NFPA No.

85

EXPLOSION PREVENTION
WATERTUBE BOILER-FURNACES
OIL OR GAS-FIRED (SINGLE BURNER)
1973

NFPA®

$2.00

NATIONAL FIRE PROTECTION ASSOCIATION
International
470 Atlantic Avenue, Boston, MA 02210

5M-6-73-FP
Printed in U.S.A.

Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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SHOULD is intended to indicate recommendations or that which is advised but not required.

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This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

Standard for

Prevention of Furnace Explosions in Fuel Oil- and Natural Gas-Fired Watertube Boiler-Furnaces with One Burner

NFPA No. 85 — 1973

1973 Edition of No. 85

This edition of NFPA No. 85 was prepared by Subcommittee No. 2 and approved by the Committee on Boiler-Furnace Explosions. It was adopted in May 1973 and supersedes the 1972 edition. The revisions and added material are essentially editorial, but a number of recommendations have been made mandatory.

Origin and Development of No. 85

This standard was originally adopted at the 1964 Annual Meeting as NFPA No. 85A and covered natural gas-fired units. At the 1965 Annual Meeting, Tentative Standard NFPA No. 85C-*T* — 1964, covering fuel oil-fired units, was combined with NFPA No. 85A and the combined standard issued as NFPA No. 85. Revisions were adopted in 1967 and 1972.

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Standard for

Prevention of Furnace Explosions in Fuel Oil- and Natural Gas-Fired Watertube Boiler-Furnaces with One Burner

NFPA No. 85 — 1973

FOREWORD

The Committee on Boiler-Furnace Explosions was organized in 1960 at the request of the American Boiler Manufacturers Association, American Society of Mechanical Engineers, Edison Electric Institute and others, because of concern over the growing hazard to personnel and economic loss from fuel explosions in industrial and public utility boiler-furnaces.

The Committee on Boiler-Furnace Explosions functioned until 1970 with two Sectional Committees. The Sectional Committee on Industrial Units was concerned with watertube boilers with a single burner having a capacity of 10,000 lb/hr and up and was responsible for this Standard. The Sectional Committee on Public Utility Units was concerned with large multiple burner boiler-furnaces and was responsible for NFPA Nos. 85B, 85D and 85E.

In 1970 the Sectional Committees were disbanded and replaced by Sub-Committee No. 1, which is concerned with multiple burner boiler-furnaces; Sub-Committee No. 2 is concerned with single burner boiler-furnaces.

No standard can be promulgated which will guarantee the elimination of furnace explosions. Technology in this area is under constant development, which will be reflected in revisions to this Standard. The user of this Standard must recognize the complexity of fuel firing, both as to types of equipment and the characteristics of the fuel. Implementation of this Standard depends upon the judgment of the designer and the operator to suit the specific conditions under his responsibility.

1. PURPOSE AND SCOPE

11. The purpose of this Standard is to establish minimum standards for the design, installation, operation and maintenance of single burner oil or gas-fired watertube boilers rated at 10,000 pounds of steam per hour and above. This Standard is to apply to the burning of:

(a) natural gas

(b) fuel oil of No. 2, 4, 5 or 6 grade

(c) combination natural gas or fuel oil with controls arranged to permit firing only one fuel at a time except for transfer of one fuel to another as specified in Chapter 8.

12. Because this Standard is based upon the present state of the art, application to existing installations is not mandatory. Nevertheless, operating companies are encouraged to adopt those features of this Standard which are considered applicable and reasonable for existing installations.

13. Emphasis is placed upon the importance of combustion control equipment, safety interlocks, alarms, trips and other related controls which are essential to safe boiler operation.

2. GENERAL

21. Basic Cause of Furnace Explosions

211. The basic cause of furnace explosions is the ignition of an accumulated combustible mixture within the confined space of the furnace and/or the associated boiler passes, ducts and fans which convey the gases of combustion to the stack. This entire volume may be conveniently referred to as the boiler-furnace enclosure or setting.

212. A dangerous combustible mixture within the boiler-furnace enclosure consists of the accumulation of an excessive quantity of combustibles mixed with air in proportions which will result in rapid or uncontrolled combustion when an ignition source is supplied. A furnace explosion may 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-furnace enclosure. The magnitude and intensity of the explosion will depend upon both the relative quantity of combustibles which has accumulated and the proportion of air which 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 systems, or equipment or control system malfunction.

213. Numerous situations can arise in connection with the operation of a boiler-furnace which will produce explosive conditions; the most common experiences are:

2131. An interruption of the fuel or air supply or ignition energy to the burners, sufficient to result in momentary loss of flames, followed by restoration and delayed reignition of an accumulation.

2132. Fuel leakage into an idle furnace and the ignition of the accumulation by a spark or other source of ignition.

2133. Repeated unsuccessful attempts to light off without appriate purging can result in an accumulation of an explosive mixture.

214. The conditions favorable to a boiler-furnace explosion described in 213 are typical examples, and an examination of numerous reports of boiler-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 incidence of furnace explosions.

22. Manufacture, Design and Engineering

221. This Standard advocates that the manufacturers and the purchaser or his agent cooperate in determining equipment design and operating criteria so that the purchaser or his agent can assure himself that the unit is not deficient in apparatus which will insure its safe operation insofar as it is practical not only with respect to its pressure parts and fuel burning equipment, including air and fuel metering, but also in connection with provisions for safe lighting and maintenance of stable flame.

222. Because the interruption of the fuel supply by foreign substances has contributed to a number of explosions, the design of the fuel supply subsystem should make adequate provisions to prevent such foreign substances from interfering with the fuel supply to the burner.

23. Installation

231. Many units have been put in service before the completion and checkout of instrumentation and protective devices which provide the required margins of operating safety.

2311. The constructor responsible for the erection and installation of the equipment should see that all pertinent apparatus is properly installed and connected.

2312. The practice of starting up a boiler before the completion of an adequate safeguard and instrumentation system shall be avoided. The purchaser, the engineering consultant, the equipment manufacturer and the operating company shall avoid boiler operation until such adequate safeguards have been tested to operate properly as a system. In some instances it may be necessary to install temporary interlocks and instrumentation to meet these requirements. Any such temporary system shall be reviewed by the purchaser, the engineering consultant, the equipment manufacturer, and the operating company, and agreement should be reached on its suitability in advance of start-up.

2313. Testing and checkout of the safety interlock system and protective devices should be accomplished jointly by the organization which designed the system and those who operate and maintain such system and devices during the normal operating life of the plant. This should be done before, not after, initial operation.

24. Coordination of Design, Construction and Operation

241. Although statistics suggest that the cause of the majority of furnace explosions is human error, rather than equipment malfunction or design deficiencies, it is important to consider whether the error was the result of:

2411. Lack of proper understanding of, or failure to use, safe operating procedures.

2412. Unfavorable operating characteristics of the equipment and/or its control.

2413. Lack of functional coordination of the various components of the steam generating system and its controls.

242. Furnace explosions have occurred as a result of unfavorable functional design. Frequently the investigation has revealed the human error, and has completely overlooked the chain of causes which triggered the operating error. This emphasizes the extreme importance of integrating the design, installation, and functional objectives of the overall system of components and their controls. Careful consideration must be given to the man-machine relationships which will exist during the operating life of the system.

243. The importance of the coordination of design with the operating personnel during the planning and the engineering phases of power plant construction cannot be overstressed.

