NFPA 8501
Standard for Single Burner Boiler Operation

1997 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Single Burner Boiler Operation

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This edition of NFPA 8501, *Standard for Single Burner Boiler Operation,* was prepared by the Technical Committee on Single Burner Boilers, released by the Technical Correlating Committee on Boiler Combustion System Hazards, and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 19–22, 1997, in Los Angeles, CA. It was issued by the Standards Council on July 24, 1997, with an effective date of August 15, 1997, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 8501 was approved as an American National Standard on August 15, 1997.

Origin and Development of NFPA 8501

Originally, this standard was adopted at the 1964 Annual Meeting as NFPA 85A and covered natural gas–fired units. At the 1965 Annual Meeting, Tentative Standard NFPA 85C-T–1964, covering fuel oil–fired units, was combined with NFPA 85A and the combined standard was issued as NFPA 85. Revisions were adopted in 1967, 1972, and 1973.

In 1982, the committee suggested that the document be renumbered to 85A to distinguish it from the remainder of the Boiler-Furnace standards, which are referred to as the NFPA 85 series.

Major revisions in 1982 included changes to the scope of the standard so that it applied to boilers with fuel input that was greater than 12,500,000 Btu/hr (3663 kW) rather than 10,000 lb of steam per hour.

In 1987, NFPA 85A was completely revised. Various technical changes were incorporated, and other revisions were made to conform with the NFPA *Manual of Style*.

The 1992 edition was a partial revision and included a variety of changes. Foremost was the renumbering and retitling of the document to NFPA 8501, *Standard for Single Burner Boiler Operation*. This was consistent with an initiative by the NFPA Boiler project to remove the letter designations and use shorter document titles.

This latest edition is a partial revision that includes changes to improve the standard. Included are new or revised definitions, new appendix material, and revised requirements for logic control systems.

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Committee Scope: This Committee shall have primary responsibility for documents on the reduction of combustion system hazards in single- and multiple-burner 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, heat recovery steam generators, and stoker-fired boilers, at any heat input rate.

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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.

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

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.

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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 Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix B.

FOREWORD

Technological advances in recent years, and in particular the persuasiveness of microprocessor-based hardware, make it even more important that only highly trained individuals be employed in the translation of these guidelines into operating systems. Each type of hardware has its own unique features and operational modes. It is vital that the designer of the safety system be completely familiar with the features and foibles of the specific hardware as well as possess a thorough understanding of these standards and their intent.

It is neither possible for these standards to encompass specific hardware applications nor should these standards be considered a "cookbook" for the design of a safety system.

When applying any type of equipment to a safety system, the designer must carefully consider all of the possible failure modes and the effect that each might have on the integrity of the system and the safety of the unit and personnel. In particular, no single point failure should result in an unsafe or uncontrollable condition or in a masked failure of a microprocessor-based system that could result in the operator unwittingly taking action that could lead to an unsafe condition.

This document is to be used for the design, installation, operation, and maintenance of single burner firetube and watertube boilers and their burner management and combustion control systems. The standard is organized as follows:

(a) Introduction and common sections that apply to all fired fuels covered in this standard (Chapters 1 through 4)

(b) Detailed sections that are specific to the particular operation described (Chapter 5 applies to starting up a cold boiler. Chapter 6 applies to operating systems, including automatic recycling and automatic nonrecycling systems for both watertube and firetube boilers and supervised manual systems for oil- or gas-fired watertube boilers. Chapter 7 applies to simultaneous firing of fuels. Chapter 8 applies to fuel transferring. Chapter 9 applies to dual atomizers in a single burner. Chapter 10 applies to inspection and maintenance.)

When using this standard, the common sections should be used in conjunction with the sections covering the specific operation that is described.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This standard applies to boilers with a fuel input rating of 12,500,000 Btu/hr (3663 kW) or greater. This standard applies only to boilers using single burners that fire the following fuels:

(a) Natural gas as defined in Chapter 3

(b) Other gas having a Btu value and characteristics that are similar to natural gas

(c) Fuel oil of No. 2, 4, 5, or 6 grade

(d) Gas and oil that are fired simultaneously for fuel transfer

(e) Gas and oil that are fired simultaneously and continuously

1-1.2* This standard is not retroactive. This standard is applicable to new installations and to major alterations or extensions of existing equipment for the preparation and burning of fuel that are contracted for use subsequent to the date of this standard.

1-1.3 Furnaces, such as those of process heaters that are used in chemical and petroleum manufacture wherein steam generation is incidental to the operation of a processing system, are not covered by this standard.

1-1.4 Since this standard is based on the present state of the art, its application to existing installations is not mandatory. Nevertheless, operating companies are encouraged to adopt those features of this standard that are considered applicable and reasonable for existing installations.

1-1.5 Revisions to this document reflect the current state of knowledge and do not imply that previous editions were inadequate.

1-2 Purpose.

1-2.1 The purpose of this standard is to establish minimum standards for the design, installation, operation, and maintenance of single burner boilers, their fuel-burning systems, and related systems to contribute to safe operation and, in particular, to the prevention of furnace explosions.

1-2.2* No standard that will guarantee the elimination of furnace explosions can be promulgated. Technology in this area is under constant development, reflected in part by revisions to this standard. The user of this standard must recognize the complexity of fuel firing as to the type of equipment and the characteristics of the fuel. Therefore, the designer is cautioned that the standard is not a design handbook and does not do away with the need for competent, engineering judgment. It is intended that a designer who is capable of applying more complete and rigorous analysis to special or unusual problems shall have latitude in the development of such designs. In such cases, the designer is responsible for the validity of the approach.

1-2.3 Emphasis is placed on the importance of operation and maintenance procedures, combustion control equipment, safety interlocks, alarms, trips, and other related controls that are essential to safe boiler operation.

1-2.4 The effect of gas cleanup systems that are located downstream of the post–combustion gas passes of the boiler is known to be significant. Coordination of the operating procedures and designs of the boiler and air quality system's air/flue gas path is required. Such coordination shall include requirements for ensuring a continuous flow path from the forced draft fan inlet through the stack. This standard offers only the general requirements of these systems because of the many variations of the designs.

Chapter 2 General

2-1 Furnace Explosions.

2-1.1 The basic cause of furnace explosions is the ignition of an accumulated combustible mixture within the confined space of the furnace or within the associated boiler passes, ducts, and fans that convey the gases of combustion to the stack.

2-1.2 A dangerous combustible mixture within the boiler enclosure consists of the accumulation of an excessive quantity of combustibles that are mixed with air in proportions that will result in rapid or uncontrolled combustion when an ignition source is supplied. A furnace explosion can result from ignition of this accumulation if the quantity of combustible mixture and the proportion of air to fuel are such that an explosive force is created within the boiler enclosure. The magnitude and intensity of the explosion will depend on both the relative quantity of combustibles that has accumulated and the proportion of air that is mixed therewith at the moment of ignition. Explosions, including "furnace puffs," are the result of improper procedures by operating personnel, improper design of equipment or control system, or equipment or control system malfunction.

2-1.3 Numerous situations can arise in connection with the operation of a boiler that will produce common explosive conditions such as the following:

(a) An interruption of the fuel or air supply or ignition energy to the burners that is sufficient to result in momentary loss of flames and is followed by restoration and delayed reignition of an accumulation

(b) Fuel leakage into an idle furnace and the ignition of the accumulation by a spark or other source of ignition

(c) Repeated, unsuccessful attempts to light off without appropriate purging, resulting in the accumulation of an explosive mixture

(d) The accumulation of an explosive mixture of fuel and air as a result of a complete furnace flameout, and the ignition of the accumulation by a spark or other ignition source, such as that from attempting to light a burner

2-1.4 The conditions that are favorable to a furnace explosion as described in 2-1.3 are typical examples, and an examination of numerous reports of furnace explosions suggests that the occurrence of small explosions, furnace puffs, or near misses has been far more frequent than is usually recognized. It is believed that improved instrumentation, safety interlocks and protective devices, proper operating sequences, and a clearer understanding of the problem by both designers and operators can greatly reduce the risks and actual incidences of furnace explosions.

2-1.5 In a boiler, upset conditions or control malfunction could lead to an air/fuel mixture that could result in a flameout that is followed by reignition after a combustible air/fuel ratio has been reestablished. Dead pockets could exist in the boiler enclosure or other parts of the unit where combustible mixtures can accumulate under upset furnace conditions. These accumulations can ignite with explosive force in the presence of an ignition source.

2-2 Manufacture, Design, and Engineering.

2-2.1 The purchaser or the purchaser's agent shall, in cooperation with the manufacturer, ensure that the unit is not deficient in any apparatus that is required for proper operation, so far as is practical, with respect to pressure parts, fuel-burning equipment, air and fuel metering, and safe lighting and maintenance of a stable flame.

2-2.2 All fuel systems shall include provisions to prevent foreign substances from interfering with the fuel supply to the burner.

2-2.3 An evaluation shall be made to determine the optimum integration of manual and automatic safety features, considering the advantages and disadvantages of each trip function.

NOTE: The maximum number of automatic trip features does not necessarily provide for maximum overall safety. Some trip actions result in additional operations that increase exposure to hazards.

2-2.4 This standard requires a minimum degree of automation. The trend toward more complex plants or increased automation requires added provisions for the following:

(a) Information about significant operating events permitting the operator to make a rapid evaluation of the operating situation. Usable displays of variables shall be provided that will allow the operator to avoid unsafe conditions.

(b) In-service maintenance and checking of system functions without impairing the reliability of the overall control system.

(c) An environment conducive to proper decisions and actions.

2-2.5 The burner front piping and equipment shall be designed and constructed to prevent the formation of hazardous concentrations of combustible gases that could exist under normal operating conditions.

2-3 Installation.

2-3.1 The boiler shall not be released for operation before the installation and checkout of the required safeguards and instrumentation system.

2-3.2 The constructor who is responsible for the erection and installation of the equipment shall see that all pertinent apparatus is installed and connected properly.

2-3.3 The purchaser, the engineering consultant, the equipment manufacturer, and the operating company shall avoid boiler operation until such safeguards have been tested to operate properly as a system. In some instances, installing temporary interlocks and instrumentation to meet these requirements could be necessary. Any such temporary system shall be reviewed by the purchaser, the engineering consultant, the equipment manufacturer, and the operating company; and agreement shall be reached on its suitability in advance of start-up.

2-3.4 The safety interlock system and protective devices shall be tested jointly by the organization with responsibility for the system design and those who operate and maintain such systems and devices during the normal operating life of the plant. These tests and checks shall be accomplished before initial operation.

2-4 Coordination of Design, Construction, and Operation.

2-4.1 Statistics indicate that human error can be a contributing factor in the majority of furnace explosions. However, it is important to consider whether the error is also a result of the following:

(a) Lack of understanding of, or failure to use, proper operating procedures, safeguards, and equipment

(b) Unfavorable operating characteristics of the equipment or its controls

(c) Lack of functional coordination of the various components of the steam-generating system and its controls

2-4.2 Furnace explosions have occurred as a result of unfavorable functional design. Frequently, the investigation has revealed human error and has overlooked completely the chain of causes that triggered the operating error. Therefore, the design, installation, and functional objectives of the overall system of the components and their controls shall be integrated. Consideration shall be given to the ergonomics that will exist during the operating life of the system.

2-4.3 In the planning and engineering phases of plant construction, design shall be coordinated with operating personnel.

2-4.4 The proper integration of the various components—which consist of the boiler, burner, fuel and air supply equipment; controls, interlocks, and safety devices; operator and maintenance functions; and communication and training—shall be the responsibility of the operating company and shall be accomplished by the following steps:

(a) Providing design and operating personnel who possess a high degree of competence in this field and who are required to bring about these objectives

(b) Periodic analysis to compare the plant to evolving technology so that improvements can be made to make the plant safer and more reliable

(c) Maintaining documentation of plant equipment, system, and maintenance

2-5 Maintenance Organization. A program shall be provided for the maintenance of equipment at intervals that are consistent with the type of equipment, the service requirements, and the manufacturer's recommendations. *(See Chapter 10.)*

2-6 Basic Operating Objectives.

2-6.1 Basic operating objectives shall include the following:

(a) Establish operating procedures that will result in the minimum number of manual operations.

(b) Standardize all operating procedures. The use of interlocks is essential to minimize improper operating sequences and to stop sequences when conditions are not proper for continuation. It is particularly important that purge and start-up procedures with necessary interlocks be established and rigidly enforced. Chapters 5 and 6 describe operating sequences that have proven to be effective in boiler operation.

