

NFPA®

85

Boiler and
Combustion Systems
Hazards Code

2023



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Boiler and Combustion Systems Hazards Code

2023 Edition



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NFPA® 85

Boiler and Combustion Systems Hazards Code

2023 Edition

This edition of NFPA 85, *Boiler and Combustion Systems Hazards Code*, was prepared by the Technical Committees on Fluidized Bed Boilers, Fundamentals of Combustion Systems Hazards, Heat Recovery Steam Generators, Multiple Burner Boilers, Pulverized Fuel Systems, Single Burner Boilers, and Stoker Operations and released by the Correlating Committee on Boiler Combustion System Hazards. It was issued by the Standards Council on November 29, 2022, with an effective date of December 19, 2022, and supersedes all previous editions.

This edition of NFPA 85 was approved as an American National Standard on December 19, 2022.

Origin and Development of NFPA 85

NFPA 85 has a long history of documents that were combined to form the present-day NFPA 85. (See Annex J, which is a flowchart depicting the complex development of NFPA 85.) The first of these documents, in 1924, was NBFU 60, "Regulations of the National Board of Fire Underwriters for the Installation of Pulverized Fuel Systems as Recommended by the National Fire Protection Association," which changed from an NBFU/NFPA document to an NFPA code in 1946.

The 2001 edition of NFPA 85 was a compilation of the following six standards:

NFPA 8501, *Standard for Single Burner Boiler Operation*

NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers*

NFPA 8503, *Standard for Pulverized Fuel Systems*

NFPA 8504, *Standard on Atmospheric Fluidized-Bed Boiler Operation*

NFPA 8505, *Standard for Stoker Operation*

NFPA 8506, *Standard on Heat Recovery Steam Generator Systems*

In the 2001 edition, significant new material was added for multiple burner boilers, including requirements for reburn systems. For heat recovery steam generators, the minimum purge flow requirements prior to starting the combustion turbine were reduced.

The 2004 edition was reorganized to provide administrative requirements in Chapters 1, 2, and 3 and common requirements in Chapter 4, Fundamentals of Boiler Combustion Systems.

Subsequent chapters covered the specific requirements for each of the boiler and combustion systems covered by the document. The 2004 edition also provided new requirements that addressed selective catalytic reduction (SCR) systems for multiple burner boilers.

In the 2007 edition, Annex M was added to assist users to better understand the complex development of what is now known as NFPA 85. Chapter 4 in the 2007 edition also included new requirements for flue gas path auxiliary systems and flame proving, along with supporting annex material.

The 2007 edition recognized the use of valve-proving systems for single burner boilers in Chapter 5. Furnace structural design requirements for multiple burner boilers were added to Chapter 6 and account for the impact of booster fans. Implosion protection was clarified as not being required on units that have no fan in the flue gas stream downstream of the boiler. In conjunction with those changes, a definition of booster fan was added to Chapter 3. New requirements for flue gas path auxiliary systems were added to Chapters 6 and 7 for multiple burner boilers and fluidized-bed boilers, respectively. New requirements were added for lance and burner safety shutoff valves on fluidized-bed boilers.

The scope of Chapter 8 was expanded in the 2007 edition from heat recovery steam generators to include other combustion turbine exhaust systems that present similar fire and explosion hazards, including those with no heat recovery. The definition of combustion turbine exhaust systems was added to Chapter 3, and other changes were made throughout the code as required for consistency. Additional combustion turbine interlocks were added to ensure fuel gas in-leakage does not occur during the combustion turbine purge and that excessive fuel is not introduced during combustion turbine light-off.

The 2011 edition incorporated a renumbering and reorganization of Chapter 4 to make it easier to use and cite. In addition, Chapter 4 expanded requirements and annex guidance for burner management systems to describe the types of signals and transmitters used to initiate safety alarms and interlocks and how those signals should be monitored for reliability. Chapter 4 was updated with modified requirements for continuous trend display for single burner boilers to require only those parameters critical to operation.

A definition of *combustion turbine purge credit* was added to Chapter 3, and requirements for the credit to Chapter 8, in the 2011 edition. The combustion turbine purge credit enables designers and operators to establish and maintain a “purged” condition for HRSGs for an extended period of time between restarts.

Guidance was also added to Annex A of the 2011 edition regarding flue gas analyzers in Chapters 5, 6, and 7 concerning the potential for certain types to provide a source of ignition during start-up. In Chapter 6, which addresses multiple burner boilers, the “all fan trip” purge requirements were revised for clarity and to improve the safety of that procedure.

The 2015 edition incorporated new requirements in Chapter 4 for safely purging fuel gas piping systems, both into and out of service. The coverage in NFPA 85 began at the newly defined *equipment isolation valve*. All gas- and liquid fuel-fired boilers are required to be installed with an identifiable equipment isolation valve that demarcates equipment within the scope of NFPA 85 from piping and equipment within the scope of other codes and standards, such as NFPA 54, *National Fuel Gas Code*, or ASME B31.1, *Power Piping*. The new purge requirements contain provisions addressing piping and equipment, both upstream and downstream of the equipment isolation valve.

Several provisions were moved from Chapter 6, Multiple Burner Boilers, to Chapter 4, Fundamentals, so that they apply to all equipment under the scope of NFPA 85. These include requirements for conducting a process hazard analysis for unattended operation, removing interlocks from service during start-up or operation, and preventing the flow of flue gases from a common stack into an idle boiler or HRSG. A provision was added to Chapter 5 to exempt some single burner boilers from the process hazard analysis.

The 2015 edition recognized the use of safety-rated programmable logic controllers for use with single burner boilers where they are certified as at least SIL 3 capable according to IEC 61508, *Functional Safety of Electrical/Electronic Programmable Electronic Safety-Related Systems*.

Chapter 9, Pulverized Fuel Systems, was completely rewritten in the 2015 edition to separate requirements for direct-fired and indirect-fired systems to assist users in identifying and applying requirements for specific equipment. The requirements for indirect-fired systems were greatly expanded and clarified so that the chapter is easier to apply to the unique hazards related to those types of systems. In addition, the “strength of equipment” requirements were modified to recognize that the 344 kPa (50 psi) pressure threshold is really a maximum allowable working pressure (MAWP) and that this MAWP is associated with pulverized fuel having P_{max} of 10 bar-g (145 psig) or less, as identified in NFPA 69, *Standard on Explosion Prevention Systems*. Chapter 9 was updated to reflect the new terminology and methodology.

Finally, the annex material was reorganized so that all supplemental information on stokers is in Annex F and all supplemental information on fluidized bed boilers is in Annex D.

The 2019 edition incorporated new and revised definitions for *interlock*, *trip*, and *permissive*, and correlated terms related to these (such as safety interlock, interlock system, safety or interlock device, master fuel trip, and emergency shutdown) throughout the document for consistency. New language was added to require specification of autoignition temperature for fuels over the range of expected operating conditions. Revisions were made to more accurately describe the allowed uses of Class 2 and Class 3 igniters. Requirements for overpressure protection, which had been repeated in multiple equipment-specific chapters, were moved forward to Chapter 4, with additional detail added to clarify the application of overpressure protection and methods to achieve it. The single burner boiler requirements were reformatted to eliminate repetition and combine similar procedures used for both water-tube and fire-tube boilers. Annex material was added to provide guidance on the frequency of testing for multiple burner boiler interlocks, and operational leak test frequencies were clarified and revised to specify that the test does not need to be repeated if completed within 8 hours. Language was added to clarify that a combustion turbine purge is not required on subsequent starts if purge credit is maintained. The material on supervised manual systems in Annex B was removed and replaced with information on concentrated flame igniters.

The 2023 edition has added new requirements, expanded and clarified existing language, and defined additional terms. Chapter 4 has new requirements and annex text that prescribe a written commissioning plan for all new and retrofitted boilers. Signage and procedures, along with any necessary personal protective equipment to reduce the risk of injury, are now required for observation ports that open into enclosures. Additionally, an alternative to the current vent sizing has been introduced

where the potential leakage of the upstream valve is known and a valve-proving system is in use. The definition for *noncombustible material* has also been revised for consistency with other NFPA documents.

The 2023 edition has changed the safety integrity level (SIL) for single burner boilers in Chapter 5 from SIL 3 to SIL 2 to ensure that the programmable logic controller (PLC) and input/output (I/O) modules are certified by an independent organization and not the manufacturer. Additionally, new SIL requirements clarify that the burner management system logic is implemented in the safety area of the processor and not with the control system in the general-purpose area of the processor.

Multiple burner boiler requirements in Chapter 6 have been expanded for interlock functional tests, and new annex material that outlines the intent and goals of the test has been added. Additionally, the starting sequence for multiple burner boilers has been revised to specify that the trial timer begins when the individual igniter safety shutoff valve(s) is energized and not when proven open. The nomenclature *leak test* has been changed to *fuel gas header system tightness test* to better reflect the requirement to ensure the main safety shutoff valve and upstream individual burner safety shutoff valves are not leaking. The multiple burner boiler annex material for this test has also been rewritten to better contextualize the requirements for the user. The starting sequence for multiple burner boilers has been revised throughout Chapter 6 to reflect that overfire air is in service before the boiler is operating.

Minimum safety requirements and informational text have been added in Chapter 8 and its associated annex material to more accurately describe the conditions under which a turbine/heat recovery steam generator (HRSG) system can achieve combustion turbine purge credit.

Throughout Chapter 9, the term *coal* has been replaced with *fuel*, since the specific type of raw fuel being used is not necessarily coal.

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(Alt. to Kazuhiro Domoto)

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Committee Scope: This Committee shall have primary responsibility for documents on the reduction of combustion system hazards in single-burner boilers, multiple-burner boilers, and stoker-fired boilers with a heat input rate of 12,500,000 Btu/hr and above. This includes all fuels. This Committee also is responsible for documents on the reduction of hazards in pulverized fuel systems, fluidized-bed boilers, and heat recovery steam generators and other combustion turbine exhaust systems at any heat input rate.

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(Alt. to Robert M. Herdman)

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Thomas Wassel, Air Techniques Inc., NC [IM]

Wesley Weaver, Southern Company Services, AL [U]

Alternates

Philip Blanchard, Schneider Electric, LA [M]
(Alt. to Farshad Hendi)

Stephen Garner, Exponent, Inc., IL [SE]
(Alt. to Mark T. Fecke)

Eric Pedaci, Fives North American Combustion Inc., OH [M]
(Alt. to Ted Jablowski)

Nick M. Salem, Babcock & Wilcox Power Generation Group, Inc., OH [M]

(Alt. to Gail J. Lance)

Stewart Wyatt, General Electric/ALSTOM Power Inc., CT [M]
(Alt. to Randy J. Kleen)

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Randy J. Kleen, General Electric Company, TX [M]

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Elia Sung, Sargent & Lundy LLC, IL [SE]

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Ilya Yarinovsky, Bechtel Corporation, PA [SE]

Alternates

Donald W. Bairley, General Electric, CT [M]

(Alt. to Randy J. Kleen)

Humberto Gonzalez, Siemens Energy Inc., FL [M]

(Alt. to Thomas Primke)

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(Alt. to David E. Dexter)

Karen Whitehead, Black & Veatch Corporation, KS [SE]

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Franklin R. Switzer, Jr., S-safe, Inc., NY [SE]

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Donald Zissa, SIS-TECH, TX [SE]

Alternates

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(Alt. to Frank J. Bennett)

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

Committee Scope: This Committee shall have primary responsibility for documents covering the reduction of combustion system hazards and the prevention of boiler furnace explosions and implosions in multiple burner boilers with a heat input rate of 12,500,000 Btu/hr and above. This includes all fuels.

Technical Committee on Pulverized Fuel Systems

Joseph E. Bittinger, Jr., *Chair*

American Electric Power Company, Inc., OH [U]

Denise Beach, FM Global, MA [I]

John C. Dage, DTE Electric Company, MI [U]

Rory G. Eastman, General Electric/ALSTOM Power Inc., CT [M]

Mark T. Fecke, Exponent, Inc., IL [SE]

Gray Kahl, Apex Power Services Pty. Ltd., Australia [SE]

Ben Lawrence, Luminant, TX [U]

Yancy P. McWain, Babcock & Wilcox PGG Inc., OH [M]

Roy Reeves, Emerson Automation Solutions, PA [M]

Cleveland B. Skinker, Bechtel Infrastructure and Power Corporation, VA [SE]

William A. (Andy) Smith, American International Group, Inc. (AIG), GA [I]

Erdem A. Ural, Loss Prevention Science & Technologies, Inc., MA [SE]

Alternates

Stephen Garner, Exponent, Inc., IL [SE]

(Alt. to Mark T. Fecke)

Stanley Edward Kmietek, General Electric, CT [M]

(Alt. to Rory G. Eastman)

Glenn Richter, Emerson Automation Solutions, WI [M]

(Alt. to Roy Reeves)

Heath Dehn, NFPA Staff Liaison

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

Committee Scope: This Committee shall have primary responsibility for documents on the operation and design requirements for the reduction of hazards associated with pulverized fuel systems at any heat input rate.

Technical Committee on Single Burner Boilers

Peter J. Willse, *Chair*

Portland Fire Marshal's Office, CT [E]

Denise Beach, FM Global, MA [I]

David Bohling, John Zink Company LLC, CA [M]

Jeff M. Breidenbach, Liberty Mutual, KY [I]

Zach Brooks, Emerson Automation Solutions, MO [M]

David Paul Cannon, QA Support LLC, TX [SE]

Kevin J. Carlisle, Karl Dungs, Inc., MN [M]

John T. Connor, Burns & McDonnell Engineering Company, MO [SE]

Fedja Drndarevic, Technical Standards and Safety Authority, Canada [E]

Joseph E. Fehr, Affiliated Engineers, Inc., KS [SE]

Robert Frohock, Preferred Utilities, CT [M]

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

Travis F. Hardin, UL LLC, NC [RT]

Marc L. Hunter, Rockwell Automation, IL [M]

Ted Jablkowski, Fives North American Combustion, Inc., CT [M]

Patrick Jennings, Hartford Steam Boiler, CT [I]

Charles G. Keith, Keith-Pfaendtner Engineering LLC, MN [SE]

Raymond Labore, Carrier/Fireye Inc., NH [M]

David M.J. Lauterbach, The DuPont Company, Inc., TX [U]

John D. Martens, Exponent, Inc., IL [SE]

Anthony Joseph Mayle, Babcock & Wilcox, OH [M]

Karen D. Morton, Hargrove Controls Automation, LA [SE]

Gary Persichini, Victory Energy Operations LLC, OK [M]

Peter S. Pinto, SCC, Inc., IL [M]

Carlos Santos, Jr., Schneider Electric, TX [M]

Gary J. Shrider, Norec Automation, OH [SE]

William A. (Andy) Smith, American International Group, Inc. (AIG), GA [I]

Franklin R. Switzer, Jr., S-safe, Inc., NY [SE]

Mark V. Urda, Synergy Systems Inc., IL [SE]

Scott G. Vickery, Ascend Performance Materials, TX [U]

Marc A. Wolff, Federal Bureau of Prisons, DC [U]

Donald Zissa, SIS-TECH, TX [SE]

Alternates

Emily Cheng, John Zink Company, LLC, CA [M]
(Alt. to David Bohling)

Alberto Dib, SIS-TECH Solutions, TX [SE]
(Alt. to Donald Zissa)

Brent Diley, Babcock & Wilcox, OH [M]
(Alt. to Anthony Joseph Mayle)

Mark T. Fecke, Exponent, Inc., IL [SE]
(Alt. to John D. Martens)

James E. Franks, AXA XL/Global Asset Protection Services, LLC, TN [I]
(Voting Alt.)

Enrique Jorge Jimenez, Burns and McDonnell, TX [SE]
(Alt. to John T. Connor)

Steven M. Kormann, Emerson Automation Solutions, MO [M]
(Alt. to Zach Brooks)

Michael McArdle, FM Global, MO [I]
(Alt. to Denise Beach)

Eric Pedaci, Fives North American Combustion Inc., OH [M]
(Alt. to Ted Jablkowski)

Mark Waszczak, SCC, Inc., IL [M]
(Alt. to Peter S. Pinto)

Heath Dehn, NFPA Staff Liaison

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

Committee Scope: This Committee shall have primary responsibility for documents on the reduction of combustion system hazards and the prevention of boiler furnace explosions in single burner boilers with a heat input rate of 12,500,000 Btu/hr and above. This includes all fuels.

Technical Committee on Stoker Operations

Mark T. Fecke, *Chair*
Exponent, Inc., IL [SE]

John F. Kane, Covanta, NC [U]

Robert S. Morrow, Detroit Stoker Company, MI [M]

Alternates

Stephen Garner, Exponent, Inc., IL [SE]
(Alt. to Mark T. Fecke)

Jacob Welch, Detroit Stoker Company, MI [M]
(Alt. to Robert S. Morrow)

Heath Dehn, NFPA Staff Liaison

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

Committee Scope: This Committee shall have primary responsibility for documents covering the operation of stokers and related fuel burning equipment with a heat input rate of 12,500,000 BTU/hr and above. This includes all fuels.

Contents

Chapter 1 Administration	85– 14	Chapter 7 Atmospheric Fluidized Bed Boilers	85– 79
1.1 Scope.	85– 14	7.1 Application.	85– 79
1.2 Purpose.	85– 14	7.2 Purpose.	85– 79
1.3 Application.	85– 14	7.3 General.	85– 79
1.4 Retroactivity.	85– 15	7.4 Equipment Requirements.	85– 80
1.5 Equivalency.	85– 15	7.5 Furnace Pressure Excursion Prevention.	85– 86
1.6 Enforcement.	85– 15	7.6 Sequence of Operations.	85– 88
Chapter 2 Referenced Publications	85– 15	7.7 Sequence of Operations for Gas-Fired Warm-Up Burners.	85– 93
2.1 General.	85– 15	7.8 Sequence of Operations for Oil-Fired Warm-Up Burners.	85– 98
2.2 NFPA Publications.	85– 15	7.9 Interlocks.	85– 106
2.3 Other Publications.	85– 15	7.10 Alarm System.	85– 112
2.4 References for Extracts in Mandatory Sections. ...	85– 16	Chapter 8 Heat Recovery Steam Generators and Other Combustion Turbine Exhaust Systems	85– 114
Chapter 3 Definitions	85– 16	8.1 Application.	85– 114
3.1 General.	85– 16	8.2 Purpose.	85– 114
3.2 NFPA Official Definitions.	85– 16	8.3 Project Coordination.	85– 114
3.3 General Definitions.	85– 16	8.4 Equipment.	85– 114
Chapter 4 Fundamentals	85– 22	8.5 HRSG Enclosure and Other Combustion Turbine Exhaust Systems.	85– 117
4.1 Manufacture, Design, and Engineering.	85– 22	8.6 Electrical.	85– 118
4.2 Installation and Commissioning.	85– 22	8.7 Controls, Monitoring, Alarms, and Interlocks.	85– 118
4.3 Coordination of Design, Construction, and Operation.	85– 23	8.8 Purge, Start-up, Operation, and Shutdown of HRSG and Other Combustion Turbine Exhaust Systems.	85– 120
4.4 Maintenance, Inspection, Training, and Safety.	85– 23	8.9 Combustion Turbine Exhaust Bypass Systems.	85– 126
4.5 Basic Operating Requirements.	85– 24	8.10 Combustion Turbine and HRSG with Fresh Air Firing Capability.	85– 128
4.6 Structural Design.	85– 24	8.11 Combustion Turbine Exhaust System.	85– 129
4.7 Functional Requirements of Fuel-Burning System.	85– 24	Chapter 9 Pulverized Fuel Systems	85– 129
4.8 Multiple Boilers or HRSGs.	85– 25	9.1 Application.	85– 129
4.9 Gaseous Vent System Requirements.	85– 26	9.2 Purpose.	85– 129
4.10 Fuel System Piping.	85– 26	9.3 General.	85– 129
4.11 Burner Management System Logic.	85– 27	9.4 Direct-Fired Pulverized Fuel Systems.	85– 130
4.12 Flame Monitoring and Tripping Systems.	85– 28	9.5 Indirect-Fired Pulverized Fuel Systems.	85– 135
4.13 Combustion Control System.	85– 29	9.6 Operation.	85– 139
4.14 Power Supplies.	85– 29	9.7 Special Systems.	85– 141
4.15 Operating Information.	85– 29	Chapter 10 Stokers	85– 146
4.16 Selective Catalytic Reduction.	85– 30	10.1 Purpose.	85– 146
4.17 Noncombustible Material.	85– 30	10.2 Fuel-Burning System.	85– 146
Chapter 5 Single Burner Boilers	85– 30	10.3 Combustion Control System.	85– 147
5.1 Application.	85– 30	10.4 Operation.	85– 147
5.2 Purpose.	85– 30	10.5 Furnace Inspection.	85– 149
5.3 Unattended Operation.	85– 30	10.6 On-Line Maintenance.	85– 149
5.4 Equipment Requirements.	85– 30	10.7 Access Doors or Observation Ports.	85– 149
5.5 Starting of a Cold Boiler.	85– 33	10.8 Ash Hopper Access Doors.	85– 150
5.6 Burner Management Systems.	85– 34	10.9 Ash Handling.	85– 150
5.7 Simultaneous Firing of Oil and Gas Fuels.	85– 36	Annex A Explanatory Material	85– 150
5.8 Simultaneous Firing of Oil and Gas for Fuel Transfer Only.	85– 38	Annex B Concentrated Flame Igniter Supplemental Information	85– 191
5.9 Dual Oil Atomizers in a Single Burner.	85– 40	Annex C Multiple Burner Boiler Low NOx Operation — Special Considerations	85– 193
Chapter 6 Multiple Burner Boilers	85– 41	Annex D Fluidized Bed Boilers Supplemental Information	85– 194
6.1 Application.	85– 41	Annex E Common Pulverized Fuel System Designs	85– 198
6.2 Purpose.	85– 41	Annex F Supplemental Information on Stoker-Fired Boilers	85– 207
6.3 Mechanical Equipment Requirements.	85– 41		
6.4 Burner Management and Combustion Control Requirements.	85– 41		
6.5 Furnace Implosion Protection.	85– 50		
6.6 Fuel Gas Systems.	85– 52		
6.7 Fuel Oil Systems.	85– 61		
6.8 Pulverized Coal Systems.	85– 70		
6.9 Selective Catalytic Reduction (SCR) Systems with Bypass Capability.	85– 79		

Annex G	Sample Ordinance Adopting NFPA 85	85– 214	Annex J	Origin and Development of NFPA 85	85– 219
Annex H	Safety	85– 215	Annex K	Informational References	85– 221
Annex I	Fuel Hazards	85– 216	Index		85– 223

NFPA 85

Boiler and Combustion Systems Hazards Code

2023 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. 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 shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1* Scope. This code applies to the following:

- (1) Single burner boilers, multiple burner boilers, stokers, and atmospheric fluidized bed boilers with a fuel input rating of 3.7 MW_t (12.5 million Btu/hr) or greater
- (2) Pulverized fuel systems at any heat input rate
- (3) Fired or unfired steam generators used to recover heat from combustion turbines [heat recovery steam generators (HRSGs)] and other combustion turbine exhaust systems at any heat input rate

1.1.1 This code covers design, installation, operation, maintenance, and training.

1.1.2 This code covers strength of the structure, operation and maintenance procedures, combustion and draft control equipment, interlocks, alarms, and other related controls that are essential to safe equipment operation.