244. The ultimate responsibility for proper integration of the various components consisting of boiler, burner, fuel and air supply equipment, combustion controls, interlocks and safety devices, operator functions, operator communication and training, must of course, rest with the operating company. This integration can be accomplished by:

2441. Providing design and operating staffs who possess a high degree of competence in this field, and who are required to bring about these desired objectives as a result of collectively broad knowledge of the design and operating objectives, or,

2442. Appropriate administrative action in employing competent consultants who can achieve these same objectives.

2443. Periodic analysis to compare the plant to the evolving technology so that deficiences can be corrected to make the plants safer and more reliable.

25. Maintenance Organization

251. The advances in technology and the increasing complication of power plant equipment and controls tend to emphasize the need for competent maintenance to sustain the degree of reliability designed into the equipment. The quality of maintenance of control equipment, including interlocks and alarms, must be at least equal to that required to maintain the boiler and its related components in safe and reliable operating condition. Furthermore, all such equipment should be designed so that, with reasonable operation and maintenance, it will operate over an acceptable period of time without being taken out of service.

252. Too frequent maintenance results either from poorly designed equipment or from a poor quality of maintenance, requiring equipment shutdowns or the removal of control components from service. This not only reduces availability of steam production but also increases the exposure to operating hazards while equipment is being taken out of or restored to regular service.

253. The statistical history of furnace explosions points to the need for increased emphasis upon the problems of coordinating operation and maintenance with design decisions, and the need to maintain technical competence at the plant level during the life of the equipment.

254. A program shall be provided for suitable maintenance of equipment at suitable intervals consistent with type of equipment and service requirements.

26. Gas and Oil Firing — Special Problems

261. Hazards Peculiar to Gas Firing

2611. Common hazards are involved in the combustion of solid, gaseous and liquid fuels. Each of these fuels, in addition, has special hazards related to its physical characteristics. Characteristics of gas and gas-firing which require special consideration include:

(a) Because gas is colorless, a leak usually cannot be visibly detected. Although some natural gas is detectable by odor, this cannot be relied upon. Hence, it is desirable to provide for leakage detection.

(b) 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 this and the preceding hazard.

(c) Because of the nature of gas fuel it is possible to experience severe departures from safe air-fuel ratios without any visible evidence at the burners, furnace or stack, and to cascade into a progressively worse condition. Thus, combustion control systems which respond to reduced boiler steam pressure or steam flow with an impulse for more fuel, unless proteced 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 45 for requirements of combustion control system to avoid such hazards.)

(d) Particularly with respect to natural gas systems, the gas may 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 flame-out and possible reignition. Because the latter could result in a furnace explosion, suitable provisions should be made on all systems with special attention to wet gas supply systems. (For details see NFPA No. 54A, Industrial Gas Piping and Equipment.)

(e) Some plants are supplied with gas from either a single source or multiple sources, having significant differences in volumetric heating value; this can introduce unacceptable hazards. Therefore, boilers in such plants should be provided with suitable instruments responsive to Btu changes (e.g., a specific gravity meter) and with appropriate alarms and/or suitable compensation in the combustion controls.

(f) Discharges from relief valves or from any other form

of atmospheric vents can become hazardous unless special precations are taken.

(g) Maintenance and repair of gas piping can be hazardous unless accepted methods are used for purging and recharging the line respectively before and after making the repairs. (See NFPA No. 54A, Industrial Gas Piping and Equipment.)

262. Fuel Oil Firing — General Considerations

2621. 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 received at a plant are within the specific ranges of the fuel handling and burning equipment.

The more important characteristics of fuel oils are defined in ASTM specifications. As shown in Table 1, taken from ASTM D396/69 "Standard Specifications for Fuel Oils," the characteristics of the commonly used grades can be identified readily. Thus it is relatively simple to identify oils which require special provisions for storing, heating, pumping, atomizing, etc. Generally speaking, grades 1, 2 and 4 of Table 1 have lower viscosities and less water and sediment than grades 5 or 6, hence 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, more care is required in design and operation of fuel oil systems supplied with grade 6 oil than with the other ASTM grades, to avoid flame-outs attributable to interruptions or pulsation of the fuel supply, or plugging of strainers or burner tips.

All of the following characteristics may have a bearing upon the problem of properly and safely burning fuel oils:

(a) Fuel oil is a complex mixture of hydrocarbons of differing molecular weights, boiling and freezing points. Accumulations of the fuel when subjected to sufficiently high temperature will partially decompose and/or volatize, thus creating new liquid, gaseous and solid fuels with unpredictable properties.

(b) Fuel oil should be introduced into the furnace as an extremely fine mist to intimately mix with the combustion air in order to burn quickly and completely. In power boilers this is accom-

Table 1.* — Detailed Require-

Grade of Fuel Oil		Flash Point, deg F (deg C)	Pour Point, deg F (deg C)	Water and Sediment, percent by volume	Carbon Residue on 10 percent Bottoms, percent	Ash, percent by weight
		Min	Max	Max	Max	Max
No. 1	A distillate oil intended for vaporizing pot-type burners and other burners requiring this grade of fuel	100 or legal (38)	0[d]	trace	0.15	
No. 2	A distillate oil for general purpose domestic heating for use in burners not requiring No. 1 fuel oil	100 or legal (38)	20[d] (—7)	0.05	0.35	
No. 4	Preheating not usually required for handling or burning	130 or legal (55)	20 (—7)	0.50		0.10
No. 5 (Light)	Preheating may be required depending on climate and equipment	130 or legal (55)		1.00		0.10
No. 5 (Heavy)	Preheating may be required for burning and, in cold climates, may be required for handling	130 or legal (55)		1.00		0.10
No. 6	Preheating required for burning and handling	150 (65)	..	2.00[g]	.	..

[a] It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade.

[b] Outside USA the sulfur limit for No. 2 shall be 1.0 percent.

[c] Legal requirements to be met.

[d] Lower or higher pour points may be specified whenever required by conditions of storage or use. When pour point less than 0 F is specified, the minimum viscosity shall

*This table reprinted from ASTM D-396-69. See complete specification ASTM D-396-69.

ments for Fuel Oils.[a]

Distillation Temperatures, deg F (deg C)			Saybolt Viscosity, sec				Kinematic Viscosity, centistokes				Gravity, deg. API	Copper Strip Corrosion	Sulfur, percent
10 percent Point	90 percent Point		Universal at 100 F (38 C)		Furol at 122 F (50 C)		At 100 F (38 C)		At 122 F (50 C)				
Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max
420 (215)	..	550 (288)	..	..	.		1.4	2.2		.	35	No. 3	0.5 or legal
[e]	540[d] (282)	640 (338)	(32.6)[f]	(37.93)	..	.	2.0[d]	3.6	.		30		0.5[b] or legal
			45	125		.	(5.8)	(26.4)	.				[c]
.	.		150	300	..	.	(32)	(65)			.		[c]
.			350	750	(23)	(40)	(75)	(162)	(42)	(81)		.	[c]
		..	(900)	(9000)	45	300		..	(92)	(638)	..	..	[c]

be 1.8 cSt (32.0 sec, Saybolt Universal) and the minimum 90 percent point shall be waived.

[e] The 10 percent distillation temperature point may be specified at 440 F (226 C) maximum for use in other than atomizing burners.

[f] Viscosity values in parentheses are for information only and not necessarily limiting.