2-6.2 Written operating procedures and detailed checklists for operator guidance shall be provided for achieving these basic operating objectives. All manual and automatic functions shall be described.

2-7* Gas and Oil Firing—Special Problems. Common hazards are involved in the combustion of solid, liquid, or gaseous fuels. Each of these fuels has special hazards that relate to its physical characteristics.

Chapter 3 Definitions

For the purpose of this standard, terms shall have the following meanings.

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

Air/Fuel Ratio.

Air-Rich. An air/fuel ratio, supplied to a furnace, that provides more air than that required for an optimum air/fuel ratio.

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

NOTE: This is not "Air-Rich" as previously defined.

Fuel-Rich. A ratio of air to fuel supplied to a furnace that provides less air than that required for an optimum air/fuel ratio.

Theoretical Air (Stoichiometric Air). The chemically correct amount of air that is required for complete combustion of a given quantity of a specific fuel.

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

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

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

Approved.* Acceptable to the authority having jurisdiction.

Atomizer. The device in an oil burner that emits liquid fuel in a finely divided state.

Atomizer, Mechanical. The device in an oil burner that emits liquid fuel in a finely divided state without using an atomizing medium.

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

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Automatic. See Burner Management System.

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.

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

Boiler Enclosure. The physical boundary for all boiler pressure parts and for the combustion process.

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

Burner Management System. The control system that is dedicated to boiler safety, operator assistance in the starting and stopping of fuel preparation and burning equipment, and the prevention of misoperation of and damage to fuel preparation and fuel-burning equipment.

Types of systems used in this document include the following:

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

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

Manual. A system by which a furnace is purged and a burner is started, ignited, and stopped manually.

Supervised Manual. A system by which a furnace is purged and a burner is started, ignited, and stopped manually. Interlocks are included to ensure that the operation follows established, proper procedures.

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. This control system includes the furnace draft control where applicable.

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

Excessive Steam Pressure Switch. A pressure-actuated device that is arranged to effect a safety shutdown of the burner when the steam pressure exceeds a preset pressure.

Excessive Water Temperature Switch. A temperature-actuated device that is arranged to effect a safety shutdown of the burner when the water temperature exceeds a preset temperature.

Extension. An addition to the boiler system, such as, but not limited to, air quality control.

Flame. The visible or other physical evidence of the chemical process of rapidly converting fuel and air into products of combustion.

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

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

Fuel Trip. The automatic shutoff of a specific fuel as the result of an interlock or operator action.

Furnace. An enclosure that is designed for the combustion of fuel.

Furnace Purge. See definition of Purge.

Gas. See definitions of LP-Gas and Natural Gas.

High Gas Pressure Switch. A pressure-actuated device that is arranged to effect a safety shutdown or to prevent starting when the gas pressure exceeds the preset value.

High Oil Temperature Switch. A temperature-actuated device that initiates a signal when oil temperature rises above the limits that are required to maintain the viscosity range recommended by the burner manufacturer.

High Steam Pressure Switch. A pressure-actuated device that is arranged to effect a normal burner shutdown when the steam pressure exceeds a preset pressure.

High Water Temperature Switch. A temperature-actuated device that is arranged to effect a normal burner shutdown when the water temperature exceeds a preset temperature.

Igniter. A device that provides proven ignition energy to immediately light off the main burner.

Class 1. 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, generally in excess of 10 percent of fuel load burner input, at its associated burner to raise any credible combination of burner inputs of both fuel and air above the minimum ignition temperature. Class 1 igniters shall be permitted to also operate as Class 2 or Class 3 igniters.

Class 2. An igniter that is applied to ignite the fuel input through the burner under prescribed light-off conditions. It is also used to support ignition under low load or certain adverse operating conditions. The range of capacity of such igniters is generally 4 percent to 10 percent of full load burner fuel input. Class 2 igniters shall be permitted to be operated as Class 3 igniters.

Class 3. An igniter that is applied particularly to gas and oil burners to ignite the fuel input to the burner under prescribed light-off conditions. The capacity of such igniters generally does not exceed 4 percent of the full load burner fuel input.

Class 3 Special (Direct Electric Igniter). A special Class 3, high-energy, electrical igniter that is capable of directly igniting the main burner fuel.

Inerting. The dilution of the oxygen content of an air/fuel mixture to a point where it is no longer explosive. Inerting is accomplished through the addition of an inert gas or vapor.

Interlock. A device or group of devices that are arranged to sense a limit or off-limit condition or improper sequence of events and to shut down the related equipment or to prevent proceeding in an improper sequence to avoid a hazardous condition.

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.

Light-Off. The establishment of the combustion of fuel entering the furnace.

Light-Off Time Limit Timer. A device that is used on supervised manual systems that limits the allowable time between completion of purge and light-off. This time shall be no more than five minutes.

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 identified standards or has been tested and found suitable for a specified purpose.

Logic System. The decision-making and translation elements of the burner management system.

(a) *Hard-Wired Systems.* Individual devices and interconnecting wiring.

(b) *Microprocessor-Based Systems.*

1. Computer hardware, power supplies, I/O devices, and interconnections between these items

2. Operating systems and logic software

Low Fire. The minimum fire rate that results in stable combustion.

Low Gas Pressure Switch. A pressure-actuated device that is arranged to effect a safety shutdown or to prevent starting when the gas pressure falls below the preset value.

Low Oil Pressure Switch. A pressure-actuated device that is arranged to effect a safety shutdown or to prevent starting when the oil pressure falls below the preset value.

Low Oil Temperature Switch. A temperature-actuated device that initiates a signal when the oil temperature falls below the limits that are required to maintain the viscosity range recommended by the burner manufacturer.

Low Water Cutout. A device that is arranged to effect a shutdown of the burner when the water level in the boiler falls to a predetermined low level.

Auxiliary Low Water Cutout. A device that is arranged to effect a safety shutdown [requires manual reset *(see the definition for Shutdown, Safety)*] of the burner when the water level in the boiler falls to a predetermined low level.

LP-Gas. A material that is composed predominantly of any of the following hydrocarbons or mixtures of them: propane, propylene, n-butane, isobutane, and butylenes.

Main Burner Establishing Period. See definitions for Trial-for-Ignition Period.

Manual. See Burner Management System.

Modulate. To gradually vary the fuel and air flows to the burner in accordance with load demand.

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

Natural Gas. A gaseous fuel occurring in nature and consisting mostly of a mixture of organic compounds—normally methane, ethane, propane, and butane. The Btu value of natural gases varies between about 700 Btu per ft^3 and 1500 Btu per ft^3(26.1 MJ/m^3 and 55.9 MJ/m^3), the majority averaging 1000 Btu per ft^3 (37.3 MJ/m^3).

Normal Fuel Supply Pressure. The pressure at the fuel service connection for which the fuel burning system has been designed.

Oil. See definition of Fuel Oil.

Operating Range. The region between the maximum fuel input and minimum fuel input in which the burner flame can be maintained continuous and stable.

Outlet Draft. The flue gas pressure at the outlet of the last convection pass of the boiler.

Postpurge. A purge performed after a burner is shut down.

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

Purge. A flow of air through the furnace, boiler gas passages, and associated flues and ducts that will effectively remove any gaseous combustibles and replace them with air. Purging also can be accomplished by an inert medium.

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

Repair. A process that returns the boiler system to its original design specifications or criteria.

Repeatability. The ability of a device to maintain a constant set point characteristic.

Restart. A manually initiated start-up.

Safety Shutdown Trip Relay. An electromechanical relay that is used to trip all required equipment simultaneously.

Safety Shutoff Valve (Safety Trip Valve). A fast-closing valve that automatically and completely shuts off the fuel supply to the main burner(s) or the igniter(s) in response to a normal or a safety shutdown signal.

Semiautomatic. The terms "automatic (nonrecycling)" and "supervised manual" are used in this standard to describe the functions that conventionally are attributed to "semiautomatic."

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

Set Point. A predetermined value to which an instrument is adjusted and at which it shall perform its intended function.

Shall. Indicates a mandatory requirement.

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

Shutdown.

Normal. Stopping burner operation by shutting off all fuel and ignition energy to the furnace.

Safety. Stopping burner operation by shutting off all fuel and ignition energy to the furnace by means of a safety interlock or interlocks and requiring a manual restart.

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

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

Supervised Manual. See Burner Management System.

Trained Operator. A person meeting the requirements of A-10(b)1.

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

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

Unit. The confined spaces of the furnace and the associated boiler passes, ducts, and fans that convey the gases of combustion to the stack.

Valve-Proving System. A system that proves the leak tightness of all safety shutoff valves and prevents main burner or igniter light-off if the test is not satisfied.

Chapter 4 Equipment Requirements

4-1 Fuel Supply (Oil).

4-1.1 Fuel shall be properly stored, prepared, and delivered to the oil service connection under anticipated operating conditions in accordance with the applicable portions of NFPA 31, *Standard for the Installation of Oil-Burning Equipment.*

4-1.2 Operation of the burner shall not be attempted until a satisfactory fuel supply is assured.

4-1.3 Fuel shall be delivered continuously to the combustion chamber in a finely atomized form that can be ignited readily and consumed.

4-1.4 All equipment that is associated with pumping, heating, and straining the fuel from storage to the service connection shall be properly designed, sized, and interconnected so as to provide a suitable fuel supply over a full range of conditions. Relief valves shall be installed after the pump to prevent overpressure in the system.

4-1.5 Fuel being burned shall be delivered to the burner at proper temperature and pressure.

NOTE: Excessively heated oil may create vapor-lock, which can prevent continuous operation. Cold oil may prevent satisfactory atomization.

4-1.6 Where the fuel must be heated, care shall be taken to ensure that the interlocks and instruments reflect correct values of the variable being measured, particularly in dead-end lines where heavy oil will tend to solidify.

4-1.7 The operation of a burner system that has the capability to burn heated and unheated oils shall include a procedure to ensure that the proper type of oil, compatible with the selected mode of operation, is being supplied to the burner. Precautions shall include the intended routing of recirculated oil.

4-1.8* Two safety shutoff valves in series, each with proof of closure, shall be provided in the oil line to the main burner.

CAUTION: Means shall be provided to prevent or relieve excess pressure between these valves.

4-1.9 Oil piping materials and system design shall be in accordance with NFPA 31, *Standard for the Installation of Oil-Burning Equipment.*

4-2* Fuel Supply (Gas).

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.

4-2.2 Gas piping shall be of ample size to maintain the desired constant pressure for the maximum burner flow.

4-2.3* Two safety shutoff valves in series, each with proof of closure, shall be provided in the gas line to the main burner. An automatic vent valve shall be provided between the two valves. Where the automatic vent valve is prohibited by the authority having jurisdiction, two safety shutoff valves in series, each with proof of closure switches, supervised by a listed automatic valve-proving system, shall be provided in the gas line to the main burner. Valve proving shall be performed either after every burner shutdown or prior to every burner light-off.

4-2.4 Foreign matter such as welding beads, chips, scale, dust, and debris shall be removed from the gas piping.

4-2.5 A drip leg shall be provided in the gas piping. *(See A-4-2.3 and A-4-4.1.)*

4-2.6 Gas piping materials and system design shall be in accordance with NFPA 54, *National Fuel Gas Code.*

4-2.7* The discharge from atmospheric vents and vents to the atmosphere shall be located so that there is no possibility of the discharged gas being drawn into the air intake, ventilating system, or windows of the boiler room or adjacent buildings. The discharge shall be extended sufficiently above the boiler and adjacent structures so that gaseous discharge does not present a fire hazard. There shall be no cross connection between venting systems of different boilers.

4-2.8 Permanent means shall be provided for making leakage-tightness tests of the main burner gas safety shutoff valves. Leakage-tightness tests of the main safety shutoff valves shall be conducted at least annually.

4-3 Alternate Fuel Firing.

4-3.1 Manual Fuel Selection. Where oil and gas are to be burned alternately, a manually positioned, 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.

4-3.2 Automatic Fuel Selection. 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. Provisions for manual changeover of the system shall be provided in accordance with 4-3.1 and Chapter 8. For simultaneous firing of oil and gas fuels, see Chapter 7.

4-4 Fuel-Burning Equipment.

4-4.1* Ignition.

4-4.1.1 The main burner shall be equipped with a permanently installed igniter.

