heated.
3.3.31 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**, 2007]
3.3.32* Valve Proving System. A system used to check the closure of safety shutoff valves by detecting leakage. [**86**, 2007]
3.3.33 Vent Limiter. A fixed orifice that limits the escape of gas from a vented device into the atmosphere. [**86**, 2007]

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 Wiring and equipment installed in hazardous (classified) locations should comply with the applicable requirements of NFPA 70, *National Electrical Code*.
4.1.3.3* 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 changing 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 18in. (450 mm) clearance for un-insulated 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 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 Fluid heaters should be located with space above and on all sides for inspection and maintenance purposes.
5.1.4.2 In addition to the requirement of 5.1.4.1, when applicable, adequate space should be provided for the installation of extinguishing systems, and 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 noncombustible 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 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 psig should be stamped as ASME 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 heater should have welded connections. Tubing or piping outside the heater should have either flanged or welded connections. Threaded connections should never be used inside the heater.
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 these 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 these 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 recirculation 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 or 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 noncombustible walls, floors, or partitions, the space around the duct should be sealed with noncombustible material to maintain the fire 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 enter a building.
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, piping materials should be in accordance with ANSI/ASME B31.1, Power Piping, or ANSI/ASME B31.3, *Process Piping*.
5.5.1.3* Flanged and threaded connections in the flow circuit should be minimized.
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 filling with fluid.
5.5.1.8 Thermal insulation used on pipes and equipment should be selected for the intended purpose and compatible with the fluid.
5.5.1.8.1 The thermal insulation selected should be nonabsorbent where there is a potential for fluid system leaks.
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 only be applied 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) Located for ease of observation, adjustment, and maintenance
(2) 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 Baffles, reflectors, and internal component supports should be designed to minimize warpage due to expansion and contraction to prevent fluid heater damage.
5.7.2 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 to prevent fluid heater damage.
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 purpose 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* A remotely located shutoff valve should be provided to allow the fuel to be turned off in an emergency and should be located so that fire or explosion at the fluid heater does not prevent access to this valve.
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.)*
6.2.5 Equipment Fuel Gas Piping.
6.2.5.1 Individual manual shutoff valves for equipment isolation should be provided for shutoff of the fuel to each piece of equipment.
(A) Manual shutoff valves should have permanently affixed visual indication of the valve position.
(B) Quarter-turn valves should not allow the wrench handle to be perpendicular to the fuel gas line when the valve is open.
(C) Wrenches or handles should remain affixed to valves.
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.

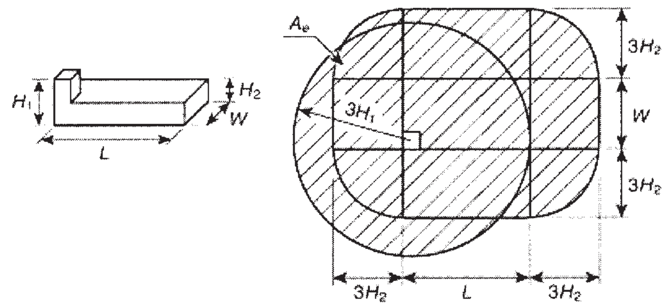

Figure 6.2.6.2 Method of Installing a Tee Fitting Sediment Trap.

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.

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 or 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 (LEL) 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.

6.2.7.8 The size of the vent manifold specified in 6.2.7.8 should be not less than the area of the largest vent line plus 50 percent of the additional vent line area.

6.2.8 Flow Control Valves. Where the minimum or the maximum flow of combustion air or the 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.

6.2.9* Air–Fuel Gas Mixers. Subsection 6.2.9 applies only to mixtures of fuel gas with air.

6.2.9.1 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 6.2.9.2(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.

6.2.9.2 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 6.2.9.3(C) 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.

6.2.10 Fuel Gas Burners.

6.2.10.1 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.

6.2.10.2 Burners should be used only with the fuels for which they are designed.

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

6.2.10.4 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 blow-off.

6.2.11 Fuel Ignition.

6.2.11.1* 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.

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

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

6.2.12 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) A remotely located liquid fuel shutoff valve
(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.
6.3.5 Equipment Fuel Piping.
6.3.5.1 Manual Shutoff Valves should comply with the following:
(A) Individual manual shutoff valves for equipment isolation should be provided for shutoff of the fuel to each piece of equipment.
(B) Manual shutoff valves should be installed to avoid fuel spillage during servicing of supply piping and associated components.
(C) Manual shutoff valves should display a visual indication of the valve position.
(D) 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.
(E) 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:
(1) An open valve when the handle is parallel to the pipe
(2) A closed valve when the handle is perpendicular to the pipe
(F)* Valves should be maintained in accordance with the manufacturer's instructions.
(G) 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 maintain a stable flame over the burner operating range.
6.3.5.4* Filters and Strainers. A filter or strainer should be as follows:
(1) Selected for the maximum operating pressure and temperature anticipated
(2) Selected to filter particles larger than the most critical clearance in the liquid fuel system
(3) 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 the 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.
(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 blow-off.
6.3.8.5 If purging of fuel passages upon termination of a firing cycle is required, it should be done prior to shutdown, with the initial ignition source present and with all associated fans and blowers in operation.
6.3.9 Fuel Ignition.
6.3.9.1* The ignition source should be applied at the design location with the design intensity to ignite the air–fuel mixture.
6.3.9.2 Fixed ignition sources should be mounted so as to prevent unintentional changes in location and in direction with respect to the main flame.
6.3.10 Dual-Fuel and Combination Burners. Where fuel gas and liquid fuel are fired individually (dual-fuel) or simultaneously (combination), the provisions of Sections 6.2, 6.3, and 8.12 should apply equally to the respective fuels.
6.4 Oxygen-Enhanced Fuel-Fired Units. For guidance regarding oxygen-enhanced fuel fired units, refer to NFPA 86.
6.5 Flue Product Venting. Means should be provided to ensure ventilation of the products of combustion from fuel-fired equipment.
6.6 Electrically Heated Units.
6.6.1 Scope. Section 6.6 should apply to all types of heating systems where electrical energy is used as the source of heat.
6.6.2 Safety Equipment. Safety equipment, including airflow interlocks, time relays, and temperature switches, should be in accordance with Chapter 8.
6.6.3 Electrical Installation. All parts of the electrical installation should be in accordance with *NFPA 70, National Electrical Code*.
6.6.4 Resistance Heating Systems.
6.6.4.1 The provisions of 6.6.4 should apply to resistance heating systems, including infrared lamps, such as quartz, ceramic, and tubular glass types.
6.6.4.2 Resistance heating systems shall be constructed in accordance with the following:
(A) The heater housing should be constructed so as to provide access to heating elements and wiring.
(B) Heating elements and insulators should be supported securely or fastened so that they do not become easily dislodged from their intended location.
(C) Heating elements that are electrically insulated from and supported by a metallic frame should have the frame electrically grounded.
(D) Open-type resistor heating elements should be supported by electrically insulated hangers and should be secured to prevent the effects of motion induced by thermal stress, which could result in adjacent segments of the elements touching one another, or the effects of touching a grounded surface.
(E) External parts of heaters that are energized at voltages that could be hazardous as specified in *NFPA 70, National Electrical Code*, should be guarded.

Chapter 7 Commissioning, Operations, Maintenance, Inspection, and Testing

7.1 Scope. Chapter 7 applies to safety systems and their application to fluid heaters.
7.2 Commissioning.
7.2.1* Commissioning is recommended for all new installations or for any changes that impact the safety system.
7.2.2 The party responsible should ensure that all pertinent apparatus is installed and connected in accordance with the system design.
7.2.3 The party responsible should not release the fluid heater for operation before the installation and checkout of the recommended safety systems have been successfully completed.
7.2.4 The party responsible should ensure that any changes to the original design made during commissioning are reflected in the documentation.
7.2.5* The party responsible should ensure that set points of all safety interlocks are documented.
7.2.6* The party responsible should perform a test of the fire protection system to verify proper functioning of all interlocks and actuators.
7.2.7 The party responsible should verify that distribution piping for the extinguishing agent is unobstructed.
7.2.8* If hazardous conditions can result from the presence of air, water, and other contaminants, they should be removed from the fluid system prior to charging.
7.2.9* The fluid should be added to the heater system according to the heater manufacturer's instructions.
7.2.10* Initial preheating and operation of the heater should be conducted according to the heater manufacturer's instructions.
7.2.11 Minimum fluid flow should be established before the burner is operated.
7.3 Training.
7.3.1* The personnel responsible for operating, maintaining, and supervising the fluid heater should be thoroughly instructed and trained in their respective job functions under the direction of a qualified person(s).
7.3.2 The personnel responsible for operating, maintaining, and supervising the fluid heater should be required to demonstrate understanding of the equipment, its operation, and the practice of safe operating procedures in their respective job functions.
7.3.3 Operating, maintenance, and supervisory personnel should receive regularly scheduled retraining and testing.
7.3.4* The training program should cover startup, operation, shutdown, maintenance, and emergency procedures in detail.
7.3.5 The training program should be kept current with changes in equipment and operating procedures, and training materials should be available for reference.
7.4 Operations.
7.4.1 The fluid heater should be operated in accordance with the design parameters.

7.4.2 Operating instructions that include all of the following should be provided by the parties responsible for the system design:
(1) Design limits (maximum and minimum) on process parameters such as firing rate, turndown, fluid flow rates, and fluid characteristics
(2) Schematic piping and wiring diagrams and instrument configurations
(3) Startup procedures
(4) Shutdown procedures
(5) Emergency procedures occasioned by loss of essential utilities, such as electric power, instrument air, and inert gas
(6) Emergency procedures occasioned by process upsets, such as low fluid flow, excess firebox temperature, and indicators of fluid-fed fires
(7) Maintenance procedures, including interlock and valve tightness testing

7.4.3* When the original equipment manufacturer no longer exists, the user should develop inspection, testing, and maintenance procedures.
7.4.4 The user should establish plant operating procedures that cover normal and emergency conditions, and the use of fire protection equipment.
7.4.4.1 Plant operating procedures should be directly applicable to the equipment involved and should be consistent with safety requirements and the manufacturer's recommendations.
7.4.4.2 Plant operating procedures should be kept current with changes in equipment and processes.
7.4.4.3 Where different modes of operation are possible, plant operating procedures should be prepared for each operating mode and for switching from one mode to another.
7.4.5 Personnel should have access to operating instructions at all times.
7.4.6 Plant operating procedures should prohibit the removal or disabling of safety devices.
7.4.7* The system should be operated within the limits specified by the manufacturer of the heat transfer fluid and by the manufacturer of the heater.
7.5 Inspection, Testing, and Maintenance.
7.5.1 Safety devices should be maintained in accordance with the manufacturer's instructions.
7.5.2 It should be the responsibility of the fluid heater manufacturer to provide instructions for inspection, testing, and maintenance.
7.5.3* For recirculating fluid systems, this should include instructions for inspection, testing, and maintenance of the heat transfer fluid.
7.5.3.1 If indications of fluid overheating or contamination are observed, an investigation should be performed to evaluate and eliminate the cause of the overheating and contamination. The fluid should be drained from the heater and evaluated.
7.5.3.2 If there are indications that the material being heated is infiltrating into the fluid loop, an investigation should be performed to determine the internal leakage point identified.
7.5.3.3 The fluid should be replaced if the fluid testing results indicate an unacceptable level of degradation or contamination.
7.5.4 It should be the responsibility of the user to establish, schedule, and enforce the frequency and extent of the inspection, testing, and maintenance program, as well as the corrective action to be taken.
7.5.5* A test of the fire protection system to verify proper functioning of all interlocks and actuators should be performed annually.
7.5.6 Fluid and fuel leaks should be repaired promptly.
7.5.7 Fluid spills and releases should be cleaned promptly, and fluid-soaked insulation should be replaced.
7.5.8* Pressure relief valves should be tested in accordance with applicable codes and regulations.
7.5.9 When cleaning the inside or outside of heater tubes, such cleaning should not adversely affect tube integrity.
7.5.10 All safety interlocks should be tested for function at least annually.
7.5.11* The set point of temperature, pressure, or flow devices used as safety interlocks should be verified at least annually.
7.5.12 Safety device testing should be documented at least annually.
7.5.13 Explosion relief devices, if installed, should be visually inspected at least annually to ensure that they are unobstructed and properly labeled.
7.5.14 Pressure relief devices should be tested at least annually to ensure that they are functioning properly.
7.5.15* Valve seat leakage testing of fuel gas safety shutoff valves should be performed in accordance with the manufacturer's instructions. Testing frequency should be at least annually.
7.5.16 Manual shutoff valves should be maintained in accordance with the manufacturer's instructions.
7.5.17* Lubricated manual shutoff valves should be lubricated and subsequently leak tested for valve closure at least annually.
7.5.18 The temperature indication of the excess temperature controller should be verified to be accurate, at least annually.
7.5.19 Whenever any safety interlock is replaced, it should be tested for function.
7.5.20 Whenever any temperature, pressure, or flow device used as a safety interlock is replaced, the setpoint should be verified.
7.5.21 An inspection should be completed at least annually to verify that all designed safety interlocks are present and have not been bypassed or rendered ineffective.
7.6 Record Retention. Records of inspection, testing, and maintenance activities should be retained for the period of 1 year or until the next inspection, testing, or maintenance activity, whichever is longer.
7.7* Procedures. The user's operational and maintenance program should include procedures that apply to worker safety in accordance with all applicable regulations.