[g] The amount of water by distillation plus the sediment by extraction shall not exceed 2.00 percent. The amount of sediment by extraction shall not exceed 0.50 percent. A deduction in quantity shall be made for all water and sediment in excess of 1.0 percent.

plished by spraying through small orifices with high pressure drops (mechanical atomization) or by using steam or air to break up small oil streams. Viscosity and volatility are characteristics of the oil which indicate ease of atomization.

(c) Viscosity affects ease of pumping and atomization. Temperature significantly affects viscosity.

(d) Flash point is an indicator of volatility and, thus, of potential for flammable vapors.

(e) Some fuel oils contain constituents which, when overheated, may decompose, forming solids or may solidify when exposed to low ambient temperatures. The presence of such solids in the fuel may cause interruptions.

263. Hazards Peculiar to Oil Firing

2631. Common hazards are involved in the combustion of solid, liquid and gaseous fuels. Furthermore, each of these fuels has special hazards related to its physical characteristics. When firing fuel oil, the following require special consideration to avoid unacceptable risks:

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

(b) When firing oils identified as Grades 4, 5 or 6 in Table 1, the viscosity of oil flowing to the burners must be held within acceptable limits to maintain proper atomization.

(c) Water or sludge in fuel oil storage tanks or improperly located suction take-offs from the storage tank may result in hazardous interruptions or pulsations of the fuel supply to the burners. A flame-out, either immediately or at a later time, may result because of plugged strainers or burner tips.

(d) Storage in the same tank of two shipments of fuel oil having widely different viscosity or specific gravity characteristics may result in a significant change in fuel input rate to the burners, without an equivalent change in air flow, or without an appropriate change in fuel oil temperature to restore the flowing viscosity to the proper value. It can also cause a precipitation of sludge that can lead to trouble as described in 2631 (c).

(e) There is the ever-present hazard of inserting an oil gun in the burner assembly without a tip or sprayer plate. This can result in an unsafe operating condition.

(f) The incompressibility of fuel oil, coupled with the rela-

tively inelastic piping system normally used, can create very rapid transients in oil flow through operating burners upon:

(1) rapid operation of oil supply valve.

(2) rapid operation of individual burner shutoff valves.

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

Such uncontrolled changes in fuel input to the furnace can introduce very hazardous conditions. Particular consideration should be given to the creation of such conditions due to failure of valve or actuator or any time fast valve operation is provided.

3. DEFINITIONS

AIR CHANGE — A quantity of air, provided through the burner, equal to the volume of furnace and boiler gas passes. (Air volume to be calculated at 14.7 psia and 70 F.)

AIR/FUEL RATIO

OPTIMUM — A minimum ratio of air to fuel supplied to a furnace which will provide complete combustion of the fuel with sufficient range of excess air to maintain a stable flame envelope.

AIR RICH — A ratio of air to fuel supplies to a furnace which provides more air than that required for an optimum air/fuel ratio.

FUEL RICH — A ratio of air to fuel supplied to a furnace which provides less air than that required for an optimum air/fuel ratio.

AIR-THEORETICAL — The chemically correct amount of air 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.

ATOMIZER — That device in an oil burner which emits liquid fuel in a finely divided state.

ATOMIZING MEDIUM — A supplementary fluid, such as steam or air, which assists in breaking down oil into a finely divided state.

MECHANICAL ATOMIZER — That device in an oil burner which emits liquid fuel in a finely divided state without using an atomizing medium.

BURNER — A device for the introduction of fuel and air into a furnace at the required velocities, turbulence and concentration to establish and maintain proper ignition and stable combustion of fuel within the furnace.

BURNER CONTROL SYSTEMS

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

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

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

SUPERVISED MANUAL — A system by which a furnace is purged and burner is started, and ignited manually, which is modulated automatically, and which is stopped manually, with certain steps and conditions supervised by safety interlocks.

CLEANER — A device to remove foreign matter from fuel.

DRIP LEG — A chamber of ample volume, with suitable clean-out and drain connections, into which gas is discharged so that liquids and solids are trapped.

EXPLOSIVE MIXTURE — A flammable mixture in a confined space.

FUEL OIL — Nos. 2, 4, 5, or 6 fuel oil in accordance with Tentative Specifications for Fuel Oils, ASTM D 396-63T.*

*Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

FURNACE — An enclosure for the combustion of fuel.

GAS — (See LP-Gas and Natural Gas.)

HIGH GAS PRESSURE SWITCH — A pressure actuated device arranged to effect a *safety shutdown* of the burner or prevent it from starting when the gas supply pressure exceeds the normal supply pressure by 20 per cent.

HIGH STEAM PRESSURE SWITCH — A pressure actuated device arranged to effect a normal burner shutdown when the steam pressure exceeds a preset pressure.

IGNITER — A device which provides proven ignition energy required to immediately light-off the main burner.

INTERMITTENT — A gas or oil igniter which burns during light-off, and which can be placed in or taken out of service while the main burner is firing, and which shall be shut off with the main burner on a safety shutdown.

INTERRUPTED — A gas or oil igniter which burns during light-off, and which is shut off (interrupted) during normal operation of the main burner.

INTERRUPTED ELECTRICAL — A high energy electrical device used for direct ignition of the main oil burner.

IGNITER ESTABLISHING PERIOD — That interval of time during light-off during which a safety control circuit permits the igniter fuel safety shutoff valve(s) to be opened before the flame safeguard is required to prove the presence of the igniter flame.

INERTING — Scavenging of the furnace and boiler gas passes of a fuel rich or unknown gas mixture by dilution with an inert atmosphere.

INTERLOCK — A device which senses a limit or off-limit condition or improper sequence of events and shuts down the offending or related piece of equipment or prevents proceeding in an improper sequence in order to prevent a hazardous condition.

LIGHT-OFF — To establish combustion of fuel entering the furnace.

LIGHT-OFF TIME LIMIT TIMER — A device used on supervised manual systems which limits the allowable time between completion of purge and light-off. This time shall be no more than 5 minutes.

LOW GAS PRESSURE SWITCH — A pressure actuated device arranged to effect a *safety shutdown* of the burner or prevent it from starting when the gas supply pressure falls below 50 per cent of the normal gas supply pressure.

LOW OIL PRESSURE SWITCH — A pressure actuated device arranged to effect a *safety shutdown* of the oil burner or prevent it from starting when the oil supply pressure falls below that recommended by the burner manufacturer.

LOW OIL TEMPERATURE SWITCH — A temperature actuated device arranged to effect the *safety shutdown* of the oil burner or prevent it from starting when the oil temperature falls below the limits required to maintain the viscosity range recommended by the burner manufacturer.

LOW WATER CUTOUT — A device arranged to effect a *safety shutdown* of the burner when water level in the steam drum falls to a predetermined low level.

LP-GAS — A material composed predominantly of any of the following hydrocarbons, or mixtures of them: propane, propylene, normal butane, isobutane and butylenes.

MAIN BURNER ESTABLISHING PERIOD — (See Trial-for-Ignition Period).

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

MONITOR — To sense and alarm a condition requiring attention, without initiating corrective action.

NATURAL GAS — A gaseous fuel occurring in nature consisting mostly of a mixture of organic compounds (normally methane, butane, propane, and ethane). The Btu value of natural gases varies between 700 and 1,500 Btu per cubic foot, the majority averaging 1,000 Btu.

NORMAL FUEL SUPPLY PRESSURE — The pressure at the fuel service connection for which the fuel burning system has been designed.

