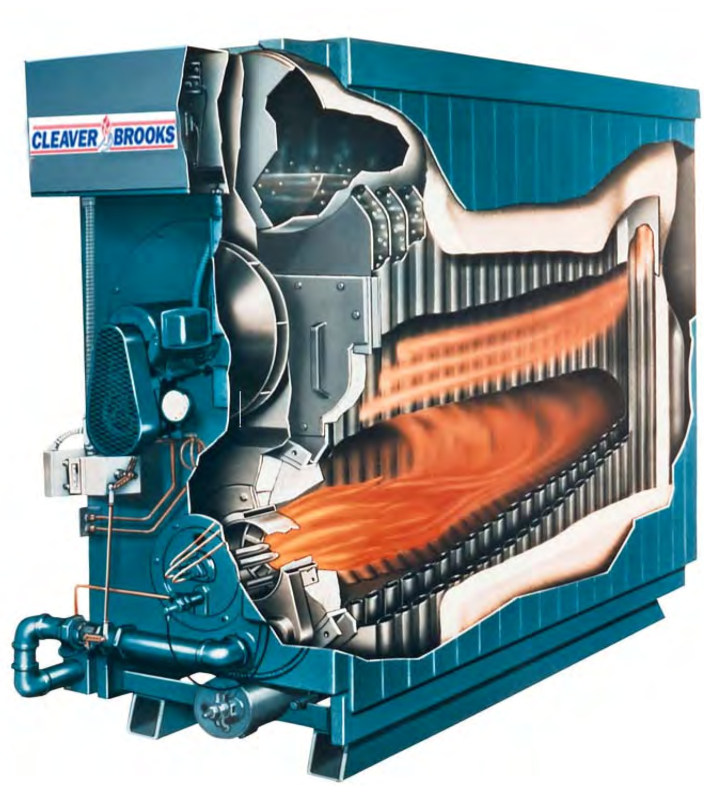
CLEAVER-BROOKS

Model 4 Boiler

Operation and Maintenance Manual



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Model 4

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CHAPTER 1

Introduction

1.1 — Model M4 Features and Benefits

1.1.1 — Compact Watertube Design

The Model M4 boiler is a compact horizontally fired watertube boiler (Figure 1-1) of the three-pass heat transfer design. Two rows of membrane watertube design provide a very high level of performance in a small footprint (fits through a standard 36" doorway). The Model M4 is designed to fire natural gas or light fuel oil as standard or when optionally equipped, and it can fire LP Gas or Digester Gas.

1.1.2 — Construction

Built in an IS) 9001 certified manufacturing facility and in accordance with the AMerican Society of Mechanical Engineers (ASME) Code, high quality design, safety, and reliability are ensured. The burner and controls are in accordance with UL standards and relative to the project requirements may also include compliance with Factory Mutual (FM), XL-GAPS (formerly IRI), NFPA 85 or other underwriting standards.

1.1.3 — Ease of Maintenance

The front burner windbox is mounted onto the front of the boiler and secured with a pivoting hinge. This permits the windbox and burner to swing away from the boiler providing full access to the fan, burner internals and via an access door on the vessel, access to the furnace for fireside inspection and maintenance. Handholes are provided in the upper drum and lower drum to provide visual inspection of the waterside. A hinged door on the control panel provides access to the electrical controls and wiring interface.