Chapter 8 Heating System Safety Equipment and Application

8.1 Scope.
8.1.1 Chapter 8 applies to safety equipment and its application to the fluid heater heating system.
8.1.2 Section 8.3 should be applied to all safety controls included in this recommended practice.
8.1.3* For the purpose of this chapter, the term *heating system* includes the heating source, associated piping, wiring, and controls used to heat the fluid heater and the fluid therein.
8.2 General.
8.2.1 All safety devices should be one of the following:
(1) Listed for the service intended
(2) Approved, where listed devices are not available
(3) Programmable controllers applied in accordance with 8.3.3

8.2.2 Safety devices should be applied and installed in accordance with this recommended practice and the manufacturer's instructions.
8.2.3 Electric relays should not be used as substitutes for electrical disconnects, and safety shutoff valves should not be used as substitutes for manual shutoff valves.
8.2.4 Regularly scheduled inspection, testing, and maintenance of all safety devices should be performed. *(See Section 7.5.)*
8.2.5 Safety devices should be installed, used, and maintained in accordance with the manufacturer's instructions.
8.2.6 Safety devices should be located or guarded to protect them from physical damage.
8.2.7 Safety devices should not be bypassed electrically or mechanically.
8.2.7.1 The requirement in 8.2.7 should not prohibit safety device testing and maintenance in accordance with 8.2.4. Where a system includes a "built-in" test mechanism that bypasses any safety device, it should be interlocked to prevent operation of the system while the device is in the test mode, unless listed for that purpose.
8.2.7.2 The requirement in 8.2.7 should not prohibit a time delay applied to the action of pressure proving, flow proving, or proof-of-closure safety switch as used in accordance with 8.7.1.3(2)(c), where the following conditions exist:
(1) There is an operational need demonstrated for the time delay.
(2) The use of a time delay is approved.
(3) The time delay feature is not adjustable beyond 5 seconds.
(4) A single time delay does not serve more than one pressure-proving or flow-proving safety device.
(5) The time from an abnormal pressure or flow condition until the holding medium is removed from the safety shutoff valves does not exceed 5 seconds.

8.2.8* A manual emergency switch should be provided to initiate a safety shutdown.
8.3* Logic Systems.
8.3.1 General.
8.3.1.1 Purge, ignition trials, and other burner safety sequencing should be performed using either devices listed for such service or programmable controllers used in accordance with 8.3.3.
8.3.1.2 The activation of any safety interlock recommended in Chapter 8 should result in a safety shutdown.
8.3.2 Hardwired Logic Systems.
8.3.2.1 Safety interlocks should be in accordance with one or more of the following:
(1) Hardwired without relays in series ahead of the controlled device
(2) Connected to an input of a programmable controller logic system complying with 8.3.3
(3) Connected to a relay that represents a single safety interlock configured to initiate safety shutdown in the event of power loss
(4) Connected to a listed safety relay that represents one or more safety interlocks and initiates safety shutdown upon power loss

8.3.2.2* Electrical power for safety control circuits should be DC or single-phase AC, 250 volt maximum, one-side grounded, with all breaking contacts in the ungrounded, fuse-protected, or circuit breaker–protected line.
8.4* Programmable Logic Controller Systems.
8.4.1 Programmable logic controller–based systems listed for combustion safety service should be used in accordance with the listing requirements and the manufacturer's instructions.
8.4.1.1 Programmable logic controllers except those listed for combustion safety service should be used in accordance with 8.4.2 through 8.4.4.
8.4.2 General.
8.4.2.1 Before the programmable logic controller is placed in operation, documentation should be provided that confirms all related safety devices and safety logic are functional.
8.4.2.2 All changes to hardware or software should be documented and maintained in a file that is separate from the fluid heater programmable controller.
8.4.2.3 System operation should be tested and verified for compliance with the design criteria when the programmable logic controller is replaced, repaired, or updated.

8.4.2.4 The control system should have at least one manual emergency switch that initiates a safety shutdown.
8.4.2.5 The programmable logic controller should detect the following conditions:
(1) Failure to execute any program or task containing safety logic
(2) Failure to communicate with any safety input or output
(3) Changes in software set points of safety functions
(4) Failure of outputs related to safety functions
(5) Failure of timing related to safety functions
8.4.2.6 A safety shutdown should occur within 3 seconds of detecting any condition listed in 8.3.3.2.1(E).
8.4.2.7 A dedicated programmable logic controller output should initiate a safety shutdown for faults detected by the programmable logic controller.
8.4.2.8 The following devices and logic should be hardwired external to the programmable logic controller as follows:
(1) Manual emergency switch
(2) Combustion safeguards
(3) Safe start checks
(4) Ignition transformers
(5) Trial-for-ignition periods
(6) Excess temperature controllers
(7) Valve proving systems
8.4.2.9 A combustion safeguard should directly control at least one safety shutoff valve between the fuel gas supply and the monitored burner.
8.4.2.10 Where airflow proving logic is performed in the programmable logic controller, the logic should include the following:
(1) Verification of a change of state in each airflow proving device during the startup of the related ventilation equipment
(2) Initiation of a safety shutdown if a change of state in an airflow proving device is not detected
8.4.3 Hardware.
8.4.3.1 Memory that retains information on loss of system power should be provided for software.
8.4.3.2 The programmable logic controller should have a minimum mean time between failure rating of 250,000 hours.
8.4.3.3 Only one safety device should be connected to a programmable logic controller input or output.
8.4.3.4 Output checking should be provided for programmable logic controller outputs controlling fuel safety shutoff valves.
8.4.4 Software.
8.4.4.1 Access to the programmable logic controller and its logic should be restricted to authorized personnel.
8.4.4.2 The following power supplies should be monitored:
(1) Power supplies used to power programmable logic controller inputs and outputs that control fluid heater safety functions
(2) Power supplies used to power pressure and flow transmitters recommended by 8.3.3.4
8.4.4.3 When any power supply recommended by 8.4.4.2(1) fails, the dedicated programmable logic controller output recommended in 8.4.2.7 should be deactivated.
8.4.4.4 When the voltage of any power supply recommended by 8.4.4.2(2) is detected outside the manufacturer's recommended range, the dedicated programmable logic controller output recommended in 8.4.2.7 should be deactivated.
8.4.4.5 Software should be documented as follows:
(1) Labeled to identify elements or group of elements containing safety software
(2) Labeled to describe the function of each element containing safety software
8.4.4.6 A listing of the program with documentations should be available.
8.4.5 Programmable logic controllers that do not comply with 8.4.1 or 8.4.1.2 should comply with the following:
(1) The programmable logic controller should not perform required safety functions.
(2) The programmable logic controller should not interfere with or prevent the operation of the safety interlocks.
(3) Only isolated programmable logic controller contacts should be used in the required safety circuits.
8.4.6 Where programmable logic controller–based systems use flow transmitters in place of flow switches and pressure transmitters in place of pressure switches for safety functions, the following should apply:
(1) The transmitter should be listed, possess a minimum mean time between failure rating of 250,000 hours, or possess a safety integrity level rating of 2.
(2) Upon transmitter failure the programmable logic controller should detect the failure and initiate a safety shutdown.
(3) The transmitter should be dedicated to safety service unless listed for simultaneous process and safety service.
8.5 Safety Control Application for Fuel-Fired Heating Systems.
8.5.1 Pre-ignition Purging. Prior to each heating system startup, provision should be made for the removal of all flammable vapors and gases that have entered the heating chambers during the shutdown period.
8.5.1.1 Mechanical Purging. When a combustion air blower or exhaust blower is provided, a timed pre-ignition purge should be provided that incorporates all of the following:
(1) At least 4 standard cubic feet (scf) of fresh air or inert gas per cubic foot (4 m^3/m^3) of system volume is introduced during the purging cycle.
(2) The system volume includes the heating chambers and all other passages that handle the recirculation and exhaust of products of combustion.
(3) To begin the timed pre-ignition purge interval, both of the following conditions are satisfied:
(a) The minimum required pre-ignition purge airflow is proved.
(b) The safety shutoff valve(s) is proved closed.
(4) The minimum required pre-ignition purge airflow is proved and maintained throughout the timed pre-ignition purge interval.
(5) Failure to maintain the minimum required pre-ignition purge airflow stops the pre-ignition purge and resets the purge timer.
8.5.1.1.1 Prior to the re-ignition of a burner after a burner shutdown or flame failure, a pre-ignition purge should be accomplished.

CAUTION: Repeated ignition attempts can result in a combustible concentration greater than 25 percent of the LEL. Liquid fuels can accumulate, causing additional fire hazards.

8.5.1.1.2 Repeating the pre-ignition purge can be omitted where any one of the following conditions is satisfied:
(1) The heating chamber temperature is proven above 1400°F (760°C).
(2) For any fuel-fired system, all of the following conditions are satisfied:
(a) Each burner and pilot is supervised by a combustion safeguard in accordance with Section 8.9.
(b) Each burner system is equipped with safety shutoff valves in accordance with Section 8.7.
(c) At least one burner remains operating in the common combustion chamber of the burner to be re-ignited.
(3) All of the following conditions are satisfied (does not apply to liquid fuel systems):
(a) Each burner and pilot is supervised by a combustion safeguard in accordance with Section 8.9.
(b) Each burner system is equipped with gas safety shutoff valves in accordance with Section 8.7.
(c) It can be demonstrated that the combustible concentration in the heating chamber and all other passages that handle the recirculation and exhaust of products of combustion cannot exceed 25 percent of the LEL.
8.5.1.2 Natural Draft Purging. When no combustion air blower or exhaust blower is provided, a natural draft purge is permissible provided all of the following conditions are satisfied:
(1)* A permanently installed, interlocked combustible gas analyzer is provided that samples the firebox atmosphere in a location selected to account for the characteristics of the heater and the fuel(s) used:
(2) Means are provided for proving that inlet air registers and outlet dampers are in the fully-open position to admit air.
8.5.1.2.1 The purge should be considered complete when all of the following conditions are satisfied:
(1) The flammable vapor or gas concentration in the combustion chamber is measured to be 25 percent or less of the lower explosive limit of the fuel in air:
(2) The inlet air registers and outlet dampers are proved in the fully-open position.
8.5.2* Trial-for-Ignition Period.
8.5.2.1 The trial-for-ignition period of the pilot burner should not exceed 15 seconds.
8.5.2.2 The trial-for-ignition period of the main gas burner should not exceed 15 seconds, unless both of the following conditions are satisfied:
(1) A written request for an extension of trial for ignition is approved by the authority having jurisdiction.
(2) It is determined that 25 percent of the LEL cannot be exceeded in the extended time.
8.5.2.3 The trial-for-ignition period of the main liquid fuel burner should not exceed 15 seconds.
8.5.2.4 Electrical ignition energy for direct spark ignition systems should be terminated after the main burner trial-for-ignition period.
8.6 Combustion Air Safety Devices.
8.6.1 Where air from the exhaust or recirculating fans is required for combustion of the fuel, airflow should be proved prior to an ignition attempt.
8.6.2 Reduction of airflow to a level below the minimum required level should result in closure of the safety shutoff valves.
8.6.3 Where a combustion air blower is used, the minimum combustion airflow or source pressure needed for burner operation should be proved prior to each attempt at ignition.
8.6.4 Motor starters on equipment required for combustion of the fuel should be interlocked into the combustion safety circuitry.
8.6.5* Combustion air minimum pressure or flow should be interlocked into combustion safety circuitry by any of the following methods:
(1) A low pressure switch that senses and monitors the combustion air source pressure
(2) A differential pressure switch that senses the differential pressure across a fixed orifice in the combustion air system
(3) An airflow switch
8.6.6* Where it is possible for combustion air pressure to exceed the maximum safe operating pressure, a high pressure switch interlocked into the combustion safety circuitry should be used.
8.7 Safety Shutoff Valves (Fuel Gas or Liquid Fuel).

8.7.1 General.

8.7.1.1 Safety shutoff valves are a key safety control to protect against explosions and fires.

8.7.1.2* Each safety shutoff valve recommended in 8.7.2.1 and 8.7.3.1 should automatically shut off the fuel to the burner system after interruption of the holding medium (such as electric current or fluid pressure) by any one of the interlocking safety devices, combustion safeguards, or operating controls, unless otherwise permitted by 8.7.1.3.