OIL — (See 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. This range shall be determined by test.

OUTLET DRAFT — The flue gas pressure at the outlet of the last convection pass of the boiler.

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 which will effectively remove any gaseous combustibles and replace them with air.

RECYCLE — A start-up initiated by steam pressure following a normal shutdown.

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

RE-START — A manually initiated start-up.

SEMIAUTOMATIC — Not defined. The terms "automatic (non-recycling)" and "supervised manual" have been used to describe the functions conventionally attributed to "semiautomatic."

SERVICE CONNECTION — A point at which fuel, 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.

SHUT-DOWN

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 re-start.

SOOT BLOWER — A mechanical device for introducing steam or air to clean heat absorbing surfaces.

SUPERVISE — To sense and alarm a condition requiring attention, and initiate corrective action.

TRIAL-FOR-IGNITION PERIOD (MAIN BURNER ESTABLISHING PERIOD) — That interval of time during light-off during which a safety control circuit permits the main burner fuel safety shutoff valves to be opened before the flame detection system is required to supervise the main burner flame only.

4. EQUIPMENT REQUIREMENTS

41. Fuel Supply (Oil)

411. 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 Standard for the Installation of Oil Burning Equipment, No. 31.

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

4121. Fuel shall be continuously delivered to the combustion chamber in a finely atomized form that can be readily ignited and consumed.

4122. All equipment associated with pumping, heating, and straining the fuel from storage to the service connection shall be carefully designed, sized, and interconnected to the unit so as to always provide a suitable fuel supply over full range of conditions. Relief valves shall be installed after the pump to prevent over-pressure in the system.

4123. 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.

4124. Where the fuel must be heated, care shall be taken to insure 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.

4125. The fuel shall be maintained free from sludge, water or other contaminants that could deposit or result in fuel interruptions or interfere with proper operation of control or measuring equipment.

42. Fuel Supply (Gas)

421. The gas supply at the gas service connection shall be controlled at the pressure for which the fuel burning system has been designed.

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

423. Gas shall be free of all foreign matter (solid or liquid). Welding beads, chips, scale, dust and debris shall be removed from the gas piping.

424. A drip leg shall be provided as shown in Appendices A, B, C, G, H and I.

43. Alternate Fuel Firing

431. When 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.

44. Fuel Burning Equipment

441. Ignition

4411. The main burner shall be equipped with an interrupted or intermittent igniter. If an intermittent igniter is used, the main burner flame shall be proven independently of the igniter.

4412. The igniter flame or arc shall impinge on the main burner air/fuel mixture and supply sufficient ignition energy to provide immediate ignition of all fuel discharge from the main burner under interlock light-off conditions.

4413. The igniter shall be easily removable for inspection and maintenance.

4414. If LP-Gas igniters are used, special attention is required to materials of construction in valves and their lubrication.

442. Main Burner

4421. 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 and so that no deposits detrimental to the combustion process will be formed by continuous firing.

4422. The burner shall be provided with at least one convenient observation port of a size to permit satisfactory visual inspection of the igniter and main burner flames.

4423. Any manual adjustment features on the burner shall be provided with positive locking devices.

4424. The atomizing equipment for oil burners shall be designed for convenient removal, cleaning and maintenance.

4425. When shutting down the unit for extended periods, it may be desired to clear the atomizer and piping into the furnace. This shall be accomplished while the fan is operating and the igniter is re-established, or the main flame is continuously proven during this operation.

4426. Clearing of the oil passages of the atomizer into the furnace immediately after a safety shutdown shall be prohibited.

443. Atomizing Medium for Oil Burners

4431. When 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.

4432. The atomizing medium shall be provided at the pressures required for proper operation.

4433. Provisions shall be made to insure that fuel cannot enter the atomizing medium line during or after operation.

444. Air Supply

4441. The air supply equipment shall be capable of supplying sufficient air for the optimum air/fuel ratio over the entire operating range of the burner.

4442. Provision shall be made for convenient cleaning of the air supply equipment.

445. Main Combustion Chamber

4451. The main combustion chamber shall be designed to promote main burner stability while minimizing zones which cannot be purged.

4452. At least one observation port shall be provided to permit observation of the burner flame and furnace.

446. Combustion Products Removal

4461. The outlet draft equipment shall be capable of removing combustion products without adversely affecting stable flame conditions.

4462. If two or more boilers are connected to a common stack, each connection shall be equipped with a damper system. Each damper shall be equipped with operating and locking devices which are readily accessible. This equipment shall be compatible with the combustion control systems of all boilers.

45. Combustion Control System

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

452. The system shall sense an index of pressure, temperature, or flow and adjust the firing rate accordingly.

453. 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 operation investigation.

46. Interlock System

461. An interlock system shall be provided to prevent operation under unsafe conditions.

462. The interlocks shall be suitable for the operating system used and shall provide the desired function with high reliability.

4621. Approved equipment shall be used whenever possible.

4622. Each interlock device shall be equipped with a method of readily determining the position of the sensing element switch without having to disassemble any part of the device.

4623. Each interlock shall be provided with a method of securing the set point condition. The set point characteristics shall have a high degree of repeatability within limits that will provide reliable, safe operation.

4624. Interlock devices shall be able to perform under high and low temperature, humidity, vibration, and corrosive ambient conditions.

4625. Interlock devices shall include proper snubbers, time delays, or other means to provide control action consistent with the purposes of this Standard without causing unnecessary shutdowns.

463. The interlock on the low water cut-out may be bypassed for blow down purposes only. This bypass shall be of a type which is temporarily held during blow down.

464. For oil firing, certain bypassing of interlocks may be necessary for cold starts. See Section 5.

465. No interlocks shall be manually bypassed at any time during normal operation except as provided in 463 and 464.

466. Electrical installations shall conform to the National Electrical Code (NFPA No. 70).

4661. Safety control AC circuits shall be two wire, one side grounded, preferably not exceeding nominal 120 volts and shall be protected with suitable fuses, or circuit breakers.

4662. Switching contacts shall be in the "hot" ungrounded line.

4663. Safety control DC circuits shall be arranged as called for in 4661 and 4662, when grounding is possible. When grounding is *not* possible and circuit voltage exceeds 50, the circuit shall have switching contacts in one side of the line and ground fault detectors provided.

467. Flame Safety Shutdown System

4671. The time interval between loss of flame and stopping the fuel flow to the burner shall be not more than four seconds.

4672. The fuel safety shutoff valve(s) are the "key unit" of all safety shutdown systems.

4673. Permanent and ready means for making easy, accurate, periodic tightness tests of the main burner fuel safety shutoff valve(s) shall be provided in the piping.

5. METHODS OF STARTING A COLD BOILER

51. In no case shall a boiler be started from a cold condition without a qualified operator being present.

52. Follow applicable start-up procedures for the burner control system provided. Firing rate shall be limited in accordance with the manufacturer's instructions.

53. In the event that starting of a boiler becomes necessary without steam available for heating oil or as an atomizing medium where required, one of the starting methods described in 531, 532 and 533 shall be used.

531. Auxiliary Air Atomizing of Heavy Oil

5311. Equipment Required

(a) Motor driven FD Fan.

(b) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for the flow and temperature through the atomizer required for stable flame.

(c) Compressed air supply.

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

5312. Facilities Required

(a) An atomizing air supply piped as shown in Appendices D, E, F, G, H, and I.

5313. Starting Procedure

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

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

(c) Set combustion control at a low 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 described in Section 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.