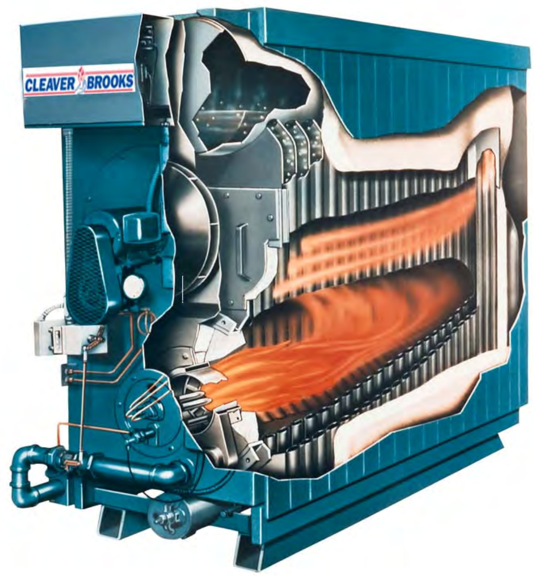

FIGURE 1-1. **Model 4 Cutaway View**

1.1.4 — Burner Control Simplicity

As standard, the integral burner operates on the modulating firing rate principle with linkage connections from the damper drive motor to the fuel input control valve for gas and via electronics, staged input for the oil firing valves from low to high firing. Simple modulating control provides high efficiency of the burner at all firing rates. As an option, the gas side may be equipped with linkageless electronics for the fuel air ratio control to afford precise repeatability of the firing rate control.

1.1.5 — Designed for Steam or Hot Water

The M4 is applicable for steam service at low pressure 15 psig design or high pressure of 150 psig design. As an option the M4 can be built to 600 psig design for high pressure process applications. For hot water, the M4 is designed for 140 psig and maximum operating temperature of 235º F as standard with an option to 250 psig and 350º F temperature.

1.2 — The Model M4 Boiler

Traditionally, commercial application boilers are rated in Btu/hr input which indicates the maximum burner firing rate. Relative to this input, one normally utilizes a nominal 80% factor of efficiency to determine the rated output of the boiler, whether for steam service or hydronic heating. This can then be converted to relative horsepower (1 BHP = 33,475 Btu/hr). The table below denotes the M4 input ratings, corresponding horsepower ratings, and Btu/hr output. Specific information of the project's boiler can be found on the dimensional diagram for the application.

TABLE 1-1. Model M4 Boiler Sizes

Boiler Size	Input MBH	Heat Output MBH	Equivalent HP	Steam LB/hr
1500	1500	1200	35	1237
2000	2000	1600	47	1649
2500	2500	2000	59	2062
3000	3000	2400	71	2474
3500	3500	2800	83	2887
4000	4000	3200	95	3299
4500	4500	3600	107	3711
5000	5000	4000	119	4124
6000	6000	4800	143	4949

Steam boilers are designed and built in accordance with ASME Section IV for 15 psig design with an H Stamping for Heating Boilers and in accordance with ASME Section I for 150 psig design with an S Stamping for High Pressure Steam. Hot Water Boilers are designed and built in accordance with ASME Section IV for 140 psig with an H Stamping for heating boilers. Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler, and is referred to as Maximum Allowable Working Pressure (MAWP). This is not to be interpreted as the normal operating pressure.

Typically, the safety valves are set at or below the stamped design pressure (MAWP). Operating pressure is the pressure of the boiler at which it normally operates. In order to prevent the safety valve from opening too frequently during normal operation, the operating pressure should not exceed 90% of the safety valve setting or 5 psig below the valve setting, whichever is greatest. For example

- steam application: 150 psig safety valve setting, maximum operating pressure should not exceed 135 psig.
- hot water: Relief valve set at 30 psig, operating pressure of the hydronic system should not exceed 25 psig. Note that for hydronic systems, a minimum operating pressure of 10 psig should be maintained.

As with any boiler, waterside care and maintenance are of critical importance. Planned attention to water requirements will pay dividends in the form of longer life, less downtime, and prevention of costly repairs.

For steam applications, feedwater equipment should be ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

1.3 — Water Treatment

Properly treated boiler water will result in maximum effectiveness and long trouble-free life of the pressure vessel. Contact your local Cleaver-Brooks representative or water treatment consultant for complete information on how to prevent damage from inadequate water treatment.

⚠ Caution

The Model 4 boiler requires soft water. Failure to observe this requirement can lead to improper operating conditions, and may result in damage to the pressure vessel.

The objectives of water treatment in general are:

- Prevent hard scale and soft sludge deposits that inhibit heat transfer and that could lead to overheated metal and costly repairs and downtime.
- Eliminate corrosive gasses in the supply or boiler water.
- Eliminate corrosive oxygen pitting of the boiler metal.

To accomplish these objectives, the boiler requires proper water treatment before and after introduction of water into the vessel. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, the amount of makeup water needed, system operating conditions, etc.

Because of the variables involved, no single boiler compound can be considered a cure-all, nor is it advisable to experiment with homemade treating methods. A sound water treatment program should include a periodic analysis of the water in the system and boiler.