8.7.1.3 In fuel gas systems or liquid fuel systems only, where multiple burners or pilots operate as a burner system firing into a common heating chamber, the loss of flame signal at one or more burners should either comply with 8.7.1.2 or should shut off those burner(s) by closing a single safety shutoff valve, where the following conditions are satisfied:

(1) Individual burner safety shutoff valve meets one of the two following conditions:

(a) It is demonstrated, based on available airflow, that failure of the valve to close will result in a fuel concentration not greater than 25 percent of the LEL.

(b) The safety shutoff valve has proof of closure acceptable to the authority having jurisdiction.

(2) The safety shutoff valve upstream of the individual burner safety shutoff valves should close when any of the following conditions occurs:

(a) Upon activation of any operating control or interlocking safety device other than the combustion safeguard

(b) Where the individual burner valves do not have proof of closure as described in 8.7.1.3(1)(b) and the number of failed burners is capable of exceeding 25 percent of the LEL if single burner safety shutoff valves fail in the open position

(c) Where individual burner valves have proof of closure as described in 8.7.1.3(1)(b) and verification that the individual burner safety shutoff valve has closed following loss of flame signal at the burner is not present

(d) Upon loss of flame signal at all burners in the burner system or at a number of burners in the burner system that will result in a fuel concentration greater than 25 percent of the LEL

(e) When the heating chamber is proved at or above 1400°F (760°C) and both of the following conditions exist:

i. Individual burners are shut off by closing a single safety shutoff valve equipped with proof-of-closure switch and proven closed.

ii. If a burner is shut off by closing one safety shutoff valve and that safety shutoff valve is not proven closed, a second safety shutoff valve upstream closes within 5 seconds.

8.7.1.4 Safety shutoff valves should not be used as modulating control valves unless they are designed as both safety shutoff and modulation valves and tested for concurrent use.

8.7.1.5 The use of listed safety shutoff valves designed as both a safety shutoff valve and a modulating valve, and tested for concurrent use, are permitted.

8.7.1.6 Valve components should be of a material selected for compatibility with the fuel handled and for ambient conditions.

8.7.1.7 Safety shutoff valves in systems containing particulate matter or highly corrosive fuel gas should be operated at time intervals in accordance with the manufacturer's instructions in order to maintain the safety shutoff valves in operating condition.

8.7.1.8 Valves should not be subjected to supply pressures in excess of the manufacturer's ratings.

8.7.1.9* Valves should be selected to withstand the maximum anticipated back pressure of the system.

8.7.1.10* If the inlet pressure to a fuel pressure regulator exceeds the pressure rating of any downstream component, overpressure protection should be provided.

8.7.1.11 Local visual position indication should be provided at each safety shutoff valve to burners or pilots in excess of 150,000 Btu/hr (44 kW).

(A) The local visual position indication should directly indicate the physical position, closed and open, of the valve.

(B) Where lights are used for position indication, the absence of light should not be used to indicate open or closed position.

(C) Indirect indication of valve position, such as by monitoring operator current voltage or pressure, should not be permitted.

8.7.2* Fuel Gas Safety Shutoff Valves.

8.7.2.1 Each main and pilot fuel gas burner system should be separately equipped with two safety shutoff valves piped in series.

8.7.2.2* Where the main or pilot fuel gas burner system capacity exceeds 400,000 Btu/hr (117 kW), at least one of the safety shutoff valves between each burner and the fuel supply should be proved closed and interlocked with the preignition purge interval.

(A) A proved closed condition should be accomplished by either of the following means:

(1) A proof-of-closure switch

(2) A valve proving system

(B) Auxiliary and closed position indicator switches do not satisfy the proved closed recommendation of 8.7.2.2(A).

8.7.2.3 Means for testing all fuel gas safety shutoff valves for valve seat leakage should be installed.

8.7.3 Liquid Fuel Safety Shutoff Valves.

8.7.3.1 At least one liquid fuel safety shutoff valve should be provided.

8.7.3.2 Two safety shutoff valves should be used where any one of the following conditions exists:

(1) The pressure is greater than 125 psi (862 kPa).

(2) The liquid fuel pump operates without the main liquid fuel burner firing, regardless of the pressure.

(3) The liquid fuel pump operates during the fuel gas burner operation of combination gas and liquid fuel burners.

8.7.3.3* Where the burner system capacity exceeds 400,000 Btu/hr (117 kW), at least one of the safety shutoff valves between each burner and the fuel supply should be proved closed and interlocked with the pre-ignition purge interval.

8.8 Fuel Pressure Switches (Gas or Liquid Fuel).

8.8.1 A low fuel pressure switch should be provided and should be interlocked into the combustion safety circuitry.

8.8.2 A high fuel pressure switch should be provided and should meet the following criteria:

(1) Be interlocked into the combustion safety circuitry

(2) Be located downstream of the final pressure-reducing regulator

8.8.3 Pressure switch settings should be made in accordance with the operating limits of the burner system.

8.9 Combustion Safeguards (Flame Supervision).

8.9.1 Each burner flame should have a combustion safeguard that has a maximum flame failure response time of 4 seconds or less, that performs a safe-start check, and that is interlocked into the combustion safety circuitry in accordance with the following:

(1) The flame supervision is not required in the combustion safety circuitry of a fluid heater when the combustion chamber temperature is greater than 1400°F (760°C), and the following criteria are met:

(a) When the combustion chamber temperature drops to less than 1400°F (760°C), the burner is interlocked to allow its operation only if flame supervision has been re-established.

(b) A 1400°F (760°C) bypass controller is used to meet the requirement of 8.8.1(1)(a).

(2) Burners without flame supervision are interlocked to prevent their operation when the combustion chamber temperature is less than 1400°F (760°C) by using a 1400°F (760°C) bypass controller.

8.9.2* Flame Supervision. Each pilot and main burner flame should be equipped with flame supervision in one of the following ways:

(1) Main and pilot flames supervised with independent flame sensors

(2) Main and interrupted pilot flames supervised with a single flame sensor

(3)* Self-piloted burner supervised with a single flame sensor

8.10 Liquid Fuel Atomization (Other than Mechanical Atomization).

8.10.1 The pressure of the atomizing medium should be proved and interlocked into the combustion safety circuitry.

8.10.2 The low pressure switch used to supervise the atomizing medium should be located downstream from all valves and other obstructions that can shut off flow or cause pressure drop of atomization medium.

8.10.3 Where the atomizing medium requires modulation, an additional low atomizing medium pressure switch, located upstream of the modulating valve, should be provided to meet the requirements of 8.10.1.

8.11* Liquid Fuel Temperature Limit Devices.
Where equipment is used to regulate liquid fuel temperature, liquid fuel temperature limit devices should be provided and interlocked into the combustion safety circuitry if it is possible for the liquid fuel temperature to rise above or fall below the temperature range required by the burners.

8.12 Multiple Fuel Systems.

8.12.1* Safety equipment in accordance with the requirements of this recommended practice should be provided for each fuel used.

8.12.2 Where dual-fuel burners, excluding combination burners, are used, positive provision should be made to prevent the simultaneous introduction of both fuels.

8.13 Air–Fuel Gas Mixing Machines.

8.13.1 Safety shutoff valves should be installed in the fuel gas supply connection of any mixing machine.

8.13.2 The safety shutoff valves should be arranged to shut off 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.

8.14 Ignition of Main Burners — Fuel Gas or Liquid Fuel.
Where a reduced firing rate is required for ignition of the burner, an interlock should be provided to prove the control valve has moved to the design position prior to each attempt at ignition.

8.15* Stack Excess Temperature Limit Interlock.

8.15.3 A stack excess temperature limit interlock should be provided and interlocked into the combustion safety circuitry.

8.15.4 The stack excess temperature limit interlock should operate before the maximum stack temperature, as specified by the fluid heater manufacturer, is exceeded.

8.15.2.1 Operation of the stack excess temperature limit interlock should cut off the heating system.

8.15.2.2 If the process fluid is combustible, operation of the stack excess temperature limit interlock should also cut off the process fluid supply.

8.15.3 Operation of the stack excess temperature limit interlock should require manual reset before restart of the fluid heater or affected zone.

8.15.4* The temperature-sensing element of the stack excess temperature limit interlock should be selected for the temperature and atmosphere to which they are exposed.

8.15.5* The temperature-sensing element of the stack excess temperature limit interlock should be located where recommended by the fluid heater manufacturer.

8.16 Fluid Excess Temperature Limit Interlock.
8.16.1 All heaters should have the fluid excess temperature measurements on the heater outlet.
8.16.1.1 The temperature-sensing device should be compatible with the fluid being measured and the expected operating temperature and pressure.
8.16.1.2 Temperature-sensing devices should be located so that they are exposed to the stream and are not in a stagnant location or where they might be insulated by deposits.
8.16.2 The fluid excess temperature set point should be set no higher than the maximum temperature specified by the fluid manufacturer, the heater design, or downstream process limits, whichever is lowest.
8.16.3 The fluid excess temperature limit interlock should be provided and interlocked into the combustion safety circuitry.
8.16.4 Operation of the fluid excess temperature limit interlock should require manual reset before restart of the fluid heater or affected zone.
8.16.5 Open-circuit failure of the temperature-sensing components of the fluid excess temperature limit interlock should cause the same response as an excess temperature condition.
8.16.6 Fluid excess temperature interlocks should be equipped with temperature indication.
8.16.7 The fluid excess temperature limit interlock should indicate its set point in temperature units that is consistent with the primary temperature-indicating controller.
8.16.8 The temperature-sensing element of the fluid excess temperature limit interlock can be monitored by other instrumentation, provided that the accuracy of the fluid excess temperature limit interlock temperature reading is not diminished.
8.16.9 The operating temperature controller and its temperature-sensing element should not be used as the fluid excess temperature limit interlock.
8.18 Electrical Heating Systems.
8.18.1 Heating Equipment Controls.
8.18.1.1* Electric heating equipment should be equipped with a main disconnect device or with multiple devices to provide backup circuit protection to equipment and to persons servicing the equipment.
8.18.1.2 The disconnecting device(s) recommended by 8.18.1.1 should be capable of interrupting maximum available fault current as well as rated load current.
8.18.1.3 Shutdown of the heating power source should not affect the operation of equipment such as pumps, ventilation or recirculation fans, cooling components, and other auxiliary equipment, unless specifically designed to do so.
8.18.1.4 Resistance heaters larger than 48 amperes should not be required to be subdivided into circuits of 48 amperes or less.
8.18.1.5* The capacity of all electrical devices used to control energy for the heating load should be selected on the basis of continuous duty load ratings where fully equipped for the location and type of service proposed.
8.18.1.6 All controls using thermal protection or trip mechanisms should be located or protected to preclude faulty operation due to ambient temperatures.
8.18.2* Heating Element Excess Temperature Limit Interlock.
8.18.2.1 An excess temperature limit interlock should be provided and interlocked into the heating element circuitry, unless it can be demonstrated that the maximum temperature limit specified by the element manufacturer cannot be exceeded.
8.18.2.2 Operation of the excess limit interlock should shut off the heating system before the heating element's maximum temperature, as specified by the element manufacturer, is exceeded.
8.18.2.3 Operation of the excess temperature limit interlock should require manual reset before restart of the fluid heater or affected zone.
8.18.2.4 Open circuit failure of the temperature-sensing components of the excess temperature limit interlock should cause the same response as an excess temperature condition.
8.18.2.5* The temperature-sensing components of the excess temperature limit interlock should be rated for the temperature and environment to which they are exposed.
8.18.2.6* The temperature-sensing element of the heating element excess temperature limit interlock should be located where recommended by the heating element manufacturer.