1.1.3 This code does not cover process heaters used in chemical and petroleum manufacture in which steam generation is incidental to the operation of a processing system.

1.1.4 Chapter 5 covers single burner boilers that fire the following fuels:

- (1) Fuel gas as defined in 3.3.65.3.
- (2)* Other gas having a calorific value and characteristics similar to natural gas
- (3) Fuel oil as defined in 3.3.65.4
- (4) Fuel gas and fuel oil that are fired simultaneously for fuel transfer
- (5) Fuel gas and fuel oil that are fired simultaneously and continuously

1.1.5 Chapter 6 covers multiple burner boilers firing one or more of the following:

- (1) Fuel gas, as defined in 3.3.65.3
- (2) Fuel oil, as defined in 3.3.65.4
- (3) Pulverized coal, as defined in 3.3.65.2.1
- (4) Simultaneous firing of more than one of the fuels stated in 1.1.5(1) through 1.1.5(3)

1.1.6 Chapter 7 covers atmospheric fluidized bed boilers.

1.1.7* Chapter 8 covers HRSG systems and other combustion turbine exhaust systems.

1.1.8 Chapter 9 covers pulverized fuel systems, beginning with the raw fuel bunker, which is upstream of the pulverizer and is the point at which primary air enters the pulverizing system, and terminating at the point where pressure can be relieved by fuel being burned or collected in a device that is built in accordance with this code. The pulverized fuel system shall include the primary air ducts, which are upstream of the pulverizer, to a point where pressure can be relieved.

1.1.9 Chapter 10 covers boilers that use a stoker to fire the following fuels:

- (1) Coal
- (2) Wood
- (3) Refuse-derived fuel (RDF)
- (4) Municipal solid waste (MSW)
- (5) Other solid fuels

1.1.9.1 Where solid fuel is fired simultaneously with other fuels (e.g., a solid fuel stoker fired in combination with fuel gas, fuel oil, or pulverized auxiliary fuel), additional controls and interlocks shall include those covered in Chapters 5, 6, and 9.

1.2 Purpose.

1.2.1* The purpose of this code is to contribute to operating safety and to prevent uncontrolled fires, explosions, and implosions in equipment described in Section 1.1.

1.2.2 This code establishes minimum requirements for design, installation, operation, training, and maintenance.

1.3 Application.

1.3.1 This code shall apply to new installations and to major alterations or extensions that are contracted for subsequent to the effective date of this code.

1.3.2 This code shall not be used as a design handbook.

1.3.2.1 A designer capable of applying more complete and rigorous analysis to special or unusual problems shall have latitude in the development of such designs.

1.3.2.2 The designer of 1.3.2.1 shall be responsible for demonstrating and documenting the validity of the proposed design.

1.3.3 Coordination of the design and operating procedures, control systems, interlocks, and structural design of the boiler furnace or HRSG system and any flue gas cleanup systems downstream of the postcombustion gas passes shall be required. Such coordination shall include requirements for ensuring a continuous flow path from the combustion air inlet through the stack.

1.3.4 Inspections required by or conducted in accordance with this code shall be the responsibility of the owner/operator or designated representative.

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

1.4.1 Unless otherwise specified, the provisions in this code shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the code. Where specified, the provisions in this code shall 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 shall be permitted to apply retroactively any portions of this code deemed appropriate.

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

1.5 Equivalency. Nothing in this code 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 code.

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

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

1.6 Enforcement. This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority. (See Annex G for sample wording for enabling legislation.)

Chapter 2 Referenced Publications

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

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

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

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

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2021 edition.

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

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2023 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2023 edition.

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

NFPA 70®, *National Electrical Code®*, 2023 edition.

2.3 Other Publications.

2.3.1 ASCE Publications. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, 2022.

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

ASME B31.1, *Power Piping*, 2020.

ASME B31.3, *Process Piping*, 2020.

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

ASTM D388, *Standard Classification of Coals by Rank*, 2019a.

ASTM D396, *Standard Specification for Fuel Oils*, 2020.

ASTM D409/D409M, *Standard Test Method for Grindability of Coal by the Hardgrove-Machine Method*, 2016.

ASTM D1655, *Standard Specification for Aviation Turbine Fuels*, 2020d.

ASTM D2880, *Standard Specification for Gas Turbine Fuel Oils*, 2020.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019.

ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2018.

2.3.4 CGA Publications. Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102.

ANSI/CGA G-2.1, *Requirements for the Storage and Handling of Anhydrous Ammonia*, 2014.

2.3.5 FCI Publications. Fluid Controls Institute, 1300 Sumner Avenue, Cleveland, OH 44115.

ANSI/FCI 70-2, *Control Valve Seat Leakage*, 2021.

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

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

2.3.7 Military Specifications. Department of Defense Single Stock Point, Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-T-5624, *Turbine Fuel, Aviation, Grade JP4, JP5, and JP5/JP8 ST*, 1995.

2.3.8 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1926.32, "General Safety and Health Provisions."

2.3.9 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2022 edition.

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

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*®, 2022 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, 2020 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2021 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3* Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

3.2.4 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.

3.2.5* 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.

3.2.6 Shall. Indicates a mandatory requirement.

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

3.2.8 Standard. An NFPA standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases "standards development process" or "standards development activities," the term "standards" includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

3.3.1 Agglomerating. A characteristic of coal that causes coking on the fuel bed during volatilization.

3.3.2 Air.

3.3.2.1 Auxiliary Air. Air that is supplied from an auxiliary source to maintain a minimum fuel mixture velocity in burner piping.

3.3.2.2 Combustion Air. Air used to react with the fuel in the combustion process. For duct burners, this generally is combustion turbine exhaust.

3.3.2.3 Design Full Load Mass Airflow. The air flow required to achieve nameplate full load. For the purposes of Chapter 6, it is the flow required to achieve nameplate full load based on the original design fuel as defined by the boiler equipment manufacturer.

3.3.2.4* Excess Air. Air supplied for combustion in excess of theoretical air.

3.3.2.5 Overfire Air. Air supplied for combustion that is admitted into the furnace at a point above the burners or fuel bed.

3.3.2.6 Primary Air. Air supplied for combustion that is admitted into the furnace through a burner premixed with the fuel.

3.3.2.6.1 Primary Air (in a Bubbling Fluidized Bed). That portion of total air used to transport or inject fuel or sorbent and to recycle material to the bed.

3.3.2.6.2 Primary Air (in a Circulating Fluidized Bed). That portion of total air introduced at the base of the combustor through the air distributor.

3.3.2.6.3 Primary Air (in a Pulverized Fuel System). In a pulverized fuel system, either air or a flue gas–air mixture; can simultaneously also be pulverizer air and/or transport air.

3.3.2.7 Pulverizer Air. Air or inert gas that is introduced into the pulverizer to dry the fuel, aid in pulverization and classification, and convey the pulverized fuel from the pulverizer.

3.3.2.8 Seal Air. Air or inert gas supplied to any device at sufficient pressure for the specific purpose of minimizing contamination.

3.3.2.9 Secondary Air. Air for combustion supplied to the burners or fuel bed in addition to the primary air.

3.3.2.9.1 Secondary Air (in a Bubbling Fluidized Bed). That portion of the air introduced through the air distributor.

3.3.2.9.2 Secondary Air (in a Circulating Fluidized Bed). That portion of the air entering the combustor at levels above the air distributor.

3.3.2.9.3 Secondary Air (in a Single or Multiple Burner Boiler). That portion of the air entering through the air registers.

3.3.2.10 Tempering Air. Cool air added to the hot primary air or gas to modify its temperature.

3.3.2.11 Transport Air. Air or inert gas that is used to convey pulverized fuel.

3.3.2.11.1* Transport Air (in a Fluidized Bed). The air used to convey or inject solid fuel or sorbent or to recycle material.

3.3.2.12 Undergrate Air. Combustion air introduced below the grate.

3.3.3 Air Change. A quantity of air, provided through a fuel burner, equal to the volume of furnace and boiler gas passes.

3.3.4 Air Register. A set of dampers for a burner, or air supply system to a particular burner, used to distribute the combustion air admitted to the combustion chamber. Frequently controls the direction and velocity of the airstream for efficient mixing with the incoming fuel.

3.3.5 Air-Rich. Indicating a ratio of air to fuel supplied to a combustion chamber that provides more than the minimum excess air needed for optimum combustion of the fuel.

3.3.6 Alarm. An audible or visible signal indicating an off-standard or abnormal condition.

3.3.7 Alteration. A change or modification that results in a deviation from the original design specifications or criteria.

3.3.8 Annunciator. A device indicating an off-standard or abnormal condition by both visual and audible signals.

3.3.9 Atmospheric Fluidized Bed Combustion. A fuel-firing technique using a fluidized bed operating at near-atmospheric pressure on the fire side.

3.3.10 Atomizer. The device in a burner that breaks down liquid fuel into a finely divided state.

3.3.10.1 Mechanical Atomizer. The device in a burner that breaks down liquid fuel into a finely divided state without using an atomizing medium.

3.3.11 Atomizing Medium. A supplementary fluid, such as steam or air, that assists in breaking down liquid fuel into a finely divided state.

3.3.12 Augmented Air Firing. Supplementary firing with the addition of air at the duct burners to support and stabilize combustion or to reduce emissions.

3.3.13* Autoignition Temperature (AIT). The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

3.3.14 Bed Compartments. Segments of a fluidized bed, which might be individually controlled with respect to combustion airflow and fuel feed.

3.3.15 Bed Drain. An opening provided in the enclosure of a fluidized bed for the removal of spent bed material and any tramp material.

3.3.16 Bed Material. Granular particles that compose a fluidized bed.

3.3.17 Bed Temperature. The average temperature of a fluidized bed.

3.3.18 Bin. An enclosure to store pulverized fuel.

3.3.19 Bin System (Storage System). A system in which the fuel is pulverized and stored in bins from which it is withdrawn through feeders, as needed, for burning.

3.3.20 Boiler. A closed vessel in which water is heated, steam is generated, steam is superheated, or any combination thereof by the application of heat from combustible fuels in a self-contained or attached furnace.

3.3.21 Boiler Enclosure. The physical boundary for the combustion process and boiler pressure parts up to the initial transition to flues as defined by the boiler manufacturer.

3.3.22 Bubbling Fluidized Bed (BFB). A fluidized bed in which the fluidizing velocity is less than the terminal velocity of individual bed particles and in which part of the fluidizing gas passes through the bed as bubbles.

3.3.23 Bunker. An enclosure to store raw fuel.

3.3.24 Burner. A device or group of devices for the introduction of fuel and air into a combustion chamber at the velocity, turbulence, and concentration required to maintain ignition and combustion of fuel.

3.3.24.1* Duct Burner. A burner, mounted in a duct or discharging into a duct, used to heat the air, flue gas, or combustion turbine exhaust gas in the duct.

3.3.24.2 Warm-Up Burner (in a Fluidized-Bed Boiler). A burner having its own air supply used to warm up the bed to the ignition temperature of the main fuel. The warm-up burner also can be used for limited load carrying.

3.3.25* Burner Management System. The field devices, logic system, and final control elements dedicated to combustion safety and operator assistance in the starting and stopping of fuel preparation and burning equipment and for preventing misoperation of and damage to fuel preparation and burning equipment.

3.3.25.1 Automatic Burner Management System — Nonrecycling.

A burner management system by which a furnace is purged and a burner is started, ignited, and stopped automatically but does not recycle automatically.

3.3.25.2 Automatic Burner Management System — Recycling.

A burner management system by which a furnace is purged and a burner is started, ignited, and stopped automatically and recycles on a preset pressure range.

3.3.25.3 Manual Supervised Burner Management System.

A burner management system by which a furnace is purged and a burner is started, ignited, and stopped manually with supervision by interlocks.

3.3.26 Bypass Stack. A stack applied in addition to and separate from the normal HRSG exhaust stack that allows combustion turbine exhaust gas to flow independently to the atmosphere.

3.3.27 Char. The unburned combustibles in solid form combined with a portion of the fuel ash and sorbent.

3.3.28 Circulating Fluidized Bed (CFB). A fluidized bed in which the fluidizing velocities exceed the terminal velocity of individual bed particles.

3.3.29 Classifier. A device to control pulverized fuel particle size distribution.

3.3.30 Coal. See 3.3.65.2.

3.3.31 Combustion Chamber. The portion of the boiler or HRSG enclosure into which the fuel is fed, ignited, and burned.

3.3.32 Combustion Turbine. A turbine in which the rotating element is actuated by the pressure of combustion gases on curved vanes.

3.3.33* Combustion Turbine Exhaust Systems. A HRSG, a heat exchanger, or an emissions control system, alone or in combination, and associated ductwork between the combustion turbine exhaust and the stack inlet.

3.3.34 Combustion Turbine Normal Shutdown. The normal sequence of events that automatically provides successful shutdown of the combustion turbine with no abnormal conditions in the combustion system.

3.3.35 Commercial Operation. The date that the full plant capacity is formally added to the power grid.

3.3.36 Commissioning. The time period of plant testing and operation between initial operation and commercial operation.

3.3.37 Competent Person. One who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. [29 CFR:1926.32(f)]

3.3.38 Confined Space. Any work location or enclosure in which either of the following exists: (1) the dimensions are such that a person who is 1.8 m (6 ft) tall cannot stand up in the middle of the space or extend his or her arms in all directions without hitting the enclosure, or (2) access to or from the enclosure is by manhole, hatch, port, or other relatively small opening that limits ingress and egress to one person at a time. Confined spaces include but are not limited to the following:

pulverizers, ducts, heaters, windboxes, cyclones, coal dust collectors, furnaces, bunkers, bins, and HRSGs.

3.3.39 Continuous Trend Display. A dedicated visual display of an operating trend(s) by any instrument such as a cathode ray tube (CRT), chart recorder, or other device to quantify changes in the measured variable(s).

3.3.40 Control System.

3.3.40.1 Boiler Control System. The group of control systems that regulates the boiler process, including the combustion control system but not the burner management system.

3.3.40.2 Combustion Control System. The control system that regulates the furnace fuel and air inputs to maintain the air-fuel ratio within the limits that are required for continuous combustion and stable flame throughout the operating range of the boiler in accordance with demand.

3.3.40.2.1 Combustion Control System in a Fluidized Bed. In a fluidized bed, the control system that regulates the furnace fuel input, furnace air input, bed inventory, and other bed heat transfer mechanisms to maintain the bed temperature and the air-fuel ratio within the limits necessary for continuous combustion and stable bed operation throughout the operating range of the boiler in accordance with demand.

3.3.40.3 HRSG Control System. The group of control systems that regulate the HRSG process, including combustion control to maintain continuous combustion and stable flame, but not the burner management system.

3.3.41 Crusher. A device for reducing the size of solid fuels.

3.3.42 Damper. A valve or plate for controlling draft or the flow of gases, including air.

3.3.42.1 Shutoff Damper. A close-fitting damper to prevent flow and minimize leakage of air or flue gas into any system component.

3.3.43 Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [68, 2018]

3.3.44 Design Full Load Mass Airflow. See 3.3.2.3.

3.3.45 Direct-Fired System. A system in which the fuel is pulverized and delivered in suspension directly to the burner(s).

3.3.46 Directional Blocking. An interlock that, upon detection of a significant error in furnace pressure or HRSG process variables, acts to inhibit the movement of all appropriate final control elements in the direction that would increase the error.

3.3.47 Distributor. A device that splits a single stream of pulverized coal and primary air into two or more streams.

3.3.48 Drip Leg. A chamber of ample volume, with suitable cleanout and drain connections, over which fuel gas is passed so that liquids and solids are trapped.

3.3.49 Dust Collector. An auxiliary separator that is used to separate the fuel dust from the air or inert gas prior to discharge of the latter from the system.

3.3.50 Exhauster. See 3.3.54.2, Exhauster Fan.

3.3.51 Explosion Vent. A vent to relieve deflagration pressures resulting from ignition of a mixture of decomposition gases and air.

3.3.52 Explosive Mixture. A flammable or combustible mixture in a confined space.

3.3.53 False Start. A condition where the combustion turbine fails to complete its ignition sequence (failure to start) and can result in unburned fuels entering the HRSG enclosure or other combustion turbine exhaust systems.

3.3.54 Fan.

3.3.54.1 Booster Fan. A fan used to assist in the supply of air to, or the removal of flue gas products from, the combustion chamber or to supplement draft capability to achieve required flow through the combustion air or flue gas flow path.

3.3.54.2 Exhauster Fan. A fan located at the pulverizer outlet used to draw the primary air through the pulverizer and to deliver the primary air-fuel mixture to the burner(s) or other apparatus.

3.3.54.3 Forced Draft (FD) Fan. A fan used to pressurize and supply ambient air to the combustion chamber to support combustion. In a fluidized bed boiler, FD fans generally include both primary air and secondary air fans.

3.3.54.4 Induced Draft (ID) Fan. A fan downstream of the combustion process used to remove the products of combustion from the boiler, HRSG, or flue gas ductwork.

N 3.3.54.5 Overfire Air (OFA) Fan. A fan that supplies air to ports downstream of the combustion zone to complete combustion while minimizing emissions of NO_x and unburned combustibles.

3.3.54.6 Primary Air Fan. A fan used to supply coal transport air to the pulverizer or to the burner lines of a storage system.

3.3.55 Fan Override Action. A control that, upon detection of significant error in combustion chamber pressure, acts to reposition the induced draft fan control device(s) in a direction to reduce the error.

3.3.56 Feed-Forward Signal. A signal used to anticipate a change in the measured variable.

Δ 3.3.57 Flame. A body or stream of gaseous material involved in the combustion process and emitting radiant energy at specific wavelength bands determined by the combustion chemistry of the fuel. [72, 2022]

3.3.58 Flame Detector. A device that senses the presence or absence of flame and provides a usable signal.

3.3.58.1 Self-Checking Flame Detector. A flame detector that automatically, and at regular intervals, tests the entire sensing and signal processing system of the flame detector.

3.3.59 Flame Envelope. The confines (not necessarily visible) of an independent process that converts fuel and air into products of combustion.