532. Auxiliary Mechanical Atomizing of Heavy Oil

5321. Equipment Required

(a) Motor driven FD fan.

(b) Approved auxiliary oil heater for start-up fuel flow with a capacity not less than that required for the flow and temperature through the atomizer required for 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.

5322. Starting Procedure

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

(b) Bypass atomizing medium interlocks, where used.

(c) Insert mechanical atomizer.

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

(e) Set combustion control at a low 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 described in Section 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.

533. AUXILIARY MECHANICAL ATOMIZING OF LIGHT (UNHEATED) OIL

5331. EQUIPMENT REQUIRED

(a) Motor driven FD fan.
(b) Mechanical atomizer.
(c) Check valves in the heavy and light oil lines.
(d) Means to bypass oil and atomizing medium interlocks where used. The fact that these are bypassed shall be made evident to the operator with adequate warning devices.

5332. FACILITIES REQUIRED

(a) Light oil supply.

5333. 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 Section 6.
(f) Set combustion control at a low firing 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 described in Section 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.

6. OPERATING SYSTEMS

61. Section 6 and Appendices A through I illustrate typical arrangements of operating systems for automatic (recycling), automatic (nonrecycling), supervised manual, and manual systems to meet the intent of this Standard. Different arrangements are permissible if they provide equivalent protection and meet the intent of this Standard.

62. Automatic (Recycling) Systems

621. An automatic (recycling) unit shall not be started from a cold condition unless a qualified 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.

622. 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.

623. An igniter as specified in 4411 shall be provided.

624. An automatic (recycling) unit shall recycle on a preset pressure and perform four major functions:

(a) pre-firing
(b) light-off
(c) modulation
(d) shutdown

6241. The pre-firing cycle shall accomplish the following in the order listed:

(a) Prove the fuel safety shutoff valve closed. For gas firing, this shall be the downstream valve.

(b) Prove no flame 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.

(h) Prove purge air flow by satisfying: (1) air pressure and "open damper" interlocks for all dampers in the flow path

*The order of these items in the sequence is optional.

or (2) air flow interlock. Purge air flow shall reach not less than 70 per cent of the air flow required at maximum continuous capacity of the unit.

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

(j) Set controls to light-off position.

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

6242. The light-off cycle for a burner with an interrupted igniter shall accomplish the following in the order listed:

(a) Ignite igniter.

(b) Prove igniter flame within 10 seconds (igniter establishing period).

(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 and, with gas igniter, vent the gas piping between igniter safety shutoff valves to atmosphere.

(d) Prove main flame.

(1) If proven, release to modulating control.

(2) If not proven, establish *safety shutdown.*

6243. The light-off cycle for a burner with an intermittent igniter shall accomplish the following in the order listed:

(a) Ignite igniter.

(b) Prove igniter within 10 seconds.

(1) If proved, admit fuel to main burner.

(2) If not proved, establish *safety shutdown.*

(c) Prove main flame within 10 seconds.

(1) If proved, release to combustion control for modulation.

(2) If not proved, establish *safety shutdown.*

6244. Modulation shall be accomplished by a combustion control system.

6245. The normal shutdown cycle shall accomplish the following in the order listed:

(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) For Gas:

(1) Interrupt spark and shut off gas to igniter if in operation.

(2) Vent gas piping between safety shutoff valves to atmosphere.

(d) After post purge shut down fan, if desired.

6246. High steam pressure shall accomplish a normal shutdown, and the burner shall be allowed to recycle when steam pressure has dropped to within the preset operating range.

6247. The *safety shutdown* cycle shall accomplish the following in the order listed and 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) For Gas:

(1) Vent gas piping between safety shutoff valves to atmosphere.

(e) Where used, energize inerting system simultaneously with (a) above.

(f) After post purge shut down fan, if desired.

(g) Lock out sequence control to require manual reset.

6248. The following conditions shall accomplish a *safety shutdown*, and the burner shall not be allowed to recycle without manual reset until a qualified 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) Under pressure in the fuel supply at the service connection.

(2) Under temperature of Nos. 5 and 6 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.
(8) Loss of atomizing medium, where used, as interlocked by (1) flow or (2) two pressure switches, one located at the service connection and the other at the burner, either one of which shall establish a safety shutdown on under pressure.

(b) For Gas:
(1) Over or under pressure in the gas supply at the service connection.
(2) Loss of combustion air supply.
(3) Loss of or failure to establish flame.
(4) Loss of control system actuating energy.
(5) Power failure.
(6) Low water level.

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.

63. Automatic (Nonrecycling) Systems

631. The provisions of 621, 622, 623, and 624 shall apply except for 6246 (see 6311).

6311. When high steam pressure establishes a normal shutdown, the burner shall not be allowed to recycle. A qualified operator shall initiate the re-start.

64. Supervised Manual Systems for Oil

641. The following steps 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.

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

643. A igniter as specified in 4411 shall be provided.

644. Prefiring Cycle

Operator Functions	Interlock Functions
(a) Check manual fuel shutoff valve(s) closed.	(a) Manual fuel shutoff valve closed.
(b) Start fan.	(b) Fan on.
(c) Where used, open atomizing medium valve.	(c) Atomizing medium supply available.
(d) Open damper(s) to purge position.	(d) (1) Air pressure and open damper(s), or (2) Air flow.
(e) Start purge timer.	(e) Purge complete.
(f) Place damper and fuel control valve in light-off position.	(f) Damper and fuel control valve in light-off position. If light-off air flow is less than purge air flow rate, start light-off time limit timer.
(g) None.	(g) Spark and igniter and main safety shutoff valves operable.

645. Light-off Cycle

Operator Functions	Interlock Functions
(a) Start igniter ignition system.	(a) Prove igniter. If air flow is less than purge air flow rate, igniter shall be proven within 10 seconds.
(b) Open fuel safety shutoff valve to main burner.	(b) None.
(c) Close recirculating valve, where used.	(c) None.
(d) Open manual fuel shutoff valve.	(d) Prove main flame 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.
(e) Bring unit to preset operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.	(e) None.
(f) On reaching preset pressure range, change to automatic combustion control.	(f) None.

646. NORMAL SHUTDOWN CYCLE

Operator Functions	Interlock Functions
(a) Shut off fuel supply to the main burner.	(a) Fuel safety shutoff valve(s) to main burner closed.
(b) Open fuel recirculating valve, where used.	(b) None.
(c) Where used, shut off atomizing medium.	(c) None.
(d) Remove fuel atomizer.	(d) None.
(e) After post purge shut down fan if desired.	(e) None.

647. SAFETY SHUTDOWN CYCLE

Operator Functions	Interlock Functions
(a) None.	(a) Shut off fuel supply to the main burner and shut off fuel supply and interrupt spark to the igniter if in operation.
(b) None.	(b) With gas igniter, vent gas piping between safety shutoff valves to atmosphere.
(c) After post purge shut down fan if desired.	(c) None.

648. The following conditions shall accomplish a *safety shutdown.*

(a) Under 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.
(g) Loss of atomizing medium.

649. The following condition shall sound an alarm:

(a) Low oil 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.