Chapter 9 Class F Heaters

9.1* General.
9.1.1 Class F heaters should be designed for relatively uniform fluid flow through parallel tube passes.
9.1.1.1 Equal flow distribution between passes should be ensured by piping geometry or fixed flow restrictions.
9.1.1.2 Adjustable balancing trim valves should not be used in multipass Class F heaters.
9.1.2 The maximum allowable bulk fluid temperature should be determined based on the maximum allowable fluid film temperature that will prevent rapid fluid degradation.
9.1.3 The heater manufacturer should determine the minimum flow rate, taking into consideration the maximum allowable bulk fluid temperature and the maximum heat input rate.
9.1.4 Where backflow into the heater presents a hazard, a means to prevent backflow should be provided.
9.1.5* The fluid system should be designed so that fluid cannot be trapped in the heated zone.
9.1.6* The fluid system should be designed to maintain at least the minimum required fluid flow through the heater under all operating conditions.
9.1.7 An expansion tank should be provided for all closed loop liquid circuits.
9.1.8 A manual emergency switch should be provided to initiate a safety shutdown of the entire fluid heater system at a remote location.
9.2 Auxiliary Equipment.
9.2.1 Pumps.
9.2.1.1* Air-cooled or water-cooled pumps with mechanical seals or magnetically coupled (seal-less) pumps should be used.
9.2.1.2 The system should be designed such that there is sufficient net positive suction head available for the pump.
9.2.1.3 Positive displacement pumping systems should incorporate features to ensure that the minimum flow through the heater is maintained.
9.2.1.4* The pumps should be compatible with the fluid used as well as the operating pressures and temperatures.
9.2.1.5* If water-cooled pumps are used, a means of verifying cooling water flow should be provided.
9.2.1.6* Cold alignment of air- and water-cooled pumps should be done in accordance with the pump manufacturer's recommendations prior to starting the pump.
9.2.1.7* Hot alignment of air- and water-cooled pumps should be done within the first 24 hours after reaching operating temperature.
9.2.1.8 Cold and hot alignment should be performed during commissioning and following pump maintenance.
9.2.2 Catch Tank.
9.2.2.1 The effluent from all pressure relief devices, vents from the expansion tank, and drains from the expansion tank should be directed to a closed catch tank.
9.2.2.2 The catch tank should have a vent to atmosphere, with the vent outlet located at an approved location outside of the heater room.
9.2.2.3 The vent should be adequately sized to handle 150 percent of the maximum flow from the heater relief device.
9.2.2.4 If the fluid being relieved is combustible, a flame arrester should be located in the vent line.
9.2.2.5 The contents should not be reused in the fluid heating system.
9.2.2.6 The catch tank inlets should be located to prevent siphoning of the contents back into the system.
9.2.2.7 A liquid level indicator should be provided on the tank.
9.2.3 Strainers.
9.2.3.1 One strainer should be placed in the suction piping of each pump.
9.2.3.2* A minimum 60 mesh stainless steel strainer element should be used.
9.2.3.3 Isolation valves should be placed in the suction and discharge piping of the pump to facilitate cleaning of the strainer.
9.2.3.4 A means should be provided to drain the strainer prior to cleaning.
9.2.3.5 A pressure gauge should be placed between the strainer and the pump inlet to indicate strainer blockage.
9.2.4 Valves.
9.2.4.1 Gate valves should be used for isolation purposes.
9.2.4.2 Globe valves or wafer valves should be used for throttling purposes.
9.2.4.3* Valves should be compatible with the fluid being used and the system operating temperatures and pressures.
9.2.4.4 Where used, automatic process equipment bypass valves should fail open upon power loss.
9.2.5 Expansion Tanks.
9.2.5.1 The expansion tank should be connected to the fluid system piping upstream of the fluid pump.
9.2.5.2* The expansion tank should be compatible with the fluid being used and the system operating temperatures and pressures.
9.2.5.3* The expansion tank should be sized to accommodate the fluid expansion in the entire system.
9.2.5.4 A low level switch should be provided.
9.2.5.4.1 The low level switch should be satisfied before the pumps and the heater can be started.
9.2.5.4.2 The low level switch should be interlocked to shut down the pump and heater if a low level occurs.
9.2.5.5 An expansion tank drain should be provided.
9.2.5.6 A means for sampling for water contamination should be provided at the low point of the expansion tank.
9.2.5.7 Local or remote indication of tank level should be provided.
9.2.5.8 Expansion tanks should be vented to the catch tank.
9.2.5.9* An expansion tank pressurized with an inert gas should be used if any of the following conditions exist:
(1) The tank is not the highest point in the system
(2) The tank contents can be at a temperature such that exposure of the fluid to air would cause degradation of the fluid.
(3) The fluid manufacturer recommends use of an inert blanket.
(4) The fluid is operated above its atmospheric boiling point.
9.2.5.10 All pressurized expansion tanks should be equipped with a pressure-relief device piped to the catch tank.
9.2.5.11 All expansion tanks that are pressurized over 15 psig should meet the requirements of ASME Section VIII Division 1.
9.2.5.12 Pressurized expansion tanks should have a low inert gas pressure alarm set at a value determined by the fluid supplier.

9.3 Safety Devices for Class F Heaters.

9.3.1 Low Fluid Flow.

9.3.1.1* Means should be provided to prove minimum fluid flow through the heater at all operating conditions.

9.3.1.2 The minimum flow proving device should be interlocked into the combustion safety circuitry.

9.3.1.3 Means should be provided to prove minimum fluid level in the expansion tank at all operating conditions.

9.3.2 Interlocks. The combustion safety circuitry should incorporate the following interlocks:

(1) High stack temperature located upstream of the stack damper
(2) High process outlet temperature
(3) Process low flow limit
(4) Low expansion tank fluid level

Chapter 10 Class G Heaters

10.1* General. (Reserved)

10.2 Auxiliary Equipment. (Reserved)

10.3 Safety Devices for Class G Heaters. (Reserved)

Chapter 11 Class H Heaters

11.1* General. (Reserved)

11.2 Auxiliary Equipment. (Reserved)

11.3 Safety Devices for Class H Heaters. (Reserved)

Chapter 12 Fire Protection

12.1* General. The user should determine the need for fire protection systems for fluid heaters or related equipment, based on the hazards associated with the equipment.

12.1.1* Where determined to be necessary, portable, manual fixed, or automatic fixed fire protection systems should be provided.

12.1.2 The fire protection system should be provided with a remotely located manual actuator.

12.1.3 The fire protection system design should be submitted for approval to the authority having jurisdiction.

12.1.4* Where a sustained fluid fire is possible, fireproofing of exposed heater supporting members is recommended.

12.1.5 If a fluid fire occurs in the combustion chamber of a heater, the following actions are recommended:

(1) Shut off the heating system fuel supply.
(2) Stop combustion air fans.
(3) Shut combustion air inlet dampers.
(4) Outlet dampers should be open to prevent overpressure of the firebox. Fail-safe damper position should be implemented.
(5) Activate the discharge of extinguishing agent or use portable extinguishers at openings to the fire box.
(6) Depressurize the fluid system to reduce the flow of fluid into the firebox.
(7) Drain the fluid to a location where it will not create a hazard to extinguish the fluid-fed fire.

CAUTION: Where a pressurized fluid is at a temperature above its atmospheric boiling point, rapid draining can lead to flashing of the fluid and the generation of combustible vapors. An emergency cooler can be provided to cool the fluid to below its atmospheric boiling point.

(8) Isolate or repair the fluid leak before restarting the heating system.

12.1.6 The Emergency Response Team (ERT) and fire service should be aware of the fluid identity and hazards, the location of fluid and fuel piping and shutoff valves, and proper fire-fighting methods.

12.2 Types of Fire Protection Systems.

12.2.1* Where automatic sprinklers are provided, they should be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, unless otherwise permitted by 12.2.2.

CAUTION: The introduction of water into a hot chamber can create a steam explosion hazard.

12.2.2 Where sprinklers that protect fluid heaters only are installed and connection to a reliable fire protection water supply is not feasible, a domestic water supply connection can be permitted to supply these sprinklers, subject to the approval of the authority having jurisdiction.

12.2.3 Where water spray systems are provided, they should be installed in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.

12.2.4 Where carbon dioxide protection systems are provided, they should be installed in accordance with NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*.

12.2.5 Where foam extinguishing systems are provided, they should be installed in accordance with NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*.

12.2.6 Where chemical protection systems are provided, they should be installed in accordance with NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* or NFPA 17A, *Standard for Wet Chemical Extinguishing Systems.*

12.2.7 Where water mist systems are provided, they should be installed in accordance with NFPA 750, *Standard on Water Mist Fire Protection Systems*.

12.2.8 Where steam extinguishing systems are provided, they should be installed in accordance with accepted industry practice. *(See Annex F.)*

12.2.9 Where portable fire extinguishing systems are provided, they should be used in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

12.2.9.1 When portable fire protection is relied upon for extinguishing internal fluid-fed fires, an effective means of access for the extinguishing agent should be provided.

12.3 Inspection, Testing, and Maintenance of Fire Protection Equipment. All fire protection equipment should be inspected, tested, and maintained as specified in the following standards:

(1) NFPA 10, *Standard for Portable Fire Extinguishers*
(2) NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*
(3) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
(4) NFPA 13, *Standard for the Installation of Sprinkler Systems*
(5) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*
(6) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
(7) NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*
(8) NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*
(9) NFPA 750, *Standard on Water Mist Fire Protection Systems*

Annex A Explanatory Material

A.1.1 Explosions and fires in fuel-fired and electric fluid heaters constitute a loss potential in life, property, and production. This recommended practice is a compilation of guidelines, rules, and methods applicable to the safe operation of this type of equipment.

Conditions and regulations that are not covered in this standard — such as toxic vapors, hazardous materials, noise levels, heat stress, and local, state, and federal regulations (EPA and OSHA) — should be considered when designing and operating fluid heaters.

Most causes of failures can be traced to human error. The most significant failures include inadequate training of operators, lack of proper maintenance, and improper application of equipment. Users and designers must utilize engineering skill to bring together that proper combination of controls and training necessary for the safe operation of equipment. This recommended practice classifies fluid heaters as Class F fluid heaters.

Class F fluid heaters operate at approximately atmospheric pressure and present a potential explosion or fire hazard that could be occasioned by the overheating and/or release of flammable or combustible fluids from the tubing that carries it through the heating chamber. Class F fluid heaters operate with a relatively constant flow of fluid through the tubes, and the flowing fluid is intended to remove sufficient heat to maintain tubing walls cool enough to avoid irreversible damage that could lead to rupture. Safeguards that reduce the risk of fire or explosion associated with the use of fuel gases or fuel oils are also a major consideration for the design and operation of Class F fluid heaters.

A.1.1.4(1) For guidance on solid fuel systems see NFPA 85, *Boiler and Combustion System Hazards Code.*

A.1.3.1 Because this standard is based on the present state of the art, application to existing installations is not mandatory. Nevertheless, users are encouraged to adopt those features of this standard that are considered applicable and reasonable for existing installations.

A.1.5 No recommended practice can guarantee the elimination of fires and explosions in fluid heaters. Technology in this area is under constant development, which is reflected in fuels, fluids, geometries, and materials. Therefore, the designer is cautioned that this recommended practice is not a design handbook and, as such, does not eliminate the need for an engineer or competent engineering judgment. It is the intention of this recommended practice that a designer capable of applying more complete and rigorous analysis to special or unusual problems has latitude in the development of fluid heater designs. In such cases, the designer should be responsible for demonstrating and documenting the safety and validity of the design.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction. The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.29.5 Proof-of-Closure Switch. A common method of effecting proof of closure is by valve seal over-travel. [**86,** 2007]

A.3.3.32 Valve Proving System. EN 1543, *International Standard for Valve Proving Systems,* requires leakage to be less than 1.76 ft^3/hr (50 L/hr). Proof of closure definition in ANSI Z21.21/CSA 6.5, *Automatic Valves for Gas Appliances,* and FM 7400, *Approval Standard for Liquid and Gas Safety Shutoff Valves,* requires leakage less than 1 ft^3/hr (28.32 L/hr). [**86,** 2007]

A.4.1.1.2 Ladder-type schematic diagrams are recommended.

A.4.1.3.1 The proximity of electrical equipment and flammable gas or liquid in an electrical enclosure or panel is a known risk and would be considered a classified area. Article 500 of *NFPA 70, National Electrical Code*, should be consulted.

Conduit connecting devices handling flammable material might carry this material to an electrical enclosure if the device fails, creating a classified area in that enclosure. Sealing of such conduits should be considered.

A.4.1.3.3 Unless otherwise required by the local environment, fluid heaters and the surrounding area are not classified as a hazardous (classified) location. The primary source of ignition associated with a fluid heater installation is the heating system or materials heated. The presence of these ignition sources precludes the need for imposing requirements for wiring methods appropriate for a hazardous (classified) location. Refer to Section 3.3 of NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, and Section 3.3 of NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, regarding equipment with open flames or other ignition sources. In addition, fluid heaters are considered unclassified internally, as proved ventilation is provided to ensure safety.

A.4.3.2 The following items are examples of compatibility issues to be studied: system materials, flow rates, temperatures, pressures, venting, inerting, and fire protection.

A.5.1.1.1 Hazards to be considered include spillage of molten metal, salt, or other molten material, hydraulic oil ignition, overheating and/or release of material being heated in the fluid heater, and escape of fuel or flue gases.

A.5.1.1.4 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, NFPA 54, *National Fuel Gas Code*, and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*.

A.5.1.1.6 Solidification of the fluid in the fluid heater and associated piping should be avoided. Consider providing insulation and heat tracing on piping and equipment where it is impractical to reliably guarantee that temperatures will not go below the minimum pumpable viscosity for an extended period of time.

A.5.1.3.5 The hazard is particularly severe where vapors from nearby processes could flow by means of gravity to ignition sources at or near floor level. See NFPA 30, *Flammable and Combustible Liquids Code*, NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, and NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*.

A.5.1.4.3 The following procedure should be followed if the fluid heater is located in contact with a wood floor or other combustible floor and the operating temperature is above 160°F (71°C). Combustible floor members should be removed and replaced with a monolithic concrete slab that extends a minimum of 3 ft (1 m) beyond the outer extremities of the fluid heater. Air channels, either naturally or mechanically ventilated, should be provided between the floor and the equipment (perpendicular to the axis of the equipment), or noncombustible insulation should be provided. (It might be necessary to provide both features.) This should be adequate to prevent surface temperatures of combustible floor members from exceeding 160°F (71°C).