3.3.60 Flashback. A recession of flame to an unwanted position (e.g., into a fuel transport pipe).

3.3.61 Fluidize. To maintain a bed of finely divided solid particles in a mobile suspension by blowing air or gas through the bed at such a velocity that the particles separate and behave much like a fluid.

3.3.62 Fluidized Bed. A bed of granular particles maintained in a mobile suspension by the velocity of an upward flow of air or gas.

3.3.63 Freeboard. In a fluidized bed boiler, the space or volume above the upper surface of the bubbling bed and below the entrance to the convection pass.

3.3.64 Fresh Air Firing. The operation of a HRSG with air instead of combustion turbine exhaust.

3.3.65 Fuel.

3.3.65.1 Auxiliary Fuel. In a fluidized bed boiler, generally a gaseous or liquid fuel used to warm the bed material sufficiently to allow ignition of the main fuel upon injection into the heated bed material.

3.3.65.2 Coal. A solid fuel classified as lignite, subbituminous, bituminous, or anthracite as defined by ASTM D388, *Standard Classification of Coals by Rank*.

3.3.65.2.1* Pulverized Coal. Coal that is reduced to fine particles.

3.3.65.3 Fuel Gas (Gas Fuel). Gaseous fuels defined as Natural Gas (see 3.3.65.3.2) or LP-Gas (see 3.3.65.3.1).

3.3.65.3.1* Liquefied Petroleum Gas (LP-Gas). Any material having a vapor pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves (except propylene) or as mixtures: propane, propylene, butane (normal butane or isobutane), and butylenes. [58, 2020]

3.3.65.3.2* Natural Gas. A material that is composed primarily of methane and that can contain minor quantities of ethane, propane, nitrogen, and other components.

3.3.65.4 Fuel Oil (Oil Fuel). Liquid fuels defined as Grades 2, 4, 5, or 6 in ASTM D396, *Standard Specification for Fuel Oils*, or as Grade 2GT in ASTM D2880, *Standard Specification for Gas Turbine Fuel Oils*.

3.3.65.5 JP4. A light, volatile fuel with a boiling point between that of gasoline and of light distillate. Its properties are defined in MIL-T-5624, *Turbine Fuel, Aviation, Grade JP4, JP5, and JP5/JP8 ST*, and are similar to ASTM D1655, *Standard Specification for Aviation Turbine Fuels (Jet B)*, and ASTM D2880, *Standard Specification for Gas Turbine Fuel Oils*.

3.3.65.6 Kerosene. A light, highly refined fuel that is slightly more volatile than No. 2 fuel oil. Its properties are defined in ASTM D396, *Standard Specification for Fuel Oils*; ASTM D1655, *Standard Specification for Aviation Turbine Fuels*; or ASTM D2880, *Standard Specification for Gas Turbine Fuel Oils*.

3.3.65.7 Main Fuel. In a fluidized bed boiler, gaseous, liquid, or solid fuel introduced into the bed after the bed temperature has reached a value sufficient to support its combustion and that is used during the normal operation of the boiler. Main fuels necessitate the use of the fluidized hot bed as their ignition source.

3.3.65.8 Municipal Solid Waste (MSW). Solid waste materials consisting of commonly occurring residential and light commercial waste. [850, 2020]

3.3.65.9* Pulverized Fuel. Solid fuel that is reduced to fine particles.

3.3.65.10 Refuse-Derived Fuel (RDF). A solid fuel prepared from municipal solid waste. The waste material is usually refined by shredding, air classification, magnetic separation, or other means. The fuel can be packed, chopped, pelletized, pulverized, or subject to other mechanical treatment.

3.3.66 Fuel-Rich. Indicating a ratio of air to fuel supplied to a furnace that provides less than the minimum excess air needed for optimum combustion of the fuel.

3.3.67 Fuel Trip. The total shutoff of a specific fuel as the result of an interlock.

3.3.68 Furnace. The portion of the boiler enclosure within which the combustion process takes place and wherein heat transfer occurs predominantly by radiation.

3.3.69 Grate. The surface on which fuel is supported and burned and through which air is passed for combustion.

3.3.70 Grindability. The characteristic of solid fuel that indicates its relative ease of pulverization, as defined by ASTM D409/D409M, *Standard Test Method for Grindability of Coal by the Hardgrove-Machine Method*.

3.3.71 Hardwired. The method of interconnecting signals or devices to a logic system or between logic systems using a dedicated interconnection for each individual signal. When the term *hardwired* is applied to the logic system itself, it refers to the method of using individual devices and interconnecting wiring to program and perform the logic functions without the use of software-based logic solvers.

3.3.72 Header. A pipe or duct through which liquid or gas is conveyed and supplied to or received from multiple branches.

3.3.73 Heat Recovery Steam Generator (HRSG). A heat exchanger that uses a series of heat transfer sections (e.g., superheater, evaporator, and economizer) positioned in the exhaust gas flow of a combustion turbine to recover heat and supply a rated steam flow at a required temperature and pressure.

3.3.73.1 HRSG Enclosure. All ductwork from the combustion turbine exhaust through the steam generator to the stack, including any bypass duct connection.

3.3.73.2 HRSG Purge. See 3.3.106.1, Combustion Turbine Purge; 3.3.106.3, Duct Burner (HRSG) Purge; and 3.3.109, Purge Rate.

3.3.73.3 HRSG System. The unit assembly from the combustion turbine inlet to the flue gas outlet to the atmosphere.

3.3.74 Igniter. A permanently installed device that provides proven ignition energy to light off the main burner.

3.3.74.1* Class 1 Igniter. An igniter that is applied to ignite the fuel input through the burner and to support ignition under any burner light-off or operating conditions. Its location and capacity are such that it will provide sufficient ignition energy at its associated burner to raise any credible combination of burner inputs of both fuel and air above the minimum ignition temperature.

3.3.74.2* Class 2 Igniter. An igniter that is applied to ignite the fuel input through the burner under prescribed light-off conditions. It is also used to stabilize the main burner flame.

3.3.74.3* Class 3 Igniter. A small igniter applied particularly to fuel gas and fuel oil burners to ignite the fuel input to the burner under prescribed light-off conditions.

3.3.74.4 Class 3 Special Igniter. A special Class 3 high energy electrical igniter capable of directly igniting the main burner fuel.

3.3.75 Inert Gas. Any gas that is nonflammable, chemically inactive, noncontaminating for the use intended, and oxygen deficient to the extent required.

3.3.76 Initial Operation. The first coordinated operation of the unit.

3.3.77* Interlock. A function that prevents, limits, stops, or initiates the operation of equipment or a subsequent function.

3.3.77.1 Permissive. An interlock that functions only to allow initiation of the operation of equipment or a subsequent function.

3.3.77.2 Trip. An interlock that shuts down equipment when a predefined set of conditions exists.

3.3.78 JP4. See 3.3.65.5.

3.3.79 Kerosene. See 3.3.65.6.

3.3.80 Lance. A device without its own air supply that provides fuel input directly into a fluidized bed.

3.3.81 Light-Off Time Limit Timer. A device that is used on supervised manual burner management systems and that limits the allowable time between completion of purge and light-off.

3.3.82 Lock Hopper. A feeding device that incorporates a double pressure seal, thus enabling solids to be fed into a system with a higher pressure than the pressure existing in the solid's storage area. Also, a letdown device that incorporates a double pressure seal, thus enabling solids to be withdrawn from a system with a higher pressure than that existing downstream of the lock hopper.

3.3.83 Logic System. A system that provides outputs in a particular sequence in response to external inputs and internal decision-making elements.

3.3.84 LP-Gas. See 3.3.65.3.1.

3.3.85* Master Fuel Trip. An event resulting in the rapid shutoff of all fuel, including igniters; for HRSGs, an event resulting in the rapid shutoff of all fuel to the duct burners, including igniters.

3.3.86 Master Fuel Trip Relay. An electromechanical relay(s) utilized to trip all required equipment simultaneously when a master fuel trip is initiated.

3.3.87 Monitor. To sense and indicate a condition without initiating automatic corrective action.

3.3.88 Natural Gas. See 3.3.65.3.2.

3.3.89 Noncombustible Material. See Section 4.17.

3.3.90 Oil. See 3.3.65.4, Fuel Oil (Oil Fuel).

3.3.91 Open Flow Path. A continuous path for movement of an airstream from the forced draft fan inlet to the stack; in a HRSG or other combustion turbine exhaust system, a continuous path for movement of an airstream through the HRSG system or other combustion turbine exhaust systems.

3.3.92 Open Register Light-Off Procedure. A procedure for purging and lighting off a boiler under specified, controlled conditions.

3.3.93 Operating Range. The range between the maximum fuel input and minimum fuel input within which the burner flame can be maintained in a continuous and stable manner.

3.3.94 Overfire Air Port. An opening in a furnace wall to enable the introduction of an overfire airstream.

3.3.95 Partial Loss of Flame. Loss of flame at any of the separate flame envelopes or burners while flame is maintained at any of the other flame envelopes or burners.

3.3.96 Permissive. See 3.3.77.1.

3.3.97 Positive Means. The physical methods of satisfying a requirement.

3.3.98 Postpurge. A purge performed after the burner(s) is shut down.

3.3.99 Pressure/Air Lock. A device for transferring pulverized fuel between zones of different pressure without permitting appreciable flow of air or gas in either direction.

3.3.100 Primary Air Fan (Pulverizer Air Fan). See 3.3.54.6, Primary Air Fan.

3.3.101* Process Hazard Analysis (PHA). A systematic review of hazards conducted by a team of experts.

3.3.102 Prove. To establish by measurement or test the existence of a specified condition such as flame, level, flow, pressure, or position.

3.3.103 Pulverized Fuel. See 3.3.65.9.

3.3.104 Pulverized Fuel Pump. A device or system for transporting fuel mechanically or pneumatically by utilizing minimum airflow.

3.3.105 Pulverizer. A machine for reducing the particle size of a solid fuel so that it burns in suspension.

3.3.106 Purge. A flow of air or an inert medium at a rate that will effectively remove gaseous or suspended combustibles and replace them with the purging medium.

3.3.106.1 Combustion Turbine Purge. A flow of air at purge rate through the combustion turbine and the appropriate portion of the HRSG enclosure or other combustion turbine exhaust systems for a number of volume changes sufficient to effectively remove gaseous or suspended combustibles and replace them with the air.

3.3.106.2 Combustion Turbine Purge Credit. A condition established by maintaining a set of parameters following a combustion turbine normal shutdown.

3.3.106.3 Duct Burner (HRSG) Purge. A flow of combustion turbine exhaust gas or air at purge rate through the HRSG enclosure for a number of volume changes sufficient to effectively remove gaseous or suspended combustibles and replace them with the purging medium.

3.3.107 Purge Into Service. To displace air in a fuel gas piping system with inert gas and then displace the inert gas with fuel gas.

3.3.108 Purge Out of Service. To displace the fuel gas in a fuel gas piping system by inert gas and then displace the inert gas with air.

3.3.109 Purge Rate. A constant flow of purging medium at velocity sufficient to achieve a purge.

3.3.110 Raw Fuel Feeder. A device for supplying a controlled amount of raw fuel.

3.3.111 Reburn. The process of admitting fuel downstream of the main burners to create a fuel-rich zone where chemical reactions reduce NO_x to molecular nitrogen.

3.3.112 Reburn Injector. A device that introduces fuel without combustion air into a furnace for the purpose of reducing NO_x emissions from the furnace.

3.3.113 Recycle. A single burner boiler start-up that is initiated by steam pressure or water temperature following a normal shutdown.

3.3.114 Refuse-Derived Fuel (RDF). See 3.3.65.10.

3.3.115 Remote Operation. Control from a location removed from the combustion area.

3.3.116 Repair. A process that returns the combustion system or subsystem to its original design specifications or criteria.

3.3.117 Restart. A manually initiated start-up.

3.3.118 Scavenging. The procedure by which liquid fuel left in a burner or igniter after a shutdown is cleared by admitting steam or air through the burner passages, typically through a dedicated scavenging medium valve.

3.3.119 Selective Catalytic Reduction (SCR). A method of reducing NO_x in flue gas.

3.3.120 Semifluidized. In a fluidized bed boiler, the state in which a uniform flow of air that is less than that necessary to fluidize the bed is admitted and is found to be sufficient to adequately remove gaseous combustibles.

3.3.121 Service Connection. A point at which fuel, an atomizing medium, or power is connected to the firing equipment or controlled devices.

3.3.122 Set Point. A predetermined value to which a device or system is adjusted and at which it performs its intended function.

3.3.123 Soot Blower. A mechanical device for introducing steam, air, or water to clean heat-absorbing surfaces.

3.3.124 Sorbent. In a fluidized bed boiler, a constituent that reacts with and captures a pollutant or, more generally, a constituent that reacts with and captures another constituent.

3.3.125 Stable Bed. In a fluidized bed boiler, a bed of granular material that maintains sustained combustion at a desired temperature.

3.3.126 Stable Flame. A flame envelope that retains its continuity throughout the maximum rate of change within the operating range of the boiler, burner, or HRSG.

3.3.127 Supervise. To sense and indicate a condition requiring attention and to automatically initiate corrective action.

3.3.128 Switch. Any set of contacts that interrupts or controls current flow through an electrical circuit.

3.3.129* Test Block Capability. The point on the fan head versus flow characteristic curve at which the fan is selected.

3.3.130 Transmitter. Any device that converts process measurements from a sensor into a variable signal to be received by a display, control, or interlock.

3.3.131 Trial for Ignition. The interval of time during light-off in which a safety control circuit permits the fuel safety shutoff valve(s) to be opened before the flame detection system is required to supervise the flame.

3.3.132 Trip. See 3.3.77.2.

3.3.133 Tuyeres. Forms of grates, located adjacent to a retort, feeders, or grate seals through which air is introduced.

3.3.134 Unattended Operation. A means of operation where the operator is not in view of operating instrumentation (local or remote) nor in a position to operate control systems.

3.3.135 Unit. The combined spaces of the furnace and the associated boiler passes, ducts, and fans that convey the gases of combustion to the stack; for HRSGs, the combined spaces of the combustion turbine, the HRSG, and the associated ducts that convey the air and combustion gases from the air intake to the stack; for other combustion turbine exhaust systems, the combined spaces of the combustion turbine, and the associated ducts that convey the air and combustion gases from the air intake to the stack.

3.3.136 Valve.

3.3.136.1 Barrier Valve. A valve, not necessarily dusttight, used to inhibit hot gases from traveling back into any system component open for inspection or maintenance.

3.3.136.2 Burner Shutoff Valve. In a pulverized fuel system, a valve that is installed in the fuel line between the pulverizer and the burner.

3.3.136.3 Charging Valve. In a gaseous or liquid fuel system, a small valve bypassing the main safety shutoff valve used for purging and charging the fuel headers and piping and for testing for leaks.

3.3.136.4 Check Valve. A valve that allows flow in one direction only. [13D, 2022]

3.3.136.5 Dusttight Valve. In a pulverized fuel system, a tight-seating valve installed in the fuel supply pipe to the burner to allow or stop flow.

3.3.136.6 Equipment Isolation Valve. A manual valve that separates the boiler, HRSG, or igniter fuel train from the fuel supply piping system.

3.3.136.7 Flow Control Valve. A valve capable of regulating quantity of throughput to a controlled range.

3.3.136.8* Safety Shutoff Valve (Safety Trip Valve). An automatic fast-closing valve that shuts off the gaseous or liquid fuel supply in response to a shutdown or trip signal.

3.3.136.9 Supervisory Shutoff Valve. In a gaseous or liquid fuel system, a manually operated shutoff valve with a means to provide a "valve closed" position signal.

N 3.3.136.10 Valve Leakage Test. A means to determine the tightness of a valve seat seal.

3.3.136.11 Vent Valve. A valve used to allow venting of air or gas from the system to the atmosphere.

3.3.137* Valve-Proving System. In a gaseous or liquid fuel system, an automatic system that proves the valve seat integrity of safety shutoff valves in series by detecting a leak which indicates a failure of the valve seat seal and prevents the main burner or igniter light-off if the test is not satisfied.

3.3.138 Volatile Matter. The portion of mass, except water vapor, that is driven off in a gaseous form when solid fuels are heated.

Chapter 4 Fundamentals

4.1* Manufacture, Design, and Engineering.

Δ 4.1.1* Unattended and Off-Site Operation. Unattended operation shall comply with both of the following:

- (1) Be approved
- (2) Have a process hazard analysis (PHA)

4.1.2 The burner or fuel feed piping and equipment shall be designed, constructed, and located to prevent the formation of hazardous concentrations of combustibles under normal operating conditions.

4.1.3* The installation of boilers or HRSGs, including the burners or fuel feed piping and equipment, in accordance with the requirements of this code shall not in and of itself determine the electrical classification.

4.1.4 Burners and associated equipment shall be accessible for maintenance.

4.2 Installation and Commissioning.

4.2.1 The boiler, heat recovery steam generator (HRSG), combustion turbine exhaust system, or pulverized fuel system shall not be released for operation before the installation and checkout of the required safeguards and instrumentation system have been successfully completed.

N 4.2.2* The equipment designer, construction manager, and owner shall prepare a written commissioning plan that all the participating parties approve.

4.2.3 The party responsible for the erection and installation of the equipment shall ensure that all pertinent apparatus is installed and connected in accordance with the system design.

4.2.4 The owner or owner's representative, the engineering consultant, the equipment manufacturer, and the operating company shall prohibit operation until the safeguards have been tested for correct operation as a system.

Δ 4.2.4.1 If temporary interlocks and instrumentation are necessary to meet the requirements of 4.2.4, any such temporary system shall be reviewed by the purchaser, the engineering consultant, the equipment manufacturer, and the operating company.

N 4.2.4.2 Where temporary interlocks and instrumentation are necessary, an agreement shall be reached on the system's ability to protect equipment and personnel before start-up.

4.2.4.3 All temporary modifications shall be documented, and permanent resolutions shall be accomplished prior to commercial operation.

4.2.5 The interlocks and associated devices shall be tested jointly by the organization responsible for the system design and by those who operate or maintain such a system.

4.2.6 After installation but before initial operation, coordinated tests of all systems shall be accomplished.

4.2.7 Documentation of the plant equipment, the system, and maintenance activities shall be updated to reflect changes in the status of equipment and operating procedures.

4.2.8* Each time fuel gas is introduced to a fuel gas supply piping system containing air or inert gas upstream of the equipment isolation valve, the source of fuel gas in the piping system upstream of the equipment isolation valve shall be confirmed to be in compliance with the applicable evacuation/purging and charging requirements in NFPA 54 or NFPA 56.

4.2.9* When fuel gas is introduced into piping downstream of the equipment isolation valve, the contents shall be displaced in accordance with one of the following:

- (1) Discharged through a permanently installed venting system; or
- (2) Discharged into the boiler or HRSG in accordance with the normal startup sequence; or
- (3) Purged into service in accordance with Chapter 7 of NFPA 56

4.3 Coordination of Design, Construction, and Operation.

4.3.1* During the planning and engineering phases of plant construction, the design shall be coordinated with operating personnel.

4.3.2* The integration of the various components, including boiler or HRSG, burner, fuel and air supply equipment, controls, interlocks and associated devices, operator and maintenance functions, and communication and training, shall be the responsibility of the owner and the operating company.

4.3.3 The owner shall specify the lowest autoignition temperature (AIT) for all fuels fired in the boiler or combustion turbine over the range of the expected operating conditions taking into consideration fuel composition, temperature, pressure, and oxygen concentration.

4.4* Maintenance, Inspection, Training, and Safety. Section 4.4 shall apply retroactively to all operating boilers and heat recovery steam generators.

4.4.1 Maintenance and Equipment Inspection. See also Annex H.

4.4.1.1* A program shall be provided for inspection and maintenance of equipment at intervals consistent with the type of equipment used, service requirements, and manufacturers' recommendations.

4.4.1.2 As a minimum, the maintenance program shall include the following:

- (1) Inspections to identify conditions that need corrective action
- (2) Planning for making repairs or modifications using qualified personnel and tools and instruments designed for the work

- (3) Equipment history and record of dates of service, conditions found, maintenance performed, and changes made
- (4) Written comprehensive maintenance procedures incorporating the manufacturer's instructions to define the tasks and skills required
- (5) Nondestructive examination requirements; tasks needing special tools; special environmental factors such as temperature limitations, dusts, contaminated or oxygen-deficient atmospheres, and limited access or confined space restrictions
- (6) Equipment condition assessment before and after maintenance
- (7) Supply of spare parts to perform required maintenance
- (8) Housekeeping essential for prevention of fires or explosions that includes the following:
 - (a) Provisions for cleaning of horizontal ledges or surfaces of buildings and equipment to prevent the accumulation of dust deposits greater than the minimum required to create an explosion hazard
 - (b) Water washing or vacuum cleaning methods to reduce the possibility of creating dust clouds
 - (c) Prohibition of the use of compressed air for cleaning

4.4.1.3* Operation, set points, and adjustments shall be verified by testing at specified intervals, and the results shall be documented.