Following boil out and initial commissioning, the internal waterside surfaces of the pressure vessel should be inspected at regular intervals for evidence of corrosion, pitting, contamination, or accumulations of foreign matter. If any of these conditions are seen, contact your local Cleaver-Brooks representative or authorized water treatment service for advice on corrective action. It is recommended that a properly sized water meter be installed in the raw water makeup line to accurately determine the amount of raw water admitted to the boiler.

Surface blowoff is available for steam boilers via the surface blowoff tapping in the rear of the upper steam drum. This option allows removal of surface water impurities through a blowdown line located at the normal operating water level of the boiler. If allowed to accumulate, surface impurities may impede steam release and could cause foaming, leading to priming and carryover into the steam lines.

The bottom drum includes tappings for bottom drum blowoff and should be piped with the proper code approved blowoff valves. Note for hot water units, periodic blowoff is not recommended or required, only steam units require this procedure.

Table 1-2 denotes the recommended guidelines for water conditions within the boiler. This may be used as a reference point when discussing your water treatment program and commissioning your water treatment requirements.

TABLE 1-2. Water Quality Guidelines

Constituent	Control Level
Total Hardness	1 PPM
pH	8.3 - 10.5
Specific Conductivity	2000 μmho/cm
Suspended Solids	300 PPM
O_2	0..1 mg/liter
CO_2	0
Iron	0.1 PPM

NOTE: Corrosion and sludge deposits in an old system must be removed prior to the commissioning of a new boiler. Also, a new boiler/system must be boiled out prior to operation.

The Model 4 steam boiler is a rapid steamer and requires proper make-up in the quantities listed in table 1-3. The boiler feed pump must be capabel of supplyling the listed amount to prevent nuisance shutdowns due to low water. The values are based on on/off pump operation and 1-1/2 time the evaporation rate of the boiler. If a proportional regulating valve is used in lieu of on/off operation, the make-up rate may be slightly less.

TABLE 1-3. Water Make-Up Rates

Boiler Size	Minimum Feed Rate GPM
1500	3.7
2000	4.9
2500	6.2
3000	7.5
3500	8.7
4000	9.9
4500	11.1
5000	12.4
6000	14.8

While hot water heating boilers do not require planned make-up, it is recommended that a water meter be installed on the water make-up line to the system so that an analysis of the raw water fed to the system can be made periodically. Any make-up should be softened before introducing into the boiler or system.

Proper care in placing the pressure vessel into initial service is vital, as the waterside of the new boiler and new or remodeled systems may contain oil, grease, or other foreign matter that must be removed before the boiler is fully integrated into the application.

Refer to Figures 1-2, 1-3, and 1-4 for general locations of the standard controls and equipment of the steam and hot water M4 boilers. Models are designated by the fuel that is used:

Model designation 700 = straight gas firing

Model designation 200 = gas firing or oil firing

Model designation 100 = straight oil firing

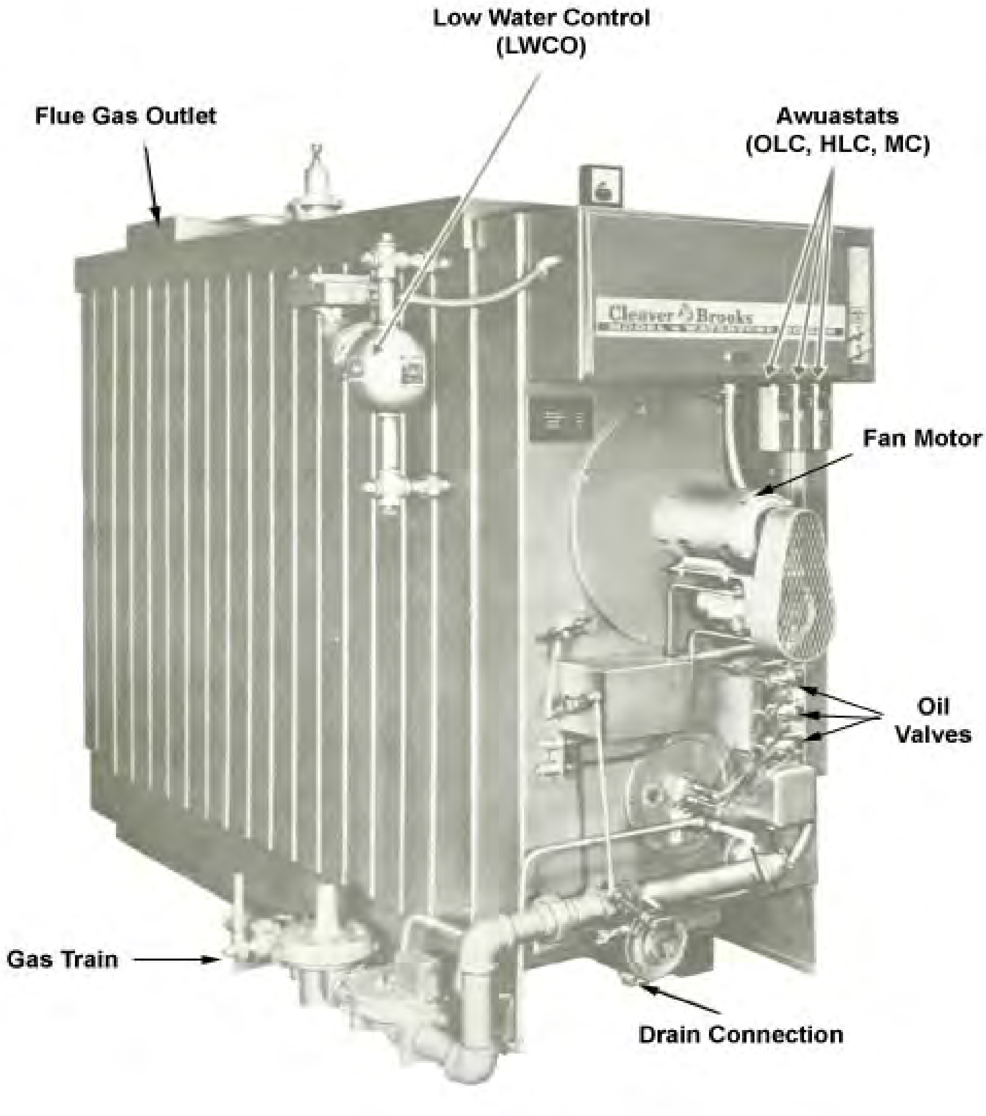

FIGURE 1-2. **Model 4 Hot Water Boiler: Light Oil and Gas Fired**

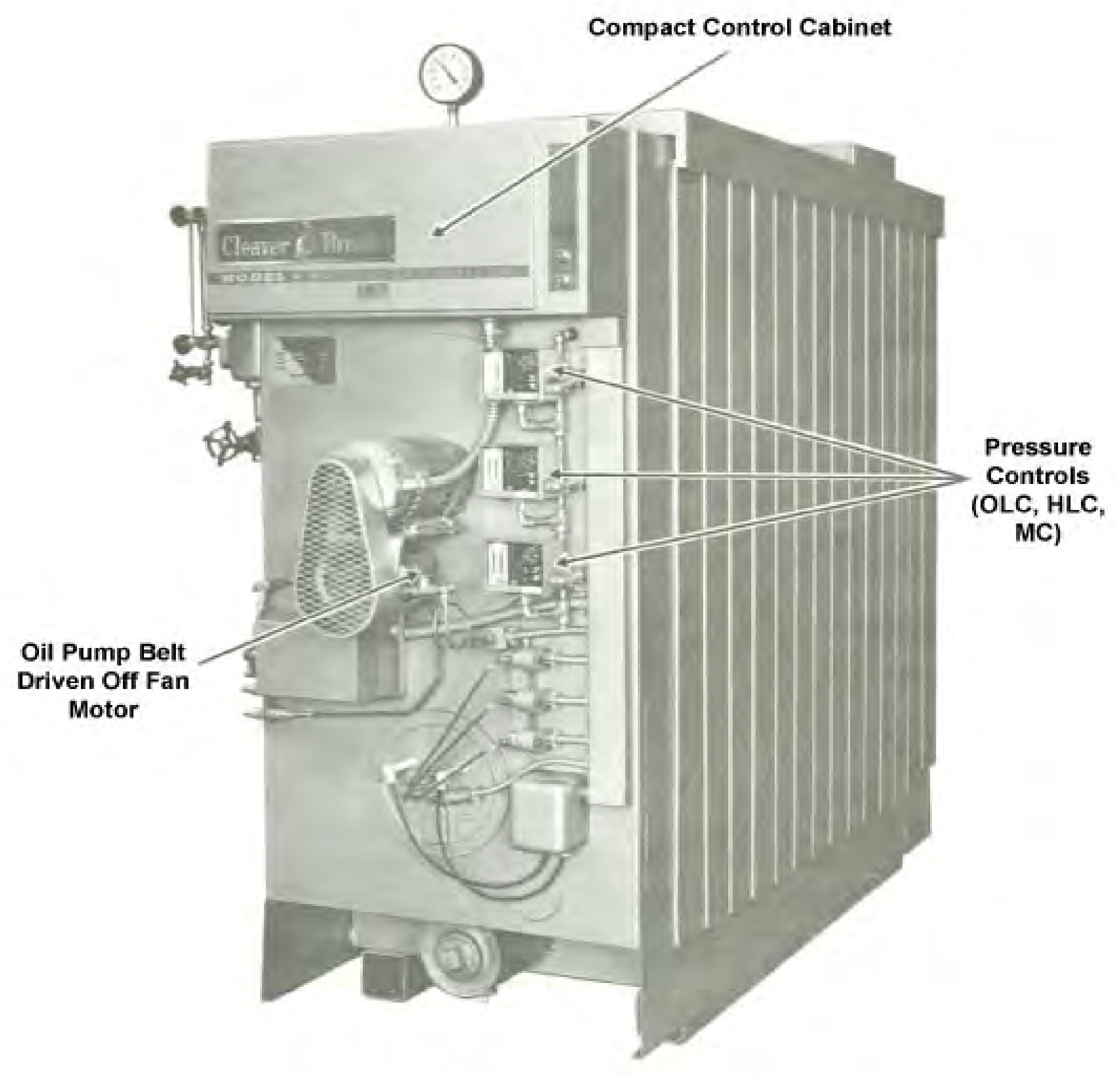

FIGURE 1-3. **Model 4 150 PSI Steam Boiler: Light Oil Fired**

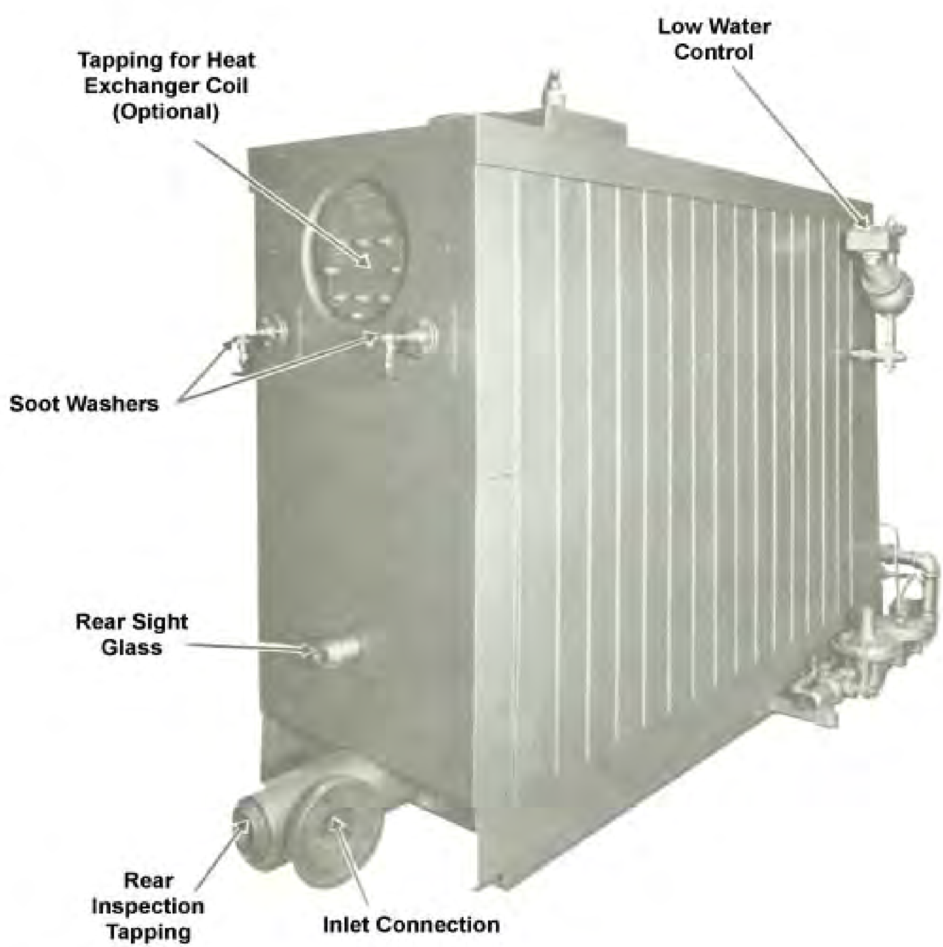

FIGURE 1-4. Model 4 Hot Water Boiler: Light Oil and Gas Fired

1.4 — The Pressure Vessel

A. Steam drum includes a handhole in the rear head for drum waterside inspection. Connections are included for the following:

- Feedwater Makeup w/internal dispersion tube.
- Surface Blowoff.
- Steam Supply.
- Safety Relief Valve.

B. Lower Drum includes handholes at each end for waterside inspection. A drain/blowoff tapping is provided at the front, bottom centerline.

C. Soot washer lances are provided on each side of the vessel between the two rows of tubes for fire-side cleaning. Soot washer drains are located at the bottom of the boiler, with connections to drain located on each side of the lower drum at the rear.

D. Refractory is limited to the furnace floor, lower drum, and burner throat tile. High temperature insulation is installed on the front water wall and furnace access door.

E. Two lifting eyes are provided on the top centerline of the upper drum for ease of installation.

F. Furnace inspection/access door is provided in the furnace front wall.

G. The exhaust gas vent is located at the top rear centerline of the boiler. A stack thermometer is shipped loose for field installation by the installing contractor into the stack.