A.5.2 Steam or hot water boilers should not be converted to fluid heating operation except under the guidance of the equipment manufacturer.

A.5.2.3 Fluid heater design should include factors of safety so as to avoid failures when operating at maximum design loading.

A.5.2.4 For fluid heaters that utilize induced draft fans, the design should account for operation at sub-ambient pressure, and should be designed to prevent implosion.

A.5.2.6.1 Ladders, walkways, and access facilities, where provided, should be designed in accordance with 29 CFR 1910.24 through 29 CFR 1910.29, and ANSI A14.3, *Safety Requirements for Fixed Ladders*.

A.5.2.10 Adequate coolant flow is vital to the safe operation of fluid heaters. Where flow switches are provided to verify flow, they should be tested regularly. Other means, such as flow indicators, should also be considered for supplementing the function of flow switches *(see A.5.9.4)*.

A.5.3 For additional information regarding explosion protection of equipment and buildings, see NFPA 68, *Standard on Explosion Prevention by Deflagrations Venting*, and NFPA 69, *Standard on Explosion Prevention Systems*.

Where explosion relief is provided, its location is a critical concern and should be close to the ignition source. Personnel considerations and proximity to other obstructions can impact the location selected for these vents. The intent of providing explosion relief in furnaces is to limit damage to the furnace and to reduce the risk of personnel injury due to explosions. To achieve these goals, relief panels and doors should be sized so that their inertia does not preclude their ability to relieve internal explosion pressures.

A.5.4 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, NFPA 54, *National Fuel Gas Code*, and NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*.

A.5.4.1 Some fluid heaters rely on the air in a building or room for safety ventilation and combustion. If the fluid heater fans must compete with other building fans (such as building exhausts), safety and performance of the fluid heater could be compromised.

When determining or reviewing the air requirements of a building or room for safety ventilation and combustion, provisions should be made for air being removed from the room for other purposes, such as for removal of heat, flue products, emergency generators, and other combustion equipment. Safety ventilation and combustion air must be in excess of air that is to be removed from the room for other purposes. Seasonal factors could also be relevant in cold climates, where building openings are closed during cold weather.

In the case of fluid heaters, especially those using natural draft, combustion air consistent with requirements identified in Section 8.3 of NFPA 54, *National Fuel Gas Code*, should be provided.

A.5.4.3.3 Ducts that pass through fire walls should be avoided.

A.5.4.3.5 High temperature or corrosive gases conveyed in the duct could compromise structural members if contacted.

A.5.4.3.6 All interior laps in the duct joints should be made in the direction of the flow.

A.5.5.1.3 Threaded connections in the flow circuit are typically not used on piping greater than 1 in. NPT.

A.5.5.1.7 Care should be taken not to over-pressurize any of the fluid heater system components. Hydrostatically testing with water can contaminate the system due to residual water in the system.

A.6.2.1 The term *ignition temperature* means the lowest temperature at which a gas–air mixture will ignite and continue to burn. This condition is also referred to as the *autoignition temperature*. Where burners supplied with a gas–air mixture in the flammable range are heated above the autoignition temperature, flashbacks could occur. In general, such temperatures range from 870°F to 1300°F (465°C to 704°C). A much higher temperature is needed to ignite gas dependably. The temperature necessary is slightly higher for natural gas than for manufactured gases, but for safety with manufactured gases, a temperature of about 1200°F (649°C) is needed, and for natural gas, a temperature of about 1400°F (760°C) is needed. Additional safety considerations should be given to dirt-laden gases, sulfur-laden gases, high-hydrogen gases, and low-Btu waste gases.

The term *rate of flame propagation* means the speed at which a flame progresses through a combustible gas–air mixture under the pressure, temperature, and mixture conditions existing in the combustion space, burner, or piping under consideration. *(See Table A.6.2.1 and Figure A.6.2.1.)*

(See Table A.6.2.1 and Figure A.6.2.1 on Page 15.)

A.6.2.3 For additional information, refer to NFPA 54, *National Fuel Gas Code*.

A.6.2.3.4 See A.5.4.1 for information on combustion air supply considerations.

A.6.2.4.1 The valve used for remote shutoff service should be identified. If the main incoming service valve is used for this purpose, it must be understood that the valve might be owned by the local utility, which could impact access and service of the valve. Remotely located valves used for shutting down fuel distribution systems that serve a number of users or pieces of equipment should be regularly exercised (by opening and closing several times) to verify their ability to operate when needed. Lubricated plug valves should be maintained annually, including the installation of sealant and leak testing.

A.6.2.5.2 NFPA 54, *National Fuel Gas Code*, provides sizing methods for gas piping systems.

A.6.2.6.3 When the fuel train is opened for service, the risk of dirt entry exists. It is not required that existing piping be opened for the sole purpose of the addition of a filter or strainer. It is good practice to have the sediment trap located upstream of the filter. The intent of the sediment trap is to remove larger particulates, while the intent of the filter is to remove smaller particulates. The reverse arrangement will result in additional maintenance and may result in removal of the filter element from service.

Table A.6.2.1 Properties of Typical Flammable Gases

Flammable Gas	Molecular Weight	Btu/ft^3	Auto-ignition (°F)	LEL% by Volume	UEL% by Volume	Vapor Density (Air = 1)	ft^3 Air Required to Burn 1 ft^3 of Gas
Butane	58.0	3200	550	1.9	8.5	2.0	31.0
CO	28.0	310	1128	12.5	74.0	0.97	2.5
Hydrogen	2.0	311	932	4.0	74.2	0.07	2.5
Natural gas (high Btu type)	18.6	1115	—	4.6	14.5	0.64	10.6
Natural gas (high methane type)	16.2	960	—	4.0	15.0	0.56	9.0
Natural gas (high inert type)	20.3	1000	—	3.9	14.0	0.70	9.4
Propane	44.0	2500	842	2.1	9.5	1.57	24.0

For SI units, 1 kJ = 0.948 Btu, 1 m^3 = 35.3 ft^3, °C = 5/9(°F –32).

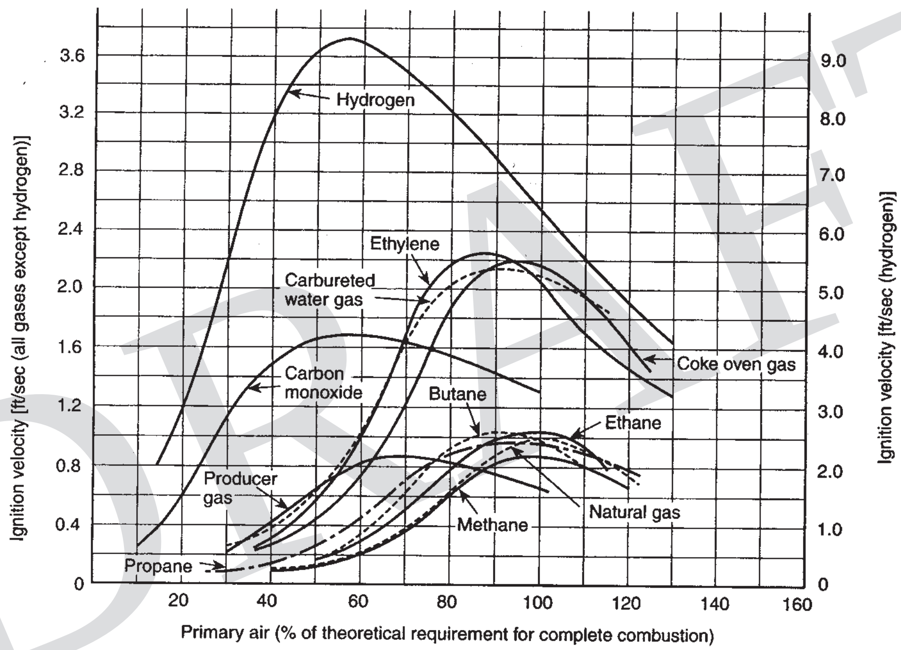

Figure A.6.2.1 Ignition Velocity Curves for Typical Flammable Gases.

A.6.2.7.3 Paragraph 6.2.7.3 covers venting of flammable and oxidizing gases only. Gases that are asphyxiants, toxic, or corrosive are outside of the scope of this recommended practice. In this regard, other standards should be consulted for appropriate venting. Flammable gases and oxidizers should be vented to an approved location to prevent fire or explosion hazards. When gases are vented, the vent pipe should be located in accordance with the following:

(1) Gas should not impinge on equipment, support, building, windows, or materials because the gas could ignite and create a fire hazard.
(2) Gas should not impinge on personnel at work in the area or in the vicinity of the exit of the vent pipe because the gas could ignite and create a fire hazard.
(3) Gas should not be vented in the vicinity of air intakes, compressor inlets, or other devices that utilize ambient air.

The vent exit should be designed in accordance with the following:

(1) The pipe exit should not be subject to physical damage or foreign matter that could block the exit.
(2) The vent pipe should be sized to minimize the pressure drop associated with length, fitting, and elbows at the maximum vent flow rate.
(3) The vent piping should not have any shutoff valves in the line.

If the gas is to be vented inside the building, the following additional guidance is offered:

(1) If the gas is flammable and lighter than air, the flammable gases should be vented to a location where the gas is diluted below its lower flammable limit (LEL) before coming in contact with sources of ignition.
(2) The gas cannot re-enter the work area without extreme dilution.

A.6.2.7.4 See NFPA 54, *National Fuel Gas Code*, for exception to vent requirements.

Vent limiters are used to limit the escape of gas into the ambient atmosphere if a vented device (e.g., regulator, zero governor, pressure switch) requiring access to the atmosphere for operation has an internal component failure. When a vent limiter is used, there might not be a need to vent the device to an approved location. Following are some general guidelines and principles on the use of vented devices incorporating vent limiters:

(1) The listing requirements for vent limiters are covered in ANSI Z21.18/CSA 6.3, *Standard for Gas Appliance Pressure Regulators*, for regulators or UL 353, *Standard for Limit Controls*, for pressure switches and limit controls. ANSI Z21.18/CSA 6.3 requires a maximum allowable leakage rate of 2.5 ft^3/hr (0.071 m^3/hr) for natural gas and 1.0 ft^3/hr (0.028 m^3/hr) for LP-Gas at the device's maximum rated pressure. UL 353 allows 1.0 ft^3/hr (0.028 m^3/hr) for natural gas and 1.53 ft^3/hr (0.043 m^3/hr) for LP-Gas at the device's maximum rated pressure. Since a vent limiter can be rated less than the device itself and can be a field-installable device, a combination listed device and vent limiter should be used.

(2) Where a vent limiter is used there should be adequate airflow through the room or enclosure in which the equipment is installed. In reality, conditions can be less ideal, and care should be exercised for the following reasons:

(a) The relative density of the gas influences its ability to disperse in air. The higher the relative density, the more difficult it is for the gas to disperse (e.g., propane will disperse more slowly than natural gas).

(b) Airflow patterns through a room or enclosure, especially in the vicinity of the gas leak, affect the ability of the air to dilute that gas. The greater the local air movement, the greater the ease with which the gas is able to disperse.

(c) The vent limiter might not prevent the formation of a localized flammable air–gas concentration for the preceding reasons.

A.6.2.7.5 See A.6.2.7.4.

A.6.2.9 In the design, fabrication, and utilization of mixture piping, it should be recognized that the air–fuel gas mixture might be in the flammable range.

A.6.2.9.2 (A) Two basic methods generally are used. One method uses a separate fire check at each burner, the other a fire check at each group of burners. The second method generally is more practical if a system consists of many closely spaced burners.

A.6.2.9.2 (E) Acceptable safety blowouts are available from some manufacturers of air–fuel mixing machines. They incorporate all the following components and design features:

(1) Flame arrester
(2) Blowout disk
(3) Provision for automatically shutting off the supply of air–gas mixture to the burners in the event of a flashback passing through an automatic fire check

A.6.2.11.1 A burner is suitably ignited when combustion of the air–fuel mixture is established and stable at the discharge port(s) of the nozzle(s) or in the contiguous combustion tunnel.

A.6.3.1 In the design and use of oil-fired units, the following should be considered:

(1) Unlike fuel gases, data on many important physical/chemical characteristics are not available for fuel oil, which, being a complex mixture of hydrocarbons, is relatively unpredictable.
(2) Fuel oil has to be vaporized prior to combustion. Heat generated by the combustion commonly is utilized for this purpose, and oil remains in the vapor phase as long as sufficient temperature is present. Under these conditions, oil vapor can be treated as fuel gas.
(3) Unlike fuel gas, oil vapor condenses into liquid when the temperature falls too low and revaporizes whenever the temperature rises to an indeterminate point. Therefore, oil in a cold furnace can lead to a hazardous condition, because, unlike fuel gas, it cannot be purged. Oil can vaporize (to become a gas) when, or because, the furnace-operating temperature is reached.
(4) Unlike water, for example, there is no known established relationship between temperature and vapor pressure for fuel oil. For purposes of comparison, a gallon of fuel oil is equivalent to 140 ft^3 (4.0 m^3) of natural gas; therefore, 1 oz (0.03 kg) equals approximately 1 ft^3 (0.03 m^3).