4.4.1.4* Defects shall be reported and corrected, and the changes or repairs documented.

4.4.1.5 System configuration, including logic, set points, and sensing hardware, shall not be changed without detailed engineering review and documentation.

4.4.1.6 System operation shall be tested and verified for compliance with the design criteria whenever a controller is replaced, repaired, reprogrammed, or updated before returning it to service.

4.4.1.7 When a unit that fires liquid fuel is out of service and available for inspection, personnel shall check for any accumulation of unburned fuel in the boiler or HRSG enclosure, especially in the fin-tube area of a HRSG.

4.4.2 Purging Fuel Gas Piping Into and Out of Service.

4.4.2.1 Prior to the opening of fuel gas piping systems for maintenance, the piping section shall be isolated from the fuel gas supply, and the fuel gas piping system downstream of the equipment isolation valve shall be purged out of service in accordance with Chapter 8 of NFPA 56.

4.4.2.2 Following maintenance, fuel gas shall be introduced into piping downstream of the equipment isolation valve in accordance with 4.2.9.

4.4.3 Training.

4.4.3.1 Operator Training.

4.4.3.1.1* The owner or the owner's representative shall be responsible for establishing a documented formal training program with a structured and defined curriculum that is consistent with the type of equipment and hazards involved to prepare personnel to operate equipment.

4.4.3.1.2 Operating procedures shall be established that cover normal and emergency conditions.

4.4.3.1.2.1 Start-up, shutdown, and lockout procedures shall all be covered in detail.

4.4.3.1.2.2 Where different modes of operation are possible, procedures shall be prepared for each operating mode.

4.4.3.1.2.3 Procedures also shall be prepared for switching from one mode to another.

4.4.3.1.3 The owner or owner's representative shall verify that operators are trained and competent to operate the equipment under all conditions prior to their operation of such equipment.

4.4.3.1.4 The owner or owner's representative shall be responsible for retraining operators, including reviewing their competence, at intervals not to exceed three years.

4.4.3.1.5 The training program and operating and maintenance manuals shall be kept current with changes in equipment and operating procedures and shall be available for reference and use at all times.

4.4.3.1.6 Operating procedures shall be directly applicable to the equipment involved and shall be consistent with safety requirements and the manufacturer's recommendations.

4.4.3.2 Maintenance Training.

Δ **4.4.3.2.1*** The owner or owner's representative shall be responsible for establishing a documented formal and ongoing program with a structured and defined curriculum that is consistent with the equipment and hazards involved for training maintenance personnel to perform all required maintenance tasks.

4.4.3.2.2 Maintenance procedures and their associated training programs shall be established to cover routine and special techniques.

4.4.3.2.3 Environmental factors such as temperature, dusts, contaminated or oxygen-deficient atmospheres, internal pressures, and limited access or confined space requirements shall be included in the maintenance procedures.

4.4.3.2.4 Maintenance procedures shall be consistent with safety requirements and the manufacturer's recommendations and shall be kept current with changes in equipment and personnel.

4.5 Basic Operating Requirements.

4.5.1 Operating procedures with a minimum number of manual operations shall be established.

4.5.2 Standard operating procedures that result in well-defined and controlled operations shall be established.

4.5.3 Interlocks shall be provided to ensure correct operating sequences and to interrupt sequences when conditions are not correct for continuation.

4.5.4* The design shall not require any deliberate defeating of an interlock to start or operate equipment.

4.5.5 Interlocks shall be permitted to be temporarily removed from service in accordance with the following:

- (1) Removal of the interlock shall be authorized by a competent person, documented in accordance with operating procedures, and communicated to operations personnel.

- (2) Alternate means shall be substituted to supervise the interlock in accordance with operating procedures.

4.5.6 Purge and start-up procedures with necessary interlocks shall be established.

4.5.7 Written operating procedures and detailed checklists for operator guidance shall be provided for achieving all automatic and manual operating functions.

4.6* Structural Design. The furnace shall be capable of withstanding transient design pressures and normal operating pressures without permanent deformation due to yield or buckling of any support member. Transient pressures to be considered shall include, but shall not necessarily be limited to, misoperation of fans or dampers and a master fuel trip while operating at maximum design load. (*Refer to individual chapters for additional guidance.*)

4.7 Functional Requirements of Fuel-Burning System. See also Annex I.

4.7.1 Function. The fuel-burning system shall function to convert continuously any ignitable input into unreactive products of combustion at the same rate that the fuel(s) and air reactants enter the combustion chamber.

4.7.2 Compatibility. The fuel-burning system shall be sized to meet the operating requirements of the unit, shall be compatible with other component systems, and shall be capable of being controlled for the full operating range of the unit.

4.7.3 System Requirements.

4.7.3.1* The fuel-burning system shall provide means for start-up, operation, and shutdown of the combustion process, including openings and configurations in the component assemblies to allow observation, measurement, and control of the combustion process.

4.7.3.2 The fuel-burning system shall consist of the boiler or HRSG enclosure and the following subsystems, as applicable: air supplies, fuel supplies, main fuel burning, ignition, and combustion products removal and re-injection. Each shall be sized and interconnected to meet the requirements of 4.7.4 through 4.7.8.

4.7.4 Enclosures. The boiler enclosure or HRSG enclosure shall meet the requirements of 4.7.4.1 through 4.7.4.3.

4.7.4.1 The enclosure shall be sized and arranged with respect to the main fuel-burning subsystem so that stable flame is maintained.

4.7.4.2 The enclosure shall be free from "dead pockets" when prescribed purge procedures are followed.

4.7.4.3 Observation ports shall be provided to allow visual inspection of the enclosure, igniter and burner flames (including the ignition zone), overfire air ports, reburn injectors, and stoker grates.

N **4.7.4.3.1** Signage shall be affixed to observation ports that are operable into an enclosure to warn of hazards.

N **4.7.4.3.2** Procedures for the use of observation ports shall be provided and identify any required personal protective equipment.

4.7.5* Air Supply Subsystem. The air supply subsystem shall meet the requirements of 4.7.5.1 through 4.7.5.3.

4.7.5.1 The air supply equipment shall be sized and arranged to ensure a continuous airflow for all operating conditions on the unit.

4.7.5.2 Drain and access openings shall be provided and shall be accessible.

4.7.5.3 The air supply equipment shall be capable of continuing the required airflow during anticipated combustion chamber pressure pulsations.

4.7.6 Fuel Supply Subsystem. Fuel supplies and main fuel-burning subsystems shall meet the applicable requirements in Chapters 5 through 10 for specific systems.

4.7.6.1 All fuel systems shall include provisions to prevent foreign substances from interfering with the fuel supply.

N 4.7.6.1.1 Gaseous fuel systems shall include drip legs, traps, strainers, filters, or similar items ahead of any components that can be impacted by contaminants.

N 4.7.6.1.2 Liquid fuel systems shall include strainers, filters, traps, or similar items.

N 4.7.6.1.3 Strainers, filters, or similar items shall be selected for the maximum particle sizes identified by the fuel train component manufacturers.

• **4.7.7* Ignition Subsystem.** The ignition subsystem shall meet the requirements of 4.7.7.1 through 4.7.7.13.

4.7.7.1 The ignition subsystem shall be sized and arranged to ignite the main burner input within the limitation of the igniter classification as follows:

- (1) It shall be verified through testing that the igniters furnished meet the requirements of the class specified in the design.
- (2) Igniters shall be designated as Class 1, Class 2, Class 3, or Class 3 special as defined in 3.3.74.1, 3.3.74.2, and 3.3.74.3, and 3.3.74.4 and as verified by test.

4.7.7.2 Class 1 igniters shall be permitted to be used as Class 2 or Class 3 igniters. Class 2 igniters shall be permitted to be used as Class 3 igniters.

4.7.7.3 Where Class 2 igniters are used, the burner shall be operated under controlled conditions to limit the potential for abnormal operation, as well as to limit the charge of fuel in the event that ignition does not occur during light-off.

4.7.7.4 Class 2 igniters shall not be used to ignite the main fuel under uncontrolled conditions.

4.7.7.5 Where Class 3 igniters are used, the igniter shall be turned off as a part of the burner light-off procedure when the time trial for ignition of the main burner has expired to ensure that the main flame is not dependent on ignition support from the igniter.

4.7.7.6* Class 2 igniters shall not be used to extend the turn-down range but shall be permitted to be used to stabilize the main burner flame.

4.7.7.7 Class 3 igniters shall not be used to stabilize the main burner flame or to extend the burner turndown range.

4.7.7.8 Except for periods when the main burner is being scavenged, Class 3 special igniters shall not be used unless supervision of the individual main burner flame is provided.

4.7.7.9* Where Class 1 and Class 2 igniters are used, the tests described in 6.6.3.2.2, 6.7.3.2.2, and 6.8.3.2.2 shall also be performed with the ignition subsystem in service to verify that the igniters furnished meet the requirements of the class specified in the design.

4.7.7.10 Tests shall be performed to determine transient limits in the ignition air and fuel supplies or in the main air and fuel supplies that do not extinguish the igniter flame or reduce the igniter's ability to perform its intended function or adversely affect other burners and igniters in operation.

4.7.7.11 Igniters shall be permanently installed under the following conditions:

- (1) They shall be supervised to verify that the requirements of 4.7.7.1 and 4.7.7.2 are met.
- (2) This supervision shall include igniter capacity and individual igniter flame monitoring.
- (3) The capacity shall be measured by igniter header pressure as a minimum.
- (4) On single burner boilers, igniters shall not require supervision of igniter capacity.

4.7.7.12 The ignition equipment shall be located in an environment free of excessive heat and accessible for maintenance.

4.7.7.13 All igniter safety shutoff valves shall be located to minimize the volume of fuel that is downstream of the valve in the individual igniter fuel lines or that could flow by gravity into the combustion chamber after a shutdown.

4.7.8 Combustion Products Removal Subsystem. The combustion products removal subsystem shall meet the requirements of 4.7.8.1 through 4.7.8.5.

4.7.8.1 The flue gas ducts, fans, and stack shall be sized and arranged to remove the products of combustion at the same rate at which they are generated by the fuel-burning process during operation of the unit.

4.7.8.2 Drain and access openings shall be provided and shall be accessible.

4.7.8.3 The flue gas ducts shall be designed so that they do not contribute to combustion chamber pulsations.

4.7.8.4 Components common to more than one boiler or HRSG shall not limit the rate of removal of products of combustion generated during the operation of all boilers or HRSGs.

4.7.8.5 Boilers or HRSGs that share a common component between the furnace outlet and the stack shall be in accordance with the following:

- (1) There shall be provisions to bypass the common component for unit purge when the common component contains a possible ignition source.
- (2) A common component shall not interrupt the open-flow air path of a boiler or HRSG during operation or purge.
- (3)* A common component shall not permit the flow of combustion products into an idle boiler or HRSG.

4.8 Multiple Boilers or HRSGs.

4.8.1 Where multiple boilers or HRSGs are supplied from the same fuel supply source, an equipment isolation valve shall be provided for each boiler and HRSG.

4.8.2 Dedicated safety shutoff valving, with related alarm, interlock, and control instrumentation, shall be provided for each boiler and HRSG.

4.9 Gaseous Vent System Requirements.

Δ 4.9.1 The discharge from atmospheric vents shall be located away from occupied areas, sources of ignition, combustion air intakes, building ventilation systems, or the windows of a boiler or HRSG room or adjacent buildings and be extended above the boiler or HRSG and adjacent structures so that gaseous discharge does not present a hazard.

4.9.2 Vent line sizes and vent valve port diameters shall not be less than the values shown in Table 4.9.2.

N 4.9.2.1* The vent line of a valve-proving system with a vent valve arrangement shall be permitted to be sized to vent at least 5 percent more than the known leak detection limit rate of the valve-proving system.

4.9.3 Manifolding of Vents.

4.9.3.1 Vents from systems operating at different pressure levels shall not be manifolded together.

4.9.3.2 Vents from systems served from different pressure-reducing stations shall not be manifolded together.

4.9.3.3 Vents from different boilers or HRSGs shall not be manifolded together.

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

4.9.3.5 Header vents shall be permitted to be manifolded together only with other header vents and only when operated and tripped in parallel.

4.9.3.6 Burner vents shall be permitted to be manifolded together only with other burner vents.

4.9.3.7 Igniter vents shall be permitted to be manifolded together only with other igniter vents.

4.9.3.8 Lance vents shall be permitted to be manifolded together only with other lance vents.

Δ 4.9.4 Where the vent line is sized in accordance with Table 4.9.2, the manifolding of these lines shall not be smaller than the largest vent line in the system.

N 4.9.4.1 Where the vent line is sized using the leak detection limit of the valve-proving system, the manifolded line shall have a cross-sectional area not less than the following:

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

4.10 Fuel System Piping.

4.10.1 Fuel Gas Piping Systems. Fuel gas piping shall be minimum Schedule 40, and material and system design shall be in accordance with NFPA 54 (for fuel gas piping inside industrial and institutional buildings), ASME B31.1, *Power Piping* (for fuel gas piping in power applications), or ASME B31.3, *Process Piping* (for fuel gas piping in process applications).

4.10.1.1 Equipment Isolation Valves. An equipment isolation valve shall be provided and shall be readily accessible at the fuel gas supply piping system connection.

4.10.1.1.1 Equipment isolation valves shall meet the following requirements:

- (1) They shall have permanently affixed visual indication of the valve position.
- (2) They shall be able to be operated from full open to full close and return without the use of tools.

4.10.1.2 Overpressure Protection.

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

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

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

- (1) A series regulator in combination with a line regulator or service pressure regulator
- (2) A monitoring regulator installed in combination with a line regulator or service pressure regulator
- (3)* A full-capacity pressure relief valve

Table 4.9.2 Vent Sizes

Fuel Line Size		Minimum Vent Line Size	
DN (mm)	NPS (in.)	DN (mm)	NPS (in.)
≤40	≤1½	20	¾
50	2	25	1
65 to 80	2½ to 3	32	1¼
90	3½	40	1½
100 to 125	4 to 5	50	2
150	6	65	2½
175	7	80	3
200	8	90	3½
>200	>8	Vent internal cross-sectional area ≥15% of the fuel line internal cross-sectional area	

- (4) An overpressure cutoff device, such as a slam-shut valve or a high-pressure switch in combination with an adequately rated shutoff valve

4.10.1.2.3 When a relief valve is used to comply with 4.10.1.2.1, the relief valve shall be a full-capacity relief type.

4.10.1.2.4 Token relief valves and internal token relief valves shall not be permitted to be used as the only overpressure protection devices.

4.10.1.2.5* Set Point of the Overpressure Protection Device. The overpressure protection device(s) shall be set not higher than the design pressure of the lowest rated downstream component.

4.10.2 Fuel Oil Piping Systems. Fuel oil piping materials and system design shall be in accordance with NFPA 31 (for fuel oil piping inside industrial or institutional buildings), ASME B31.1, *Power Piping* (for fuel oil piping in power applications), or ASME B31.3, *Process Piping* (for fuel oil piping in process applications).

4.10.3* Flue Gas Path Auxiliary Systems — Fuel, Oxidizer, and Combustible Reagent Piping.

4.10.3.1* The requirements in 4.10.3 shall apply to flue gas path auxiliary systems that inject fuel, oxidizer, or combustible reagent into the boiler enclosure or flue gas path when in operation.

4.10.3.2 Positive means to prevent leakage of fuel, oxidizer, or combustible reagent into an idle furnace or flue gas path shall be provided.

4.10.3.3 For gaseous fuels or gaseous combustible reagents, provisions shall include a double block and vent valve arrangement on the fuel or gaseous combustible reagent supply, separate from any other double block and vent valve arrangements for other systems.

4.10.3.4 For oxidizers, provisions shall include a block valve on the oxidizer supply, separate from any other block valves for other systems.

4.10.3.5 For gaseous fuels or gaseous combustible reagents, a double block and vent valve arrangement shall be provided in the fuel or gaseous combustible reagent line associated with each flue gas path injection system.

4.10.3.6 For gaseous fuels or gaseous combustible reagents, each flue gas path injection system that can be operated independent of other flue gas path injection systems shall have its own double block and vent valve arrangement.

4.10.3.7 For liquid or blown-in powder fuels or combustible reagents, provisions shall include a block valve on the fuel or combustible reagent supply, separate from any other block valves for other systems.

4.11* Burner Management System Logic.

4.11.1 Interlocks.

4.11.1.1 The interlocks shall accomplish the following:

- (1) Protect personnel from injury
- (2) Protect equipment from damage
- (3) Protect operation by limiting actions to a prescribed operating sequence or by initiating a trip when approaching an out-of-range or unstable operating condition

4.11.1.2 Additional interlocks shall be permitted.

4.11.1.3 Fuel-specific interlocks shall be provided for each design basis fuel.

4.11.1.4* Operating personnel shall be made aware of the limitations of the interlocks.

4.11.2* As a minimum, the requirements of 4.11.3 through 4.11.11 shall be included in the design to ensure that a logic system for burner management meets the intent of those requirements.

4.11.3 The logic system for burner management shall be designed specifically so that a single failure in that system does not prevent an appropriate shutdown.

4.11.4 The burner management system interlocks and alarms shall be initiated by one or more of the following:

- (1) One switch or transmitter dedicated to the burner management system
- (2) Voting logic derived from two or more switches or transmitters as follows:
 - (a) When multiple transmitters are used in the burner management system, such signals shall be permitted to be shared with other control systems for control purposes.
 - (b)* When signals from multiple switches or transmitters are provided to initiate interlocks or alarms, those signals shall be monitored in comparison to each other by divergence or other fault diagnostic alarms.
 - (c) When signals from multiple switches or transmitters are provided to initiate interlocks or alarms, the provided signals shall be generated by individual sensing devices connected to separate process taps.

4.11.5* Alarms shall be generated to indicate equipment malfunction, hazardous conditions, and misoperation.

4.11.6 The burner management system designer shall evaluate the failure modes of components, and as a minimum the following failures shall be evaluated and addressed:

- (1) Interruptions, excursions, dips, recoveries, transients, and partial losses of power
- (2) Memory corruption and losses
- (3) Information transfer corruption and losses
- (4) Inputs and outputs (fail-on, fail-off)
- (5) Signals that are unreadable or not being read
- (6) Failure to address errors
- (7) Processor faults
- (8) Relay coil failure
- (9) Relay contact failure (fail-on, fail-off)
- (10) Timer failure

4.11.7* The design of the logic system for burner management shall include and accommodate the following requirements:

- (1) Diagnostics shall be included in the design to monitor processor logic function.
- (2) Logic system failure shall not preclude proper operator intervention.
- (3) Logic shall be protected from unauthorized changes.
- (4) Logic shall not be changed while the associated equipment is in operation.

- (5) System response time (throughput) shall be short to prevent negative effects on the application.
- (6) Protection from the effects of noise shall prevent false operation.
- (7) No single component failure within the logic system shall prevent a mandatory master fuel trip.
- (8) The operator shall be provided with a dedicated manual switch(es) that shall actuate the master fuel trip relay independently and directly.
- (9) At least one manual switch referenced in 4.11.7(8) shall be identified and located remotely where it can be reached in case of emergency.
- (10)* The logic system shall be monitored for failure.
- (11) Failure of the logic system shall require a fuel trip for all equipment supervised by the failed logic system.
- (12) Logic shall be maintained either in nonvolatile storage or in other memory that retains information on the loss of system power.

4.11.8* Requirement for Independence.

4.11.8.1 The burner management system shall be provided with independent logic, independent logic solving hardware, independent input/output systems, and independent power supplies and shall be a device functionally and physically separate from other logic systems.

4.11.8.2 The burner management system shall include all required interlocks and flame monitoring.

4.11.8.3 The logic system shall be limited to one boiler or HRSG.

4.11.8.4 The same hardware type used for burner management systems shall be permitted to be used for other logic systems.

4.11.8.5 Network communications between the burner management system and other systems shall be permitted. The network communicating with other systems shall not be the same network that the burner management system uses to communicate with its input/output hardware.

4.11.8.6* Signals and the manually operated devices specified in 4.11.7(8) that initiate mandatory master fuel trips shall be hardwired.

4.11.9 Closing of Fuel Valves.

4.11.9.1 A burner trip, fuel trip, or master fuel trip, shall require operator action prior to resuming operation of the affected burner(s).

4.11.9.2* No logic sequence or device shall be permitted that allows full closing and subsequent inadvertent reopening of the main or ignition fuel valves.

4.11.10 Circuit Devices. No momentary contact or automatic resetting device, control, or switch that can cause chattering or cycling of the safety shutoff valves shall be installed in the wiring between the load side (terminal) of the primary or programming control and the main or ignition fuel valves.

