

NFPA No.

85

JUL 7 1965

EXPLOSION PREVENTION

WATERTUBE BOILER-FURNACES

OIL OR GAS-FIRED (SINGLE BURNER)

1965

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Units of Measurements

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters. One foot = 0.3048 meters. One inch = 25.40 millimeters. One pound per square inch = 0.06805 atmospheres = 2.307 feet of water. One pound = 453.6 grams.

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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 — 1965

This standard was prepared by the Sectional Committee on Industrial Units, approved by the Committee on Boiler-Furnace Explosions and adopted at the 1965 NFPA Annual Meeting on May 18, 1965.

Origin and Development of No. 85

This standard combines NFPA No. 85A, Standard for Prevention of Furnace Explosions in Natural Gas-Fired Watertube Boiler-Furnaces With One Burner, which was adopted in 1964, and NFPA No. 85C-T, Tentative Standard for Prevention of Furnace Explosions in Fuel Oil-Fired Watertube Boiler-Furnaces With One Burner, which was tentatively adopted in 1964 together with additional material covering alternate firing of gas or oil fuels.

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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 — 1965

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 functions with two Sectional Committees. The Sectional Committee on Industrial Units is concerned with watertube boilers ranging in size from 10,000 pounds of steam per hour upward to about 200,000 pounds of steam per hour. The Sectional Committee on Public Utility Units is concerned with public utility units which are generally field erected and range in size from about 200,000 pounds of steam per hour upward.

One of the more difficult parts of the preparation of this Standard was an attempt to define the term "semiautomatic" as it applies to the complete sequence of operation of a watertube boiler. Although the term is commonly encountered, the Committee found that it meant many things to many people and that all thoughts could not be resolved into a definition. Consequently, "semiautomatic" has not been included in this Standard. In its place, the terms "automatic (nonrecycling)" and "supervised manual" have been used. These terms relate to the entire operating sequence and not to the combustion controls alone and are defined in Section 4.

1. INTRODUCTION

11. Fuel explosions concern equipment manufacturers, users and owners of the equipment, and insurance carriers. Personal injury, damage to property and loss of equipment availability demand action to reduce the incidence of these boiler-furnace explosions.

12. It is recognized that advancement in engineering and improvements in equipment may result in operating systems and procedures which differ from those specifically called for in this Standard. Yet, such deviations or improvements may provide desirable safety and compatible operation meeting the intent of this Standard. Such deviations may be accepted when the authority having jurisdiction has made a special investigation of all factors and, based on sound experience and engineering judgment, concludes that the proposed deviations meet the intent of this Standard.

2. CAUSES OF BOILER-FURNACE EXPLOSIONS

21. Furnace explosions occur when sufficient quantities of fuel and air are accumulated in explosive mixtures and then ignited. Ignition energy may be supplied by the regular ignition devices, from another flame envelope, or from other sources within the furnace and boiler passes. Such accumulations of fuel and air can result from: (1) improper operating sequences, (2) inability to ignite fuel as it enters the furnace, and (3) fuel rich or unstable air/fuel ratios. These can result from improper design, application, operating procedures, maintenance, or mechanical failure of equipment components.

3. PURPOSE AND SCOPE

31. The purpose of this Standard is to establish minimum equipment requirements and operating procedures for watertube boiler furnaces, rated at 10,000 pounds of steam per hour and above, and equipped with only one burner. 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.

Manually operated and automatic units are covered beginning at their service connections.

32. Functional requirements include:

321. The fuel supply

322. The fuel burning system, consisting of:

- (a) The air supply equipment
- (b) The pilot ignition equipment
- (c) The main fuel burner equipment
- (d) The combustion products removal equipment

323. The combustion control system

324. The interlock system, covering:

- (a) Air supply
- (b) Fuel pressure
- (c) Fuel temperature (oil)
- (d) Atomizing medium (oil)
- (e) Flame proving
- (f) Water level
- (g) Steam pressure
- (h) Control system actuating energy
- (i) Combustion products removal

325. Soot blowing

4. 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, with assistance of an atomizing medium, such as steam or air.

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

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

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.*

FURNACE — An enclosure for the combustion of fuel.

GAS — (See LP-Gas and Natural Gas).

*Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pa.

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.

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.

PILOT — A burner smaller than the main burner, which is ignited by a spark or other independent and stable ignition source, and which provides ignition energy required to immediately light off the main burner.

CONTINUOUS — A pilot that burns without turn-down throughout the entire period that the boiler is in service, whether or not the main burner is firing.

INTERMITTENT — A pilot which burns during light-off, and while the main burner is firing, and which is shut off with the main burner.