4-4.1.1.1 Where a Class 1 igniter is used, the main burner flame shall be proven by a flame detector. Either the main flame or the igniter flame shall be proven.

4-4.1.1.2 Where a Class 2 igniter is used, it shall not be used to ignite main fuel under uncontrolled or abnormal conditions. 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. 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.

4-4.1.1.3 Where a Class 3 igniter is used, the igniter shall be shut down as a part of the burner light-off procedure when the time trial-for-ignition of the main burner has expired. This is to ensure that the main flame is self-supporting, is stable, and is not dependent upon ignition support from the igniter. The use of such igniters to support ignition or to extend the burner control range shall be prohibited. The main flame shall be proven by a flame scanner.

4-4.1.1.4 Where a Class 3 Special igniter is used, the main burner flame shall be proven by a flame scanner.

4-4.1.2 The igniter flame or arc shall impinge on the main burner air/fuel mixture and shall supply sufficient ignition energy to provide immediate ignition of all fuel discharge from the main burner under light-off conditions.

4-4.1.3* Two safety shutoff valves in series shall be provided in the line to the gas igniter. An automatic vent valve shall be provided between the two valves for gas igniters. One safety shutoff valve shall be provided in the line to the oil igniter. Where the automatic vent valve is prohibited by the authority having jurisdiction, two safety shutoff valves in series, supervised by a listed automatic valve-proving system, shall be provided in the gas line to the main burner. Valve proving shall be performed either after every burner shutdown or prior to every burner light-off. *(See also A-4-2.3.)*

4-4.1.4 The igniter shall be designed for periodic removal, cleaning, and maintenance.

4-4.2 Main Burner.

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.

4-4.2.2 The burner shall be provided with at least one convenient observation port of a size to permit visual inspection of the igniter and main burner flames.

4-4.2.3 The limits of stable flame for the burner shall be determined by tests. These tests shall be performed without the igniter in service and shall include the intended range and grade of fuel(s).

The tests shall verify that transients that are generated in the fuel and air systems do not adversely affect burner operation. Such transients are generated by burner control valves, dampers, and other equipment that operate at speeds faster than the speed of response of other components in the system.

4-4.2.4 Each manual adjustment feature on the burner shall be provided with means for securing it in its intended position.

4-4.2.5 The atomizing equipment for oil burners shall be designed for periodic removal, cleaning, and maintenance.

4-4.2.6 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.

4-4.2.7 Clearing of the oil passages of the atomizer into the furnace immediately after a shutdown shall be prohibited.

4-4.3 Atomizing Medium for Oil Burners.

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.

4-4.3.2 The atomizing medium shall be provided at the pressures that are required for proper operation.

4-4.3.3 Provisions shall be made to ensure that fuel cannot enter the atomizing medium line during or after operation.

4-4.4 Combustion Air Supply.

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.

4-4.4.2 Provisions shall be made for periodic cleaning of the combustion air supply equipment.

4-4.4.3 The requirements for the availability of combustion air shall be determined from NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* and NFPA 54, *National Fuel Gas Code.*

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.

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.

4-4.5 Furnace.

4-4.5.1 The furnace shall be designed to promote main burner stability while minimizing zones that cannot be purged.

4-4.5.2 At least one observation port in addition to the requirements of 4-4.2.2 shall be provided to permit observation of the burner flame and furnace.

4-4.6 Combustion Products Removal.

4-4.6.1 The outlet draft equipment shall be capable of removing combustion products without adversely affecting stable flame conditions.

CAUTION: Tall stacks can produce furnace draft conditions adversely affecting flame stability and could require special draft control provisions.

4-4.6.2 Where two or more boilers are connected to a common stack, each connection shall be equipped with a damper system. All boiler outlet dampers shall be equipped with accessible operating and locking devices. This equipment shall be compatible with the combustion control system of the boiler. Interlocks shall be provided to prevent firing against a closed damper. Provisions shall be made to prevent rendering the interlock nonfunctional if the linkage becomes disconnected. This shall be accomplished by one of the following means:

(a) Placing the interlock on the driven member

(b) Utilizing a furnace pressure switch

(c) Other appropriate means

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

4-5 Burner Management System, Logic. The intent of this section is to provide guidance in the use of logic systems in burner management.

4-5.1 General Requirements. A logic system provides outputs in a particular sequence in response to external inputs and internal logic. The logic system for burner management shall be designed specifically so that a single failure in that system shall not prevent an appropriate shutdown.

4-5.2 Specific Requirements. As a minimum, the following shall be included in the design to ensure that a logic system for burner management meets the intent of these standards.

NOTE: Some items are not applicable to specific types of logic systems, e.g., relay.

4-5.2.1 Failure Effects. The logic system designer shall evaluate the failure modes of components when considering the design application of the system. As a minimum, the following failure effects shall be evaluated and addressed:

(a) Interruptions, excursions, dips, recoveries, transients, and partial losses of power

(b) Memory corruption and losses

(c) Information transfer corruption and losses

(d) Inputs and outputs "fail-on," "fail-off"

(e) Signals that are unreadable or not being read

(f) Addressing errors

(g) Processor faults

(h) Relay coil failure

(i) Relay contact failure (fail-on or fail-off)

(j) Timer failure

4-5.2.2 Design.

(a) Diagnostics shall be included in the design to monitor processor logic functionability.

(b) Logic system failure shall not preclude proper operator intervention.

(c) Logic shall be protected from unauthorized changes.

(d) Logic shall not be changed when the associated equipment is in operation.

(e) System response time (i.e., throughput) shall be sufficiently short to prevent negative effects on the application.

(f) Noise immunity shall be adequate to prevent false operation.

(g) A single component failure within the logic system shall not prevent a mandatory safety shutdown trip.

(h) The operator shall be provided with a dedicated manual switch(es) that shall independently and directly actuate the safety shutdown trip relay. At least one identified manual switch shall be located remotely from the boiler where it can be reached in case of emergency.

4-5.2.3 Requirement for Independence.

4-5.2.3.1 The logic system performing the safety functions for burner management shall not be combined with any other logic or control system.

Exception: Boiler control systems shall be permitted to be combined with the burner management system only where the fuel/air ratio is controlled externally from the boiler control system (e.g., locked fuel/air ratio with mechanical positioning type system).

4-5.2.3.2 The burner management safety functions shall include, but not be limited to, proper purge interlocks and timing, mandatory safety shutdowns, trial timing for ignition, and flame monitoring.

4-5.2.3.3 The logic system shall be limited to one boiler only. Boiler control systems shall be permitted to be combined for more than one boiler where separated from the burner management system.

4-5.2.3.4 The burner management and boiler control system shall be provided with independent logic, independent input/output systems, and independent internal power supplies and shall be functionally and physically separate from other logic systems (i.e., another boiler system).

4-5.2.3.5 The same hardware type shall be permitted to be used for burner management and boiler control systems as is used for other logic systems.

4-5.2.3.6 Data highway communications between the burner management and boiler control system and other systems shall be permitted. Signals that initiate mandatory safety shutdowns shall be hard wired. Where remote I/O communication between a logic system processor and its input/output devices are used, the failure modes shall be evaluated and addressed.

4-5.2.3.7 No logic sequences or devices shall be permitted that allow momentary closing and subsequent, inadvertent reopening of the main or igniter fuel valves.

4-6 Combustion Control System.

4-6.1 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.

4-6.2 The system shall provide limits on fuel and air to prevent reducing furnace input below the point of stable burner operation. The minimum and maximum points of stable burner operation shall be defined by the burner manufacturer and verified by operational tests.

4-7 Interlock System.

4-7.1 The system shall be equipped with a method of determining the operating state of each interlock without disassembling any of the interlock devices.

4-7.2 Each interlock shall be provided with a method of establishing the set point. The set point shall be repeatable within prescribed limits.

4-7.3 Interlock devices shall be designed for anticipated environmental conditions, such as temperature, humidity, vibration, and corrosive agents.

4-7.4 The interlocks on the low water cutouts shall be permitted to be bypassed for blowdown purposes only. This bypass shall be of a type that is temporarily held during blowdown.

4-7.5 Interlocks shall not be manually bypassed at any time during normal operation.

Exception: See 4-7.4 and Chapter 5.

4-7.6 Each safety control ac circuit shall be two wire, one side grounded, preferably not exceeding nominal 120 volts, and shall be protected with a suitable fuse or circuit breaker in the hot side only.

4-7.7 Safety control dc circuits shall be arranged as called for in 4-7.6 where grounding is possible. 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.

4-8 Flame Safety Shutdown System.

4-8.1 The response time from flame failure to de-energization of the safety shutoff valves shall not exceed four seconds.

4-8.2 The response time from de-energization of the safety shutoff valves to full closure shall not exceed one second.

4-9 Electrical Equipment.

4-9.1* All electrical equipment and wiring shall conform to NFPA 70, *National Electrical Code®*.

4-9.2 Special fuels or applications could require components for hazardous location and shall be reviewed during the design of the system.

Chapter 5 Starting a Cold Boiler

5-1 General.

5-1.1 Starting of a cold boiler shall be accomplished in conformance with the manufacturer's recommendations. 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.

5-1.2 Applicable start-up procedures for the provided boiler shall be followed. The firing rate shall be limited in accordance with the boiler manufacturer's instructions.

5-2 Gas-Fired Boilers. The procedures of Chapter 6 shall be followed for starting a cold gas-fired boiler.

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 5-3.1, 5-3.2 or 5-3.3 shall be used.

5-3.1 Auxiliary Air Atomizing of Oil.

5-3.1.1 Required Equipment.

(a) Forced draft (FD) fan

(b) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with stable flame

(c) Compressed air supply

(d) Check valves in steam and air lines to the atomizer

5-3.1.2 Required Facility.

(a) An atomizing air supply. *(See A-4-1.8.)*

5-3.1.3 Starting Procedure.

(a) Circulate and heat oil, using auxiliary heater and recirculating system, to satisfy all interlocks, where included.

(b) Follow the normal start-up procedure, as described in Chapter 6, using air as the atomizing medium.

(c) Set combustion control at light-off firing rate.

(d) When steam pressure is raised to a point where it is adequate for heating and atomizing the oil, shut down in accordance with the normal shutdown procedure as described in Chapter 6.

(e) Close atomizing air supply and open atomizing steam supply, making certain that dry steam is available.

(f) Change over from auxiliary oil heater to steam oil heater.

(g) Follow normal start-up procedure.

5-3.2 Auxiliary Mechanical Atomizing of Heavy Oil.

5-3.2.1 Required Equipment.

(a) FD fan

(b) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for minimum fire with stable flame

(c) Mechanical atomizer

(d) Means to bypass atomizing medium interlocks (The fact that these are bypassed shall be made evident to the operator with adequate warning devices.)

5-3.2.2 Starting Procedure.

(a) Circulate and heat oil using auxiliary heater and recirculating systems to satisfy oil interlocks, where included.

(b) Bypass atomizing medium interlocks. *[See 5-3.2.1(d).]*

(c) Insert mechanical atomizer.

(d) Follow normal start-up procedure as described in Chapter 6.

(e) Set combustion control at light-off firing rate.

(f) When steam pressure is raised to a point where it is adequate for heating and atomizing the oil, shut down in accordance with the normal shutdown procedure as described in Chapter 6.

(g) Remove mechanical atomizer.

(h) Insert steam atomizer.

(i) Make atomizing medium interlocks operable.

(j) Change over from auxiliary oil heater to steam oil heater.

(k) Follow normal start-up procedure.

5-3.3 Auxiliary Mechanical Atomizing of Light (Unheated) Oil.

5-3.3.1 Required Equipment.

(a) FD fan

(b) Mechanical atomizer

(c) Check valves in the heavy and light oil lines

(d) Means to bypass oil and atomizing medium interlocks (The fact that these are bypassed shall be made evident to the operator with adequate warning devices.)

5-3.3.2 Required Facility.

(a) A light oil supply

5-3.3.3 Starting Procedure.

(a) Shut off heavy oil to system.

(b) Insert mechanical atomizer.

(c) Bypass oil and atomizing medium interlocks.

(d) Open light oil supply into the system.

(e) Follow normal start-up procedure described in Chapter 6.

(f) Set combustion control at light-off rate.

(g) When steam pressure is raised to a point where it is adequate for heating and atomizing the heavy oil, shut down in accordance with normal shutdown procedure as described in Chapter 6.

(h) Shut off light oil supply to the system.