65. Supervised Manual Systems for Gas

651. The following steps 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.

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

653. An igniter as specified in 4411 shall be provided.

654. PREFIRING CYCLE

Operator Functions	Interlock Functions
(a) Check gas safety shutoff valves closed.	(a) Gas safety shutoff valves closed.
(b) Start fan.	(b) Fan motor on.
(c) Open damper(s) to purge position.	(c) (1) Air pressure and open damper(s), or (2) Air flow.
(d) Start purge timer.	(d) Purge complete.
(e) Place damper and gas control valve in light-off position.	(e) Damper and fuel control valve in light-off position. If light-off air flow is less than purge air flow rate, start light-off time limit timer.

655. LIGHT-OFF CYCLE

Operator Functions	Interlock Functions
(a) Start igniter ignition system.	(a) Prove igniter. If air flow is less than purge air flow rate, igniter shall be proved within 10 seconds.
(b) Open gas safety shutoff valves to main burner.	(b) Prove main flame within 10 seconds.
(c) Bring unit to preset operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.	(c) None.
(d) On reaching preset pressure range, change to automatic combustion control.	(d) None.

656. NORMAL SHUTDOWN CYCLE

Operator Functions	Interlock Functions
(a) Shut off gas supply and interrupt spark to the main burner and to the igniter if in operation.	(a) Vent gas piping between safety shutoff valves to atmosphere.
(b) After post purge shut down fan if desired.	(b) None.

657. SAFETY SHUTDOWN CYCLE

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

658. The following conditions shall accomplish a *safety shutdown*:

(a) Over or under pressure in the gas 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.

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.

66. Manual Systems

661. While the requirements and functions in Nos. 61, 62, 63, 64 and 65 are essential to safe operation, it is recognized that with adequate and uninterrupted supplies of fuel and air, certain operating functions can be performed by a qualified operator as well as by control devices. However, the provisions of 6611, 6612, 6613, 6614 and 6615 shall be observed.

6611. An igniter as specified in 4411 shall be provided.

6612. Manual shutoff valve(s) shall be provided in the fuel line(s) adjacent to the burner. For gas firing, this shutoff valve shall be proved closed before the spark to the igniter can be energized and the igniter and main gas safety shutoff valves can be opened.

6613. Changes in firing rate shall be made by simultaneous adjustment of the fuel and air supplies at a pre-established optimum air/fuel ratio. This shall be accomplished by the manipulation of only one control device.

6614. 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 operating investigation.

6615. The following interlocks shall be included to accomplish a *safety shutdown*:

(a) For oil, under pressure in the fuel supply at the service connection.

(b) For gas, over and under pressure in the fuel supply at the service connection.

(c) 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 shall be avoided.

67. Soot Blowing

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

6711. Operate soot blowers only while burners are firing at rates sufficiently high to avoid extinguishing the burner flame.

6712. Boilers 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.

7. SIMULTANEOUS FIRING OF OIL AND GAS FOR FUEL TRANSFER

71. Under certain conditions, due to steam demand, transfer from one fuel to another without stopping the flow of fuel to the furnace may be necessary.

711. Certain equipment and procedures are required to avoid developing a hazardous condition.

712. Under these conditions, it is imperative that the change-over be accomplished in a manner to prevent a fuel-rich condition.

713. A qualified operator shall make the transfer.

72. Fuel transfer when a combustion control system meters and total inputs from both gas and oil fuels, alone or in any combination, and controls air flow proportionally (preferred method).

721. EQUIPMENT REQUIRED

7211. A burner capable of burning the two fuels simultaneously during the transfer period.

7212. A fuel transfer switching system which includes the following features:

(a) A gas position in which oil cannot be fired.

(b) An oil position in which gas cannot be fired.

(c) A gas-oil position which permits simultaneous firing of both fuels provided all interlocks for both fuels are satisfied.

7213. A combustion control system which meters and totals inputs from both gas and oil fuels, alone or in any combination, and controls air flow proportionally.

722. PROCEDURE FOR CHANGING FROM ONE FUEL TO THE OTHER.

7221. This procedure must be compatible with the specific equipment which makes up the combustion control system. Following the manufacturer's instructions and verify the procedure with operating tests.

73. Fuel transfer when combustion control system is suitable for firing only one fuel at a time (alternate method).

731. EQUIPMENT REQUIRED

7311. A burner capable of burning the two fuels simultaneously during the transfer period.

7312. A fuel transfer switching system which includes the following features:

(a) A gas position in which oil cannot be fired.

(b) An oil position in which gas cannot be fired.

(c) A gas-oil position which permits simultaneous firing of both fuels provided all interlocks for both fuels are satisfied, including light-off position for both fuels.

7313. Manual shutoff valves at the burner and downstream of the safety shutoff valves in each fuel line.

7314. A pressure gage in each fuel line downstream of the manual shutoff valve.

732. PROCEDURE FOR CHANGING FROM GAS TO OIL

(a) If an intermittent pilot 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) Place oil control valve in the normal light-off position.

(h) 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 manual oil valve at the burner.

(i) Observe the gas pressure downstream from the manual gas shutoff valve and slowly close 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.

(j) Simultaneously and slowly close the manual gas valve while operating the manual oil valve to light the oil flame from the gas flame. Continue to increase oil firing rate while cutting back on gas firing rate to keep a constant heat input of the combined fuels to the burner until the manual gas valve is closed and 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 fuel-air ratio or oxygen indicator, if provided. During this period, air flow is maintained at a constant rate, with only the manual fuel valves operated.

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

(l) Return the combustion control system and burner firing rate to normal operation.

733. PROCEDURE FOR CHANGING FROM OIL TO GAS

(a) If an intermittent 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) Place gas control valve in the normal light-off position.

(f) 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 gas manual valve at the burner.

(g) Observe the oil pressure downstream from the manual oil shutoff valve and slowly close 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.

(h) Simultaneously and slowly close the manual oil valve while operating the manual gas valve to light the gas flame from the oil flame. Continue to increase gas firing rate while cutting back on oil firing rate to keep a constant heat input of the combined fuel to the burner until the oil valve is closed and 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 fuel-air ratio or oxygen indicator, if provided. During this period, air flow is being maintained at a constant rate, with only the manual fuel valves operated.

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

(j) Return the combustion control system and burner firing rate to normal operation.

8. DUAL OIL ATOMIZERS IN A SINGLE BURNER

81. When a burner is equipped with main and auxiliary oil atomizers for the purpose of changing atomizers for maintenance without affecting the boiler load, care must be taken to prevent a fuel-rich condition during the changeover period.

811. This changeover shall be carried out under stable firing conditions.

812. A qualified operator shall perform this transfer operation.

82. The procedure outlined in 821 through 826 is recommended.

821. If an intermittent igniter is available, place it in service.

822. Install auxiliary atomizer.

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

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

825. Slowly open the manual valve admitting oil to the auxiliary atomizer until it ignites.

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

827. To place a main atomizer back into service and to remove auxiliary atomizer, repeat 821 through 825.

9. INSPECTION AND MAINTENANCE

91. Since the effective operation of all safety and control devices depends upon their ability to respond quickly to their activating impulses, it is important that they be in proper operating condition at all times. Systematic and thorough inspection and maintenance are necessary.

92. An inspection and maintenance schedule shall be set up on a periodic basis.

921. Any defects found shall be corrected immediately.

922. During initial operation, more frequent inspection, adjustment, cleaning, etc., will be required.

93. It is essential that individuals making inspections be thoroughly familiar with all operating procedures and equipment functions and be capable of rendering sound judgment as to when equipment is in reliable operating condition.

94. 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 the specific plant operation and equipment involved.

941. DAILY

(a) Flame failure detection system.