4.11.11 Documentation. Documentation shall be provided to the owner and the operator indicating that the burner management system meets the requirements of the application.

4.12 Flame Monitoring and Tripping Systems.

4.12.1 Functional Requirements. The basic requirements of any flame monitoring and tripping system shall be as follows:

- (1) Combustion instability situations shall be brought to the attention of the operator for remedial action.
- (2) A trip of the involved equipment shall be automatically initiated upon detection of serious combustion problems that will lead to the accumulation of unburned fuel.

4.12.2 System Objectives.

4.12.2.1 System objectives shall be developed and documented that include those requirements that are specifically related to the combustion conditions typical for particular combustion chamber configurations, burner or firing systems, and fuel characteristics.

4.12.2.2 Such objectives shall be consistent with the individual manufacturer's design philosophy.

4.12.3 Flame Detection.

4.12.3.1 Flame Detector Sighting. Field tests shall be required to establish optimum sighting angles of burners or nozzles and to check the effective angular range of flame detectors in relation to burners or nozzles.

4.12.3.2 Clean Air Supply. Clean air, where necessary, shall be supplied to minimize problems with dirty detector lenses.

4.12.3.3 Self-Checking of Flame Detectors. Where flame-sensing detectors can fail in the flame-proven mode, self-checking features shall be provided to ensure that the failure of any single component cannot result in a false indication of flame.

4.12.3.4* Reduced Emissions Control Effects.

4.12.3.4.1 Flame detector selection, sighting, and location shall be re-evaluated in accordance with 4.12.2 following implementation of methods or installation of equipment to reduce the emission of air pollutants.

4.12.3.4.2 When changes made to reduce the emission of air pollutants affect flame characteristics, main burners shall be tested for the limits of stable flame.

4.12.3.5 Flame Proving.

4.12.3.5.1 A flame detector shall not use any mechanical, electrical, or electronic means to force the flame detector into a "flame not detected" mode as part of the igniter and/or burner starting sequence.

4.12.3.5.2 A flame detector shall prove ignition of the associated fuel by proving both igniter "flame not detected" and burner "flame not detected" prior to introduction of the fuel to the igniter or burner and proving "flame detected" after introduction of that fuel to that igniter or burner.

4.12.3.5.3 An igniter flame detector shall not be required to prove "flame not detected" if the associated burner is proven in service and the associated igniter is out of service.

4.12.3.5.4 A burner flame detector shall not be required to prove "flame not detected" if an associated Class 1 igniter is proven in service.

4.12.3.5.5 The igniter flame detector(s) and/or the burner flame detector(s) shall not be required to prove "flame not

detected” after the boiler load has been elevated to the point that it is no longer possible to achieve individual flame discrimination.

4.12.3.5.6 The boiler load specified in 4.12.3.5.5 shall be proven by test to be the load level at which individual igniters and/or burner flame discrimination is no longer possible, but in no case shall the boiler load be less than that for which tests show that complete combustion will occur.

4.12.3.5.7 The response time from flame failure to the initiation of the trip signal to the fuel safety shutoff devices shall not exceed 4 seconds, including any time delay associated with the flame detector.

4.13* Combustion Control System.

4.13.1 Functional Requirements.

4.13.1.1 The combustion control system shall regulate the inputs into the combustion chamber to ensure continuous combustion and stable flame under all operating conditions.

4.13.1.2 Draft control, where applicable, shall be coordinated with the combustion control system.

4.13.1.3* On multiple burner boilers, equipment shall be provided and procedures shall be established to maintain the air-fuel ratio within design limits at each burner.

4.13.1.3.1 The equipment and procedures shall not be required to be a part of the combustion control system.

4.13.1.4 Boiler or HRSG control systems shall be permitted to be combined for more than one boiler or HRSG where the control system is separated from the burner management system.

4.13.2 System Requirements.

4.13.2.1* Airflow demand shall not be less than the minimum purge rate established by the designer.

4.13.2.2 The fuel demand shall not increase the fuel input(s) above the available airflow.

4.13.2.3 Airflow demand shall not reduce airflow below that required by the actual fuel input(s).

4.13.2.4 The fuel demand shall not exceed the capability of the operating draft fans.

4.13.2.5 If the loss or shutdown of a draft fan causes the fuel demand to be greater than the capacity of the fans in service, the fuel(s) shall be rapidly reduced to a value that can be accommodated.

4.13.2.6 Measurements.

4.13.2.6.1 Measurements used in the combustion control system shall be accurate and reproducible to maintain stable firing conditions.

4.13.2.6.2 Pressure, temperature, density, and/or viscosity corrections shall be employed, as applicable, to meet the requirement of 4.13.2.6.1.

4.13.2.7 Where multiple fuels are fired, the fuel inputs shall be totaled on the basis of their relative heat values.

4.13.2.8 The total heat input to a given burner or combustion zone shall not exceed the maximum limits specified by the boiler or HRSG manufacturer.

4.13.2.9* Means shall be provided to enable the operator to adjust the air-fuel ratio for all boilers consistent with the fuel(s) being fired.

4.13.2.10 The equipment selection and the design of the combustion control system shall facilitate the on-line calibration, testing, and maintenance requirements described in 4.4.1.

4.13.2.11 The rate of increase of reburn fuel injection shall not exceed the response capability of the main combustion control system.

4.13.3 Additional Requirements.

4.13.3.1 Any logic commands from the burner management system shall take precedence over the combustion control system.

4.13.3.2 Where applicable, automatic control of airflow shall not be permitted unless the draft control is maintained in automatic control.

4.13.3.3* Automatic Control.

4.13.3.3.1 Automatic control of the fuel input(s) shall not be permitted unless the airflow is maintained in automatic control.

4.13.3.4 The combustion control system shall neither automatically increase nor automatically decrease a fuel input beyond the fuel-burning system's operating range as determined by the manufacturer and verified by operating test.

4.14 Power Supplies. Precautions shall be taken to ensure the availability of a failure-free power supply (electric or pneumatic) to all control and burner management system components.

4.15* Operating Information.

4.15.1 Continuous trend display of steam flow rate, feedwater flow rate, total fuel flow rate, and total airflow rate as a percentage of the maximum unit load, drum level, or waterwall flow as applicable, final steam temperature, main steam pressure, and furnace or combustion chamber draft shall be simultaneously available at the operating location.

4.15.2 Alarms and indicators shall be grouped operationally and shall be visible to the operator to allow access to operational devices.

4.15.3 All emergency alarm indicators, push buttons, and selector switches shall be visible to the operator, labeled clearly, and protected to avoid inadvertent actuation.

4.15.4 All control functions shall be grouped for accessibility and in proximity to their associated alarm and indication devices.

4.15.5* Where video display units (VDUs) are used, data shall be displayed on monitor screens in a logical, operational grouping to minimize the number of keystroke operations needed to respond to system upsets.

4.15.6 Where VDUs are used, alarm functions shall be prioritized to appear on the monitor screen upon being sensed, regardless of any information already displayed.

4.15.7 Alarm systems shall be designed so that the operator receives audible and visual indication of the out-of-limits conditions.

4.15.8 The audible alarm shall be permitted to be silenced by the operator after actuation, but the visual indication shall continue until the condition is within specified limits and has been reset.

4.15.9 Defeating of the alarm shall be authorized by a competent person and documented in accordance with operating procedures.

4.15.10 When it is necessary to manually defeat an alarm, defeating the alarm shall be performed by authorized personnel, and the alarm shall be tagged as inoperative.

4.16* Selective Catalytic Reduction.

4.16.1 Where selective catalytic reduction (SCR) systems are selected for NO_x emission control, they shall be integrated into the design of the boiler system, HRSG, or combustion turbine exhaust system to operate in the flue gas temperature range required.

4.16.2 Areas in which either anhydrous or aqueous ammonia is stored or piped shall be ventilated to preclude toxic or flammable concentrations.

4.16.3 Areas in which anhydrous ammonia is stored or piped shall meet the requirements of ANSI/CGA G-2.1, *Requirements for the Storage and Handling of Anhydrous Ammonia*.

N 4.17* Noncombustible Material.

N 4.17.1 A material that complies with any one of the following shall be considered a noncombustible material:

- (1)* The material, in the form in which it is used, and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.
- (2) The material is reported as passing ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*.
- (3) The material is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*.

[5000:7.1.4.1.1]

N 4.17.2 Where the term *limited-combustible* is used in this code, it shall also include the term *noncombustible*. [5000:7.1.4.1.2]

Chapter 5 Single Burner Boilers

5.1 Application.

5.1.1 This chapter shall be used in conjunction with Chapters 1 through 4 and requires the coordination of operation procedures, control systems, interlocks, and structural design.

5.1.2 Where conflicts exist, the requirements of Chapter 5 shall apply.

5.1.3 All safety shutoff valves, devices associated with interlocks, valve-proving systems, and flame detection systems shall be listed or approved. A safety shutoff valve proof of closure switch shall be an original design component of the valve or actuator assembly and shall activate only after the valve is fully closed.

5.2 Purpose. The purpose of this chapter shall be to establish minimum requirements for the design, installation, operation, and maintenance of single burner boilers, their fuel-burning systems, and related systems to contribute to operation within design limits and, in particular, to the prevention of furnace explosions.

5.3 Unattended Operation. The process hazard analysis required by 4.1.1 shall not apply to automatic-recycling single burner boilers designed for unattended operation unless required by the authority having jurisdiction.

5.4 Equipment Requirements.

5.4.1* Fuel Supply — Oil.

5.4.1.1 Fuel shall be stored, prepared, and delivered to the oil service connection under anticipated operating conditions in accordance with the applicable portions of NFPA 31.

5.4.1.2 Operation of the burner shall not be attempted until a continuous fuel supply is ensured.

5.4.1.3 Fuel shall be delivered continuously to the combustion chamber in a finely atomized form that can be ignited readily and consumed.

5.4.1.4 All equipment that is associated with pumping, heating, and straining the fuel from storage to the service connection shall be designed, sized, and interconnected so as to provide a fuel supply that meets the boiler design requirements over a full range of conditions.

5.4.1.5 Relief valves shall be installed after the pump to prevent overpressure in the system.

5.4.1.6 Fuel being burned shall be delivered to the burner at the temperature and pressure specified by the burner manufacturer.

5.4.1.7 Where the fuel must be heated, the interlocks and instruments shall reflect the correct values of the variable being measured, particularly in dead-end lines, where heavy oil will tend to solidify.

5.4.1.8 Oil Supply.

5.4.1.8.1 The operation of a burner system that has the capability to burn heated and unheated oils shall include a procedure to ensure that the specified grade of oil, compatible with the selected mode of operation, is being supplied to the burner.

5.4.1.8.2 Precautions shall include the intended routing of recirculated oil.

5.4.1.9 Two safety shutoff valves in series, each with a proof of closure switch, shall be provided in the oil line to the main burner.

5.4.1.10 Where pressure can develop in excess of the valve or piping rated pressure(s), the piping design shall include a means to prevent or relieve excess pressure between the valves.

5.4.1.11 Oil piping materials and system design shall be in accordance with NFPA 31 (for oil piping inside industrial or institutional buildings), ASME B31.1, *Power Piping* (for oil piping in power applications), or ASME B31.3, *Process Piping* (for oil piping in process applications).

5.4.2* Fuel Supply — Gas.

5.4.2.1 The gas supply at the gas service connection shall be controlled at the pressure for which the fuel-burning system had been designed.

5.4.2.2 Gas piping shall be sized to maintain the required pressure for maximum burner flow.

5.4.2.3 Two safety shutoff valves in series, each with a proof of closure switch, shall be provided in the fuel gas line to the main burner.

5.4.2.3.1* The two safety shutoff valves required in 5.4.2.3 shall have one of the following:

- (1) An automatic vent valve provided between the two safety shutoff valves
- (2) A listed valve-proving system
- (3) A valve-proving system implemented per Section 4.11

5.4.2.3.2* Where automatic valve-proving systems are installed, valve proving shall be performed either after every burner shutdown or prior to every burner light-off.

5.4.2.4 Foreign matter such as welding beads, chips, scale, dust, and debris shall be removed from the gas piping.

5.4.2.5 A drip leg shall be provided in the gas piping. (See A.5.4.2.3.1 and A.5.4.4.1.)

5.4.2.6 Gas piping material and system design shall be in accordance with NFPA 54 (for gas piping inside industrial and institutional buildings), ASME B31.1, *Power Piping* (for gas piping in power applications), or ASME B31.3, *Process Piping* (for gas piping in process applications).

5.4.2.7 Valve Leakage Test.

5.4.2.7.1 Permanent means shall be provided for making manual valve leakage tests of the main burner gas safety shutoff valves.

5.4.2.7.2 Manual valve leakage tests of the main safety shutoff valves shall be conducted at least annually.

5.4.2.7.3 The use of an automatic valve-proving system shall not eliminate the annual leak test required in 5.4.2.7.2.

5.4.3 Alternate Fuel Firing.

5.4.3.1 Manual Fuel Selection. Where oil and gas are to be burned alternately, a manual fuel selector switch shall be provided to permit operation of the necessary interlocks, fuel safety shutoff valves, and controls for the fuel to be fired.

5.4.3.2 Automatic Fuel Selection.

5.4.3.2.1 Where oil and gas are to be burned alternately, an automatic change from one fuel to the other shall be accomplished only after a shutdown.

5.4.3.2.2 Provisions for manual changeover of the system shall be provided in accordance with 5.4.3.1 and Section 5.8.

5.4.3.2.3 For simultaneous firing of oil and gas fuels, Section 5.7 shall apply.

5.4.4 Fuel-Burning Equipment.

5.4.4.1* Ignition.

5.4.4.1.1 The main burner shall be equipped with a permanently installed igniter.

5.4.4.1.1.1 Class 1 Igniter.

(A) Where a Class 1 igniter is used, the main burner flame shall be proven by a flame detector.

(B) Either the main flame or the igniter flame shall be proven.

5.4.4.1.1.2 Class 2 Igniter.

(A) Where a Class 2 igniter is used, it shall not be used to ignite main fuel under uncontrolled or abnormal conditions.

(B) The burner shall be operated under controlled conditions to limit the potential for abnormal operation as well as to limit the charge of fuel to the furnace in the event that ignition does not occur during light-off.

(C) If the Class 2 igniter is not shut down once the main flame sequence is successfully completed, then the main burner flame shall be proven by a flame scanner independently of the igniter.

5.4.4.1.1.3 Class 3 Igniter.

(A)* Where a Class 3 igniter is used, the igniter shall be shut down as part of the burner light-off procedure when the time trial for ignition of the main burner has expired.

(B) The use of such igniters to support ignition or to extend the burner control range shall be prohibited.

(C) The main flame shall be proven by a flame scanner.

5.4.4.1.1.4 Class 3 Special Igniter. Where a Class 3 special igniter is used, the main burner flame shall be proven by a flame scanner.

5.4.4.1.2 The igniter flame or arc shall impinge on the main burner air-fuel mixture and shall supply ignition energy to provide immediate ignition of all fuel discharge from the main burner under light-off conditions.

5.4.4.1.3* Igniter Safety Shutoff Valves. Two safety shutoff valves in series shall be provided in the fuel gas line to the igniter, and an automatic vent valve shall be provided between the two valves.

5.4.4.1.3.1 When a listed automatic valve-proving system is used with two safety shutoff valves in series, the automatic vent valve shall be permitted to be omitted.

5.4.4.1.3.2* Where an automatic valve-proving system is installed, valve-proving shall be performed either after every burner shutdown or prior to every burner light-off.

5.4.4.1.4 The igniter shall be designed for periodic removal, cleaning, and maintenance.

5.4.4.2 Main Burner.

5.4.4.2.1 The main burner shall direct the fuel and air into the furnace so as to provide a stable flame and efficient combustion over its entire operating range.

5.4.4.2.2 The limits of stable flame for the burner shall be determined by tests.

5.4.4.2.2.1 These tests shall be performed without the igniter in service and shall include the intended range and grade of fuel(s).

5.4.4.2.2.2* The tests shall verify that transients that are generated in the fuel and air systems do not adversely affect burner operation.

5.4.4.2.3 Each manual adjustment feature on the burner shall be provided with means for securing it in its intended position.

5.4.4.2.4 The atomizing equipment for oil burners shall be designed for periodic removal, cleaning, and maintenance.

5.4.4.2.5 Any procedure for clearing the atomizer and piping into the furnace prior to shutdown shall be accomplished while the fan is operating and the igniter is re-established or the main flame is proven continuously during this operation.

5.4.4.2.6 Clearing of the oil passages of the atomizer into the furnace immediately after a shutdown shall be prohibited.

5.4.4.3 Atomizing Medium for Oil Burners.

5.4.4.3.1 Where the fuel is to be atomized with the assistance of another medium, this atomizing medium shall be supplied free of contaminants that could cause an interruption of service.

5.4.4.3.2 The atomizing medium shall be provided at the pressure and temperature specified by the burner manufacturer.

5.4.4.3.3 Provisions shall be made to ensure that fuel cannot enter the atomizing medium line during or after operation.

5.4.4.4 Combustion Air Supply.

5.4.4.4.1 The combustion air supply equipment shall be capable of supplying combustion air for the optimum air-fuel ratio over the entire operating range of the burner.

5.4.4.4.2 Provisions shall be made for periodic cleaning of the combustion air supply equipment.

5.4.4.4.3 The requirements for the availability of combustion air shall be determined from NFPA 31 and NFPA 54.

5.4.4.4.3.1 Louvers and grilles shall be fixed in the open position or interlocked with the equipment so that they are opened automatically or manually during equipment operation. The interlock shall be placed on the driven member.

5.4.4.4.3.2 Fans supplying air to the boiler room for combustion shall be interlocked with the burner so that airflow is proven during equipment operation.

5.4.4.4.5 Furnace. The furnace shall be designed to promote main burner stability while minimizing zones that cannot be purged.

5.4.4.6 Combustion Products Removal.

5.4.4.6.1* The outlet draft equipment shall be capable of removing combustion products without adversely affecting stable flame conditions.

5.4.4.6.2 Where two or more boilers are connected to a common stack, each connection shall be equipped with a damper system.

5.4.4.6.2.1 All boiler outlet dampers shall be equipped with accessible operating and locking devices.

5.4.4.6.2.2 This equipment shall be compatible with the combustion control system of the boiler.

5.4.4.6.2.3 Interlocks shall be provided to prevent firing against a closed damper.

5.4.4.6.2.4 To prevent the interlock from being rendered nonfunctional if the linkage becomes disconnected, one of the following means shall be provided:

- (1) Placing the interlock on the driven member
- (2) Utilizing a furnace pressure switch
- (3) Other approved means

5.4.4.6.2.5 Dampers shall not be required on the outlet of boilers of a type in which maintenance operations are performed from outside the boiler.

5.4.4.6.3* Permanently installed flue gas analyzers shall not present an ignition source hazard to the flue gas stream being sampled.

5.4.5* Combustion Control System.

5.4.5.1 The combustion control system shall be installed in accordance with the requirements of 4.13.1.

5.4.5.2 The combustion control system shall maintain air-fuel mixtures at pre-established ratios throughout the operating range of the burner and during changes in the firing rate.

5.4.5.3* The system shall provide limits on fuel and air to prevent furnace input from being reduced below the point of stable burner operation.

5.4.5.4 The minimum and maximum points of stable burner operation shall be defined by the burner manufacturer and verified by operational tests.

5.4.5.5

5.4.5.5.1 The requirements in 4.13.2.1 shall not apply.

5.4.5.5.2 The airflow demand shall not be reduced below the low limit of the fuel-burning system as determined by the burner manufacturer and verified by operating test.

5.4.5.6* Continuous display or trending of operating parameters critical to operation, as determined by the burner or boiler manufacturer, shall be provided.

5.4.6 Burner Management System.

Δ 5.4.6.1 In addition to the requirements in Section 4.11, the boiler control system for single burner boilers shall be permitted to be combined with the burner management system under one of the following conditions:

- (1)* If the fuel-air ratio is controlled externally from the boiler control system
- (2) If the combined boiler control and burner management system is specifically listed or labeled for the application
- (3) If a single safety-rated programmable logic system is permitted to be used to implement both burner management system safety and process logic in accordance with 5.4.6.1.1

N 5.4.6.1.1* A single safety-rated programmable logic system shall be permitted to be used to implement both burner management system safety and process logic where all of the following conditions are met:

- (1) The processor and input/output (I/O) modules are listed by an organization independent from the manufacturer to be at least SIL 2 capable according to IEC 61508,

Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems, or equivalent nationally recognized standard.

- (2) The processor and I/O modules are applied in accordance with the manufacturer's safety manual to achieve at least SIL 2 capability.
- (3) Access to modify the safety logic and memory is restricted to authorized users by locks, passwords, or equivalent means.
- (4) The burner management system logic is isolated in the safety area of the processor.