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

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

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.

SEMI-AUTOMATIC — 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 safeguard is required to supervise the main burner flame only.

5. EQUIPMENT REQUIREMENTS

51. Fuel Supply (Oil)

511. 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.

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

5121. Fuel shall be continuously delivered to the combustion chamber in a finely divided form that can be readily ignited and consumed.

5122. All equipment associated with pumping, heating, and straining the fuel from storage to the service connection should 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 should be installed after the pump to prevent over-pressure in the system.

5123. 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.

5124. 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.

NOTE: It is possible that heavy oil in dead-end lines will tend to solidify. Precautions should be taken to avoid this.

5125. 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.

52. Fuel Supply (Gas)

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

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

523. 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.

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

53. Alternate Fuel Firing

531. 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.

54. Fuel Burning Equipment

541. IGNITION

5411. The main burner shall be equipped with an interrupted or intermittent spark ignited oil or gas pilot as follows:

- (a) For burners designed for oil firing only, interrupted pilots shall be used.
- (b) For burners designed for gas firing only, interrupted or intermittent pilots may be used.
- (c) For burners designed for alternate firing of oil or gas, interrupted pilots shall be used.

5412. The pilot flame 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.

5413. The pilot assembly shall be easily removable for inspection and maintenance.

5414. If LP-Gas pilots are used, special attention is required to materials of construction in valves and their lubrication.

542. MAIN BURNER

5421. 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.

5422. The burner shall be provided with at least one convenient observation port of a size to permit satisfactory visual inspection of the pilot and main burner flames.

5423. Any manual adjustment features on the burner shall be provided with positive locking devices.

5424. The atomizing equipment for oil burners shall be designed for convenient removal, cleaning and maintenance.

5425. If an oil burner is equipped with a single atomizer and if provisions for clearing the passages of the atomizer into the furnace are included, such clearing should be done after a normal shutdown with the pilot ignited and the fan operating.

5426. Clearing of the oil passages of the atomizer into the furnace immediately after a safety shutdown shall be prohibited.

543. ATOMIZING MEDIUM FOR OIL BURNERS

5431. 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.

5432. The atomizing medium shall be provided at the pressures required for proper operation.

5433. Provisions shall be made to insure that fuel cannot enter the atomizing medium line during or after operation.

544. AIR SUPPLY

5441. 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.

5442. Provision shall be made for convenient cleaning of the air supply equipment.

545. MAIN COMBUSTION CHAMBER

5451. The main combustion chamber shall be designed to promote main burner stability while minimizing zones which cannot be purged.

5452. At least one observation port should be provided to permit observation of the burner flame and furnace.

546. COMBUSTION PRODUCTS REMOVAL

5461. The outlet draft equipment shall be capable of removing combustion products without adversely affecting stable flame conditions.

5462. 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.

55. Combustion Control System

551. 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.

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

553. 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.

56. Interlock System

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

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

5621. Approved equipment shall be used whenever possible.

5622. 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.

5623. 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.

5624. Interlock devices shall be able to perform under high and low temperature, humidity, vibration, and corrosive ambient conditions.

5625. 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.

563. The interlock on the low water cut-out may be bypassed for blow down purposes only. This bypass should be of a type which is manually held closed during blow down. For oil firing certain bypassing of interlocks may be necessary for cold starts. See Section 6.

564. No interlocks shall be manually bypassed at any time during normal operation except as provided in 563.

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

5651. Safety control circuits shall be two wire, one side grounded, preferably not exceeding nominal 120 volts and shall be protected with suitable fuses, or circuit breakers.

5652. Switching contacts shall be in the "hot" ungrounded line.

5653. Ungrounded DC control circuits shall have switching

contacts in one side of the line. Ground fault detectors shall be provided.

566. FLAME SAFETY SHUTDOWN SYSTEM

5661. The time interval between loss of flame and stopping the fuel flow to the burner shall be not more than two seconds.

5662. The fuel safety shutoff valve(s) are the "key unit" of all safety shutdown systems.

5663. 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.

6. METHODS OF STARTING A COLD BOILER

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

62. For cold start of a boiler normally fired with gas or No. 2 or 4 oil:

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

63. For cold start of a boiler normally fired with steam atomizing burner for No. 5 or 6 oil:

631. In the event that frequent starting of a cold boiler becomes necessary without steam available for heating Nos. 5 and 6 oils or as an atomizing medium where required, one of the starting methods described in 632, 633 and 634 should be used.

NOTE: Other methods have been developed, but their use is not sufficiently widespread to include them.