(b) Low water level cutout and alarm.

942. WEEKLY

(a) Igniter and burner operation.

943. MONTHLY

(a) Fan and airflow interlocks.

(b) Fuel safety shut-off valve(s) for leakage.

(c) Low fire start interlock.

(d) High steam pressure interlock.

(e) For Oil: Fuel pressure and temperature interlocks.

(f) For Gas: (1) Gas cleaner and drip leg.

(2) High and low fuel pressure interlocks.

944. SEMIANNUALLY or annually, as required:

(a) Igniter and burner components

(b) Combustion air supply system.

(c) Flame failure system components.

(d) Piping, wiring and connections of all interlocks and shut-off valves.

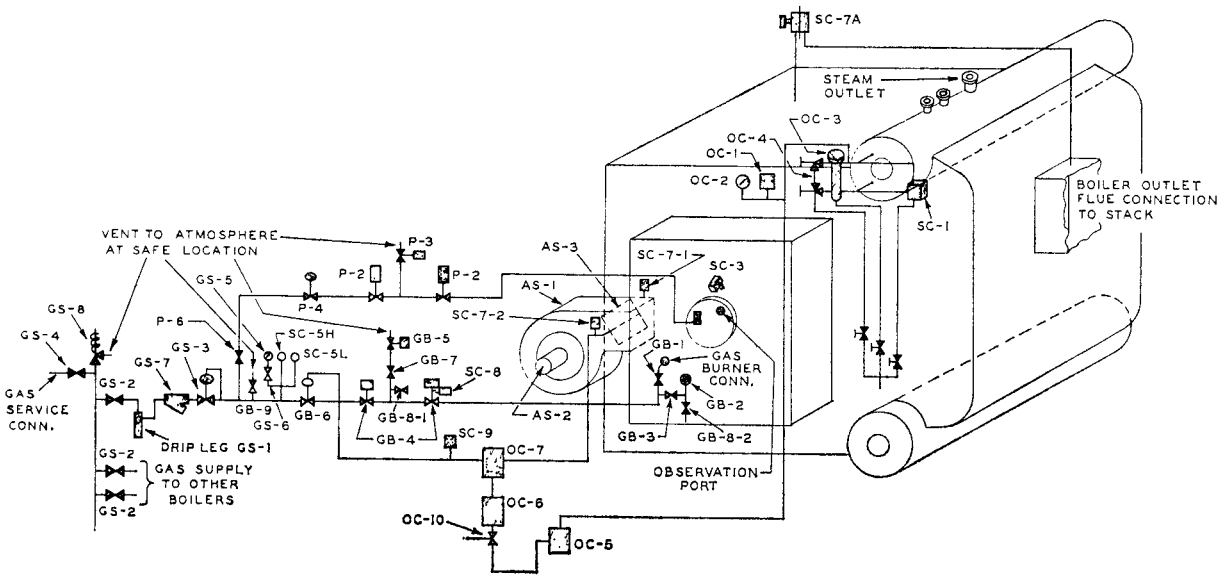
(e) Combustion control system.

(f) Calibration of indication and recording instruments.

945. AS REQUIRED FOR OIL FIRING.

(a) Atomizers.

(b) Strainers.



APPENDIX A

NATURAL GAS FIRING ONLY

Typical Schematic Arrangement of Safety Equipment
Natural Gas-Fired Watertube Boiler with One (1) Burner
Automatic (recycling) or Automatic (nonrecycling) Controls

APPENDIX A — LEGEND

Gas Supply System:

GS-1 Drip leg
GS-2 Manual plug cock
GS-3 Gas supply pressure reducing valve
GS-4 Manual gas supply shut-off valve
GS-5 Gas supply pressure gage
GS-6 Gas supply pressure gage cock
GS-7 Gas cleaner
GS-8 Relief valve

Air System:

AS-1 Forced draft fan
AS-2 Forced draft fan motor
AS-3 Forced draft fan control damper at inlet or outlet

Igniter (Pilot) System:

P-2 Safety shut-off valves, auto. opening, spring closing (NC)
P-3 Vent valve, auto. closing, spring opening (NO)
P-4 Gas pressure regulating valve optional depending on igniter pressure requirements
P-6 Manual plug cock

Gas Burner System:

GB-1 Manual plug cock
GB-2 Gas burner pressure gage
GB-3 Gas burner pressure gage cock
GB-4 Safety shut-off valves, auto. opening, spring closing (NC)
GB-5 Vent valve, auto. closing, spring opening (NO)
GB-6 Gas fuel control valve
GB-7 Vent line manual plug cock (locked or sealed in open position)
GB-8-1 Leakage test conn. upstream safety S.O. valve
GB-8-2 Leakage test conn. downstream safety S.O. valve
GB-9 Manual plug cock for venting high pressure from supply when required

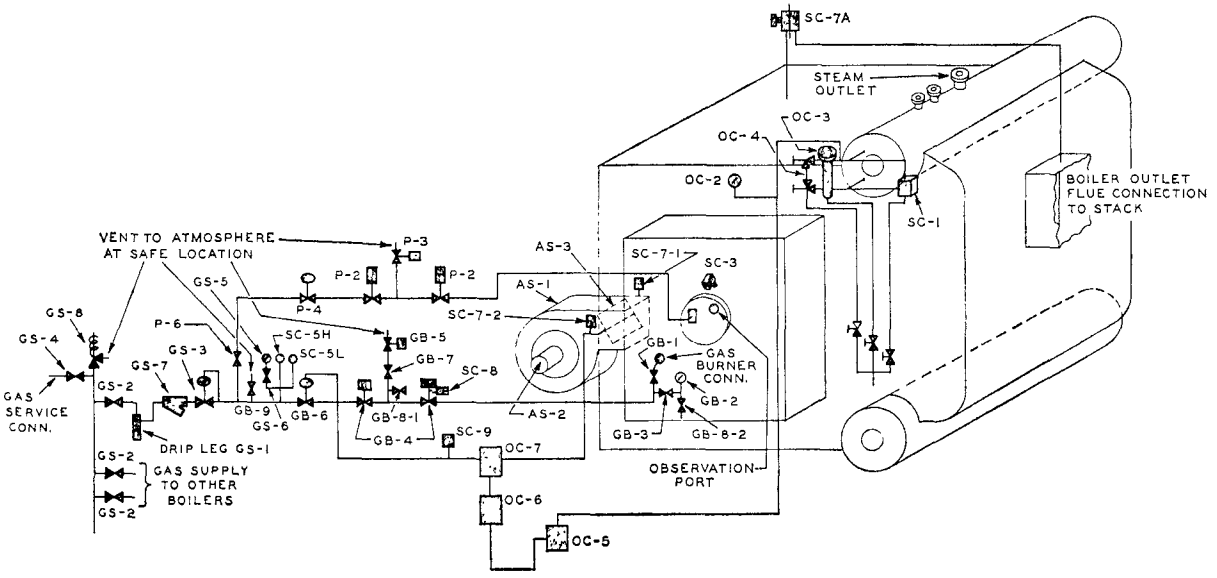
Safety Controls: (All switches in "hot" ungrounded lines. See 4662)

SC-1 Low water cut out integral with column or separate from water column
SC-3 Flame scanner
SC-5H Gas supply high pressure switch
SC-5L Gas supply low pressure switch
SC-7-1 Windbox pressure switch (note 2)
SC-7-2 Fan damper position switch (note 2)
SC-7A Purge A.F. switch (note 2)
SC-8 Closed position interlock on GB-4
SC-9 Light-off position interlock

Operating Controls & Instruments:

OC-1 High steam pressure switch (note 1)
OC-2 Steam drum pressure gage
OC-3 Water column with high & low level alarms
OC-4 Water gage and valves
OC-5 Steam pressure controller
OC-6 Manual auto. selector station
OC-7 Combustion control drive unit or units
OC-10 Modulating control low fire start positioner

NOTES: 1. With automatic (non-recycling) control an overpressure shutdown requires manual restart.
2. Purge airflow may be proved by providing either SC-7-1 and SC-7-2 (and similar devices for other dampers which are in series) or SC-7A.