N 5.4.6.1.2 One way communication from the safety area described in 5.4.6.1.1(4) to other systems shall be permitted.

5.4.6.2 The system shall be equipped with a method of determining the operating state of each interlock without disassembling any of the devices associated with the interlock.

5.4.6.3 Each interlock shall be provided with a method of establishing the set point.

5.4.6.4 Devices associated with the interlocks shall be designed for anticipated environmental conditions, such as temperature, humidity, vibration, and corrosive agents.

5.4.6.5 Bypass.

5.4.6.5.1 The design shall not require any deliberate defeating of an interlock to start or operate equipment.

5.4.6.5.2 Interlocks shall be permitted to be bypassed as allowed by 4.5.5, 5.5.3.2.1(4), and 5.5.3.3.1(4).

5.4.6.5.3 The interlocks on the low water cutouts shall be permitted to be bypassed during normal operation for blowdown purposes only.

5.4.6.5.3.1 The bypass of 5.4.6.5.3 shall be of a type that is temporarily held during blowdown.

5.4.6.6* Each safety control ac circuit shall be two wires, one side grounded, and shall be protected with a suitable fuse or circuit breaker in the hot side only.

5.4.6.7 Safety Control dc Circuits.

5.4.6.7.1 Safety control dc circuits shall be arranged as called for in 5.4.6.6 where grounding is possible.

5.4.6.7.2 Where grounding is not possible and the circuit voltage exceeds 50 volts, the circuit shall have switching contacts in one side of the line and shall be provided with ground-fault circuit interrupters.

5.4.7 Flame Safety Shutdown System.

5.4.7.1 The response time from flame failure to de-energization of the safety shutoff valves shall not exceed 4 seconds.

5.4.7.2 The response time from de-energization of the safety shutoff valves to full closure shall not exceed 1 second.

5.4.7.3 Where flame-sensing detectors can fail in the flame-proven mode, self-checking features shall be provided unless the burner is operated for periods less than 24 hours and the burner management system includes a safe-start component checking feature.

5.4.7.4 A safe-start component checking feature shall include a circuit incorporated in the burner management system that

prevents light-off if the flame-sensing relay is in the flame-present position due to component failure or due to the presence of actual or simulated flame.

5.4.8 Electrical Equipment.

5.4.8.1* All electrical equipment and wiring shall conform to *NFPA 70*.

5.4.8.2 Special fuels or applications could require components for hazardous location and shall be reviewed during the design of the system.

5.4.9* Gas and Oil Firing: Special Problems. Systems installed or designed to reduce NO_x emissions shall be evaluated to ensure that the performance of flame safety and combustion control systems are not impaired.

5.5 Starting of a Cold Boiler.

5.5.1 General.

5.5.1.1 Starting of a cold boiler shall be accomplished in conformance with the manufacturer's recommendations.

5.5.1.2 In no case shall a boiler that has been taken out of service for maintenance, repair, or extended shutdown be started from a cold condition without a trained operator present.

5.5.1.3 Start-Up Procedures.

5.5.1.3.1 Applicable start-up procedures for the provided boiler shall be followed.

5.5.1.3.2 The firing rate shall be limited in accordance with the boiler manufacturer's instructions.

5.5.2 Gas-Fired Boilers. The procedures of Section 5.6 shall be followed for starting a cold gas-fired boiler.

5.5.3 Oil-Fired Burners. When steam is not available for heating oil, as an atomizing medium, or for driving auxiliary equipment, one of the starting methods described in 5.5.3.1, 5.5.3.2, or 5.5.3.3 shall be used.

5.5.3.1 Auxiliary Air Atomizing of Oil. When auxiliary air atomizing of oil is used for a cold start-up, all the equipment, facilities, and procedures listed in 5.5.3.1.1, 5.5.3.1.2, and 5.5.3.1.3 shall be required.

5.5.3.1.1 Required Equipment. The following equipment shall be required:

- (1) Forced draft (FD) fan
- (2) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with stable flame (only for fuel oils that require heating)
- (3) Check valves in steam and air lines to the atomizer

5.5.3.1.2* Required Facility. An alternate atomizing air supply shall be required.

5.5.3.1.3 Starting Procedure. The following procedural steps shall be followed:

- (1) Circulate and heat oil, using auxiliary heater and recirculating system, to satisfy all interlocks, where included.
- (2) Follow the pre-firing and light-off cycles as described in Section 5.6, using air as the atomizing medium.
- (3) Set combustion control at the light-off firing rate.
- (4) When steam pressure has reached the point required for heating and atomizing the oil, shut down in accordance

with the normal shutdown procedure described in Section 5.6.

- (5) Close the atomizing air supply and open the atomizing steam supply, making certain that dry steam is available.
- (6) Change over from auxiliary oil heater to steam oil heater.
- (7) Continue the boiler start-up sequence.

5.5.3.2 Auxiliary Mechanical Atomizing of Heavy Oil. When auxiliary mechanical atomizing of heavy oil is used for a cold start-up, all the equipment, facilities, and procedures in 5.5.3.2.1 and 5.5.3.2.2 shall be required.

5.5.3.2.1 Required Equipment. The following equipment and facilities shall be required:

- (1) FD fan.
- (2) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with stable flame.
- (3) Mechanical atomizer.
- (4) Means to bypass atomizing medium interlocks. The bypassed interlocks shall be made evident to the operator by means of warning devices.

5.5.3.2.2 Starting Procedure. The following procedural steps shall be followed:

- (1) Circulate and heat oil using auxiliary heater and recirculating systems to satisfy oil interlocks, where included.
- (2) Bypass atomizing medium interlocks. *[See 5.5.3.2.1(4).]*
- (3) Insert mechanical atomizer.
- (4) Follow the prefiring and light-off cycles as described in Section 5.6.
- (5) Set combustion control at the light-off firing rate.
- (6) When steam pressure has reached the point required for heating and atomizing the oil, shut down in accordance with the normal shutdown procedure as described in Section 5.6.
- (7) Remove the mechanical atomizer.
- (8) Insert the steam atomizer.
- (9) Make the atomizing medium interlocks operable and place into service.
- (10) Change over from auxiliary oil heater to steam oil heater.
- (11) Continue the boiler start-up sequence.

5.5.3.3 Auxiliary Mechanical Atomizing of Light (Unheated) Oil. When auxiliary mechanical atomizing of light (unheated) oil is used for a cold start-up, all the equipment, facilities, and procedures in 5.5.3.3.1 through 5.5.3.3.3 shall be required.

5.5.3.3.1 Required Equipment. The following equipment shall be required:

- (1) FD fan.
- (2) Mechanical atomizer.
- (3) Check valves in the heavy and light oil lines.
- (4) Means to bypass atomizing medium interlocks. The bypassed interlocks shall be made evident to the operator by means of warning devices.

5.5.3.3.2 Required Facility. A light oil supply shall be required.

5.5.3.3.3 Starting Procedure. The following procedural steps shall be followed:

- (1) Shut off heavy oil to the system.
- (2) Insert the mechanical atomizer.

- (3) Bypass heavy oil and atomizing medium interlocks. *[See 5.5.3.3.1(4).]*
- (4) Open the light oil supply into the system.
- (5) Follow prefiring and light-off cycles described in Section 5.6.
- (6) Set combustion control at the light-off rate.
- (7) When steam pressure has reached the point required for heating and atomizing the heavy oil, shut down in accordance with the normal shutdown procedure as described in Section 5.6.
- (8) Shut off the light oil supply to the system.
- (9) Remove the mechanical atomizer.
- (10) Insert the steam atomizer.
- (11) Make the heavy oil and atomizing medium interlocks operable by removing bypasses.
- (12) Open the heavy oil supply to the system.
- (13) Continue the boiler start-up sequence.

5.6 Burner Management Systems.

5.6.1* General. This section shall be used to define requirements for automatic recycling, automatic nonrecycling, and manual supervised burner management systems.

5.6.1.1 Manual systems shall not be installed for new installations or major alterations.

5.6.1.2 Different arrangements shall be permitted if they provide protection and meet the intent of this code. *(See Figure A.5.4.1, Figure A.5.4.2.3.1, and Figure A.5.4.4.1 for typical arrangements.)*

5.6.2 Automatic Burner Management System — Recycling.

5.6.2.1 An automatic recycling unit shall not be started from a cold condition unless a trained operator is present. *(See Section 5.5 for instructions on starting a cold boiler.)*

5.6.2.2 Underlying all the requirements of 5.6.2 shall be the premise that the unit is hot and that steam pressure and operating water level shall have been established.

5.6.2.3 The fuel to be fired shall have been manually selected.

5.6.2.4 The alternate fuel system shall be placed in a nonfiring condition, and the manual burner valve(s) shall be closed.

5.6.2.5 An igniter as specified in 5.4.4.1.1 shall be provided.

5.6.2.6 An automatic recycling unit shall recycle on high steam pressure, high water temperature, or low water level (not determined by the auxiliary low water cutout) and perform four major functions as given in 5.6.2.6.1 through 5.6.2.6.4.4.

5.6.2.6.1 Prefiring Cycle. The prefiring cycle shall accomplish the following steps in the listed order except that the order of steps (5), (6), and (7) in the sequence shall be permitted to vary:

- (1) Prove the main fuel safety shutoff valves are closed.
- (2) Prove no flame is present at the burner.
- (3) Start the fan.
- (4) Satisfy the fan interlock.
- (5) Where an atomizing medium is used and if not already on, admit medium to the main burner.
- (6) Where an atomizing medium is used, satisfy the atomizing medium interlocks.
- (7) Satisfy fuel interlocks.

- (8) Prove the purge airflow by satisfying one of the following items:
 - (a) Air pressure and "open damper" interlocks for all dampers in the flow path
 - (b) Airflow interlock
- (9) Purge airflow must reach no less than 70 percent of the airflow required at maximum continuous capacity of the unit.
- (10) During the purge, the air dampers must be driven to their full open positions. Airflow during the period of opening the dampers and returning them to light-off position is permitted to be included in computing the time for the purge.
 - (a) For watertube boilers, the purge must be for at least eight air changes of the furnace and gas passes.
 - (b) For firetube boilers, the purge must be for at least four air changes of the furnace and gas passes.
- (11) Set controls to light-off position.
- (12) Prove the dampers and fuel control valve are in light-off position.
- (13) If a flue gas recirculation system is supplied, then purge it per the manufacturer's instructions.

5.6.2.6.2 Light-Off Cycle.

5.6.2.6.2.1 Class 3 Igniter. The light-off cycle for a burner with a Class 3 igniter shall accomplish the following in the listed order:

- (1)* Energize the ignition transformer and igniter fuel valves.
- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves; for a Class 3 special igniter, proof of igniter operation is not required.
 - (a) If proven, admit fuel to main burner. For an oil burner other than a return flow type, simultaneously shut off oil-recirculating flow.
 - (b) If not proven, initiate a master fuel trip.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, shut off igniter.
- (4) Prove main flame (*see 5.4.4.1.1.3 and 5.4.4.1.1.4*) and proceed as follows:
 - (a) If proven, release to modulating control where provided.
 - (b) If not proven, initiate a master fuel trip.

5.6.2.6.2.2 Class 2 Igniter. The light-off cycle for a burner with a Class 2 igniter shall accomplish the following in the listed order:

- (1)* Energize the ignition transformer and igniter fuel valves.
- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves and proceed as follows:
 - (a) If proven, admit fuel to the main burner. For an oil burner other than a return flow type, simultaneously shut off the recirculating flow.
 - (b) If not proven, initiate a master fuel trip.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, prove the main flame (*see 5.4.4.1.1.2*) and proceed as follows:
 - (a) If proven, release to combustion control for modulation, where provided.
 - (b) If not proven, initiate a master fuel trip.

5.6.2.6.2.3 Class 1 Igniter. The light-off cycle for a burner with a Class 1 igniter shall accomplish the following in the listed order:

- (1)* Energize the ignition transformer and igniter fuel valves.
- (2) Prove igniter flame within 10 seconds of the energization of the igniter fuel valves and proceed as follows:
 - (a) If proven, admit fuel to the main burner. For an oil burner other than a return flow type, simultaneously shut off recirculating flow.
 - (b) If not proven, initiate a master fuel trip.
- (3) After a maximum of 10 seconds for gas and Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils, prove the main flame (*see 5.4.4.1.1.1*) and proceed as follows:
 - (a) If proven, release to combustion control for modulation, where provided.
 - (b) If not proven, initiate a master fuel trip.

5.6.2.6.3 Modulation. Modulation, where provided, shall be accomplished by a combustion control system.

5.6.2.6.4 Shutdown.

5.6.2.6.4.1 Normal Shutdown. For automatic recycling boilers, high steam pressure, high water temperature, or low water level (not determined by the auxiliary low water cutout) shall accomplish a normal shutdown, and the burner shall be allowed to recycle when steam pressure, water temperature, or water level has returned to within the preset operating range.

5.6.2.6.4.2 Normal Shutdown Cycle. The normal shutdown cycle shall accomplish the following in the listed order:

- (1) Shut off the fuel supply to the main burner.
- (2) For oil, proceed as follows:
 - (a) For watertube boilers, if a Class 1 igniter is used, use the manufacturer's instructions to purge the main burner oil gun prior to continuing the normal shutdown.
 - (b) For firetube boilers, where the manufacturer's instructions permit, purging the main burner oil gun in conjunction with the operation of its igniter is permitted.
 - (c) Where used, open the recirculating valve.
 - (d) Where used, shut off atomizing medium if required by operating procedures.
- (3) Shut off the fuel supply to the igniter if in operation.
- (4) Perform a postpurge of the furnace and boiler gas passes; the duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (5) Shut down the fan if required by operating procedures.

5.6.2.6.4.3* Master Fuel Trip. Any of the conditions in 5.6.2.6.4.3(A) or 5.6.2.6.4.3(B) shall initiate a master fuel trip, and the burner shall not be allowed to recycle until a trained operator determines the cause of the shutdown and takes the necessary corrective action to ensure that conditions are within specified operating limits prior to restarting.

(A) Oil conditions shall include the following:

- (1) Low fuel pressure
- (2) Low temperature of heated oils
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy
- (6) Power failure

- (7) Low water level as determined by the auxiliary low water cutout
- (8) Loss of atomizing medium, where used, as interlocked by flow or two pressure switches (one located at the service connection and the other at the burner, either one of which shall initiate a master fuel trip on low pressure)
- (9) Excessive steam pressure or water temperature
- (10) High temperature of heated oil

(B) Gas conditions shall include the following:

- (1) High gas pressure
- (2) Low gas pressure
- (3) Loss of combustion air supply
- (4) Loss of or failure to establish flame
- (5) Loss of control system actuating energy
- (6) Power failure
- (7) Low water level as determined by the auxiliary low water cutout
- (8) Excessive steam pressure or water temperature

5.6.2.6.4.4 Master Fuel Trip Cycle. The master fuel trip cycle shall accomplish the following in the listed order and shall activate an alarm:

- (1) Shut off the fuel supply to the main burner.
- (2) Shut off the fuel supply and interrupt spark to the igniter if in operation.
- (3) For oil, proceed as follows:
 - (a) Where used, open the recirculating valve.
 - (b) Where used, shut off the atomizing medium if required by operating procedures.
- (4) Where the inerting system is used, energize it simultaneously with 5.6.2.6.4.4(1).
- (5) Perform a postpurge of the furnace and boiler gas passes. The duration of the postpurge must be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.
- (6) After postpurge, shut down the fan if desired.
- (7) Require manual reset.

5.6.3 Automatic Burner Management Systems — Nonrecycling.

5.6.3.1 An automatic nonrecycling unit shall not be started from a cold condition unless a trained operator is present.

5.6.3.2 The provisions of 5.6.2.2, 5.6.2.3, and 5.6.2.5 shall apply.

5.6.3.3 An automatic nonrecycling unit shall perform four major functions as given in 5.6.2.6.1 through 5.6.2.6.4.4.

5.6.3.4 The provisions of 5.6.2.6.4.1 shall not apply.

5.6.3.5 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle.

5.6.3.6 A trained operator shall initiate the restart.

5.6.4 Manual Supervised Burner Management Systems.

5.6.4.1 The provisions of 5.6.2 shall apply. The steps listed shall be taken by a trained operator when starting a manual supervised unit, and the required interlocks shall be satisfied at each step.

5.6.4.2 Fuel pressure and temperature, atomizing medium, control system energy, power, and water level shall have been established.

5.6.4.3 When interlocks have been satisfied, this fact shall be indicated to the operator.

5.6.4.4 A manual supervised unit shall perform the four major functions as given in 5.6.2.6.1 through 5.6.2.6.4.4.

5.6.4.5 The three specific provisions of 5.6.2.1, 5.6.2.6, and 5.6.2.6.4.1 shall not apply.

5.6.4.6 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle.

5.6.5 Soot Blowing. Where soot blowers are used, the following shall apply:

- (1) Soot blowing at nonoptimum air-fuel ratios has been known to lead to explosive formations of air-soot clouds within the boiler and shall be avoided.
- (2) Soot blowers shall be operated only while burners are firing at rates such that the burner flame cannot be extinguished.
- (3) Boilers that are equipped with automatic soot-blowing equipment shall have their controls interlocked to prevent operation when the burner is shut down or in the prefiring or light-off cycles.

5.7 Simultaneous Firing of Oil and Gas Fuels.

5.7.1* General. The equipment and procedures required in 5.7.1.1 through 5.7.1.3 shall be used to avoid a hazardous furnace condition when firing oil and gas simultaneously in a single burner boiler.

5.7.1.1 The initial prefiring cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.

5.7.1.2 Igniters shall be used during the light-off of the second fuel as required by the manufacturer and as established by test.

5.7.1.3 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.7.2 Equipment Requirements. The following equipment shall be provided for continuous firing of both oil and gas:

- (1) A burner that is capable of burning either fuel oil or fuel gas individually or both fuels simultaneously
- (2) A combustion control system that is capable of performing the following functions:
 - (a) Metering and totaling the inputs from both gas and oil fuels alone or in any combination
 - (b) Proportioning the total fuel input of each fuel individually or in any combination to total airflow in order to maintain the air-fuel ratio within design limits
 - (c) Limiting fuel demand to be less than measured airflow and limiting air demand to be greater than measured fuel flow
 - (d) For items 5.7.2(2)(a) through 5.7.2(2)(c), a control system that is designed to accommodate a fixed amount of secondary fuel without metering and totaling all fuels shall be permitted, provided the system maintains air-fuel ratios within design limits

- throughout the entire operating range of the burner
- (e) Limiting total fuel input to the maximum capacity of the boiler
- (f) Controlling and maintaining a minimum airflow rate that takes into account simultaneous fuel inputs
- (g) Controlling and maintaining minimum input rates of each fuel
- (h) Requiring a stable return to design air-fuel ratio after the trip or shutdown of either fuel
- (3) A burner management system with the following capabilities:
 - (a) Meets the requirements of 5.4.6 for each fuel being fired
 - (b) Requires, on an interlock action specific to only one of the fuels being fired, that this particular fuel automatically shut down with operation continuing on the unaffected fuel in a stable manner; shutdown of both fuels permitted
 - (c) Requires that both the first and second fuels be introduced with their flow control valves in light-off positions
 - (d) Provides for the introduction of the second fuel without requiring a boiler purge
 - (e) Requires a manual reset following any interlock shutdown
 - (f) Prohibits the simultaneous light-off of both fuels
 - (g) Requires flame detector(s) in accordance with 5.4.4 to supervise any of the following conditions:
 - 1. Igniter flame as permitted by igniter class
 - 2. Gas firing
 - 3. Oil firing
 - 4. Combined gas and oil firing
 - (h) Burner flame detectors permitted to supervise the fuels used
- (3) Install oil atomizer.
- (4) Open atomizing medium shutoff valve.
- (5) Select dual fuel firing.
- (6) Set oil control valve in light-off position.
- (7) Prove fuel oil control valve in light-off position.
- (8) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (9)* Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (10) Open oil safety shutoff valves and establish oil flow through the burner.
- (11) Gradually remove airflow bias.
- (12) Verify stable flame and that the air-fuel ratio is within design limits.
- (13) Place the combustion control system into the required mode for controlling input rate of each fuel.
- (14) Shut down igniter as required.