632. AUXILIARY AIR ATOMIZING OF HEAVY OIL

6321. 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.

6322. FACILITIES REQUIRED

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

6323. 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 7 using air as the atomizing medium.
- (c) Set combustion control in manual position 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 7.
- (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.

633. AUXILIARY MECHANICAL ATOMIZING OF HEAVY OIL**6331. 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.

6332. 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 7.
- (e) Set combustion control in manual position 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 7.
- (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.

634. AUXILIARY MECHANICAL ATOMIZING OF LIGHT (UNHEATED) OIL

6341. 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.

6342. FACILITIES REQUIRED

- (a) Light oil supply.

6343. 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 7.
- (f) Set combustion control in manual position 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 7.
- (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.

7. OPERATING SYSTEMS

71. Section 7 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.

72. Automatic (Recycling) Systems

721. 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.

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

723. A pilot as specified in 5411 shall be provided.

724. 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

7241. 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.

7242. The light-off cycle for a burner with an interrupted pilot shall accomplish the following in the order listed:

- (a) Ignite pilot.
- (b) Prove pilot flame within 10 seconds (pilot 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 pilot and, with gas pilot, vent the gas piping between pilot safety shutoff valves to atmosphere.
- (d) Prove main flame.
 - (1) If proven, release to modulating control.
 - (2) If not proven, establish *safety shutdown*.

7243. The light-off cycle for a burner with an intermittent pilot shall accomplish the following in the order listed:

- (a) Ignite pilot.
- (b) Prove pilot 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*.

7244. Modulation shall be accomplished by a combustion control system.

7245. 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 pilot if in operation.
 - (2) Vent gas piping between safety shutoff valves to atmosphere.
- (d) Shut down fan, if desired.

7246. 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.

7247. 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 pilot 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) Shut down fan, if desired.
- (g) Lock out sequence control to require manual reset.

7248. 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.

73. Automatic (Nonrecycling) Systems

731. The provisions of 721, 722, 723, and 724 shall apply except for 7246 (see 7311).

7311. When high steam pressure establishes a normal shutdown, the burner shall not be allowed to recycle. A qualified operator shall initiate the re-start.

74. Supervised Manual Systems for Oil

741. 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.

742. 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.

743. A pilot as specified in 5411 shall be provided.

744. PREFIRING CYCLE

Operator Functions

- (a) Check manual fuel shutoff valve(s) closed.
- (b) Start fan.
- (c) Where used, open atomizing medium valve.
- (d) Open damper(s) to purge position.
- (e) Start purge timer.
- (f) Place damper and fuel control valve in light-off position.
- (g) None.

Interlock Functions

- (a) Manual fuel shutoff valve closed.
- (b) Fan on.
- (c) Atomizing medium supply available.
- (d) (1) Air pressure and open damper(s), or
(2) Air flow.
- (e) Purge complete.
- (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) Spark and pilot and main safety shutoff valves operable.

745. LIGHT-OFF CYCLE

Operator Functions

- (a) Close recirculating valve, where used.
- (b) Start pilot ignition system.
- (c) Open fuel safety shutoff valve to main burner.
- (d) Open manual fuel shutoff valve.
- (e) Bring unit to preset operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.
- (f) On reaching preset pressure range, change to automatic combustion control.

Interlock Functions

- (a) None.
- (b) Prove pilot. If air flow is less than purge air flow rate, pilot shall be proven within 10 seconds.
- (c) None.
- (d) Prove main flame within 10 seconds for Nos. 2 and 4 oils or 15 seconds for Nos. 5 and 6 oils. Close pilot safety shutoff valve(s). For gas pilot, vent gas piping between safety shutoff valves.
- (e) None.
- (f) None.

746. NORMAL SHUTDOWN CYCLE**Operator Functions**

- (a) Shut off fuel supply to the main burner.
- (b) Open fuel recirculating valve, where used.
- (c) Where used, shut off atomizing medium.
- (d) Remove fuel atomizer.
- (e) Shut down fan if desired.

Interlock Functions

- (a) Fuel safety shutoff valve(s) to main burner closed.
- (b) None.
- (c) None.
- (d) None.
- (e) None.

747. SAFETY SHUTDOWN CYCLE**Operator Functions**

- (a) None.
- (b) None.

Interlock Functions

- (a) Shut off fuel supply to the main burner and shut off fuel supply and interrupt spark to the pilot if in operation.
- (b) With gas pilot, vent gas piping between safety shutoff valves to atmosphere.

748. 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.

749. 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.

75. Supervised Manual Systems for Gas

751. 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.

752. 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.