(i) Remove mechanical atomizer.

(j) Insert steam atomizer.

(k) Make oil and atomizing medium interlocks operable by removing bypasses.

(l) Open heavy oil supply to the system.

(m) Follow normal start-up procedure.

Chapter 6 Operating Systems

6-1* General. Chapter 6 and Figures A-4-1.8, A-4-2.3, and A-4-4.1 illustrate typical arrangements of operating systems for automatic (i.e., recycling), automatic (i.e., nonrecycling), and supervised manual systems to meet the intent of this standard. Manual systems, while not recommended, are discussed in A-6-1. Different arrangements are permissible if they provide equivalent protection and meet the intent of this standard.

6-2 Automatic (Recycling) Systems for Watertube Boilers.

6-2.1 An automatic (i.e., recycling) unit shall not be started from a cold condition unless a trained operator is present. In this section, it is assumed that the unit is hot and that steam pressure and operating water level have been established.

6-2.2 It is further assumed that the fuel to be fired has been manually selected. The alternate fuel system shall be placed in a nonfiring condition, and the manual burner valve(s) shall be closed.

6-2.3 An igniter as specified in 4-4.1.1 shall be provided.

6-2.4 An automatic (i.e., recycling) unit shall recycle on a preset pressure and perform four major functions as follows:

(a) Prefiring cycle

(b) Light-off cycle

(c) Modulation, where provided

(d) Shutdown cycle

6-2.4.1 Prefiring Cycle. The prefiring cycle shall accomplish the following in the listed order:

(a) Prove the main fuel safety shutoff valves are closed.

(b) Prove no flame is present at the burner.

(c) Start fan.

(d) Satisfy fan interlock.

(e) Where atomizing medium is used and if not already on, admit medium to main burner.

(f) Where atomizing medium is used, satisfy atomizing medium interlocks.

(g) Satisfy appropriate fuel interlocks.

NOTE: The order of items (e), (f), and (g) in the sequence is optional.

(h) Prove purge airflow by satisfying one of the following two items:

1. Air pressure and “open damper” interlocks for all dampers in the flow path

2. Airflow interlock

Purge airflow shall reach no less than 70 percent of the airflow required at maximum continuous capacity of the unit.

(i) The purge shall be sufficient for at least eight air changes. Airflow during the time to open the damper and return it to light-off position can be included in computing the time for eight air changes.

(j) Set controls to light-off position.

(k) Prove dampers and fuel control valve are in light-off position.

6-2.4.2 Light-Off Cycle, Interrupted Igniter. The light-off cycle for a burner with an interrupted igniter shall accomplish the following in the listed order:

(a) Energize igniter.

(b) Prove igniter flame is within 10 seconds. For direct electric igniter, proof of igniter operation shall not be required.

1. If proven, admit fuel to main burner. For an oil burner other than return flow type, simultaneously shut off oil-recirculating flow.

2. If not proven, establish safety shutdown.

(c) 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. For gas igniters, vent the gas piping between igniter safety shutoff valves to the atmosphere.

(d) Prove main flame.

1. If proven, release to modulating control where provided.

2. If not proven, establish safety shutdown.

6-2.4.3 Light-Off Cycle, Intermittent Igniter. The light-off cycle for a burner with an intermittent igniter shall accomplish the following in the listed order:

(a) Energize igniter.

(b) Prove igniter flame is within 10 seconds.

1. If proven, admit fuel to main burner. For an oil burner other than return flow type, simultaneously shut off recirculating flow.

2. If not proven, establish safety shutdown.

(c) 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.

1. If proven, release to combustion control for modulation where provided.

2. If not proven, establish safety shutdown.

6-2.4.4 Modulation. Modulation, where provided, shall be accomplished by a combustion control system.

6-2.4.5 Normal Shutdown Cycle. The normal shutdown cycle shall accomplish the following in the listed order:

(a) Shut off fuel supply to main burner.

(b) Interrupt spark and shut off fuel supply to igniter, if in operation.

(c) For oil:

1. Where used, open recirculating valve.

2. Shut off atomizing medium, if desired.

(d) Where gas is used, gas piping between safety shutoff valves shall be vented to the atmosphere.

(e) Perform a postpurge of the boiler furnace enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.

(f) Shut down fan, if desired.

6-2.4.6 For automatic (i.e., recycling) boilers, the 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.

6-2.4.7 Safety Shutdown Cycle. The safety shutdown cycle shall accomplish the following in the listed order and shall activate an alarm:

(a) Shut off fuel supply to main burner.

(b) Shut off fuel supply and interrupt spark to the igniter if in operation.

(c) For oil:

1. Where used, open recirculating valve.

2. Where used, shut off atomizing medium, if desired.

(d) Where gas is used, gas piping between safety shutoff valves shall be vented to the atmosphere.

(e) Where the inerting system is used, it shall be energized simultaneously with 6-2.4.7(a).

(f) Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.

(g) After postpurge, shut down fan, if desired.

(h) Require manual reset.

6-2.4.8* Any of the following conditions shall accomplish a safety shutdown, 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 assure that safe operating conditions prevail before restarting:

(a) For oil:

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 safety shutdown on low pressure.)
9. Excessive steam pressure or water temperature
10. High temperature of heated oil

(b) For gas:

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

CAUTION: Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and shall be avoided.

6-3 Automatic (Nonrecycling) Systems for Watertube Boilers.

6-3.1 The provisions of 6-2.2, 6-2.2, 6-2.3, and 6-2.4 shall apply.

Exception: 6-2.4.6 shall not apply.

6-3.2 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle. A trained operator shall initiate the restart.

6-4 Automatic (Recycling) Systems for Firetube Boilers.

6-4.1 In this section, it is assumed that the equipment is in accordance with Chapter 4, that the boiler has been placed in service in accordance with Chapter 5, and that the operating water level has been established.

6-4.2 An automatic (i.e., recycling) unit shall recycle on a preset pressure or temperature and perform four major functions as follows:

(a) Prefiring cycle

(b) Light-off cycle

(c) Modulation, where provided

(d) Shutdown cycle

6-4.2.1 Prefiring Cycle. The prefiring cycle shall accomplish the following in the listed order:

(a) Prove the fuel safety shutoff valves are closed.

(b) Prove no flame is present at burner.

(c) Start fan.

(d) Satisfy fan interlock.

(e) Where atomizing medium is used and if not already on, admit medium to main burner.

(f) Where atomizing medium is used, satisfy atomizing medium interlocks.

(g) Satisfy appropriate fuel interlocks.

NOTE: The order of items (e), (f), and (g) in the sequence is optional.

(h) Prove purge airflow by satisfying one of the following two items:

1. Air pressure and "open damper" interlocks for all dampers in the flow path.

2. Airflow interlock.

(i) The purge of the furnace and boiler gas passes shall be sufficient for at least four air changes. During the purge, the air damper shall be driven to the full open position. Airflow during the time to open the damper and return it to light-off position can be included in computing the time for four air changes.

(j) Prove control system is in light-off position.

6-4.2.2 Light-Off Cycle. The light-off cycle shall accomplish the following in the listed order:

(a) Energize interrupted igniter.

(b) Prove igniter flame is within 10 seconds. For direct electric igniter, proof of igniter operation shall not be required.

1. If proven, admit fuel to main burner.

2. If not proven, establish safety shutdown.

(c) 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. For gas igniters, vent the gas piping between igniter safety shutoff valves to the atmosphere.

(d) Prove main flame.

1. If proven, release to modulating control where provided.

2. If not proven, establish safety shutdown.

6-4.2.3 Modulation. Modulation, where provided, shall be accomplished by a combustion control system.

6-4.2.4 High steam pressure, high water temperature, or low water (not determined by the auxiliary low water cutoff) 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.

6-4.2.5 Normal Shutdown Cycle. The normal shutdown cycle shall accomplish the following in the listed order:

(a) Shut off fuel supply to main burner.

(b) For oil:

1. Where used, open recirculating valve.

2. Where used, shut off atomizing medium, if desired.

(c) Where gas is used, gas piping between safety shutoff valves shall be vented to the atmosphere.

(d) Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.

(e) After postpurge, shut down fan, if desired.

6-4.2.6 Safety Shutdown Cycle. The safety shutdown cycle shall accomplish the following in the listed order:

(a) Shut off fuel supply to main burner.

(b) Shut off fuel supply and interrupt spark to the igniter if in operation.

(c) For oil:

1. Where used, open recirculating valve.

2. Where used, shut off atomizing medium, if desired.

(d) Where gas is used, gas piping between safety shutoff valves shall be vented to the atmosphere.

(e) Where the inerting system is used, it shall be energized simultaneously with 6-2.4.7(a).

(f) Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.

(g) After postpurge, shut down fan, if desired.

(h) Require manual reset.

6-4.2.7 Any of the following conditions shall accomplish a safety shutdown, 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 assure that safe operating conditions prevail before restarting:

(a) For oil:

1. Low oil 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. Low water level as determined by the auxiliary low water cutout

7. Loss of atomizing medium where used
8. Excessive steam pressure or water temperature
9. Power failure
10. High temperature of heated oil

(b) For gas:

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. Low water level as determined by the auxiliary low water cutout
7. Excessive steam pressure or water temperature
8. Power failure

CAUTION: Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and shall be avoided.

6-5 Automatic (Nonrecycling) Systems for Firetube Boilers.

6-5.1 The provisions of 6-4.1 and 6-4.2 shall apply.

Exception: 6-4.2.4 shall not apply.

6-5.2 When high steam pressure, high water temperature, or low water level establishes a normal shutdown, the burner shall not be allowed to recycle. A trained operator shall initiate the restart.

6-6 Supervised Manual Systems for Oil-Fired Watertube Boilers.

6-6.1 The following steps *[see Tables 6-6.1(a), 6-6.1(b), 6-6.1(c), and 6-6.1(d)]* shall be taken by the operator when starting a supervised manual unit, and the indicated interlocks shall be satisfied at each step. It is assumed that fuel pressure and temperature, atomizing medium, control system energy, power, and water level have been established. When interlocks have been satisfied, this fact shall be indicated to the operator.

6-6.2 Select the fuel to be fired. The alternate fuel system shall be placed in a nonfiring condition, and the manual burner valve(s) shall be closed.

6-6.3 An igniter as specified in 4-4.1.1 shall be provided.

Table 6-6.1(a) Prefiring Cycle (in listed order).

Operator Functions	Interlock Functions
1. Check that manual fuel shutoff valve(s) is closed.	1. Manual fuel shutoff valve(s) is closed.
2. Start fan.	2. Fan is on.
3. Where used, open atomizing medium valve.	3. Atomizing medium supply is available.
4. Open damper(s) to purge position.	4. (a) Air pressure and open damper(s), or (b) Airflow. *[See 6-2.4.1(h) and (i).]*
5. Start purge timer.	5. Purge is complete.
6. Place damper and fuel control valve in light-off position.	6. Damper and fuel control valve are in light-off position. If light-off airflow is less than purge airflow rate, start light-off time limit timer.
7. None.	7. Spark and igniter and main safety shutoff valves are ready for operation.

Table 6-6.1(b) Light-Off Cycle (in listed order).

Operator Functions	Interlock Functions
1. Energize igniter.	1. Prove igniter flame is within 10 seconds. (For direct electric ignition, proof of igniter operation shall not be required.)
2. Open fuel safety shutoff valve to main burner.	2. None.
3. Close recirculating valve, where used.	3. None.
4. Open manual fuel shutoff valve.	4. Prove main flame is within 10 seconds for Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils. Close igniter safety shutoff valve(s). For gas igniter, vent gas piping between safety shutoff valves.
5. Bring unit to present operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.	5. None.
6. On reaching preset pressure range, change to automatic combustion control.	6. None.

Table 6-6.1(c) Normal Shutdown Cycle (in listed order).

Operator Functions	Interlock Functions
1. Shut off fuel supply to the main burner.	1. Fuel safety shutoff valve(s) to main burner is closed.
2. Open fuel recirculating valve, where used.	2. None.
3. Where used, shut off atomizing medium.	3. None.
4. Remove fuel atomizer.	4. None.
5. Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.	5. None.
6. After postpurge, fan can be shut down.	6. None.

Table 6-6.1(d) Safety Shutdown Cycle (in listed order).

Operator Functions	Interlock Functions
1. None.	1. Shut off fuel supply to the main burner; shut off fuel supply and interrupt spark to the igniter if in operation.
2. None.	2. With gas igniter, vent gas piping between safety shutoff valves to the atmosphere.
3. Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.	3. None.
4. After post purge, fan can be shut down.	4. None.