APPENDIX B

NATURAL GAS FIRING ONLY

Typical Schematic Arrangement of Safety Equipment
Natural Gas-Fired Watertube Boiler with One (1) Burner
Supervised Manual Controls

Gas Supply System:

GS-1 Drip leg
GS-2 Manual plug cock
GS-3 Gas supply pressure reducing valve
GS-4 Manual gas supply shut-off valve
GS-5 Gas supply pressure gage
GS-6 Gas supply pressure gage cock
GS-7 Gas cleaner
GS-8 Relief valve

Air System:

AS-1 Forced draft fan
AS-2 Forced draft fan motor
AS-3 Forced draft fan control damper at inlet or outlet

Igniter (Pilot) System:

P-2 Safety shut-off valves, auto. opening, spring closing (NC)
P-3 Vent valve, auto. closing, spring opening (NO)
P-4 Gas pressure regulating valve optional depending on igniter pressure requirements
P-6 Manual plug cock

Gas Burner System:

GB-1 Manual plug cock
GB-2 Gas burner pressure gage
GB-3 Gas burner pressure gage cock
GB-4 Safety shut-off valves, spring closing (NC)
GB-5 Vent valve, auto. closing, spring opening (NO)
GB-6 Gas fuel control valve
GB-7 Vent line manual plug cock (locked or sealed in open position)
GB-8-1 Leakage test conn. upstream safety S.O. valve
GB-8-2 Leakage test conn. downstream safety S.O. valve
GB-9 Manual plug cock for venting high pressure from supply when required

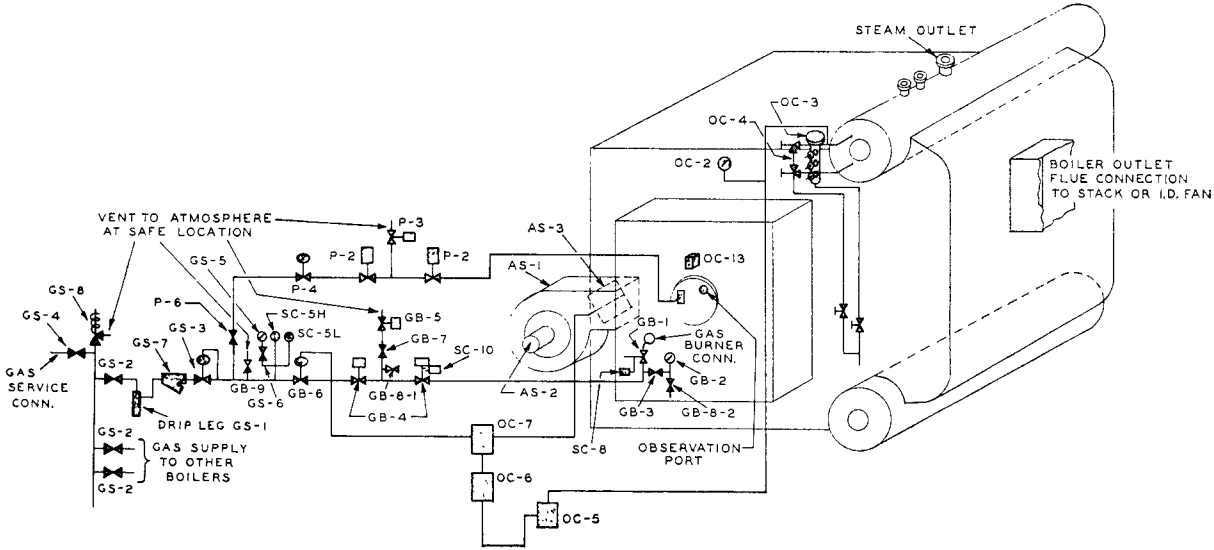
Safety Controls: (All switches in "hot" ungrounded lines. See 4662)

SC-1 Low water cut out integral with column or separate from water column
SC-3 Flame scanner
SC-5H Gas supply high pressure switch
SC-5L Gas supply low pressure switch
SC-7-1 Windbox pressure switch (note 1)
SC-7-2 Fan damper position switch (note 1)
SC-7A Purge A.F. switch (note 1)
SC-8 Closed position interlock on GB-4
SC-9 Light-off position interlock

Operating Controls & Instruments:

OC-2 Steam drum pressure gage
OC-3 Water column with high & low level alarms
OC-4 Water gage and valves
OC-5 Steam pressure controller (optional)
OC-6 Manual auto. selector station (included if OC-5 furnished)
OC-7 Combustion control drive unit or units

NOTE: 1. Purge airflow may be proved by providing either SC-7-1 and SC-7-2 (and similar devices for other dampers which are in series) or SC-7A.



APPENDIX C

NATURAL GAS FIRING ONLY

Typical Schematic Arrangement of Safety Equipment
Natural Gas-Fired Watertube Boiler with One (1) Burner
Manual Controls

Gas Supply System:

GS-1 Drip leg
GS-2 Manual plug cock
GS-3 Gas supply pressure reducing valve
GS-4 Manual gas supply shut-off valve
GS-5 Gas supply pressure gage
GS-6 Gas supply pressure gage cock
GS-7 Gas cleaner
GS-8 Relief valve

Air System:

AS-1 Forced draft fan
AS-2 Forced draft fan motor
AS-3 Forced draft fan control damper at inlet or outlet

Igniter (Pilot) System:

P-2 Safety shut-off valves, auto. opening, spring closing (NC)
P-3 Vent valve, auto. closing, spring opening (NO)
P-4 Gas pressure regulating valve optional depending on igniter pressure requirements.
P-6 Manual plug cock

Gas Burner System:

GB-1 Manual plug cock
GB-2 Gas burner pressure gage
GB-3 Gas burner pressure gage cock
GB-4 Safety shut-off valves, spring closing (NC)
GB-5 Vent valve, auto. closing, spring opening (NO)
GB-6 Gas fuel control valve
GB-7 Vent line manual plug cock (locked or sealed in open position)
GB-8-1 Leakage test conn. upstream safety S.O. valve
GB-8-2 Leakage test conn. downstream safety S.O. valve
GB-9 Manual plug cock for venting high pressure from supply when required

Safety Controls: (All switches in "hot" ungrounded lines. See 4662)

SC-5H Gas supply high pressure switch
SC-5L Gas supply low pressure switch
SC-8 Closed position interlock on GB-1
SC-10 Open position interlock on GB-4

Operating Controls & Instruments:

OC-2 Steam drum pressure gage
OC-3 Water column with high & low level alarms
OC-4 Water gage and valves
OC-5 Steam pressure controller (optional)
OC-6 Manual auto. selector station (included if OC-5 furnished)
OC-7 Combustion control drive unit or units
OC-13 Pilot manual control station