753. A pilot as specified in 5411 shall be provided.

754. PREFIRING CYCLE

Operator Functions

- (a) Check gas safety shutoff valves closed.
- (b) Start fan.
- (c) Open damper(s) to purge position.
- (d) Start purge timer.
- (e) Place damper and gas control valve in light-off position.

Interlock Functions

- (a) Gas safety shutoff valves closed.
- (b) Fan motor on.
- (c) (1) Air pressure and open damper(s), or
(2) Air flow.
- (d) Purge complete.
- (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.

755. LIGHT-OFF CYCLE

Operator Functions

- (a) Start pilot ignition system.
- (b) Open gas safety shutoff valves to main burner.
- (c) Bring unit to preset operating pressure at an acceptable rate, maintaining an optimum air/fuel ratio.
- (d) On reaching preset pressure range, change to automatic combustion control.

Interlock Functions

- (a) Prove pilot. If air flow is less than purge air flow rate, pilot shall be proved within 10 seconds.
- (b) Prove main flame within 10 seconds.
- (c) None.
- (d) None.

756. NORMAL SHUTDOWN CYCLE

Operator Functions

- (a) Shut off gas supply and interrupt spark to the main burner and to the pilot if in operation.
- (b) Shut down fan if desired.

Interlock Functions

- (a) Vent gas piping between safety shutoff valves to atmosphere.
- (b) None.

757. SAFETY SHUTDOWN CYCLE**Operator Functions**

(a) None.

(b) None.

Interlock Functions

(a) Shut off gas supply to the main burner and shut off fuel supply and interrupt spark to the pilot if in operation. Where used, simultaneously energize interlocking system.

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

758. 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.

76. Manual Systems

761. While the requirements and functions in Nos. 71, 72, 73, 74 and 75 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 7611, 7612, 7613, 7614 and 7615 shall be observed.

7611. A pilot as specified in 5411 shall be provided.

7612. 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 pilot can be energized and the pilot and main gas safety shutoff valves can be opened.

7613. 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.

7614. 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.

7615. 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.

8. SOOT BLOWING

81. 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.

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

812. Boilers equipped with automatic soot blowing equipment shall have their controls interlocked to prevent operation when the burner is shut down or in the prefire or light-off cycles.

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. Minimum Schedule:

941. DAILY

- (a) Check flame failure detection system.
- (b) Test low water level cutout and alarm.

942. WEEKLY

- (a) Check pilot.

943. MONTHLY

- (a) Test all fan and air pressure interlocks.
- (b) Check main burner safety shutoff valve(s) for leakage.
- (c) Check low fire start switch.
- (d) For Oil:
 - (1) Test fuel pressure and temperature interlocks.
- (e) For Gas:
 - (1) Check gas cleaner and drip leg.
 - (2) Test high and low fuel pressure switches.

944. SEMIANNUALLY

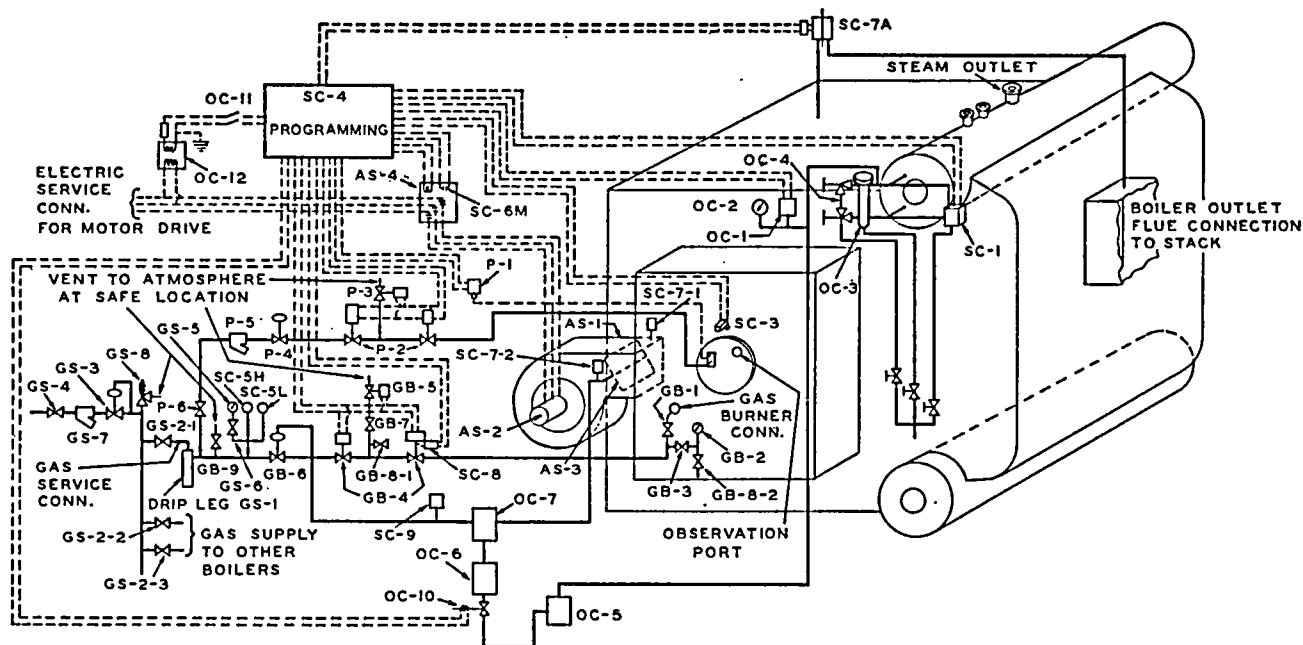
- (a) Inspect burner components.
- (b) Check flame failure system components, such as vacuum tubes, amplifier, and relays.
- (c) Check piping and wiring of all interlocks and shutoff valves.
- (d) Recalibrate all indicating and recording gages.