6-6.4 Any of the following conditions shall accomplish a safety shutdown:

(a) Low pressure in the fuel supply at the service connection

(b) Loss of combustion air supply

(c) Loss of or failure to establish flame

(d) Loss of control system actuating energy

(e) Power failure

(f) Low water level as determined by the auxiliary low water cutout

(g) Loss of atomizing medium

(h) Excessive steam pressure or water temperature

CAUTION: Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and shall be avoided.

6-6.5 The following conditions, where oil heating is provided, shall sound alarms:

(a) Low oil temperature

(b) High oil temperature

6-7 Supervised Manual Systems for Gas-Fired Watertube Boilers.

6-7.1 The following steps *[see Tables 6-7.1(a), 6-7.1(b), 6-7.1(c), and 6-7.1(d)]* shall be taken by the operator when starting a supervised manual unit, and the indicated interlocks shall be satisfied at each step. It is assumed that control system energy, power, and water level have been established. When interlocks have been satisfied, this fact shall be indicated to the operator.

Table 6-7.1(a) Prefiring Cycle (in listed order).

Operator Functions	Interlock Functions
1. Check that gas safety shutoff valves are closed.	1. Gas safety shutoff valves are closed.
2. Start fan.	2. Fan motor is on.
3. Open damper(s) to purge position.	3. (a) Air pressure and open dampers(s), or (b) Airflow. *[See 6-2.4.1(h) and (i).]*
4. Start purge timer.	4. Purge is complete.
5. Place damper and gas control valve in light-off position.	5. Damper and fuel control valve are in light-off position. If light-off airflow is less than purge airflow rate, start light-off time limit timer.

Table 6-7.1(b) Light-Off Cycle (in listed order).

Operator Functions	Interlock Functions
1. Energize igniter.	1. Prove igniter flame is within 10 seconds. (For direct electric ignition, proof of igniter operation shall not be required.)
2. Open gas safety shutoff valves to main burner.	2. Prove main flame is within 10 seconds.
3. Bring unit to preset operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.	3. None.
4. On reaching preset range, change to automatic combustion control.	4. None.

Table 6-7.1(c) Normal Shutdown Cycle (in listed order).

Operator Functions	Interlock Functions
1. Shut off gas supply to the main burner and to the igniter, if in operation, and interrupt spark.	1. Vent gas piping between safety shutoff valves to the atmosphere.
2. Perform a postpurge of the boiler enclosure. The duration of the postpurge shall be no less than 15 seconds at an airflow rate not exceeding that at which the unit was shut down.	2. None.
3. After postpurge, fan can be shut down.	3. None.

Table 6-7.1(d) Safety Shutdown Cycle (in listed order).

Operator Functions	Interlock Functions
1. None.	1. Shut off gas supply to the main burner, shut off fuel supply, and interrupt spark to the igniter if in operation. Where used, simultaneously energize inerting system.
2. None.	2. Vent gas piping between safety shutoff valves to the atmosphere.

6-7.2 Select the fuel to be fired. The alternate fuel system shall be placed in a nonfiring condition, and the manual burner valve(s) shall be closed.

6-7.3 An igniter as specified in 4-4.1.1 shall be provided.

6-7.4 Any of the following conditions shall accomplish a safety shutdown:

(a) High gas pressure

(b) Low gas pressure

(c) Loss of combustion air supply

(d) Loss of or failure to establish flame

(e) Loss of control systems actuating energy

(f) Power failure

(g) Low water level as determined by the auxiliary low water cutout

(h) Excessive steam pressure or water temperature

CAUTION: Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and shall be avoided.

6-8 Soot Blowing.

6-8.1 Soot blowing is necessary to maintain high thermal efficiency in oil-fired boilers. However, if this operation is not performed with an optimum air/fuel ratio, explosions can occur from the formation and ignition of air-soot dust clouds within the boiler.

6-8.1.1 Soot blowers shall be operated only while burners are firing at rates that are sufficiently high to avoid extinguishing the burner flame.

6-8.1.2 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.

Chapter 7 Simultaneous Firing of Oil and Gas Fuels

7-1 General. When it is necessary or desirable to fire both oil and gas simultaneously in a single burner boiler on a continuous basis, the following equipment and procedure shall be used to avoid a hazardous furnace condition.

7-1.1 Hazards that are related to gas firing alone and oil firing alone are included in Section 2-7 and A-2-7. In addition, the simultaneous firing of gas and oil increases the potential for the following possibilities:

(a) A fuel-rich condition

(b) Abrupt change in the air/fuel ratio

(c) Over-firing of a boiler

7-2 Continuous Firing. The following equipment shall be provided for continuous firing of both oil and gas:

(a) A burner that is capable of burning either oil or gas fuel individually or both fuels simultaneously

(b) A combustion control system that is capable of performing the following functions:

1. Proportioning total fuel input, each fuel individually or in any combination, to total airflow to obtain a proper air/fuel ratio. A control system that is designed to accommodate a fixed amount of secondary fuel without metering and totaling all fuels shall be acceptable, provided it maintains proper air/fuel ratios throughout the entire operating range of the burner.

2. Limiting total fuel input to the maximum capacity of the boiler.

3. Controlling a minimum airflow rate.

4. Controlling minimum input rates of each fuel.

5. Providing a stable return to proper air/fuel ratio after the trip of either one of the two fuels.

(c) A safety interlock system with the following capabilities:

1. Meets the requirements of Section 4-7 for each fuel being fired.

2. Provides, on an interlock action peculiar to only one of the fuels being fired, that this particular fuel shall automatically shut down with operation continuing on the unaffected fuel in a stable manner.

NOTE: Shutdown of both fuels is acceptable.

3. Provides that both the first and second fuels be introduced with their flow control valves in light-off positions.

4. Provides for the introduction of the second fuel without requiring a boiler prepurge.

5. Requires a manual reset following any interlock shutdown.

6. Prohibits the simultaneous light-off of both fuels.

7. Provides detector(s) to supervise any of the following conditions:

a. Igniter flame

b. Gas firing

c. Oil firing

d. Combined gas and oil firing

7-3 Light-Off Cycles.

7-3.1 Prefiring and light-off cycles for the initial fuel to be fired shall be in accordance with Section 6-6 for oil and Section 6-7 for gas.

7-3.2 When oil is introduced as the second fuel, the procedure shall be as follows:

(a) Establish oil fuel system to satisfy interlocks.

(b) Install oil atomizer.

(c) Open atomizing medium shutoff valve.

(d) Place oil control valve in light-off position.

(e) Open oil safety shutoff valve and establish oil flow through the burner.

(f) Verify stable flame and proper air/fuel ratio.

(g) Place the combustion control system into the desired mode for controlling input rate of each fuel.

7-3.3 When gas is introduced as the second fuel, the procedure shall be as follows:

(a) Establish gas fuel system to satisfy interlocks.

(b) Place gas control valve in light-off position.

(c) Open safety shutoff valves, close vent valve, and establish gas flow through the burner.

(d) Verify stable flame and proper air/fuel ratio.

(e) Place the combustion control system into the desired mode for controlling input rate of each fuel.

7-4 Normal Shutdown Procedure.

7-4.1 The normal shutdown procedure for oil while continuing to fire gas shall be as follows:

(a) Reduce oil flow to light-off rate.

(b) Shut off oil supply to burner and open oil recirculating valve, where used.

(c) Verify stable flame and adjust air/fuel ratio in preparation for purging oil atomizer.

(d) Purge oil passages of oil atomizer.

(e) Shut off atomizing medium if required.

(f) Remove oil atomizer from burner if required.

(g) Verify stable flame and proper air/fuel ratio of the gas fire.

7-4.2 The normal shutdown procedure for gas while continuing to fire oil shall be as follows:

(a) Reduce gas flow to light-off rate.

(b) Shut off gas supply to the burner.

(c) Verify stable flame and proper air/fuel ratio of the oil fire.

7-4.3 Safety Shutdowns.

7-4.3.1 Any of the following operating conditions shall accomplish a safety shutdown of the oil supply to the burner (i.e., fuel trip):

(a) Low oil pressure

(b) Low temperature of heated oils

(c) Loss of atomizing medium

(d) High temperature of heated oil

7-4.3.2 Either of the following conditions shall accomplish a safety shutdown of the gas supply to the burner (i.e., fuel trip):

(a) High gas pressure

(b) Low gas pressure

7-4.3.3 Any of the following conditions shall accomplish a complete safety shutdown of the boiler:

(a) Loss of combustion air supply

(b) Loss of or failure to establish flame

(c) Loss of control system actuating energy

(d) Power failure

(e) Excess steam pressure or water temperature

(f) Low water level as determined by the auxiliary low water cutout

(g) The occurrence of either the oil or the gas fuel trip when only that fuel is being fired

Chapter 8 Simultaneous Firing of Oil and Gas for Fuel Transfer Only

8-1 Transfer Without Shutdown. When it is necessary or desirable to transfer from one fuel to another without stopping the flow of fuel to the furnace, the changeover shall be accomplished in a manner to prevent a fuel-rich condition. The following equipment and procedures shall be used to avoid a hazardous furnace condition.

8-2 Simultaneous Firing on a Continuous Basis. When a transfer combustion control system is designed for simultaneous firing of oil and gas fuels on a continuous basis, Chapter 7 shall apply.

8-3 Single Fuel Firing Without Airflow Biasing. When a combustion control system is designed for firing only one fuel at a time and no capability of biasing the airflow upward is provided, the following equipment and procedures shall be used.

8-3.1 Required Equipment.

(a) A burner that is capable of firing the two fuels simultaneously during the transfer period

(b) A fuel transfer system that includes the following:

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, provided all interlocks for both fuels are satisfied, including light-off position for both fuel valves
4. A control device, transfer timer, and an alarm for 8-3.1(b)3, to limit continuous operation in this mode

(c) A safety interlock system with the following capabilities:

1. Meets the requirements of Section 4-7 for each fuel being fired.
2. Provides, on an interlock action peculiar to only one of the fuels being fired, that this particular fuel shall automatically shut down with operation continuing on the unaffected fuel in a stable manner.

NOTE: Shutdown of both fuels is acceptable.

3. Provides that both the first and second fuels be introduced with their flow control valves in light-off positions.
4. Provides an interlock action that will trip either fuel should its respective flow control valve leave a predetermined low rate during fuel transfer.
5. Provides for the introduction of the second fuel without requiring a boiler purge.
6. Requires a manual reset following any interlock shutdown.
7. Prohibits the simultaneous light-off of both fuels.
8. Provides detector(s) to supervise any of the following conditions:
   a. Igniter flame
   b. Gas firing
   c. Oil firing
   d. Combined gas and oil firing
   e. Manual shutoff valves at the burner, downstream of the safety shutoff valves in each fuel line
   f. A pressure gauge in each fuel line downstream of the manual shutoff valve

8-3.2 Procedure required for changing from gas to oil:

(a) Where a Class 1 or 2 igniter is available, place it in service.

(b) Check that the manual oil valve at the burner is closed.

(c) Establish oil fuel system to satisfy interlocks.

(d) Install oil atomizer.

(e) Open atomizing medium shutoff valve.

(f) Place combustion control system in manual position.

(g) Reduce gas-firing rate to light-off flow.

(h) Place oil control valve in the normal light-off position.

(i) Place fuel transfer–switching system into oil/gas position. If the oil safety interlocks are satisfied, the oil safety shutoff valve will open. Fuel oil pressure now will be upstream of the manual oil valve at the burner.

(j) Observe the gas pressure downstream from the manual gas shutoff valve and slowly close 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 normal control valve.

(k) Simultaneously and slowly close the manual gas valve while opening the manual oil valve to light the oil flame from the gas flame. Continue to increase the oil-firing rate while cutting back on the gas-firing rate to keep 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. Care must be taken to maintain an adequate amount of excess air at all times by continuously observing the burner flame or by observing the air/fuel ratio or oxygen indicator, if provided. During this period, airflow is maintained at a constant rate with only the manual fuel valves operated.

(l) Place the fuel transfer system in the oil position.

(m) Return the combustion control system and burner-firing rate to automatic operation.

8-3.3 Procedure required for changing from oil to gas:

(a) Where a Class 1 or 2 igniter is available, place it in service.

(b) Check that the manual gas valve at the burner is closed.