5.7.3.4 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the light-off cycle for the gas shall accomplish the following in the listed order:

- (1) Place fuel oil flow and airflow control loops in automatic mode.
- (2) Satisfy fuel gas system interlocks.
- (3) Select dual fuel firing.
- (4) Set gas control valve in light-off position.
- (5) Prove fuel gas control valve in light-off position.
- (6) With airflow in automatic mode, gradually bias up airflow by a preset amount corresponding to fuel input of fuel gas in light-off.
- (7) Establish ignition energy in accordance with manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2, 5.6.2.6.2.2, or 5.6.2.6.2.3 for operating requirements.
- (8) Close the vent valve (where used), open the gas safety shutoff valves, and establish gas flow to the burner.
- (9) Gradually remove airflow bias.
- (10) Verify stable flame and that the air-fuel ratio is within design limits.
- (11) Place the combustion control system into the required mode for controlling input rate of each fuel.
- (12) Shut down igniter as required.

5.7.4 Shutdown Cycle.

5.7.4.1 Normal Oil Shutdown Cycle. The normal shutdown procedure for oil while continuing to fire gas shall be in the following order:

- (1) Reduce the oil flow to the light-off rate.
- (2) Verify stable flame and adjust air-fuel ratio.
- (3) Shut off the oil supply to the burner and open the oil recirculating valve, where used.
- (4) Purge oil passages of the oil atomizer, where used, if required.
- (5) Shut off the atomizing medium, if required.
- (6) Remove the oil atomizer from the burner, if required.
- (7) Verify stable flame and that the air-fuel ratio of the gas fire is within design limits.

5.7.3 Simultaneous Firing of Oil and Gas Fuels (Second Fuel Start). This subsection shall define the requirements and procedures for a light-off and subsequent operation on a continuous basis of a second fuel.

5.7.3.1 Equipment Requirements. Equipment requirements shall be in accordance with 5.7.2 and 5.7.3.2.

5.7.3.2 A fuel transfer mode with the following functions shall be provided:

- (1) A gas-firing mode in which oil cannot be fired
- (2) An oil-firing mode in which gas cannot be fired
- (3) A gas-oil-firing mode that permits simultaneous firing of both fuels
- (4) The capability to signal the combustion control system to bias up the airflow, to position the control valve for the second fuel to light-off, and to open the safety shutoff valve(s) of the fuel being introduced
- (5) The capability to bias up the airflow by a preset value in response to a fuel transfer signal while the airflow remains in automatic mode

5.7.3.3 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the light-off cycle for the oil shall accomplish the following in the listed order:

- (1) Place fuel gas flow and airflow control loops in automatic mode.
- (2) Satisfy fuel oil system interlocks.

5.7.4.2 Normal Gas Shutdown Cycle. The normal shutdown procedure for gas while continuing to fire oil shall be in the following order:

- (1) Reduce the gas flow to the light-off rate.
- (2) Shut off the gas supply to the burner.
- (3) Verify stable flame and that the air-fuel ratio of the oil fire is within design limits.

5.7.4.3* Oil Fuel Trip.

5.7.4.3.1 Any of the following operating conditions shall accomplish a trip of the oil supply to the burner:

- (1) Low fuel pressure
- (2) Low temperature of heated oils, where used
- (3) Loss of atomizing medium, where used, as interlocked by flow or two pressure switches, one located at the service connection and the other at the burner, either one of which shall initiate a safety shutdown on low pressure
- (4) High temperature of heated oil, where used

5.7.4.3.2 A master fuel trip shall occur if oil is the only fuel being fired.

5.7.4.4 Gas Fuel Trip.

5.7.4.4.1 Either of the following conditions shall accomplish a trip of the gas supply to the burner:

- (1) High gas pressure
- (2) Low gas pressure

5.7.4.4.2 A master fuel trip shall occur if gas is the only fuel being fired.

5.7.4.5 Master Fuel Trip. Any of the following conditions shall initiate a master fuel trip of the boiler:

- (1) Loss of combustion air supply
- (2) Loss of or failure to establish flame
- (3) Loss of control system actuating energy
- (4) Power failure
- (5) Excessive steam pressure or water temperature
- (6) Low water level as determined by the auxiliary low water cutout
- (7) The occurrence of either an oil or a gas fuel trip when only that fuel is being fired

5.8 Simultaneous Firing of Oil and Gas for Fuel Transfer Only.

5.8.1* General. The equipment and procedures of 5.8.1.1 through 5.8.1.4 shall be used to avoid a hazardous furnace condition when operation of the boiler is transferred from fuel oil to fuel gas or from fuel gas to fuel oil without requiring a shutdown of the boiler.

5.8.1.1 Simultaneous Firing for Fuel Transfer on a Continuous Basis. When the combustion control system and the burner management system are both designed for fuel transfer and simultaneous firing of oil and gas fuels on a continuous basis, the requirements of Section 5.7 shall apply.

5.8.1.2 Igniters shall be used during the fuel transfer as required by the manufacturer and as established by test.

5.8.1.3 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.8.1.4 The initial prefiring cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.

5.8.2 Required Equipment. The following equipment shall be required:

- (1) A burner that is capable of firing the two fuels simultaneously during the transfer period
- (2) A combustion control system that is capable of performing the following functions:
 - (a) Proportioning fuel flow for each fuel individually
 - (b) Limiting total fuel input to the maximum capacity of the boiler
 - (c) Controlling a minimum airflow rate
 - (d) Controlling minimum input rates of each fuel
 - (e) Providing a stable return to design air-fuel ratio after the trip or shutdown of either fuel
- (3) A fuel transfer mode that includes the following:
 - (a) A gas-firing mode in which oil cannot be fired
 - (b) An oil-firing mode in which gas cannot be fired
 - (c) A gas-oil-firing mode that permits simultaneous firing of both fuels, provided all interlocks for both fuels are satisfied, including light-off position for both fuel valves
 - (d) A control device, transfer timer, and an alarm for 5.8.2(3)(c), to limit continuous operation in this mode
- (4) A burner management system with the following capabilities:
 - (a) Meets the requirements of 5.4.6 for each fuel being fired
 - (b) Provides an independent interlock to each fuel being fired that automatically shuts down the affected fuel with operation continuing on the unaffected fuel in a stable manner; shutdown of both fuels is permitted
 - (c) Provides that both the first and second fuels be introduced with their flow control valves in light-off positions
 - (d) Provides an interlock action that will trip either fuel should its respective flow control valve deviate from a predetermined setting during fuel transfer
 - (e) Provides for the introduction of the second fuel without requiring a boiler purge
 - (f) Requires a manual reset following any interlock shutdown
 - (g) Prohibits the simultaneous light-off of both fuels
 - (h) Provides detector(s) to supervise any of the following conditions:
 - i. Igniter flame as permitted by igniter class
 - ii. Gas firing
 - iii. Oil firing
 - iv. Combined gas and oil firing
 - (i) Burner flame detectors shall be permitted to supervise multiple fuels.

5.8.3 Simultaneous Firing of Oil and Gas for Fuel Transfer Only (Automated Transfer). This subsection shall define the requirements and procedures to be used for an automated transfer of operation from one fuel to a second fuel without requiring a shutdown of the burner.

5.8.3.1 Required Equipment. Equipment requirements shall be in accordance with 5.8.2 and 5.8.3.1.1 through 5.8.3.1.3.

5.8.3.1.1 The combustion control system shall have the capability to automatically increase the airflow by a preset value in response to a fuel transfer signal.

5.8.3.1.2 The airflow shall be held in a fixed position for the transfer period.

5.8.3.1.3 The fuel transfer mode shall have the capability to signal the combustion control system to increase airflow and open the safety shutoff valve(s) of the fuel being introduced.

5.8.3.2 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the transfer cycle from gas to oil shall be in the following order:

- (1) Satisfy fuel oil system interlocks.
- (2) Install an oil atomizer.
- (3) Open the atomizing medium shutoff valve.
- (4) Select dual fuel firing.
- (5) Set the gas-firing rate to light-off flow.
- (6) Set the oil control valve in the light-off position.
- (7) Prove fuel gas and fuel oil control valves are in light-off position.
- (8) Gradually increase airflow by a preset amount corresponding to fuel input of fuel oil in light-off.
- (9)* Establish ignition energy in accordance with the manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2.2 or 5.6.2.6.2.3 for operating requirements.
- (10) Open the oil safety shutoff valves and establish oil flow to the burner.
- (11) Verify stable flame and that the air-fuel ratio is within design limits.
- (12) Select the oil firing mode, which automatically trips the gas safety shutoff valves.
- (13) Gradually remove airflow increase.
- (14) Return the combustion control system and burner firing rate to automatic operation.
- (15) Shut down igniter as required.

5.8.3.3 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the transfer cycle from oil to gas shall be in the following order:

- (1) Establish the fuel gas system to satisfy interlocks.
- (2) Select the dual fuel firing mode.
- (3) Set the oil-firing rate to light-off flow.
- (4) Set the gas control valve to the light-off position.
- (5) Prove fuel gas and fuel oil control valves are in light-off position.
- (6) Increase airflow by a preset amount corresponding to fuel input of fuel gas in light-off.
- (7)* Establish ignition energy in accordance with the manufacturer's instructions. Where an igniter is required, see 5.6.2.6.2.2 or 5.6.2.6.2.3 for operating requirements.
- (8) Close the vent valve (where used), open the gas safety shutoff valves, and establish gas flow to the burner.
- (9) Verify stable flame and that the air-fuel ratio is within design limits.
- (10) Select the gas-firing mode, which automatically trips the oil safety shutoff valves.
- (11) Gradually remove airflow increase.
- (12) Return the combustion control system and burner-firing rate to automatic operation.
- (13) Purge the oil gun into furnace, if required.
- (14) Close atomizing medium shutoff valve, if required.

(15) Remove oil atomizer, if required.

(16) Shut down igniter as required.

5.8.4 Simultaneous Firing of Oil and Gas for Fuel Transfer Only (Manual Transfer). This subsection shall define the requirements and procedures to be used for a manual transfer of operation from one fuel to a second fuel without requiring a shutdown of the burner.

5.8.4.1 Required Equipment. Equipment requirements shall be in accordance with 5.8.2 and 5.8.4.1.1 through 5.8.4.1.3.

5.8.4.1.1 The combustion control system shall have the capability to manually adjust the airflow.

5.8.4.1.2 Manual shutoff valves shall be provided at the burner, downstream of the safety shutoff valves for each fuel.

5.8.4.1.3 A pressure gauge shall be provided in each fuel line downstream of the manual shutoff valve.

5.8.4.2 Subsequent Fuel Light-Off — Oil. When oil is introduced as the second fuel, the procedure to transfer from gas to oil shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions as required.
- (2) Confirm that the manual oil valve at the burner is closed.
- (3) Satisfy fuel oil system interlocks.
- (4) Install an oil atomizer.
- (5) Open the atomizing medium shutoff valve.
- (6) Place the combustion control system in manual mode.
- (7) Reduce the gas-firing rate to light-off flow.
- (8) Place the oil control valve in the light-off position.
- (9) Place the fuel transfer in oil/gas mode, with the following results:
 - (a) When the oil interlocks are satisfied, the oil safety shutoff valves open.
 - (b) Fuel oil pressure now will be upstream of the manual oil valve at the burner.
- (10) Slowly close the manual gas shutoff valve while observing the gas pressure downstream of the valve until the gas pressure starts to drop. At this point, the gas flow rate is controlled by the manual valve instead of by the control valve.
- (11) Slowly close the manual gas valve while simultaneously opening the manual oil valve to light the oil flame from the gas flame and proceed as follows:
 - (a) Continue to increase the oil-firing rate while cutting back on the gas-firing rate to maintain a constant heat input of the combined fuels to the burner, until the manual gas valve is closed and the manual oil valve is fully open.
 - (b) Excess air must be maintained at all times by continuously observing the burner flame or by observing the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (12) Place the fuel transfer mode in the oil position.
- (13) Return the combustion control system and burner-firing rate to automatic operation.
- (14) Shut down igniter as required.

5.8.4.3 Subsequent Fuel Light-Off — Gas. When gas is introduced as the second fuel, the procedure to transfer from oil to gas shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions.
- (2) Confirm that the manual gas valve at the burner is closed.
- (3) Satisfy fuel gas system interlocks.
- (4) Place the combustion control system in manual mode.
- (5) Reduce the oil-firing rate to light-off flow.
- (6) Place the gas control valve in the light-off position.
- (7) Place fuel transfer in the gas/oil mode, with the following results:
 - (a) When the gas interlocks are satisfied, the gas safety shutoff valves open.
 - (b) Gas pressure now will be upstream of manual gas valve at the burner.
- (8) Slowly close the manual oil valve while observing the oil pressure downstream of the valve until the oil pressure starts to drop. At this point, the oil flow is controlled by the manual valve instead of by the control valve.
- (9) Slowly close the manual oil valve while simultaneously opening the manual gas valve to light the gas flame from the oil flame, then proceed as follows:
 - (a) Continue to increase the gas-firing rate while cutting back on the oil-firing rate to maintain a constant heat input of the combined fuels to the burner until the manual oil valve is closed and the manual gas valve is fully open.
 - (b) Excess air must be maintained at all times by continuously observing the burner flame or by observing the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (10) Place the fuel transfer mode in the gas position. The oil safety shutoff valves close.
- (11) Return the combustion control system and burner-firing rate to automatic operation.
- (12) Purge the oil gun into the furnace, if required.
- (13) Shut off the atomizing medium, if required.
- (14) Remove the oil atomizer from burner, if required.
- (15) Shut down the igniter as required.

5.8.5 Fuel Trips. Fuel trips shall be initiated in accordance with 5.7.4.3 through 5.7.4.5.

5.9 Dual Oil Atomizers in a Single Burner.

5.9.1* General. Where a burner is equipped with main and auxiliary oil atomizers for the purpose of changing atomizers for maintenance without affecting the boiler load, the change-over of atomizers shall be carried out manually under stable firing conditions by a trained operator.

5.9.1.1 Igniters shall be used during the fuel transfer as required by the manufacturer and as established by test.

5.9.1.2 Each boiler shall be tested during initial start-up to determine whether any modifications to the procedures specified in Section 5.6 are required to establish ignition or to satisfy other design limitations during light-off, warm-up, or normal operation.

5.9.1.3 The initial prefiring cycle, light-off cycle, and normal shutdown cycles for the initial fuel to be fired and for single fuel operation shall be completed in accordance with Section 5.6.

5.9.2 Required Equipment. The following equipment shall be required:

- (1) A burner that is capable of firing two oil atomizers simultaneously during the transfer period
- (2) A combustion control system that is capable of limiting the total fuel input to the maximum capacity of the boiler and that has the capability to manually adjust the airflow
- (3) A burner management system in accordance with 5.4.6 that also prohibits the simultaneous light-off of both atomizers
- (4) Manual oil shutoff valves at the burner, downstream of the safety shutoff valves for each atomizer
- (5) A pressure gauge in the fuel line downstream of each manual shutoff valve
- (6) Manual atomizing media shutoff valves for each atomizer except on mechanically atomized systems

5.9.3 Oil Atomizer Changeover Procedure. The procedures for a manual transfer of operation from one oil atomizer (main or auxiliary) to a second oil atomizer (auxiliary or main) without requiring a shutdown of the burner shall be as follows:

- (1) Where a Class 1 or Class 2 igniter is available, place it in service in accordance with the manufacturer's instructions.
- (2) Confirm that the manual oil valve at the burner for the atomizer to be started is closed.
- (3) Install the second oil atomizer.
- (4) Place the combustion control system in manual mode.
- (5) Slowly close the manual shutoff valve while observing the oil pressure downstream of the valve until the oil pressure starts to drop. At this point, the oil flow rate is controlled by the manual valve instead of by the control valve.
- (6) For non-mechanically atomized oil atomizers, slowly open the second atomizing medium shutoff valve until it is fully open.
- (7) Slowly close the manual oil valve for the atomizer in service while simultaneously opening the manual oil valve of the second atomizer to light the second atomizer from the first and proceed as follows:
 - (a) Continue to slowly increase the oil-firing rate on the second atomizer while cutting back on the firing rate of the first atomizer to maintain a constant heat input of the combined atomizers until the manual valve of the first atomizer is closed and the manual oil valve of the second atomizer is fully open.
 - (b) Excess air shall be maintained at all times by continuous observation of the burner flame or by observation of the air-fuel ratio, oxygen indicator, or opacity indicator, if provided.
 - (c) During this period, airflow must be maintained at a constant rate with only the manual fuel valves operated.
- (8) Close the atomizing media shutoff valve on the first atomizer, if present.
- (9) Return the combustion control system and burner-firing rate to automatic operation.
- (10) Shut down the igniter as required.

Chapter 6 Multiple Burner Boilers

6.1 Application.

6.1.1 This chapter shall be used in conjunction with Chapter 4 and requires the coordination of operation procedures, control systems, interlocks, and structural design. Where conflicts exist, the requirements of this chapter shall apply.

6.1.2 The sections of this code that are common to all fuels to be burned in a multiple burner boiler shall be used in conjunction with those sections that are applicable to a specific fuel being utilized.

6.1.3 Section 6.5 shall apply to minimizing the risk of negative furnace draft in excess of furnace structural capability.

6.1.4 Section 6.6 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing fuel gas as defined in 3.3.65.3.

6.1.5 Section 6.7 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing fuel oil as defined in 3.3.65.4.

6.1.6 Section 6.8 shall apply to burner management, combustion control systems, and operating procedures for multiple burner boilers utilizing pulverized coal fuel as defined in 3.3.65.2.1.

6.1.7 This chapter shall also apply to fired flue gas reheaters (duct burners) installed in the flue gas path downstream of a multiple burner boiler furnace.

6.2 Purpose.

6.2.1 The purpose of this chapter shall be to contribute to operating safety and to prevent furnace explosions and implosions in multiple burner boiler installations from the forced draft fan inlet(s) to the stack inlet.

6.2.2 This chapter establishes minimum requirements that shall be followed for the design, installation, operation, and maintenance of multiple burner boilers and their fuel-burning, air supply, and combustion products removal systems.

6.2.3* The user of this chapter shall recognize the complexity of firing fuel with regard to the type of equipment and the characteristics of the fuel.

6.3 Mechanical Equipment Requirements.

6.3.1 General requirements for mechanical equipment shall be in accordance with Sections 4.6 through 4.16.

6.3.2 Forced draft (FD) and induced draft (ID) fans shall include all fans whose purpose is to supply air for combustion or remove products of combustion, including associated booster fans, and exclude fans in the pulverized coal system.

6.3.3 Fuel Gas and Fuel Oil Safety Shutoff Valves.

6.3.3.1 A header safety shutoff valve and individual burner safety shutoff valves shall be provided.

6.3.3.2 Proof of closure shall be provided for all header and burner safety shutoff valves.

6.3.3.3 Multiple burners supplied from a common set of burner safety shutoff valves shall be treated as a single (individual) burner. (See 6.6.7.1.3 and 6.7.7.1.3 for two-burner units.)

6.3.3.4 Where fuel gas or fuel oil igniters are provided, a common igniter fuel header safety shutoff valve and individual igniter safety shutoff valves shall also be provided. The igniter header safety shutoff valve shall be dedicated to the igniter subsystem.

6.3.3.5 Multiple igniters supplied from a common set of igniter safety shutoff valves shall be treated as a single (individual) igniter.

6.3.3.6 Proof of closure in accordance with 6.4.1.2.4.5 shall be provided for all individual igniter safety shutoff valves.

6.3.3.7 Burner and igniter safety shutoff valves shall be located as close as practicable to the igniters or burners to minimize the volume of fuel downstream of the valve.

6.4 Burner Management and Combustion Control Requirements. Burner management and combustion control general requirements shall be in accordance with Sections 4.11 through 4.15.

6.4.1 Interlocks.

6.4.1.1 Functional Requirements.

6.4.1.1.1 The operation of any interlock that causes a trip shall be annunciated.

6.4.1.1.2 The interlocks shall be installed, adjusted, and tested to confirm design function and timing.

6.4.1.1.2.1 The actuation values and time of action of the initiation devices shall be tuned to the furnace and equipment on which they are installed.

6.4.1.1.2.2 After adjustment, each path and the related interlocks shall be tested to verify the adjustments.

6.4.1.1.3* A functional test of all the required interlocks as identified in 6.4.1.2 shall be performed at least annually.

N 6.4.1.1.3.1 For continuously fired units that have not been subject to a functional test in over 12 months, a functional test shall be conducted during the next scheduled boiler shutdown.

N 6.4.1.1.3.2 Functional testing shall confirm that field devices activate interlocks at the designed set points.

N 6.4.1.1.3.3 All functional tests shall be documented and the records compared to previous functional tests.

N 6.4.1.1.3.4 Deficiencies found during the functional test shall be corrected through repair, replacement, or additional troubleshooting.

N 6.4.1.1.3.5 All repairs made to correct deficiencies shall be retested for verification.

6.4.1.1.4 If a reburn system is employed, the reburn interlocks shall be integrated with the boiler interlocks.

6.4.1.1.5 Interlocks associated exclusively with the reburn system shall trip only the reburn system and shall not generate a master fuel trip.