945. ANNUALLY

- (a) Replace vacuum tubes, scanners, or flame rods in the flame failure system.
- (b) Test all coils, diaphragms, and other operating parts of all safety shutoff and control valves.
- (c) Recondition low water cutout.

946. AS REQUIRED FOR OIL FIRING

- (a) Remove and clean atomizers.
- (b) Clean oil strainers.

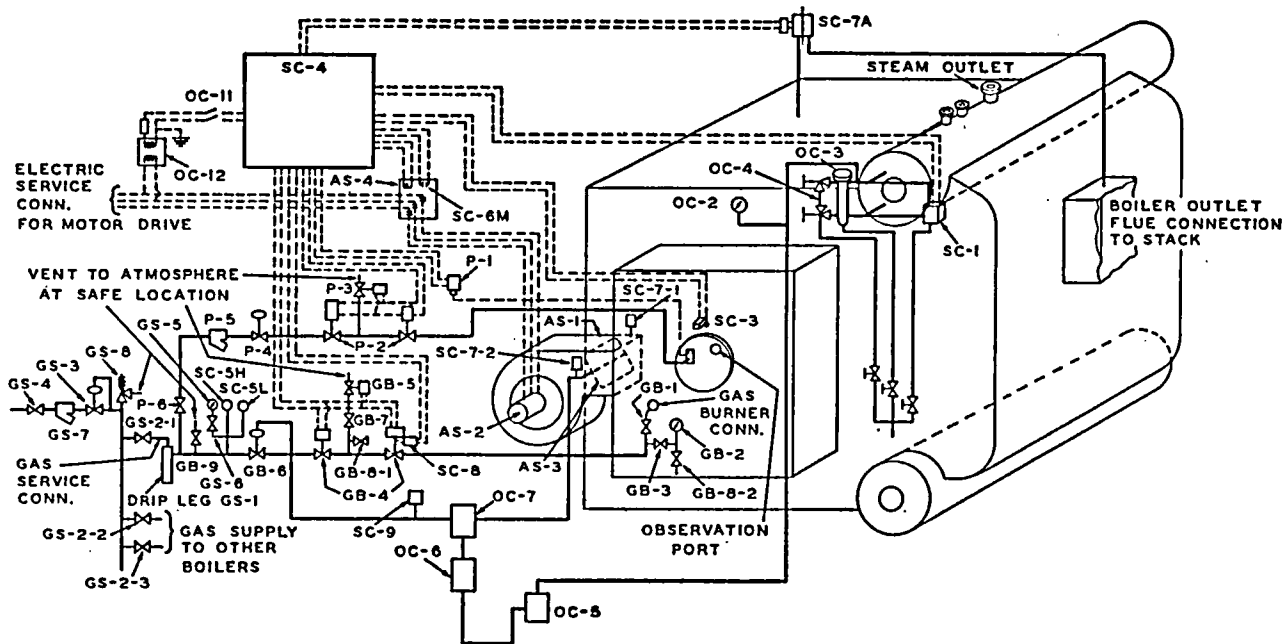


APPENDIX A
NATURAL GAS FIRING ONLY
 Typical Schematic Arrangement of Safety Equipment
 Natural Gas-Fired Watertube Boiler with One (1) Burner
 Automatic (recycling) or Automatic (nonrecycling) Controls

APPENDIX A

85-29

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.