(c) Establish gas fuel system to satisfy interlocks.

(d) Place combustion control system in manual position.

(e) Reduce oil-firing rate to light-off flow.

(f) Place gas control valve in the normal light-off position.

(g) Place fuel transfer–switching system in the gas/oil position. If the gas safety interlocks are satisfied, the gas safety

shutoff valves will open. Gas pressure now will be upstream of manual gas valve at the burner.

(h) Observe the oil pressure downstream from the manual oil shutoff valve and slowly close 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 normal control valve.

(i) Simultaneously and slowly close the manual oil valve while opening the manual gas valve to light the gas flame from the oil flame. Continue to increase the gas-firing rate while cutting back on the oil-firing rate to keep a constant heat input of the combined fuel to the burner until the oil valve is closed and the manual gas valve is fully open. Care must be taken to maintain an adequate amount of excess air at all times by continuously observing the burner flame or by observing the air/fuel ratio or oxygen indicator, if provided. During this period, airflow is being maintained at a constant rate with only the manual fuel valves operated.

(j) Place the fuel transfer system in the gas position. The oil safety shutoff valve will now close.

(k) Return the combustion control system and burner-firing rate to automatic operation.

(l) Shut off atomizing medium, if required.

(m) Remove oil atomizer from burner, if required.

8-4 Single Fuel Firing with Airflow Biasing. When a combustion control system is designed for firing only one fuel at a time and the capabilities have been provided to enable the airflow to be automatically biased up to a preset amount when either fuel is fired at a predetermined low rate, the following equipment and procedures shall be used.

8-4.1 Required Equipment.

(a) A burner that is capable of firing the two fuels simultaneously during the transfer period

(b) A fuel transfer system that includes the following:

1. A gas-firing mode in which oil cannot be fired (except during fuel transfer)

2. An oil-firing mode in which gas cannot be fired (except during fuel transfer)

3. A momentary contact push button enabling fuel transfer

(c) A safety interlock system with the following capabilities:

1. Meets the requirements of Section 4-7 for each fuel being fired.

2. Provides, on an interlock action peculiar to only one of the fuels being fired, that this particular fuel shall automatically shut down with operation continuing on the unaffected fuel in a stable manner.

NOTE: Shutdown of both fuels is acceptable.

3. Provides that both the first and second fuels be introduced with their flow control valves in light-off positions.

4. Provides an interlock action that will trip either fuel should its respective flow control valve leave the predetermined low rate during fuel transfer as described in Section 8-4.

5. Provides for the introduction of the second fuel without requiring a boiler purge.

6. Requires a manual reset following any interlock shutdown.

7. Prohibits the simultaneous light-off of both fuels.

8. Provides detector(s) to supervise any of the following conditions:

a. Igniter flame
b. Gas firing
c. Oil firing
d. Combined gas and oil firing

9. Provides a momentary contact fuel transfer push button *[see 8-4.1(b)3]* to simultaneously bias the airflow by a preset value and open the safety shutoff valve(s) of the fuel being introduced.

8-4.2 The following procedure is required for changing from gas to oil:

(a) Establish oil fuel system to satisfy interlocks.

(b) Install oil atomizer.

(c) Open atomizing medium shutoff valve.

(d) Place combustion control system in manual position.

(e) Reduce gas-firing rate to light-off flow.

(f) Place oil control valve in the normal light-off position.

(g) Depress fuel transfer push button.

(h) Observe that oil firing has commenced.

(i) Move fuel selector switch to the oil-firing position.

(j) Release fuel transfer push button, which automatically trips the gas safety shutoff valves.

(k) Return the combustion control system and burner-firing rate to automatic operation.

8-4.3 The following procedure is required for changing from oil to gas:

(a) Establish gas fuel system to satisfy interlocks.

(b) Place combustion control system in manual position.

(c) Reduce oil-firing rate to light-off flow.

(d) Place gas control valve in the normal light-off position.

(e) Depress fuel transfer push button.

(f) Observe that gas firing has commenced.

(g) Move fuel selector switch to the gas-firing position.

(h) Release fuel transfer push button, which automatically trips the oil safety shutoff valves.

(i) Return the combustion control system and burner-firing rate to automatic operation.

(j) Close atomizing medium shutoff valve, if required.

(k) Remove oil atomizer, if required.

Chapter 9 Dual Oil Atomizers in a Single Burner

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 changeover of atomizers shall be carried out under stable firing conditions by a trained operator.

CAUTION: Care shall be taken to prevent a fuel-rich condition during the changeover period.

9-2 Changeover Procedures. The following procedure for changing atomizers shall be followed:

(a) Where an intermittent igniter is available, place it in service.

(b) Install auxiliary atomizer.

(c) Slowly open atomizing medium valve to auxiliary atomizer until pressure reaches that required for light-off.

(d) Slowly close manual fuel valve on main atomizer until it is in control of oil flow.

(e) Slowly open the manual valve, admitting oil to the auxiliary atomizer until it ignites.

(f) Divert the atomizing medium and oil flow from the main atomizer to the auxiliary atomizer until the main atomizer is out of service.

(g) To place a main atomizer back into service and to remove auxiliary atomizer, repeat the procedure as outlined in Section 9-2(a) through 9-2(f), substituting the main atomizer for the auxiliary atomizer.

Chapter 10* Inspection and Maintenance

10-1 General. Since the effective operation of all safety and control devices depends upon their ability to respond quickly to their activating impulses, a systematic and thorough inspection and maintenance shall be performed.

10-2 Inspection and Maintenance Schedule. An inspection and maintenance schedule shall be established and performed on a periodic basis.

10-2.1 Operability and set points on all devices, where applicable, shall be verified by periodic testing, and the results shall be recorded in the log book.

10-2.2 Any defects found shall be corrected immediately.

10-2.3 Frequent inspection, adjustment, and cleaning shall be performed during initial operation.

10-3 Familiarity with Equipment and Procedures. The individuals making inspections and tests shall be thoroughly familiar with all operating procedures and equipment functions and shall be capable of rendering sound judgment as to when equipment is in reliable operating condition.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 1997 edition.

NFPA 54, *National Fuel Gas Code,* 1996 edition.

NFPA 70, *National Electrical Code®,* 1996 edition.

11-1.2 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 396, *Standard Specifications for Fuel Oils,* 1996.

Appendix A

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1.2 In existing units, strictly applying the provisions of this standard is not always practical. Physical limitations could cause disproportionate effort or expense with little increase in protection. In such cases, the authority having jurisdiction should be satisfied that reasonable protection is provided.

In existing units, any condition that represents a serious boiler combustion system hazard should be mitigated by application of appropriate safeguards. Modification of conditions that do not represent a significant threat, even if such conditions are not in strict conformance with the requirements of this standard, are not required.

A-1-2.2 Although NO_x and other emissions during start-up and extremely low-load operation are low, they might not comply with increasingly stringent emission limits. Deviation from the light-off procedure, purge, and minimum airflow requirements defined in this standard to meet these limits is not recommended. There are insufficient data and operating experience to justify changes to this standard.

A-2-7 Gas and Oil Firing—Special Problems.

(a) *Hazards Peculiar to Gas Firing.* Characteristics of gas and gas firing that require special consideration are as follows:

1. Gas is colorless; therefore, a leak usually cannot be detected visually. Also, reliance cannot be placed on detection of a gas leak by the presence of odor.

2. Potentially hazardous conditions are most likely to occur within buildings, particularly where the gas piping is routed through confined areas. In the latter instance, adequate ventilation should be provided. Outdoor boilers tend to minimize confined area problems.

3. The nature of gas fuel makes experiencing severe departures from safe air/fuel ratios possible without any visible evidence at the burners, furnace, or stack which could cascade into a progressively worse condition. Thus, combustion control systems that respond to reduced boiler steam pressure or steam flow with an impulse for more fuel, unless protected or interlocked to prevent a fuel-rich mixture, should be considered potentially hazardous. The same applies to manual firing without the above-mentioned interlocks or alarms. *(See Section 4-6 for requirements to avoid such hazards.)*

4. Particularly with respect to natural gas systems, the gas can be either "wet" or "dry." A wet gas usually implies the presence of distillate, which may be characteristic of a particular source. In the case of such a wet gas, the carryover of distillate into the burners could result in a momentary flameout and possible reignition. Reignition could result in a furnace explosion. Therefore, special precautions should be taken with wet gas supply systems. *(For details, see NFPA 54, National Fuel Gas Code.)*

5. Widely different characteristics of gas from either a single source or multiple sources can result in a significant change in the Btu (kJ) input rate to the burner(s) without an equivalent change in airflow.

6. Discharges from relief valves or any other form of atmospheric vents can become hazardous unless special precautions are taken. *(See A-4-4.1.3 and A-6-2.4.8.)*

7. Maintenance and repair of gas piping can be hazardous unless proper methods are used for purging and recharging the line, respectively, before and after making the repairs. *(See NFPA 54, National Fuel Gas Code.)*

(b) *Hazards Peculiar to Oil Firing.*

1. Characteristics of fuel oil and fuel oil firing that require special considerations include the following:

a. Fuel oils have high volumetric heats of combustion; therefore, even small leaks can create potential fire hazards.

b. When firing oils that require preheating, the viscosity of oil flowing to the burners should be held within limits to maintain proper atomization.

c. Water or sludge in fuel oil storage tanks or improperly located suction takeoffs from the storage tank can result in hazardous interruptions or pulsations of the fuel supply to the burners. A flameout, either immediately or at a later time, can result because of plugged strainers or burner tips.

d. Widely different characteristics of fuel oil from either a single source or multiple sources can result in a significant change in the Btu (kJ) input rate to the burner(s) without an equivalent change in airflow or without an appropriate change in fuel oil temperature to restore the flowing viscosity to the proper value. Different shipments of fuel oil with dissimilar characteristics can cause a precipitation of sludge that can lead to hazards as described in A-2-7(b)1.c.

e. On installations that are designed to fire both heated and unheated fuel oils, consideration should be given to the design of the burner management system to ensure proper interlocks are activated for the selected fuel oil. Similar consideration should be given to the fuel oil piping supply to the burner as well as oil-recirculating piping to the fuel storage tanks, depending on the arrangement of the provided equipment.

f. There is the ever-present hazard of inserting an oil gun in the burner assembly without a tip, new gaskets, or sprayer plate. This action can result in an unsafe operating condition.

g. Proper pumping and atomization of fuel oils are dependent upon control of viscosity. Changes in viscosity in relation to temperature vary for different oils and blends of oils. Close attention to the design and operation of viscosity control systems should be followed for each fuel when the source or properties are variable.

h. Clean distillate fuels have low conductivities and will generate static electrical charges in the fuel stream that can be dangerous unless flowing velocities are limited. *(See NFPA 77, Recommended Practice on Static Electricity, and API-RP 2003, Recommended Practice for Protection Against Ignitions Arising Out of Static Lighting and Stray Currents.)*

i. The incompressibility of fuel oil can create very rapid transients in oil flow through an operating burner upon the following operations:

(i) Rapid operation of oil supply valve

(ii) Rapid operation of burner shutoff valves

(iii) Rapid operation of regulating valve in the return oil line from the burner header (on systems using this type of control)

2. The term fuel oil refers to liquid fuels with widely differing characteristics. A fuel oil burning system is designed for a specific range of oil characteristics. Attempting to burn an oil whose characteristics differ widely from those for which the system was designed can cause serious operating difficulties and potential safety hazards. Hence, care must be exercised to ensure that oils that are received at a plant are within the specific ranges of the fuel-handling and fuel-burning equipment.

3. The more important characteristics of fuel oils are defined in ASTM D 396, *Standard Specifications for Fuel Oils.* Thus, it is relatively simple to identify oils that require special provisions for storing, heating, pumping, atomizing, and so forth. Generally speaking, grades 1, 2, and 4 have lower viscosities and less water and sediment than grades 5 or 6; hence, they require fewer special provisions to ensure proper handling and burning. However, most power boiler fuel oil systems are designed for the heavier grades 5 and 6; hence, such systems include provisions for preheating these usually viscous fuels. Furthermore, to avoid flameouts that are attributed to interruptions or pulsation of the fuel supply, or plugging of strainers, or burner tips, more care is required in the design and operation of fuel oil systems that are supplied with grade 6 oil than with the other ASTM grades.