Additional considerations that are beyond the scope of this recommended practice should be given to other combustible liquids not specified in 6.3.1.

A.6.3.3 For additional information, refer to NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

A.6.3.4.4 A long circulating loop, consisting of a supply leg, a back-pressure regulating valve, and a return line back to the storage tank, is a means of reducing air entrainment. Manual vent valves might be needed to bleed air from the high points of the oil supply piping.

A.6.3.4.6 The weight of fuel oil is always a consideration in vertical runs. When going up, pressure is lost. A gauge pressure of 100 psi (689 kPag) with a 100 ft (30.5 m) lift nets only a gauge pressure of 63 psi (434 kPag). When going down, pressure increases. A gauge pressure of 100 psi (689 kPag) with a 100 ft (30.5 m) drop nets a gauge pressure of 137 psi (945 kPag). This also occurs with fuel gas, but it usually is of no importance. However, it should never be overlooked where handling oils.

A.6.3.5.1(F) Lubricated plug valves require lubrication with the proper lubricant to shut off tightly. The application and type of gas used can require frequent lubrication to maintain the ability of the valve to shut off tightly when needed.

A.6.3.5.3 Customarily, a filter or strainer is installed in the supply piping to protect the pump. However, this filter or strainer mesh usually is not sufficiently fine for burner and valve protection.

A.6.3.5.5 Under some conditions, pressure sensing on fuel oil lines downstream from feed pumps can lead to gauge failure when rapid pulsation exists. A failure of the gauge can result in fuel oil leakage. The gauge should be removed from service after initial burner start-up or after periodic burner checks. An alternative approach would be to protect the gauge during service with a pressure snubber.

A.6.3.7.1 The atomizing medium might be steam, compressed air, low pressure air, air–gas mixture, fuel gas, or other gases. Atomization also might be mechanical (mechanical atomizing tip or rotary cup).

A.6.3.9.1 A burner is suitably ignited when combustion of the air–fuel mixture is established and stable at the discharge port(s) of the nozzle(s) or in the contiguous combustion tunnel.

A.7.2.1 Commissioning could be required again following modification, reactivation, or relocation of the furnace.

A.7.2.5 It is recommended that all system settings and parameters are documented for future maintenance and operational needs.

A.7.2.6 A test involving discharge of extinguishing agent in a sufficient amount to verify that the system is properly installed and functional is recommended. The discharge test can be simulated by an appropriate means. The discharge test can be omitted if damage to the equipment or surroundings will result.

A.7.2.8 Using inert gas that is heated can help vaporize water trapped within the system.

A.7.2.9 Addition of fluid should be at a low point of the piping. A small positive displacement pump is typically used to fill the fluid heater system.

A.7.2.10 Raising the temperature slowly helps prevent spalling during refractory dry out and curing, minimizes thermal stresses on the equipment, and prevents rapid vaporization of residual water in the piping.

A.7.3.1 The training program can include one or more of the following components:

(1) Review of operating and maintenance information
(2) Periodic formal instruction
(3) Use of simulators
(4) Field training
(5) Other procedures
(6) Comprehension testing

The following training topics should be considered for inclusion when developing the training program:

(1) Process and equipment inspection testing
(2) Combustion of fuel–air mixtures
(3) Explosion hazards, including improper purge timing and purge flow and safety ventilation
(4) Sources of ignition, including autoignition (e.g., by incandescent surfaces)
(5) Functions of controls, safety devices, and maintenance of proper set points
(6) Handling and processing of hazardous materials
(7) Management of process fluid level, flow, and temperature
(8) Confined space entry procedures
(9) Operating instructions *(see 7.4.2)*
(10) Lockout/tagout procedures
(11) Hazardous conditions resulting from interaction with surrounding processes
(12) Fire protection systems
(13) Molten material

A.7.3.4 Training should include recognition of upset conditions that could lead to dangerous conditions. Operator training should cover the relationship between firing rate, fluid flow rate, and fluid temperature increase, so that if a high fluid temperature is detected, the cause can be determined quickly.

A.7.4.3 See Annex B.

A.7.4.7 If a new operating envelope is desired, contact the equipment manufacturer and the fluid supplier to establish new operating limits.

A.7.5.3 Consult the fluid manufacturer to help determine where in the system to take samples. The samples should be sent to the supplier. Facilities with laboratories might be able to perform independent tests, provided a base-line sample is available for comparison purposes.

A.7.5.5 Tests involving the discharge of the extinguishing agent should be performed at a frequency recommended by the fire protection system manufacturer.

A.7.5.8 See, for example, the *National Board Inspection Code.*

A.7.5.11 In cases where minimal operating states (e.g., minimum fluid flow) must be established to prevent a hazardous condition, it is recommended that the precision of the set point be confirmed. When precision is inadequate, the component should be either recalibrated or replaced. Frequency of this testing and calibration should be established based on the component's mean time between failure (MTBF) data and the component manufacturer's recommendations.

A.7.5.15 An example of a leak test procedure for safety shutoff valves on direct gas-fired ovens with a self-piloted burner and intermittent pilot follows. With the oven burner(s) shut off, the main shutoff valve open, and the manual shutoff valve closed, proceed as follows:

(1) The tube should be placed in test connection 1 and immersed just below the surface of a container of water.
(2) The test connection valve should be opened. If bubbles appear, the valve is leaking and the manufacturer's instructions should be referenced for corrective action. The auxiliary power supply to safety shutoff valve No. 1 should be energized, and the valve should be opened.
(3) The tube should be placed in test connection 2 and immersed just below the surface of a container of water.
(4) The test connection valve should be opened. If bubbles appear, the valve is leaking. The manufacturer's instructions should be referenced for corrective action.

This procedure is predicated on the piping diagram shown in Figure A.7.5.15(a) and the wiring diagram shown in Figure A.7.5.15(b).

It is recognized that safety shutoff valves are not entirely leak-free. Valve seats can deteriorate over time and require periodic leak testing. Many variables are associated with the valve seat leak testing process, including gas piping and valve size, gas pressure and specific gravity, size of the burner chamber, length of downtime, and the many leakage rates published by recognized laboratories and other organizations.

Leakage rates are published for new valves and vary by manufacturer and the individual listings to which the manufacturer subscribes. It is not expected that valves in service can be held to these published leakage rates, but rather that the leakage rates are comparable over a series of tests over time. Any significant deviation from the comparable leakage rates over time will indicate to the user that successive leakage tests can indicate unsafe conditions. These conditions should then be addressed by the user in a timely manner.

The location of the manual shutoff valve downstream of the safety shutoff valve affects the volume downstream of the safety shutoff valve and is an important factor in determining when to start counting bubbles during a safety shutoff valve seat leakage test. The greater the volume downstream of the safety shutoff valve, the longer it will take to fully charge the trapped volume in the pipe between the safety shutoff valve and the manual shutoff valve. This trapped volume needs to be fully charged before starting the leak test.

Care should be exercised when performing the safety shutoff valve seat leakage test, because flammable gases will be released into the local environment at some indeterminate pressure. Particular attention should be paid to lubricated plug valves if used as manual shutoff valves, in order to ensure that they have been properly serviced prior to the valve seat leakage test.

The referenced publications in Annex D include examples, although not all-inclusive, of acceptable leakage rate methodologies that the user can employ.

Figure A.7.5.15(a) through Figure A.7.5.15(c) show examples of gas piping and wiring diagrams for leak testing.

The following example is predicated on the piping diagram shown in Figure A.7.5.15(a) and the wiring diagram shown in Figure A.7.5.15(b).

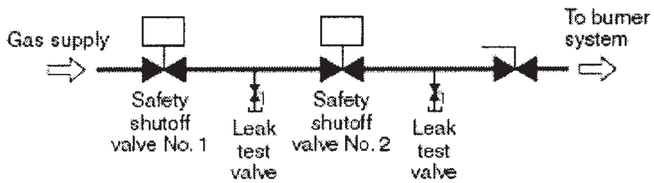

Figure A.7.5.15(a) Example of a Gas Piping Diagram for Leak Test.

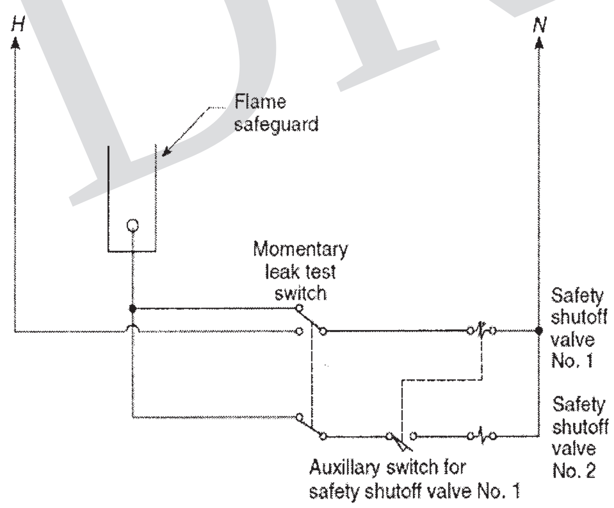

Figure A.7.5.15(b) Example of a Wiring Diagram for Leak Test.

With the burner(s) shut off, the equipment isolation valve open, and the manual shutoff valve located downstream of the second safety shutoff valve closed, proceed as follows:

(1) Connect the tube to leak test valve No. 1.

(2) Bleed trapped gas by opening leak test valve No. 1.

(3) Immerse the tube in water per Figure A.7.5.15(c). If bubbles appear, the valve is leaking and the manufacturer's instructions should be referenced for corrective action. Examples of acceptable leakage rates are given in Table A.7.5.15.

(See Table A.7.5.15 on Page 18.)

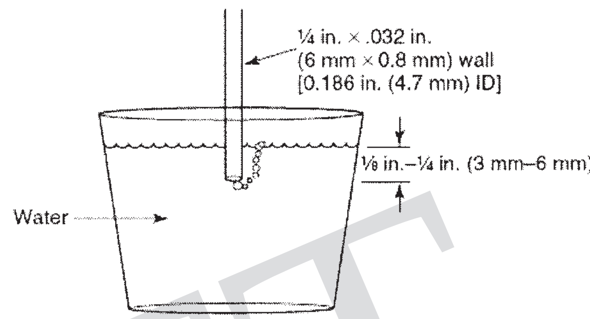

Figure A.7.5.15(c) Bubble Test for a Safety Shutoff Valve.

(4) Apply auxiliary power to safety shutoff valve No. 1. Close leak test valve No. 1. The tube should be connected to A.7.5.15(c).

(5) Open leak test valve No. 2. If bubbles appear, the valve is leaking and the manufacturer's instructions should be referenced for corrective action. Examples of acceptable leakage rates are given in Table A.7.5.15.

[**86**, 2007]

Table A.7.5.15 Acceptable Leakage Rates

NPT Nominal Size (in.)	DN Nominal Size (mm)	UL 429, ANSI Z21.21/CSA 6.5				FM 7400				EN 161			
		ft^3/hr	mL/hr cc/hr	mL/min cc/min	Bubbles /min	ft^3/hr	mL/hr cc/hr	mL/min cc/min	Bubbles /min	ft^3/hr	mL/hr cc/hr	mL/min cc/min	Bubbles/ min
0.38	10	0.0083	235	3.92	26	0.014	400	6.7	44	00014	40	0 67	4
0.50	15	0.0083	235	3.92	26	0.014	400	6.7	44	0.0014	40 0	67	4
0.75	20	0.0083	235	3.92	26	0.014	400	6.7	44	0.0014	40 0	67	4
1.00	25	0.0083	235	3.92	26	0.014	400	6.7	44	0.0014	40 0	67	4
1.25	32 0	0.083	235	3.92	26	0.014	400	6.7	44	0.0021	60	1.00	7
1.50	40	0.0124	353	5.88	39	0.014	400	6.7	44	0.0021	60	1.00	7
2.00	50	0.0166	470	7.83	52	0.014	400	6.7	44	0.0021	60	1.00	7
2.50	65	0.0207	588	9.79	65	0.014	400	6.7	44	0.0021	60	1.00	7
3.00	80	0.0249	705	11.75	78	0.014	400	6.7	44	0.0035	100	1.67	11
4.00	100	0.0332	940	15.67	104	0.014	400	6.7	44	0.0035	100	1.67	11
6.00	150	0.0498	1,410	23.50	157	0.014	400	6.7	44	0.0053	150	2.50	17
8.00	200	0.0664	1,880	31.33	209	0.014	400	6.7	44	0.0053	150	2.50	17

[**86,** 2007]

A.7.5.17 Lubricated plug valves require lubrication with the proper lubricant in order to shut off tightly. The application and type of gas used can require frequent lubrication to maintain the ability of the valve to shut off tightly when needed.