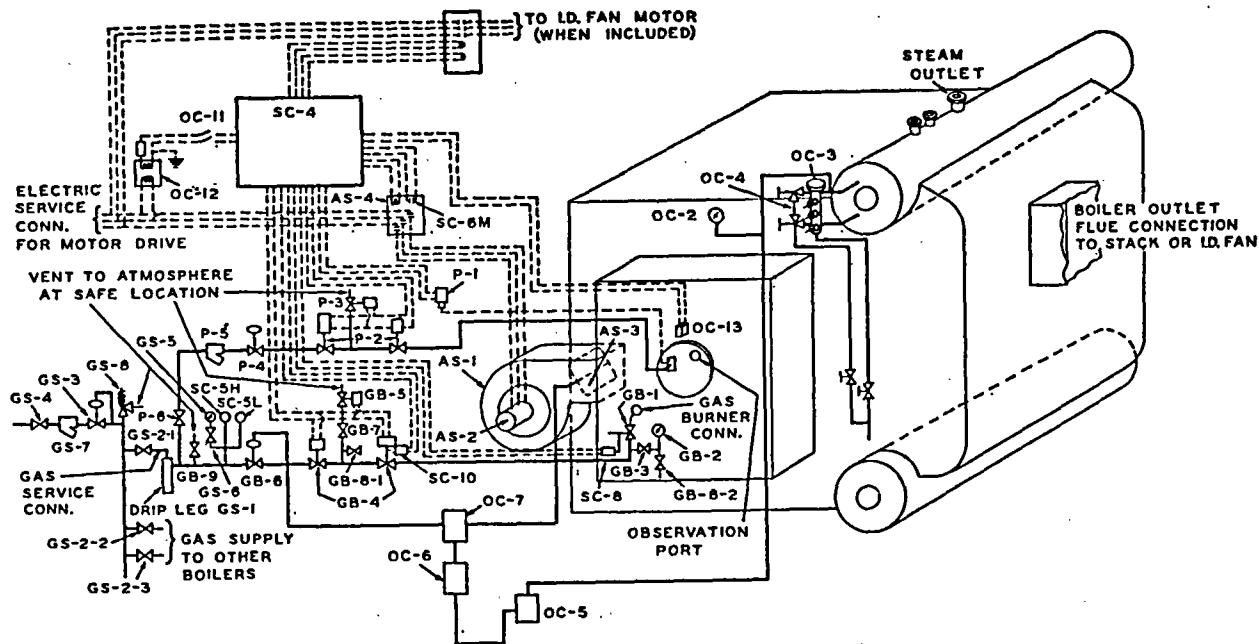


APPENDIX B
NATURAL GAS FIRING ONLY
 Typical Schematic Arrangement of Safety Equipment
 Natural Gas-Fired Watertube Boiler with One (1) Burner
 Supervised Manual Controls

APPENDIX B — LEGEND

Gas Supply System: GS-1 Drip leg GS-2-1 Manual plug cock, required only when single pressure reducing valve serves more than one boiler 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	P-5 Gas cleaner 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 5652) SC-1 Low water cut out integral with column or separate from water column	SC-3 Flame scanner SC-4 Control cabinet (contains lights, switches, relays, timers, etc.) SC-5H Gas supply high pressure switch SC-5L Gas supply low pressure switch SC-6M Loss of air supply aux. contact in motor starter 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
Air System: AS-1 Forced draft fan AS-2 Forced draft fan motor AS-3 Forced draft fan control damper at inlet or outlet AS-4 Forced draft fan motor starter Pilot System: P-1 Pilot ignition transformer 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 pilot pressure requirements		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-11 Manual operating switch OC-12 Control transformer

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

APPENDIX C — LEGEND

Gas Supply System:

- GS-1 Drip leg
- GS-2-1 Manual plug cock, required only when single pressure reducing valve serves more than one boiler
- 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
- AS-4 Forced draft fan motor starter

Pilot System:

- P-1 Pilot ignition transformer
- 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 pilot pressure requirements.
- P-5 Gas cleaner
- P-6 Manual plug cock

Gas Burner System:

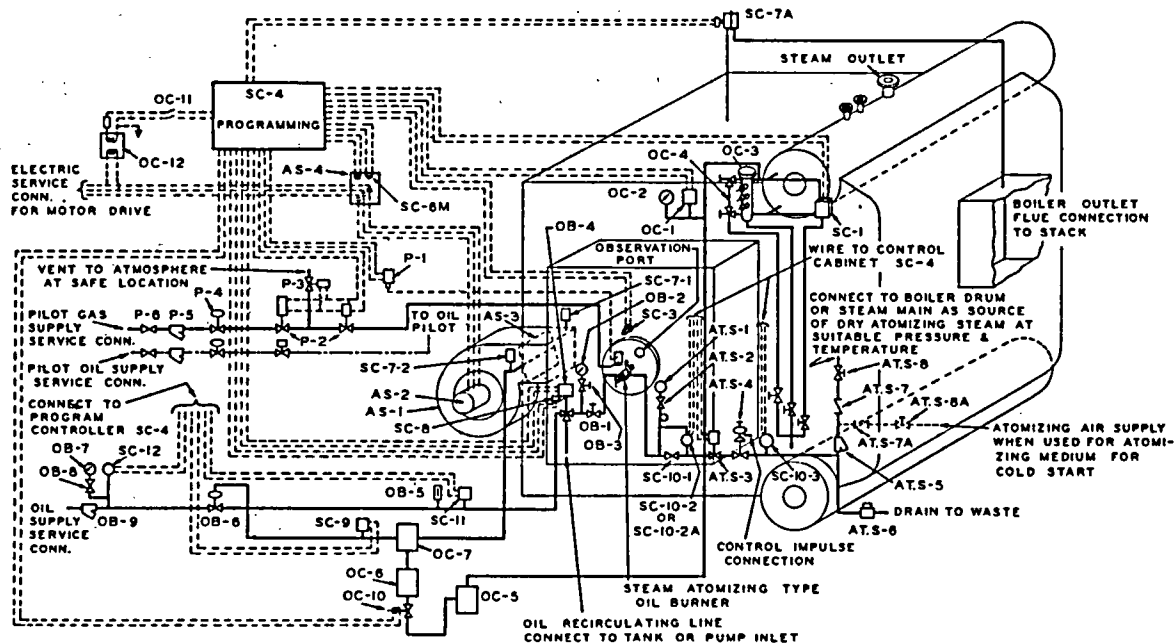
- GB-1 Manual plug cock
- GB-2 Gas burner pressure gage
- GB-3 Gas burner pressure gage cock
- GB-4 Safety shut-off valves, spring closing (NC)
- GB-5 Vent valve, auto. closing, spring opening (NO)
- GB-6 Gas fuel control valve
- GB-7 Vent line manual plug cock (locked or sealed in open position)
- GB-8-1 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 5652)

- SC-4 Control cabinet (contains lights, switches, relays, timers, etc.
- SC-5H Gas supply high pressure switch
- SC-5L Gas supply low pressure switch
- SC-6M Loss of air supply aux. contact in motor starter
- SC-8 Closed position interlock on GB-1
- SC-10 Open position interlock on GB-4

Operating Controls & Instruments:

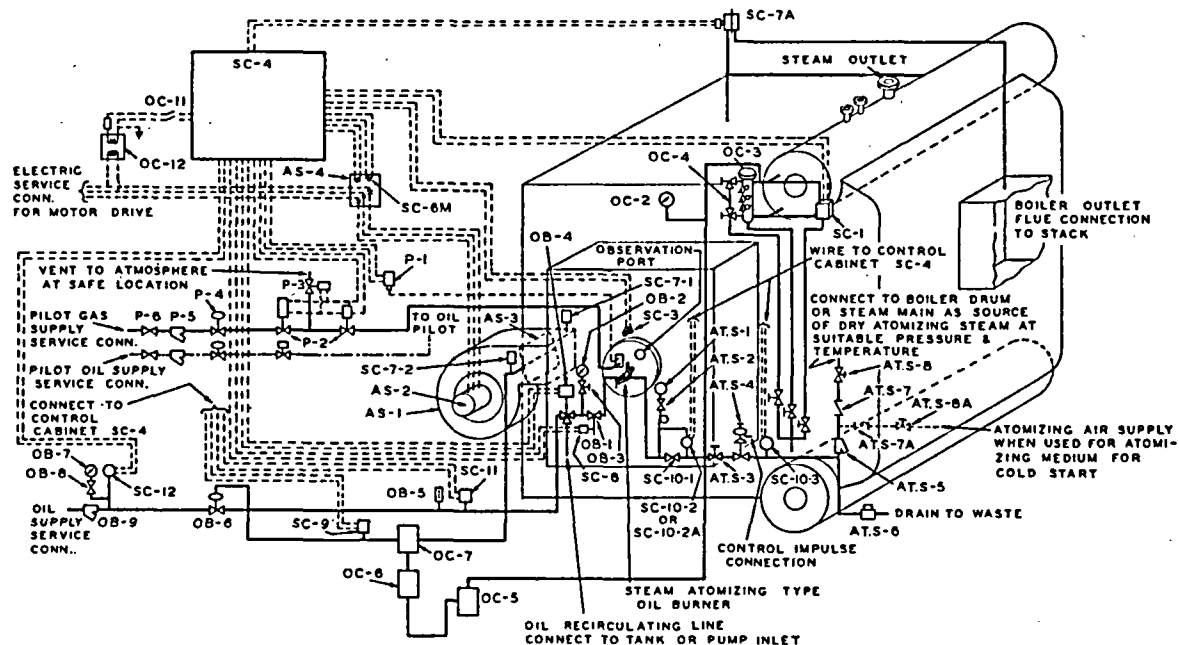
- OC-2 Steam drum pressure gage
- OC-3 Water column with high & low level alarms
- OC-4 Water gage and valves
- OC-5 Steam pressure controller (optional)
- OC-6 Manual auto. selector station (included if OC-5 furnished)
- OC-7 Combustion control drive unit or units
- OC-11 Manual operating switch
- OC-12 Control transformer
- OC-13 Pilot manual control station