4. All of the following characteristics could have a bearing on the problem of properly and safely burning fuel oils:

a. Fuel oil is a complex mixture of hydrocarbons of differing molecular weights and boiling and freezing points. When fuel oil is subjected to sufficiently high temperature, it will partially decompose or vaporize, thus, creating new liquid, gaseous, and solid fuels with unpredictable properties.

b. Fuel oil is introduced into the furnace as an extremely fine mist to mix intimately with the combustion air to burn quickly and completely. In power boilers this is accomplished by spraying high pressure drops through small orifices (i.e., mechanical atomization) or by using steam or air to break up small oil streams. Viscosity and volatility are characteristics of the oil that indicate ease of atomization.

c. Flash point is an indicator of volatility and, thus, of potential for flammable vapors. It is a function of pressure and fuel composition.

d. Some fuel oils contain constituents that, when overheated, could decompose, forming solids, or could solidify when exposed to low ambient temperature. The presence of such solids in the fuel could cause interruptions.

(i) When storing, handling, or burning fuel oils that could have flash points below 100°F (38°C) (Class I liquids as defined in NFPA 30, *Flammable and Combustible Liquids Code*) or that could be heated above their flash point, consideration should be given to electrical installations in areas where flammable vapors or gases could be present in the atmosphere. Typical locations are burner areas, fuel-handling equipment areas, fuel storage areas, pits, sumps, and low spots where fuel leakage or vapors can accumulate. Article 500 of NFPA 70, *National Electrical Code,* provides for classifying such areas and defines requirements for electrical installations in the areas so classified.

e. Purging the burner atomizer before removal will minimize the probability for hazardous concentrations of flammable vapors at the burner front during maintenance operations. With such provisions, the burner front is not normally classified more restrictively than Class I, Division 2.

f. The operating company is responsible for classifying areas where fuel is stored, handled, or burned and for revising the classification if conditions are changed. Installations should conform to NFPA 30, *Flammable and Combustible Liquids Code;* NFPA 31, *Standard for the Installation of Oil-Burning Equipment;* and NFPA 70, *National Elec-*

trical Code. Guidance can be obtained from API-RP 500, *Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries.*

(c) *Low NO_x Operation—Special Problems.*

1. Air pollution control regulations require that new installations meet NO_x emission limits that are lower than emissions now obtained from many of the presently installed firing systems and furnace designs, which are using past operating procedures. In addition, air quality regulations in some local areas require a reduction of NO_x emissions from existing boilers.

2. To achieve these reductions, one or more of the following methods should be used:

a. Low excess air firing (i.e., less than the "normal" 10 percent to 25 percent excess air)

b. Multistage air admission, involving the introduction of combustion air in two or more stages partly at the fuel nozzle, which could be less than stoichiometric air, and partly by independent admission through special furnace ports; and, a second stage of air admission within the same burner housing

c. Flue gas recirculation into all or a portion of the secondary air

d. Reduced secondary air temperature

e. Fuel staging

f. On new units, the equipment manufacturers introducing new burner and furnace designs

3. Generally, the effect of all of these methods is to produce lower flame temperatures and longer, less turbulent flames, which result in lower NO_x.

(d) *Hazards of Low NO_x Firing Methods.*

1. These methods can have important implications with regard to furnace safety, particularly for existing units, and can introduce unacceptable risks if proper precautions are not taken.

a. Fuel-firing systems that are designed to reduce NO_x emissions tend to reduce the margins formerly available to prevent or minimize accumulations of unburned fuel in the furnace during combustion upsets or flameouts. Thus, it is important to trip fuel on loss of flame.

b. These methods can narrow the limits of stable flames that are produced by the burner system. The tests, which are specified in 4-4.2.3, should be repeated on existing units when any of these methods are employed.

c. When flue gas recirculation is used, equipment should be provided to assure proper mixing and uniform distribution of recirculated gas and the combustion air. When flue gas recirculation is introduced into the total combustion air stream, equipment should be provided to monitor either the ratio of flue gas to air or the oxygen content of the mixture. When flue gas recirculation is introduced so that only air and not the mixture is introduced at the burner, proper provisions should be made to ensure the prescribed distribution of air and the recirculating flue gas/air mixture.

d. All of the methods tend to increase the possibility of an unstable flame and unburned combustibles throughout the unit and ducts. Therefore, recommendations of the boiler, burner, and instrument manufacturers should be followed or tests should be conducted to verify operating margins.

2. Any change in flame characteristics to reduce NO_x emissions can require changing either or both the type and location of flame detectors on existing units.

A-3 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

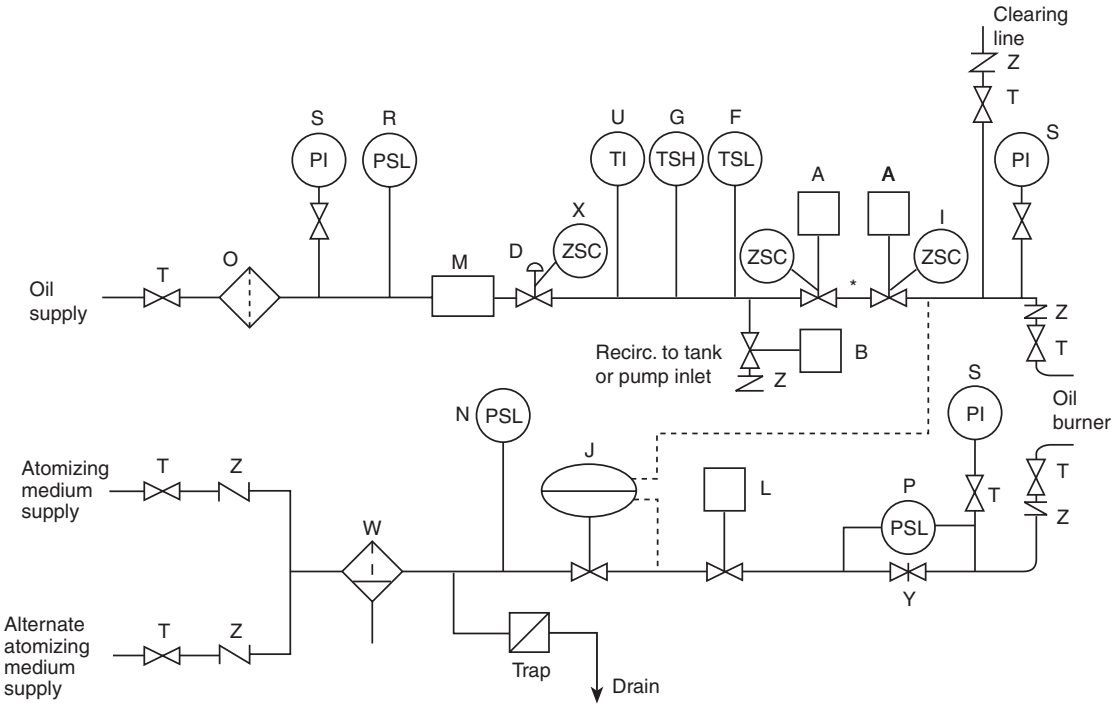
A-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-4-1.8 See Figure A-4-1.8.

A-4-2 For additional information, see NFPA 54, *National Fuel Gas Code,* and NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

A-4-2.3 Main Burner Gas Supply. Most natural gas that is supplied to boilers typically is lighter than air and presents no special problems in the atmosphere over and above those addressed in this standard. Because of developing energy cost considerations, many boilers are using a gas or a mixture of gases with heavier-than-air characteristics. These heavier-than-air gases, such as propane/air mixtures, refinery gases, and so forth, require special consideration in storing, handling, and venting to prevent accumulations in depressions or in confined areas.

An alternative to the automatic venting of heavier-than-air gases is to eliminate the vent valve from between the two main gas safety shutoff valves. *(See Figure A-4-2.3 and Table A-4-2.3.)*



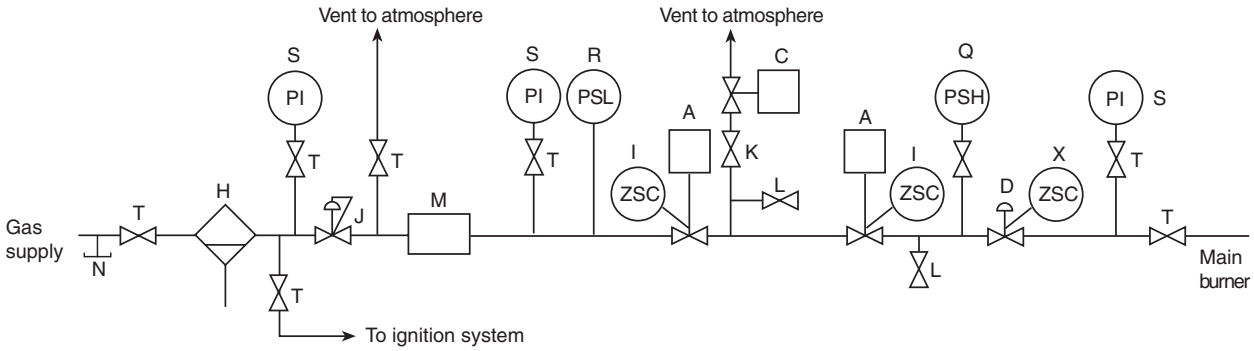
A Safety shutoff valve, spring closing (NC)
B Oil recirculation valve atomizing (NO) (optional for unheated oil)
D Oil flow control valve
F Low oil temperature switch (not applicable for unheated oil)
G High oil temperature switch (not applicable for unheated oil)
I Closed position interlock on safety shutoff valve
J Atomizing medium differential control valve
L Automatic atomizing medium shutoff valve
M Oil meter (optional)
N Low atomizing medium pressure switch
O Oil strainer
P Atomizing medium flow interlock differential switch, or pressure interlock switch
R Low pressure switch
S Pressure gauge
T Manual shutoff valve
U Oil temperature gauge (optional for unheated oil)
W Atomizing medium strainer
X Low fire start switch
Y Atomizing medium flow orifice
Z Check valve

Safety shutdown interlocks (not shown)

Flame detector(s)
Excessive steam pressure interlock
Auxiliary low water cutoff (one required)
Combustion air supply interlock

* Caution: Means shall be provided to prevent or relieve excess pressure between these valves

Figure A-4-1.8 Typical fuel and atomizing medium supply systems and safety controls for oil burner.



A Safety shutoff valve, spring closing (NC)
B Vent valve, spring opening (NO)
D Gas flow control valve
H Gas strainer
I Closed position interlock on valves safety shutoff
J Constant gas pressure regulator valve
K Vent line manual shutoff valve for leakage testing (locked or sealed open)
L Leakage test connection
M Gas meter (optional)
N Drip leg
Q High gas pressure switch
R Low gas pressure switch
S Pressure gauge
T Manual shutoff valve
X Low fire start switch

Note: NC = normally closed, de-energized
NO = normally open, de-energized

Safety shutdown interlocks (not shown)

Flame detector(s)
Excessive steam pressure interlock
(excessive water temperature and pressure interlock for hot water boilers)
Auxiliary low water cutoff (one required)
Combustion air supply interlock

Figure A-4-2.3 Typical fuel supply systems and safety controls for gas burner.

Table A-4-2.3 Vent Line Sizes

Gas Supply Line Size	Shutoff System Minimum Vent Port and Line Size
($1^1/_2$ in.	$^3/_4$ in.
2 in.	1 in.
$2^1/_2$ in. to 3 in.	$1^1/_4$ in.
$3^1/_2$ in.	$1^1/_2$ in.
4 in. to 5 in.	2 in.
$5^1/_2$ in. to 6 in.	$2^1/_2$ in.
$6^1/_2$ in. to $7^1/_2$ in.	3 in.
8 in.	$3^1/_2$ in.
>8 in.	15% of supply line cross-sectional area

A-4-2.7 Atmospheric vent valves that are located between shutoff valves are intended to relieve any gas pressure that could build up due to failure of the first (upstream) shutoff valve. This design minimizes the potential for leakage into a furnace. To perform properly, these valves should be large enough to relieve gas to the atmosphere at a rate that is equal to the potential leakage rate. In absence of other justification, vent pipe sizes and vent valve port diameters should conform to Table A-4-2.3. When manifolding is allowed, the cross-sectional area of the manifold pipe should be equal to or greater than the sum of the cross-sectional areas of the two largest vents that are involved.

A-4-4.1 See Figure A-4-4.1.