A.7.7 Examples of worker safety procedures and regulations can be found in ANSI Z117.1, *Safety Requirements for Confined Spaces,* NIOSH *Pocket Guide to Chemical Substances in the Work Environment*, Title 29, Code of Federal Regulations, Chapter XVII, *Occupational Safety and Health Administration*, and other references.

A.8.1.3 For the protection of personnel and property, consideration should also be given to the supervision and monitoring of conditions in systems other than the heating system that could cause, or could lead to, a potential hazard on any installation.

A.8.2.8 For some applications, additional manual action may be required to bring the process to a safe condition.

A.8.3 Furnace controls that meet the performance-based requirements of standards such as ANSI/ISA 84.00.01, *Application of Safety Instrumented Systems for the Process Industries*, may be considered equivalent. The determination of equivalency will involve complete conformance to the safety life cycle including risk analysis, safety integrity level selection, and safety integrity level verification, which should be submitted to the authority having jurisdiction.

A.8.3.2.2 This control circuit and its non-furnace-mounted or furnace-mounted control and safety components should be housed in a dusttight panel or cabinet, protected by partitions or secondary barriers, or separated by sufficient spacing from electrical controls employed in the higher voltage furnace power system. Related instruments might or might not be installed in the same control cabinet. The door providing access to this control enclosure might include means for mechanical interlock with the main disconnect device required in the furnace power supply circuit.

Temperatures within this control enclosure should be limited to 125°F (52°C) for suitable operation of plastic components, thermal elements, fuses, and various mechanisms that are employed in the control circuit.

A.8.3.3 One programmable logic controller (PLC) approach to combustion interlocks on multiburner heating systems is as follows:

(1) Interlocks relating to purge are done via PLC.
(2) Purge timer is implemented in PLC.
(3) Interlocks relating to combustion air and gas pressure are done via PLC.
(4) Gas valves for pilot and burner directly connected to combustion safeguard should conform to requirements of 8.7.2.
(5) Operation of pilot and burner gas valves should be confirmed by the PLC.
(6) A PLC can be set up as intermittent, interrupted, or constant pilot operation. With appropriate flame safeguard it would be possible to provide an interrupted pilot with one flame sensor and one flame safeguard.

A.8.4.2 When purge is complete, there should be a limit to the time between purge complete and trial for ignition. Delay can result in the need for a repurge.

A.8.5.1.2(A) Sampling in more than one location could be required to adequately confirm the absence of combustible vapors or gas in the heating chambers and all the passages that contain the products of combustion.

A.8.6.5 In industrial combustion applications with modulating flow control valves downstream of the combustion air blower, it is most common to interlock the constant combustion air source pressure on single and multiburner systems to meet the requirements of 8.6.3 and 8.6.5.

Because the combustion air flow is proved during each purge cycle along with the combustion air source pressure, the most common convention is to prove the combustion air source pressure during burner operation following purge. In a multiburner system, the proof of combustion airflow during purge proves that any manual valves in the combustion air system are in an adequately open position. These manual air valves are provided for maintenance and combustion airflow balancing among burners in a temperature control zone. In combustion air supply systems that use either an inlet damper or a speed control, the combustion air pressure can fall below reliably repeatable levels with listed pressure switch interlocks at low fire. For these systems, the proof of minimum airflow can be a more reliable interlock.

A.8.6.6 The maximum safe operating pressure can be exceeded where compressed air is utilized.

A.8.7.1.2 See Figure A.8.7.1.2.

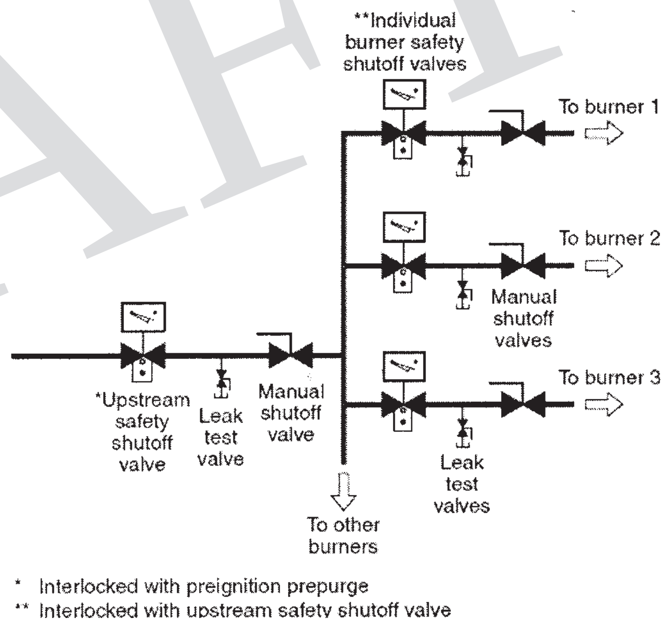

Figure A.8.7.1.2 Multiple Burner System Using Proof of Closure Switches.

A.8.7.1.9 Back pressure can lift a valve from its seat, permitting combustion gases to enter the fuel system. Examples of situations that create back-pressure conditions are leak testing, combustion chamber back pressure, and combustion air pressure during prepurge.

A.8.7.1.10 See A.6.2.7.3.

A.8.7.2 See Figure A.8.7.2 on Page 19).

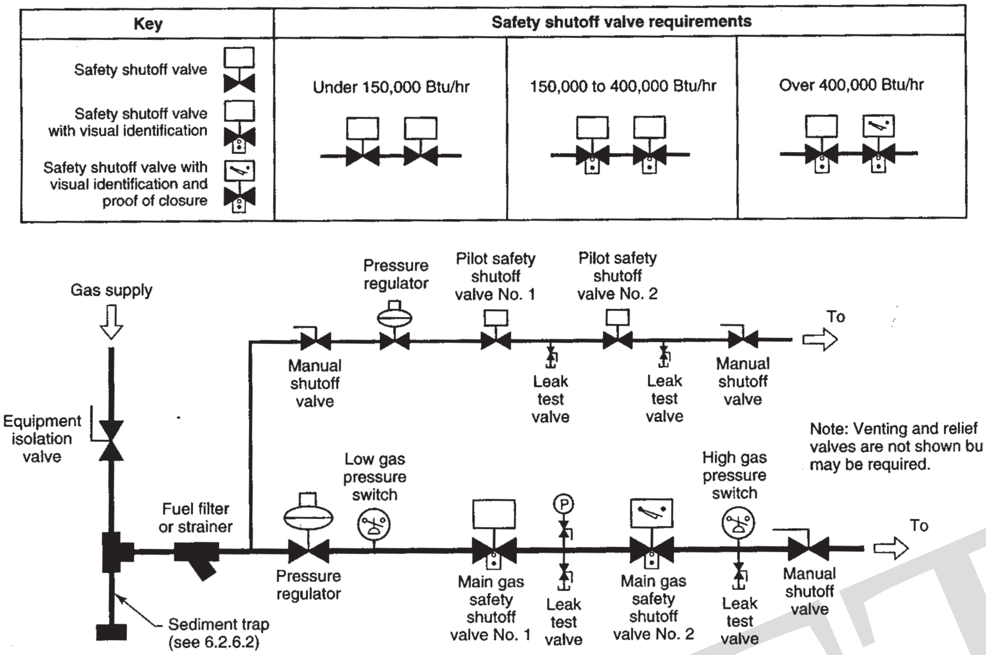

Figure A.8.7.2 Typical Piping Arrangement Showing Fuel Gas Safety Shutoff Valves.

A.8.7.2.2 An additional safety shutoff valve located to be common to the heating system and is proved closed and interlocked with the preignition purge circuit can be used to meet the requirements of 8.7.2.2.

A.8.7.3.2 An additional safety shutoff valve located to be common to the heating system and is proved closed and interlocked with the preignition purge circuit can be used to meet the requirements of 8.7.3.2.

A.8.9.2 Ultraviolet detectors can fail in such a manner that the loss of flame is not detected. When these detectors are placed in continuous service, failures can be detected by using a self-checking ultraviolet detector or by periodically testing the detector for proper operation.

A.8.9.2(3) The term *self-piloted burner* is defined in NFPA 86, 3.3.5.14.

A.8.11 Some liquid fuel can become too viscous for proper atomization at low temperatures. Some liquid fuels can congeal if their temperature falls below their pour point. Some liquid fuels can vaporize at higher temperatures and negatively impact burner stability.

A.8.12.1 The fact that oil or gas is considered a standby fuel should not reduce the safety requirements for that fuel.

A.8.15 The fluid should be protected with an additional temperature limit interlock to prevent excess fluid temperatures.

A.8.15.4 Temperature-sensing components, such as thermocouple and extension wires, that are not rated for the environment are at greater risk of short circuits.

A.8.18.1.1 Abnormal conditions that could occur and require automatic or manual de-energization of affected circuits are as follows:

(1) A system fault (short circuit) not cleared by normally provided branch-circuit protection *(see NFPA 70, National Electrical Code)*
(2) The occurrence of excess temperature in a portion of the furnace that has not been abated by normal temperature-controlling devices
(3) A failure of any normal operating controls where such failure can contribute to unsafe conditions
(4) A loss of electric power that can contribute to unsafe conditions

A.8.18.1.5 The requirements of 8.18.1.5 could require derating some components as listed by manufacturers for uses such as for other types of industrial service, motor control, and as shown in Table A.8.18.1.5.

Table A.8.18.1.5 Heater Ratings

	Resistance Type-Heating Devices		**Infrared Lamp and Quartz Tube Heaters**	
Control Device	**Rating (% actual load)**	**Permissible Current (% rating)**	**Rating (% actual load)**	**Permissible Current (% rating)**
Fusible safety switch (% rating of fuse employed)	125	80	133	75
Individually enclosed circuit breaker	125	80	125	80
Circuit breakers in enclosed panelboards	133	75	133	75
Magnetic contactors				
0–30 amperes	111	90	200	50
30–100 amperes	111	90	167	60
150–600 amperes	111	90	125	80

Note: Table A.8.18.1.5 applies to maximum load or open ratings for safety switches, circuit breakers, and industrial controls approved under current NEMA standards.

A.8.18.2 The excess temperature set point should be set no higher than the maximum element temperature specified by the element manufacturer. The fluid should be protected with an additional temperature limit controller to prevent excess fluid temperatures.

A.8.18.2.5 Temperature-sensing components, such as thermocouple and extension wires, that are not rated for the environment are at greater risk of short circuits.

A.8.18.2.6 The sensing element should be positioned where the difference between the temperature control sensor and the excess temperature limit sensor is minimized. The temperature-sensing element of the excess temperature limit interlock should be located where it will sense the excess temperature condition that will cause the first damage to the heating element.

A.9.1 Class F heaters have 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 outside of the tubes. A fluid bypass loop should be considered to achieve variable flow to the user.

Class F fluid heaters present the following two major hazards:

(1) Uncontrolled release of the fluid such as tube cracking or rupture, pump seal failure, fire, or explosion

(2) Combustible accumulation and explosion

A.9.1.5 The installation of a pressure relief valve between the blocking valves or the use of a block valve at the inlet to the heater and a check valve at the outlet can be used.

A.9.1.6 Three-way valves or an automatic process equipment bypass can be used to maintain the minimum flow through the heater.

A.9.2.1.1 If magnetically coupled pumps are used, over-temperature protection of the pump coupling location should be provided.

A.9.2.1.4 The fluid manufacturer and heater manufacturer should be consulted to provide recommendations on the appropriate pump for the application.

A.9.2.1.5 Loss of cooling can cause seal failure and a subsequent fire hazard.

A.9.2.1.6 Misalignment can cause seal failure and a subsequent fire hazard.

A.9.2.1.7 The alignment of the pump can change during the transition from cold to operating temperatures.

A.9.2.3.2 Refer to the pump manufacturer's manual for additional instructions.

A.9.2.4.3 Cast steel or ductile iron valves with steel or stainless steel trim are typically used.

A.9.2.5.2 Expansion tanks are typically fabricated from carbon and stainless steel.

A.9.2.5.3 Expansion tanks are typically 2.5 times the expansion volume of the system. The operating temperature, the expansion coefficient of the fluid, and the system volume are used to calculate this value. Some vapor space should remain in the tank when the system is at operating temperature. If the tank is located outdoors, an inert blanket should be considered to minimize moisture ingress into the system.

A.9.2.5.9 Nitrogen is typically used as the inert blanket.

A.9.3.1.1 The required minimum fluid flow rate is based on design requirements. Only detecting "flow"/"no flow" conditions may be inadequate. A pressure switch at the pump discharge, a pump rotation switch, and a flow paddle switch are all examples of proving devices that are not recommended to prove minimum flow. For example, restriction of flow will result in an increase in the fluid outlet temperature, which in turn will drive a reduction in heat input (low fire). Low flow rates under this condition could cause laminar flow in the tubes, resulting in undetected localized fluid skin over-temperature conditions. Using a vortex-shedding meter or similar flow measurement device can provide very reliable minimum flow verification. However, a failure modes and effects analysis should be conducted to ensure that the implementation is sufficiently reliable for a safety function implementation. Another option is to use a combination of pressure differential measurements across a known restriction combined with low and high pressure limits. The high pressure limits will detect blockage or other abnormal flow restrictions that maintain high differential pressures at low flow conditions. Conversely, low pressure limits can detect system leaks or bypass flows.