APPENDIX D — LEGEND

Atomizing Steam System:		P-4	Pressure regulating valve — optional depending on pilot pressure requirements.	SC-7A	Purge airflow switch (Note 2)
ATS-1	Burner atomizing steam pressure gage	P-5	Strainer	SC-8	Closed position interlock on OB-4
ATS-2	Burner atomizing steam pressure gage cock	P-6	Manual plug cock	SC-9	Light-off position interlock
ATS-3	Atomizing steam shut-off valve	Oil Burner System:		SC-10-1	Atomizing steam flow interlock orifice
ATS-4	Atomizing steam differential pressure control valve	OB-1	Manual oil shutoff valve	SC-10-2	Atomizing steam flow interlock differential pressure switch
ATS-5	Atomizing steam supply strainer	OB-2	Oil burner pressure gage	SC-10-2A	Atomizing steam pressure interlock switch
ATS-6	Atomizing steam supply trap	OB-3	Oil burner pressure gage cock	SC-10-3	Atomizing steam supply pressure interlock switch
ATS-7	Atomizing steam supply check valve	OB-4	Safety shutoff and recirculating valve	SC-11	Low oil temperature interlock (Note 4)
ATS-7A	Atomizing air supply check valve	OB-5	Oil temperature thermometer or gage (Note 4)	SC-12	Low oil supply pressure interlock
ATS-8	Atomizing steam supply shut-off valve	OB-6	Oil control valve	Operating Controls & Instruments:	
ATS-8A	Atomizing air supply shut-off valve	OB-7	Oil supply pressure gage	OC-1	High steam pressure switch (Note 1)
Air System:		OB-8	Oil supply pressure gage cock	OC-2	Steam drum pressure gage
AS-1	Forced draft fan	OB-9	Oil strainer	OC-3	Water column with high & low level alarms
AS-2	Forced draft fan motor	Safety Controls: (All switches in "hot" ungrounded lines. See 5652)		OC-4	Water gage and valves
AS-3	Forced draft fan control damper at inlet or outlet	SC-1	Low water cut out integral with column or separate from water column	OC-5	Steam pressure controller
AS-4	Forced draft fan motor starter	SC-3	Flame scanner	OC-6	Manual auto. selector station
Pilot System — Gas or Oil:		SC-4	Program controller (contains lights, switches, relays, timers, etc.)	OC-7	Combustion control drive unit or units
P-1	Pilot ignition transformer	SC-6M	Loss of air supply aux. contact in motor starter	OC-10	Modulating control low fire start positioner
P-2	Safety shutoff valves — auto. opening, spring closing (NC)	SC-7-1	Windbox pressure switch (Note 2)	OC-11	Manual operating switch
P-3	Vent valve — auto. closing, spring opening (NO)	SC-7-2	Fan damper position switch (Note 2)	OC-12	Control transformer

- 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.
 3. Atomizing steam interlock may be accomplished by providing either SC-10-1 and SC-10-2 or SC-10-2A and SC-10-3.
 4. Temperature interlock and thermometer omitted for light oils which do not require heating.
 5. Arrangement shown is applicable to straight mechanical pressure atomizing oil burners by omitting atomizing steam system.



APPENDIX E

OIL FIRING ONLY

**Typical Schematic Arrangement of Safety Equipment
Fuel Oil-Fired Watertube Boiler with One (1) Burner
Supervised Manual Controls**