H. The complete vessel is fully insulated (2” fiberglass blanket) under a preformed, sectional steel jacket.

1.5 — The Burner

A. The burner is a high radiant multi-port type approved for operation on natural gas and a pressure atomizing type approved for operation with commercial grade No. 2 fuel oil.

B. Consisting of the fan which is directly connected to the fan motor, wind box, air damper that is connected to a damper drive motor by linkage, the complete assembly is factory mounted and tested.

C. To ensure proper air for pre-purge and combustion is provided by the fan, a combustion air proving switch is provided (CAPS).

D. Responding to energy demand from the drum mounted pressure or temperature control, the burner operates in the modulating firing mode. Ultra-violet (UV) flame scanner is provided for flame presence during firing.

E. An ignition transformer is provided for gas pilot ignition or on straight oil firing, direct spark ignition. For straight gas firing or standard combination burner for gas or oil, a gas pilot train is provided, that includes a manual shutoff valve, solenoid shutoff valve, and pilot pressure regulator.

F. Ignition is direct spark on straight oil fired burners, and gas pilot on straight gas or combination gas/oil burners.

G. Oil Train consists of the following:

- 4 solenoid shutoff valves providing low-fire, intermediate transitional firing from low to high and high-fire
- an oil pump is mounted (belt-driven from the fan motor) for pressure atomization of the fuel oil
- Oil Pressure Gauge
- suction and return tubing connected to an oil connection block

H. Gas Train consists of the following:

- primary gas shutoff valve with integral proof of closure switch
- a manual shutoff valve located ahead of the primary gas valve
- a plugged leakage test connection and a second manual shutoff valve for tightness checking of the primary shutoff valve
- separate gas pressure regulators for the pilot train and main gas train
- low gas pressure and high gas pressure switches for units at 3000 and greater
- a second motorized gas valve is provided in addition to the primary valve on size 6000 units

1.6 — Controls

A. The standard Combustion Flame Safeguard Control is the CB120, which is factory set to provide:

- burner sequencing with safe start check, pre-purge, trial for ignition, main flame supervision, and post purge
- flame supervision
- safety shutdown with display of lockout condition
- supervision of low and high gas pressure (standard on unit sizes 3000 and greater, optional on smaller units), air proving, high limit and low water

- supervision of low oil pressure if the burner is equipped with an optional low oil pressure switch
- supervision of fan motor starter
- supervision of gas valve open circuit

B. Primary Low Water Control - Steam (LWCO): Provides visual indication of the water level in the boiler, via gauge glass mounted on the water column. Two integral switches provide low water level cutoff and make-up water level control.