A-4-4.1.3 Heavier-than-Air Gases and Gas-Fired Igniters. Many oil-fired boilers are equipped with propane or other liquefied petroleum gas–fired (LPG) igniters. Special precautions are required in locating the vent pipe from the automatic bleed valve so that heavier-than-air, vented gases do not accumulate in depressions or in confined areas. An alternative to the automatic venting of heavier-than-air gases is to eliminate the igniter vent valve from between the two igniter safety shutoff valves.

A-4-9.1 Locations where natural gas, propane, or fuel oil systems are installed in compliance with this standard normally are not considered hazardous locations for electrical equipment as defined in NFPA 70, *National Electrical Code.*

A-6-1 Manual Systems for Watertube Boilers. The manual systems are not recommended. However, it is recognized that with adequate and uninterrupted supplies of fuel and air, certain operating functions can be performed by a trained operator as well as by control devices.

(a) *Controls and Interlocks.*

1. Interrupted or intermittent igniter.
2. Safety shutoff valves, as follows:

a. *Gas Firing.* Two automatic safety shutoff valves, spring-closing, in gas line to the main burner, with intermediate spring opening automatic vent valve

b. *Oil Firing.* Two automatic spring-closing safety shutoff valves in oil line to burner

CAUTION: Means shall be provided to prevent or relieve excess pressure between these valves.

c. *Gas-Fired Igniter.* Two spring-closing automatic safety shutoff valves in the gas line to the igniter, with intermediate, spring-opening automatic vent valve

3. Manual shutoff valve(s) in the fuel line(s) adjacent to the burner. For gas firing this shutoff valve should be proved closed before the spark to the igniter can be energized and the igniter and main gas safety shutoff valves can be opened.

4. Changes in firing rate are made by the simultaneous adjustment of fuel and air supplies at a pre-established, optimum air/fuel ratio by the manipulation of a single control device.

5. Limits on fuel and air to prevent reducing the furnace input below the point of stable burner operation are provided. The minimum and maximum points of stable burner operation are defined by the burner manufacturer and verified by operating investigation.

6. Safety shutdown interlocks include the following:

a. Low oil pressure
b. High gas pressure
c. Low gas pressure
d. Loss of combustion air supply

CAUTION: Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and should be avoided.

7. Where oil heating is provided, the following conditions sound an alarm:

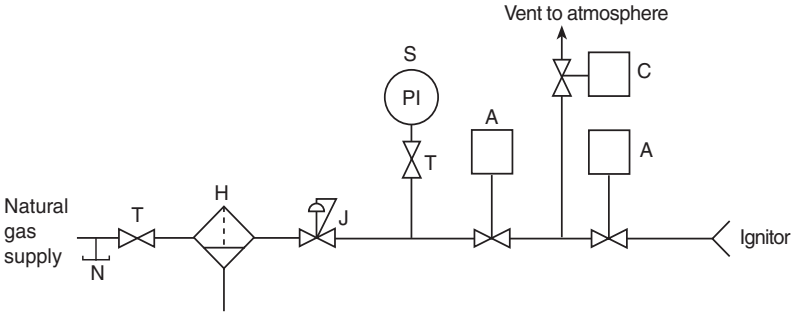
a. Low oil temperature
b. High oil temperature

A-6-2.4.8 Supplemental Recommendations and Precautions.

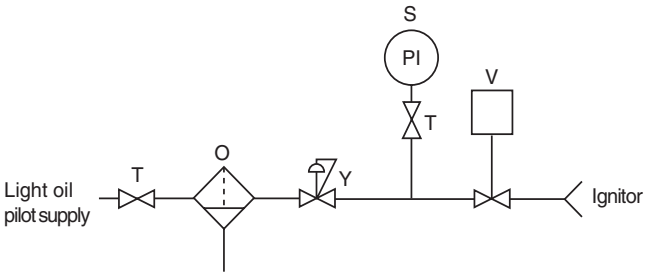
(a) *Excessive Recycling.* Excessive recycling to achieve a burner light-off can lead to accumulation of a hazardous amount of fuel in the furnace and should be avoided.

(b) *Recovering from a Fuel-Rich Furnace Condition.* If an air deficiency should develop while flame is maintained at the burners, reduce the fuel until the normal air/fuel ratio has been restored. If fuel flow cannot be reduced, slowly increase airflow until normal air/fuel ratio has been restored.

(c) *Fuel Quality.* It should be recognized that fuels that are available today contain unexpected constituents. Therefore, engineering systems and material designs must take into consideration these potential variables.



A Safety shutoff valve, spring closing (NC)
C Vent valve, spring opening (NO) (optional)
H Gas strainer
J Constant gas pressure regulator
N Drip leg
S Pressure gauge
T Manual shutoff valve



O Ignitor oil strainer
S Pressure gauge
T Manual shutoff valve
V Pilot oil safety shutoff valve, spring closing (NC)
Y Pilot oil pressure regulator (optional)

Note: NC = normally closed, de-energized
NO = normally open, de-energized

Figure A-4-4.1 Typical ignition systems for gas/oil-fired burner.

A-10 Inspection and Maintenance.

(a) *Maintenance, Inspection, Training, and Safety.*

1. The objective of a maintenance program is to identify and correct conditions relating to the safety, continued reliable operation, and efficient performance of equipment. A program should be provided for the maintenance of equipment at intervals that are consistent with the type of equipment, service requirements, and manufacturer's recommendations.

2. As a minimum, the maintenance program should include the following:

a. In-service inspections to identify conditions requiring corrective action or further study.

b. Detailed, knowledgeable planning to allow use of trained personnel, procedures, and equipment for an efficient safe repair or modification.

c. Use of comprehensive equipment history that records conditions found, maintenance work done, changes made, and date of each.

d. Written comprehensive maintenance procedures incorporating manufacturer's instructions to define tasks and skills required. Any special techniques, such as nondestructive testing or those tasks requiring special tools, should be defined. Special environmental factors should be covered, such as temperature limitations, dusts, contaminated or oxygen-deficient atmosphere, and limited access or confined space requirements.

e. Shutdown maintenance inspections, comprehensive in scope, to cover all problem areas.

f. Adequate spare parts that are available, meeting manufacturer's specifications, to provide reliable service without necessitating makeshift repairs.

3. In-service inspection of equipment should be established and followed.

4. Operation, set points, and adjustments should be verified by periodic testing and the results should be documented.

5. Defects should be reported and corrected, and repairs should be documented.

6. System configuration, including logic, set points, and sensing hardware, should not be changed without the effect being evaluated and approved.

7. Inspections, adjustments, and repairs should be performed by trained personnel using tools and instruments suitable for the work. Maintenance and repairs should be performed in accordance with the manufacturer's recommendations and applicable standards and codes.

8. It is not practical to pre-establish a single schedule for all installations. Therefore, the following typical schedule is a guide only, subject to adjustment according to specific plant operation and equipment involved. *(See 10-2.1 and 10-2.2.)*

a. Daily
(i) Flame failure detection system
(ii) Low water level cutoffs and associated alarms

b. Weekly
(i) Igniter and burner operation

c. Monthly
(i) Fan and airflow interlocks
(ii) Fuel safety shutoff valves for leakage
(iii) Low fire start interlock
(iv) High steam pressure interlock
(v) For oil:
(1) Fuel pressure and temperature interlocks
(vi) For gas:
(1) Gas strainer and drip leg
(2) High and low fuel pressure interlocks

d. Semiannually or annually as required
(i) Igniter and burner components
(ii) Combustion air supply system
(iii) Flame failure system components
(iv) Piping, wiring, and connections of all interlocks and shutoff valves
(v) Combustion control system
(vi) Calibration of indicating and recording instruments

e. As required for oil firing
(i) Atomizers
(ii) Strainers

(b) *Training.*

1. Operator training.

a. A formal training program should be established to prepare personnel to safely and effectively operate equipment. This program can consist of review of operating manuals, videotapes, programmed instruction, testing and field training, among others. The training program should be consistent with the type of equipment and hazards that are involved.

b. Operating procedures should be established that cover normal and emergency conditions. Start-up and shutdown procedures, normal operating conditions, and lockout procedures should be covered in detail.

c. Operating procedures should be directly related to the involved equipment and consistent with safety requirements and manufacturer's recommendations.

d. Procedures should be reviewed periodically to keep them current with changes in equipment and personnel.

2. Maintenance training.

a. A formal maintenance training program should be established to prepare personnel to safely and effectively perform any required maintenance tasks. This program can consist of review of maintenance manuals, videotapes, programmed instruction, testing, field training, and equipment manufacturer training, among others. The training program should be specific to the involved equipment and to potential hazards.

b. Maintenance procedures should be established to cover routine and special techniques. Any potential environmental factors, such as temperature, dust, contaminated or oxygen-deficient atmosphere, internal pressure, and limited access or confined space requirements should be included.

c. Procedures should be consistent with safety requirements and manufacturer's recommendations.

d. Procedures should be reviewed periodically to keep them current with changes in equipment and personnel.

(c) *Housekeeping.*

1. Good housekeeping is essential for safe operation and prevention of fires or explosions. Therefore, provisions should be made for periodic cleaning of horizontal ledges or surfaces of buildings and equipment to prevent the accumulation of appreciable dust deposits.

2. Creation of dust clouds should be minimized during cleaning. Compressed air should not be used to dislodge

soot or dust accumulations; water washing or vacuum cleaning methods are preferred.

(d) *Safety.*

1. *General Safety Precautions.* Protective clothing, including but not limited to hard hats and safety glasses, should be used by personnel during maintenance operations.

2. *Special Safety Precautions.*

a. Welding and flame cutting. *(See also NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes, and NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.)*

(i) Fire-resistant blankets or other approved methods should be used in such a manner as to confine weld spatter or cutting sparks.

(ii) A careful inspection of all areas near where welding or cutting has been done, including the floors above and below, should be made when the job is finished or interrupted and such areas patrolled for a period long enough to make certain that no smoldering fires have developed.

b. Where flammable dusts or dust clouds are present, sparking electrical tools must not be used. All lamps must be suitable for Class II, Division 1 locations as defined in NFPA 70, *National Electrical Code.*

c. Either ground fault protected or specially approved low voltage (i.e., 6 volt or 12 volt) extension cords and lighting should be used for all confined spaces and where moisture could be a hazard.

d. Explosion-operated tools and forming techniques should not be used where flammable dust or dust clouds are present. When these operations become necessary, all equipment, floors, and walls should be cleaned and all dust accumulation should be removed by an approved method. A careful check should be made to be sure that no cartridges or charges are left in the work area.

3. *Confined space.*

a. A confined space is any work location or enclosure in which any of the following could exist:

(i) The dimensions are such that a person who is 6 ft (1.8 m) tall cannot stand up in the middle of the space or extend his or her arms in all directions without hitting the enclosure.

(ii) 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.

(iii) Confined spaces can include, but are not limited to, ducts, heaters, windboxes, cyclones, dust collectors, furnaces, bunkers, or bins.

b. Specific procedures, as follows, should be developed and used for personnel entering a confined space:

(i) Positively prevent inadvertent introduction of fuel, hot air, steam, or gas.

(ii) Positively prevent inadvertent starting or moving of mechanical equipment or fans.

(iii) Prevent accidental closing of access doors or hatches.

(iv) Include tags, permits, or locks to cover confined space entry.

(v) Determine need for ventilation or self-contained breathing apparatus where the atmosphere may be stagnant, depleted of oxygen, or contaminated with irritating or combustible gases. Tests for an explosive or oxygen-deficient atmosphere should be made.

(vi) Provide for a safety attendant. The safety attendant should remain outside of the confined space with appropriate rescue equipment and should be in contact, preferably visual contact, with those inside.

(vii) Provide for use of proper safety belts or harnesses, which should be properly tied off when such use is practical.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 11. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 1997 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes,* 1997 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* 1994 edition.

NFPA 54, *National Fuel Gas Code,* 1996 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases,* 1995 edition

NFPA 70, *National Electrical Code,* 1996 edition.

NFPA 77, *Recommended Practice on Static Electricity,* 1993 edition.

B-1.2 Other Publications.

B-1.2.1 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 396, *Standard Specifications for Fuel Oils,* 1996.

B-1.2.2 API Publications. American Petroleum Institute, 1220 L. Street, NW, Washington, DC 20005.

API-RP 500, *Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries,* 1991.

API-RP 2003, *Recommended Practice for Protection Against Ignitions Arising Out of Static Lighting and Stray Currents,* 1991.

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