6.4.1.1.6 The starting procedure and operation shall be supervised to ensure that design operating parameters and sequences are used.

6.4.1.1.7 The minimum amount of equipment shall be tripped in the correct sequence when the safety of personnel or equipment is jeopardized.

6.4.1.1.8 The initiating cause of the trip shall be indicated, and no portion of the process shall be started until stable operating conditions within design parameters are established.

6.4.1.1.9 Where automatic equipment is not installed or in service to accomplish the intended function, instrumentation or alternative means to enable the operator to complete the operating sequence shall be provided.

6.4.1.1.10 The design shall retain as much flexibility with respect to alternative modes of operation as is consistent with operating procedures and parameters.

6.4.1.1.11 The capability for preventive maintenance shall be provided.

6.4.1.1.12* The mandatory master fuel trip-sensing elements and circuits shall be independent of all other control elements and circuits.

Exception No. 1: Individual burner flame detectors also shall be permitted to be used for initiating master fuel trips.

Exception No. 2: Signals from the boiler control system shall be permitted to be used for a master fuel trip, provided all the following conditions are met:

- (1) *These interlocks are hardwired into the burner management system.*
- (2) *Tripping set points are protected from unauthorized changes.*
- (3) *Any single component failure of these sensing elements and circuits does not prevent a mandatory master fuel trip.*

6.4.1.1.13 Misoperation of the interlocks due to an interruption or restoration of the interlock energy supply shall be prevented.

6.4.1.2* Required Interlocks.

6.4.1.2.1* Figure 6.4.1.2.1 and Table 6.4.1.2.1(a) through Table 6.4.1.2.1(c) show the minimum required interlocks that shall be provided for basic furnace protection for a multiple-burner boiler operated in accordance with this code.

6.4.1.2.2 Each source of operation of the master fuel trip relay shall actuate a cause-of-trip indication, which informs the operator of the initiating cause of the tripping impulse.

6.4.1.2.3 Main fuel oil-recirculating valves shall be permitted to be reset separately and opened following a trip of the master fuel trip relay only after all burner safety shutoff valves have been proven closed.

6.4.1.2.4 Purge Requirements.

6.4.1.2.4.1 A boiler enclosure purge shall be performed as part of the open register, continuous purge light-off procedures specified in 6.6.5.1.5.7, 6.7.5.1.5.7, and 6.8.5.1.5.7.

6.4.1.2.4.2 A boiler enclosure purge shall be completed before resetting of the master fuel trip relay shall be permitted.

6.4.1.2.4.3 A boiler enclosure purge shall be required after the occurrence of a master fuel trip or if any purge permissive, as defined in 6.4.1.2.4.5, is lost prior to the introduction of any fuel or ignition source to the boiler enclosure.

(A)* On a master fuel trip where FD and ID fans remain in service, boiler enclosure purge conditions shall be established and a boiler enclosure purge completed. Purge rate airflow shall be established in accordance with the following procedure:

- (1) All fans in the combustion air and flue gas streams that are in service at the time of the trip shall be left in service. This shall not include primary air fans or pulverizer exhausters used to convey coal into the furnace.
- (2) The airflow shall not be changed by deliberate manual or automatic control action except as permitted in 6.4.1.2.4.3(A)(3) and 6.4.1.2.4.3(A)(4).
- (3) If the airflow is greater than the purge rate, it shall be permitted to be decreased gradually to the purge rate for a boiler enclosure purge.
- (4) If the airflow is less than the purge rate at the time of the trip, it shall be continued at the existing rate for 5 minutes and then increased gradually to the purge rate airflow and held at that value for a boiler enclosure purge. If increasing the airflow to the purge rate requires starting fans, they shall be started in accordance with Section 6.5.
- (5) During a master fuel trip event, the overfire air system shall remain at the same setting as when the event occurred for such time as the main combustion airflow is held.
- (6) Following the hold period, the overfire air shall be permitted to be gradually adjusted to overfire air purge settings or cooling flows either manually or automatically.

(B)* All Fan Trip.

- (1) On a master fuel trip where no fans remain in service, no action shall be taken other than damper actions necessary to prevent positive or negative furnace pressure transients beyond design limits.
- (2) The flue gas recirculation system shall be operated as recommended by the boiler manufacturer.
- (3) Except as noted in 6.4.1.2.4.3(B)(4), once the FD and ID fan(s) have stopped, slowly open all dampers in the air and flue gas passages to the full open position.
- (4)* When the flue gas flow path is combined with the flue gas flow path(s) of other operating boilers, it shall be permitted to isolate the flue gas path for the tripped unit once the ID and FD fan(s) have stopped.
- (5) The conditions in 6.4.1.2.4.3(B)(3) or 6.4.1.2.4.3(B)(4) shall be maintained for an all fan trip hold period of at least 15 minutes prior to allowing any ID or FD fan to be restarted.
- (6) At the end of this 15 minute period, the fan(s) shall be started in accordance with Section 6.5.
- (7) The airflow shall be increased gradually to the purge rate, and a boiler enclosure purge shall be completed.

(C) After completion of the boiler enclosure purge, one of the following actions shall be permitted:

- (1)* Shut down the FD and ID fans and open all dampers to allow an open flow path through the boiler enclosure.
- (2)* Shut down the FD and ID fans and close dampers in the boiler flue gas path and air path.
- (3) Relight in accordance with 6.6.5, 6.7.5, or 6.8.5, as applicable, depending on the fuels being fired.

Table 6.4.1.2.1(a) Interlocks for a Multiple-Burner Boiler

Block Number	Action
Block 1	Loss of an individual igniter flame shall cause the following actions: (1) Close the individual igniter safety shutoff valve(s) and de-energize the spark(s). (2) Open the vent valve (fuel gas ignition only). (3) Signal the main flame protection system that the igniter flame has been lost.
Block 2a1	High or low igniter fuel gas header pressure shall be interlocked to initiate the tripping of the igniter header and individual igniter safety shutoff valves and de-energize sparks.
Block 2a2	Low igniter fuel oil header pressure shall be interlocked to initiate the tripping of the igniter header and individual igniter safety shutoff valves and de-energize sparks.
Block 2b	Where fuel oil is used for ignition fuel with air or steam atomization, atomizing air or steam pressure out of range shall trip the igniter header and individual igniter safety shutoff valves and de-energize sparks. Where direct electric igniters are used, blocks 1 and 2 shall not apply. However, the master fuel trip shall de-energize sparks and prevent re-energizing until all conditions for light-off have been re-established.
Blocks 3 through 13	These blocks represent conditions that initiate the tripping of all main and ignition fuel supplies through a master fuel trip relay contact(s). The master fuel trip relay(s) shall be of the type that stays tripped until the unit purge interlock permits it to be reset. Whenever the master fuel trip relay(s) is operated, it shall trip all fuel header, burner, and igniter safety shutoff valves and de-energize all sparks and all ignition devices within the unit and flue gas path through master fuel trip relay contact(s). Master fuel trip relay contacts shall also trip the fuel oil system circulating and recirculating valves. If the design of the fuel oil supply system is such that backflow of fuel oil through the recirculating valve is inherently impossible or positively prevented, this valve shall be permitted to be manually operated and shall not be required to be interlocked to close automatically on a master fuel trip. The master fuel trip relay contacts shall also trip primary air fans or exhausters, coal feeders, pulverizers, and coal burner line shutoff valves, or take equivalent functional action to stop coal delivery to burners. The master fuel trip relay contacts shall also trip all flue gas path auxiliary systems that introduce hazards through the addition of fuel, oxidizing agents, or ignition sources.
Block 3	The loss of all induced draft fans shall activate the master fuel trip relay.
Block 4	The loss of all forced draft fans shall activate the master fuel trip relay.
Block 5	Low combustion airflow below the permitted limits shall activate the master fuel trip relay.
Block 6 (See A.6.4.1.2.1)	High positive furnace pressure shall activate the master fuel trip relay. High negative furnace pressure shall activate the master fuel trip relay.
Block 7	Loss of all flame in the furnace shall activate the master fuel trip relay.
Block 8 (See A.6.4.1.2.1)	A partial loss of flame that results in a hazardous condition shall activate the master fuel trip relay.
Block 9 (See A.6.4.1.2.1)	When all fuel inputs to the furnace are shut off following a shutdown of the boiler for any reason, the master fuel trip relay shall be activated in accordance with Table 6.4.1.2.1(b) or Table 6.4.1.2.1(c).
Block 10a (See A.6.4.1.2.1)	For drum-type boilers, a low drum water level shall activate the master fuel trip relay.
Block 10b (See A.6.4.1.2.1)	For forced circulation boilers, circulating flow below the minimum specified by the manufacturer or related waterwall protection signals shall activate the master fuel trip relay.
Block 10c (See A.6.4.1.2.1)	For once-through boilers, waterwall flow below the minimum specified by the manufacturer or related waterwall protection signals shall activate the master fuel trip relay.
Block 11	A manual switch that actuates the master fuel trip relay directly shall be provided for use by the operator in an emergency.
Block 12	The igniter fuel trip shall activate the master fuel trip relay in accordance with Table 6.4.1.2.1(b) or Table 6.4.1.2.1(c), if igniter fuel is the only fuel in service or if it is being used to stabilize a main fuel.

(continues)

Table 6.4.1.2.1(a) *Continued*

Block Number	Action
Block 13a	When the fuel gas burner header pressure is above the maximum or below the minimum for a stable flame, that fuel shall be tripped. If fuel gas is the only fuel in service, the master fuel trip relay shall be actuated.
Block 13b	When the fuel oil burner header pressure is below the minimum for a stable flame, that fuel shall be tripped. If fuel oil is the only fuel in service, the master fuel trip relay shall be actuated.
Block 13c	This block represents operation of the fuel oil trip to prevent operation when atomizing air or steam pressure is out of range. If fuel oil is the only fuel in service, the master fuel trip relay shall be actuated.
Block 13d	This block represents the tripping/shutdown of coal-firing equipment that will cause a coal fuel trip. If coal is the only fuel in service, the master fuel trip relay shall be actuated.
Block 14a	Loss of flame at an individual fuel gas or fuel oil burner with one or more additional burners operating with stable flames that does not introduce a serious enough condition to warrant a master fuel trip as called for in block 8 shall close the individual burner safety shutoff valve(s) and associated igniter safety shutoff valve(s) and de-energize the associated igniter spark. For gang-operated burner valves, the requirements of 6.6.5.2.1.3(B)(19) and 6.7.5.2.1.3(B)(19) shall be met.
Block 14b	On loss of main coal burner flame, the tripping strategies of 6.8.4 shall be followed.

Table 6.4.1.2.1(b) Fuel Inputs Shutoff When Class 1 Igniters Are Used

Condition	Action Required
(1) First Class 1 igniter(s) fails to light after successful unit purge. <i>[See 6.6.5.2.1.3(B)(9), 6.7.5.2.1.3(B)(10), and 6.8.5.2.1.3(B)(7).]</i>	(1) Igniter valve(s) shall be closed immediately. Master fuel trip not required, but a 1-minute delay shall be required before retrieval of that or any other igniter.
(2) Any igniters proven on, all other fuel sources off, all igniter valves subsequently closed.	(2) Master fuel trip shall be actuated.
(3) Any Class 1 igniter(s) proven on, any burner valve leaves closed limit, all burner valves subsequently closed, no other main fuel in service, igniter(s) remain proven.	(3) Associated main fuel gas trip valve and/or fuel oil trip valve shall be closed (fuel gas trip and/or fuel oil trip), proven igniters shall be permitted to remain in service.
(4) Any Class 1 igniter(s) proven on, any pulverizer start-up initiated, all pulverizers subsequently stopped, no other main fuel in service, igniter(s) remain proven.	(4) Proven igniters shall be permitted to remain in service.
(5) All igniter and burner valves closed and all feeders or pulverizers stopped.	(5) Master fuel trip shall be actuated.

6.4.1.2.4.4 Purge Rate Air Flow.

(A)* The designer shall establish a minimum purge rate airflow. This purge rate airflow shall be in accordance with 6.4.1.2.4.4(B) and 6.4.1.2.4.4(C).

(B)* Purge rate airflow shall not be less than 25 percent of design full load mass airflow.

(C) Purge rate airflow shall not be greater than 40 percent of design full load mass airflow for coal-fired units.

(D) Purge rate airflow shall be maintained from the FD fan inlet through the stack.

(E) Purge rate airflow shall be maintained from purge completion through light-off and initial loading as described in 6.6.5.1.5, 6.7.5.1.5, and 6.8.5.1.5.

6.4.1.2.4.5* Boiler Enclosure Purge Permissives. Boiler enclosure purge permissives shall, at a minimum, **ensure** the following:

- (1) All igniter header and individual igniter shutoff valves are proven closed by valve position.

Exception: Where the igniter capacity is 1.5 MW_t (5 million Btu/hr) or less, proof of closure of the individual igniter safety shutoff valves by means other than valve position shall be permitted.

- (2) If coal is fired on the unit, all pulverizers are stopped and all coal flow to the furnace is stopped.
- (3) If fuel gas is fired on the unit, all main fuel gas header and individual fuel gas burner shutoff valves are proven closed by valve position.
- (4) If fuel oil is fired on the unit, all main fuel oil header and individual fuel oil burner shutoff valves are proven closed by valve position.

Table 6.4.1.2.1(c) Fuel Inputs Shutoff When Class 2 or Class 3 Igniters Are Used

Condition	Action Required
(1) First Class 2 or 3 igniter(s) fails to light after successful unit purge. [See 6.6.5.2.1.3(B)(9), 6.7.5.2.1.3(B)(10), and 6.8.5.2.1.3(B)(7).]	(1) Igniter valve(s) shall be closed immediately. Master fuel trip not required, but a 1-minute delay shall be required before retrieval of that or any other igniter.
(2) Any igniters proven on, all other fuel sources off, all igniter valves subsequently closed.	(2) Master fuel trip shall be actuated.
(3a.1) Class 2 igniter(s) proven on, first main burner trial for ignition fails.	(3a.1) Master fuel trip shall be actuated.
(3a.2) Class 2 igniter(s) proven on, last main burner is taken out of service in a normal shutdown.	(3a.2) Associated main fuel gas trip valve and/or fuel oil trip valve shall be closed (fuel gas trip and/or fuel oil trip), proven igniters shall be permitted to remain in service.
(3a.3) Class 2 igniter(s) proven on, last main burner is tripped.	(3a.3) Master fuel trip shall be actuated.
(3b.1) Class 3 igniters proven on, first main burner trial for ignition fails.	(3b.1) Master fuel trip shall be actuated.
(3b.2) Class 3 igniter(s) proven on, last main burner is taken out of service in a normal shutdown.	(3b.2) Master fuel trip shall be actuated.
(3b.3) Class 3 igniter(s) proven on, last main burner is tripped.	(3b.3) Master fuel trip shall be actuated.
(4) Any Class 2 igniter(s) proven on, any pulverizer start-up initiated, all pulverizers subsequently stopped, no other main fuel in service, igniter(s) remain proven.	(4) (a) If first pulverizer fails to ignite as described in 6.8.5.2.1.3(B)(12), master fuel trip shall be actuated. (b) If last pulverizer in service is tripped, master fuel trip shall be actuated. (c) If last pulverizer in service is taken out of service in a normal shutdown sequence by an operator, proven igniters shall be permitted to remain in service.
(5) All igniter and burner valves closed and all feeders or pulverizers stopped.	(5) Master fuel trip shall be actuated.

- (5) Any other sources of combustibles that could enter the boiler enclosure or flue gas path are proven closed by valve position or other positive means.

Exception: Where the capacity of the combustible source is 1.5 MW, (5 million Btu/hr) or less, proof of closure of the shutoff valves by means other than valve position shall be permitted.

- (6) All required burner air registers are in purge position.
 (7) Where installed, overfire air dampers are in purge position.
 (8) At least one FD fan is in service.
 (9) Where installed, at least one ID fan is in service.
 (10) Where installed, at least one OFA fan is in service.
 (11) Flue gas recirculation fans are operated as recommended by the boiler manufacturer.
 (12) Total boiler airflow is at purge rate airflow.

6.4.1.2.4.6* Component Purge Permissives. Component purge permissives shall, at a minimum, include the following:

- (1) All sources of fuel and other combustibles into the component proven closed by valve position or other positive means

- (2)* All sources of ignition energy proven off
 (3) Component purge flow rate at or above boiler enclosure purge rate airflow

6.4.1.2.4.7* Boiler Enclosure Purge.

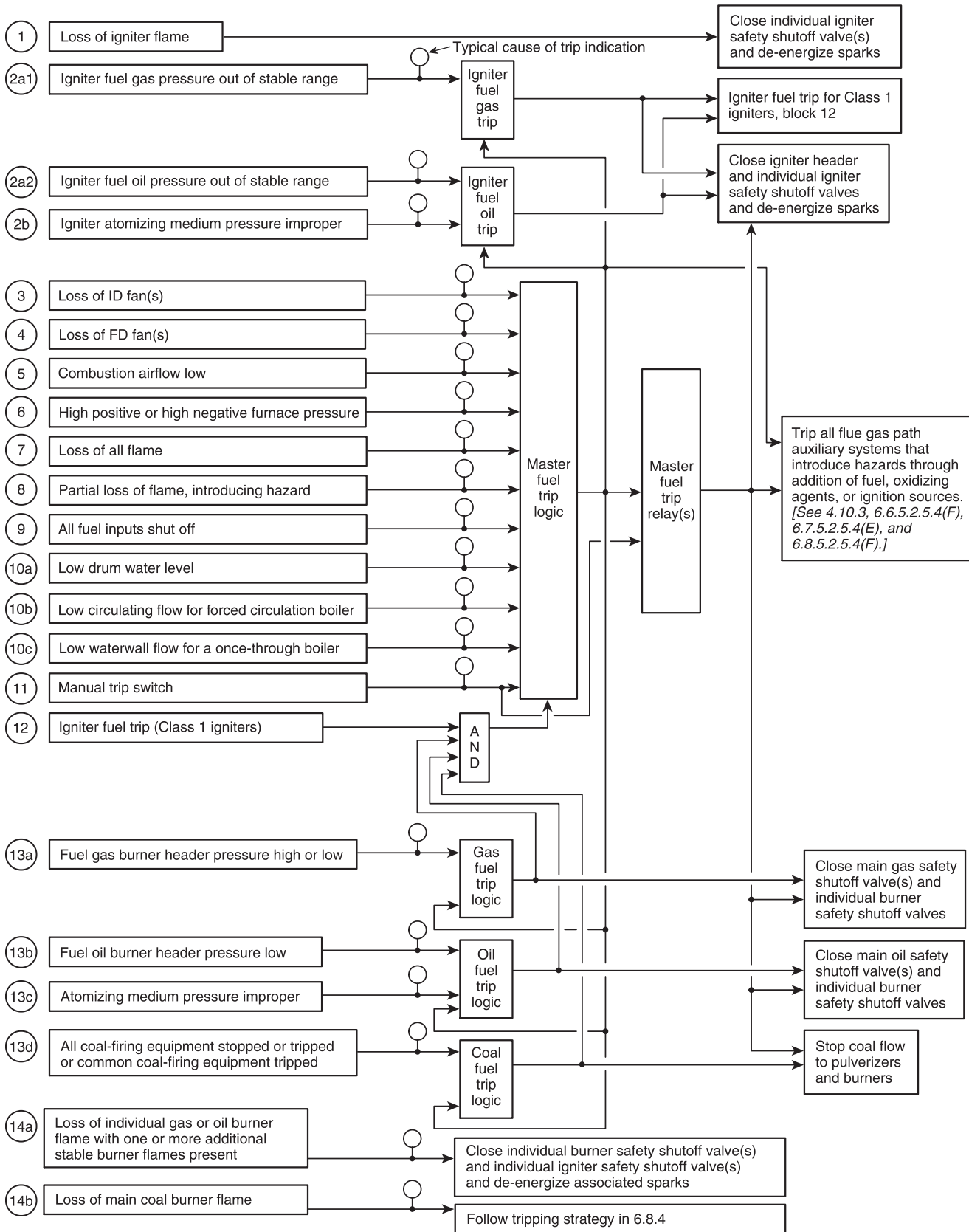
(A)* Completion of the boiler enclosure purge shall require a minimum of 5 minutes and at least five volume changes of the boiler enclosure while all the purge permissives are maintained.

(B) Accumulation of purge time and volume changes shall be permitted as soon as all the purge permissives are satisfied.

(C) Loss of any of the purge permissives during a boiler enclosure purge shall cancel any purge time and volume changes that have accumulated.

(D) Completion of boiler enclosure purge shall be indicated.

(E) After the boiler enclosure purge is complete, the master fuel trip relay(s) shall be permitted to be reset.



▲ FIGURE 6.4.1.2.1 Interlocks for a Multiple-Burner Boiler.