A.10.1 Class G heaters have 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 outside of the tubes.

Class G fluid heaters present the following two major hazards:

(1) Uncontrolled release of the fluid such as tube cracking or rupture, pump seal failure, fire, or explosion

(2) Combustible accumulation and explosion

A.11.1 Class H heaters have heat source (combustion or electricity) inside the tube(s) with fluid surrounding the tube.

Class H fluid heaters present the following two major hazards:

(1) Uncontrolled release of the fluid such as tube cracking or rupture, pump seal failure, fire, or explosion

(2) Combustible accumulation and explosion

A.12.1 This recommended practice addresses the fire protection needs of fluid heaters and related equipment. Fire protection needs external to this equipment are beyond the scope of this recommended practice.

Fire extinguishing systems and methods should be designed in accordance with fire protection engineering principles and applicable standards.

Hazards associated with combustible or high temperature fluid migration to other areas, through open or incompletely sealed floors, should be considered.

Fixed fire protection for the equipment can consist of sprinklers, water spray, carbon dioxide, foam, dry chemical, water mist, or steam extinguishing systems. The extent of protection required depends upon the construction, arrangement, and location of the fluid heater or related equipment as well as the materials being processed.

Hydrogen and other flammable gas fires are not normally extinguished until the supply of gas has been shut off because of the danger of re-ignition or explosion. Re-ignition can occur if a hot surface adjacent to the flame is not cooled with water or by other means. Personnel should be cautioned that hydrogen flames are invisible and do not radiate heat.

A.12.1.1 Where automatic fire protection systems are installed, alarming and actuation can be based on one or more of the following criteria:

(1) High values from differential flow detectors comparing fluid flowing into and out of the heater

(2) Low fluid level in the expansion tank (Note: This function can be used only if the expansion tank level is not automatically corrected with a pumped re-supply of fluid from the storage tank.)

(3) High values from flue gas combustibles analyzer

(4) Increase in opacity of smoke exiting the heater

(5) High flue gas temperature

(6) Increase in carbon monoxide in flue gas

(7) Decrease in oxygen in flue gas.

A.12.1.4 Fire resistance duration, corrosion resistance, and weathering resistance should be considered when fireproofing is applied to heater structural members.

A.12.2.1 Sprinkler protection alone cannot ensure that a fire involving a fluid release will not cause catastrophic heater or building damage.

Annex B Example Maintenance Checklist

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General. The recommendations in this annex are prepared for the maintenance of equipment. Different types of equipment need special attention. A preventive maintenance program, including adherence to the manufacturer's recommendations, should be established and followed. This program should establish a minimum maintenance schedule that includes inspection and action on the recommendations provided in the following paragraphs. An adequate supply of spare parts should be maintained, and inoperable equipment should be cleaned, repaired, or replaced, as required.

B.2 Visual Operational Checklist. The following operational checks should be performed:

(1) Check burners for ignition and combustion characteristics. Verify flame shape and confirm flames are not impinging on heat transfer surfaces.

(2) Check pilots or igniters, or both, for main burner ignition.

(3) Check air–fuel ratios.

(4) Check operating temperature.

(5) Check sight drains or gauges, or both, for cooling waterflow and water temperature.

(6) Check that burners or pilots, or both, have adequate combustion air.

(7) Check the operation of ventilating equipment.

(8) Inspect heater interior for signs of fluid leaks or tube overheating (e.g., ballooning or discoloration). Consider using infrared scanner to observe furnace interior and identify hot spots or other abnormalities.

(9) After each fuel shutoff, check the heater interior for glowing tubes (which could indicate fouling or plugging), flames due to combustible fluid leaks, or flames from burners due to fuel leaking past safety shutoff valves.

B.3 Regular Shift Checklist. The following operational checks should be performed at the start of every shift:

(1) Check the set point of control instrumentation.

(2) Check positions of hand valves, manual dampers, secondary air openings, and adjustable bypasses.

(3) Check blowers, fans, compressors, and pumps for unusual bearing noise and shaft vibration; if V-belt driven, belt tension and belt fatigue should be checked.

(4) Perform lubrication in accordance with manufacturer's requirements.

B.4 Periodic Checklist. The following maintenance checklist should be completed at intervals based on manufacturer's recommendations and the requirements of the process:

(1) Inspect flame-sensing devices for condition, location, and cleanliness.
(2) Inspect thermocouples and lead wire for shorts and loose connections. A regular replacement program should be established for all control and safety thermocouples. The effective life of thermocouples varies, depending on the environment and temperature, and these factors should be considered in setting up a replacement schedule.
(3) Check setting and operation of low and high temperature limit devices.
(4) Test visual or audible alarm systems, or both, for proper signals.
(5) Check igniters, and verify proper gap.
(6) Check all pressure switches for proper pressure settings.
(7) Check control valves, dampers, and actuators for free, smooth action and adjustment.
(8) Test the interlock sequence of all safety equipment. If possible, the interlocks should be made to fail manually, verifying that the related equipment operates as specified by the manufacturer.
(9) Test the safety shutoff valves for operation and tightness of closure as specified by the manufacturer.
(10) Test the main fuel manual valves for operation and tightness of closure as specified by the manufacturer.
(11) Test the pressure switches for proper operation at set point.
(12) Visually inspect electrical switches, contacts, or controls for signs of arcing or contamination.
(13) Test instruments for proper response to thermocouple failure.
(14) Clean or replace the air blower filters.
(15) Clean the water, fuel, gas compressor, and pump strainers.
(16) Clean the fire-check screens and valve seats, and test for freedom of valve movement.
(17) Inspect burners and pilots for proper operation, air–fuel ratio, plugging, or deterioration. Burner refractory parts should be examined to ensure good condition.
(18) Check all orifice plates, air–gas mixers, flow indicators, meters, gauges, and pressure indicators; if necessary, clean, repair or replace them. Check calibrations as appropriate.
(19) Check the ignition cables and transformers.
(20) Check the operation of modulating controls.
(21) Check the integrity of and the interior of the equipment, ductwork, and ventilation systems for cleanliness and flow restrictions.
(22) Test pressure-relief valves; if necessary, repair or replace.
(23) Inspect air, water, fuel, and impulse piping for leaks.
(24) Inspect radiant tubes and heat exchanger tubes for leakage, and repair if necessary.
(25) Lubricate the instrumentation, valve motors, valves, blowers, compressors, pumps, and other components.
(26) Test and recalibrate instrumentation in accordance with manufacturer's recommendations.
(27) Test flame safeguard units. A complete shutdown and restart should be made to check the components for proper operation.
(28) Check electric heating elements for contamination, distortion, cracked or broken refractory element supports, and proper position. Repair or replace if grounding or shorting can occur.
(29) Check electric heating element terminals for tightness.
(30) Perform required pressure vessel or pressure piping inspection and testing (e.g., in accordance with the requirements of the National Board of Boiler and Pressure Vessel Inspectors).
(31) If indications of overheating are observed, the fluid should be drained from the heater and an internal inspection should be performed to evaluate and eliminate the cause of the overheating and assess the need for repair.
(32) Consider nondestructive testing of wall thicknesses by eddy-current, ultrasonic, or other means.
(33) Perform a fluid system leakage test by pressurizing the entire system to $1^1/_2$ times working pressures or maximum pump pressure, whichever is lower, but do not exceed the pressure setting of the pressure relief valves.

Annex C Steam Extinguishing Systems

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 General. Steam extinguishes fire by the exclusion of air or the reduction of the oxygen content of the atmosphere in a manner similar to carbon dioxide or other inert gases. The use of steam precedes other modern smothering systems. Steam is not a practical extinguishing agent except where a large steam supply is continuously available. The possible burn hazard should be considered in any steam extinguishing installation. A visible cloud of condensed vapor, popularly described as steam, is incapable of extinguishment. Although many fires have been extinguished by steam, its use often has been unsuccessful due to lack of understanding of its limitations. Except for specialized applications, other types of smothering systems are preferred in modern practice. No complete standard covering steam smothering systems has yet been developed. One pound of saturated steam at 212°F (100°C) and normal atmospheric pressure has a volume of 26.75 ft^3 (0.76 m^3).

A larger percentage of steam is required to prevent combustion than in the case of other inert gases used for fire extinguishment. Fires in substances that form glowing coals are difficult to extinguish with steam, because of the lack of cooling effect. For some types of fire, such as fires involving ammonium nitrate and similar oxidizing materials, steam is completely ineffective.

Steam smothering systems should be permitted only where oven temperatures exceed 225°F (107°C) and where large supplies of steam are available at all times while the oven is in operation. Complete standards paralleling those for other extinguishing agents have not been developed for the use of steam as an extinguishing agent, and, until this is done, the uses of this form of protection is not as dependable, nor are the results as certain, as those provided by water, carbon dioxide, dry chemical, or foam. Release devices for steam smothering systems should be manual, and controls should be arranged to close down oven outlets to the extent practicable.

C.2 Life Hazard.

C.2.1 Equipment should be arranged to prevent operating of steam valves when doors of box-type ovens or access doors or panels of conveyor ovens are open.

C.2.2 A separate outside steam manual shutoff valve should be provided for closing off the steam supply during oven cleaning. The valve should be locked closed whenever employees are in the oven.

C.2.3 The main valve should be designed to open slowly, as the release should first open a small bypass in order to allow time for employees in the vicinity to escape and also to protect the piping from severe water hammer. A steam trap should be connected to the steam supply near the main valve to keep this line free of condensate.

C.3 Steam Outlets. If steam is used, steam outlets should be sufficiently large to supply 8 lb/min (3.6 kg/min) of steam for each 100 ft^3 (2.8 m^3) of oven volume. They preferably should be located near the bottom of the oven but might be located near the top, pointing downward, if the oven is not over 20 ft (6.1 m) high. Steam jets should be directed at dip tanks (in a manner to avoid disturbing the liquid surface) or other areas of special hazard.

Annex D: Informational References

D.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this recommended practice and are not part of the recommendations of this document unless also listed in Chapter 2 for other reasons.

D.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.
NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2006 edition.
NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2007 edition.
NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids,* 2007 edtion.
NFPA 54, *National Fuel Gas Code,* 2009 edition.
NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2007 edition.
NFPA 69, *Standard on Explosion Prevention Systems,* 2008 edition.

NFPA 70®, *National Electrical Code®,* 2008 edition.
NFPA 85, *Boiler and Combustion Systems Hazards Code,* 2007 edition.
NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.
NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,* 2008 edition.
NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,* 2008 edition.

D.1.2 Other Publications.

D.1.2.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI A14.3, *Safety Requirements for Fixed Ladders,* 2008.
ANSI/ISA 84.00.01, *Application of Safety Instrumented Systems for the Process Industries,* 2004.
ANSI Z21.18/CSA 6.3, *Standard for Gas Appliance Pressure Regulators,* 2007.
ANSI Z21.21/CSA 6.5, *Automatic Valves for Gas Appliances,* 2005.
ANSI Z117.1, *Safety Requirements for Confined Space,* 2003.

D.1.2.2 EN Publications. European Committee for Standardization, 36, rue de Stassart, B-1050, Brussels, Belgium.

EN 1543, *International Standard for Valve Proving Systems*, 1998.

D.1.2.3 FM Publications. FM Global, 1301 Atwood Avenue, P.O. Box 7500, Johnston, RI 02919.

FM 7400, *Approval Standard for Liquid and Gas Safety Shutoff Valves*, 1998.

D.1.2.4 NBBPVI Publications. National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229.

National Board Inspection Code, 2007.

D.1.2.5 NIOSH Publications. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Atlanta, GA 3033.

NIOSH *Pocket Guide to Chemical Substances in the Work Environment*, 2005.

D.1.2.6 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 353, *Standard for Limit Controls*, 1995.

D.1.2.7 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Chapter XVII, *Occupational Safety and Health Administration*.
Title 29, Code of Federal Regualtions, Parts 1910.24–1910.29 and Part 1910.111, "Storage and Handling of Anhydrous Ammonia."

D.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the recommendations of this document.

D.2.1 NFPA Publications. (Reserved)

D.2.2 ABMA Publications. American Boiler Manufacturers Association, 4001 N. 9th Street, Suite 226, Arlington, VA 2203-1900.

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D.2.3 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ISA S77.41, *Fossil Fuel Power Plant Boiler Combustion Controls,* 1997.
ANSI/ISA S77.42.01, *Fossil Fuel Plant Feedwater Control System—Drum Type,* 1999.
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D.3 References for Extracts in Informational Sections.

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