C. Primary Low Water Control - Hot Water: This device may be a probe device inserted into the upper drum or column, or may be a float level device mounted external to the upper drum. Provides low water level cutoff if water level in the boiler is insufficient for proper operation.

D. Auxiliary Low Water Control - Steam (ALWCO): Most frequently used with steam boilers, this device is a second low water cutoff control, normally a manual reset type, to prevent or stop the burner in the event of the primary low water cutoff failure.

E. High Limit Control - manual reset (HLC): For water boilers a temperature sensing control and for steam boilers a pressure sensing control that breaks the limit circuit to stop burner operation on a rise of boiler pressure or temperature above the safe limit setting of the operating limit control. This control requires a manual reset to restore circuit continuity.

F. Operating Limit Control (OLC): For water boilers a temperature sensing control and for steam boilers a pressure sensing control that breaks the limit circuit to stop burner operation on a rise of boiler pressure or temperature above the normal operating requirement of the boiler. This control resets automatically as temperature or steam pressure reduces to restore circuit continuity.

G. Firing Rate Control [Modulation] (MC): For water boilers a temperature sensing control and for steam boilers a pressure sensing control that positions the damper motor at various firing rate requirements relative to the energy demand in the system.

H. Damper Motor (DM or MDM): An electrically actuated motor that positions the air damper and gas input fuel valve through a mechanical linkage system, for proper fuel-air ratio at required firing rate requirements. For oil firing, auxiliary switches connected to the damper motor shaft are closed as the shaft rotates to permit opening of the oil fuel valves. Auxiliary switches are also included to prove low-fire position for ignition and high-fire pre-purge position during the start cycle.

1.7 — Control Panel

As standard, the Control Panel is located above the fan motor on the burner windbox. The standard panel is rated National Electrical Manufacturer's Association (NEMA) 1A and includes the following components as standard:

A. Blower Motor Starter (BMS): Provided with thermal overload protection of the fan motor, enables the fan motor to start when voltage is present and the flame safeguard permits burner operation.

B. Combustion Flame Safeguard Control: Controls the operation of the burner.

C. Burner On/Off Switch (BS): Manually operated start-stop switch used to interrupt control circuit power to the controls and burner. This is not the main power shutoff switch.

D. Load Demand Light (LDL): This light is powered on whenever there is a demand for energy to be provided by the boiler, that is steam pressure is below operating set point or water temperature is below operating temperature.

E. Flame Failure Light (FFL): This light will be on whenever a fault condition caused by ignition failure or burner flame failure is sensed.

F. Low Water Light (LWL): Indicates that the water level is below normal operating settings.

G. Fuel Valve Light (FVL): This light will indicate when the fuel valve circuit is energized to open the fuel valves.

H. Fuel Selector Switch - combination fuel burners only (GOS): Manually operated switch to select the fuel to be burned, either gas or fuel oil.

I. Control Circuit Fuse (CCF): Interrupts control circuit voltage due to over current of the control circuit.

J. Combination Air Proving Switch (CAPS): Air sensing switch to ensure adequate combustion air is present to support combustion.

K. Wiring Terminal Blocks (TB)

1.8 — Optional Equipment

Certain options may have been provided in addition to the standard boiler package. Normally, these optional items will have been selected at the time the package was manufactured. In addition, some options may have been provided that are not part of Cleaver-Brooks scope of supply. In either case, the Cleaver-Brooks authorized representative should be consulted regarding specific project requirements.

Optional features may include:

- Blowdown or drain valves.
- Feedwater stop and check valves.
- Steam stop valve.

- Feedwater regulator, tank, and pump assembly.
- Blowdown separator.
- Lead/lag controls.
- Linkageless fuel air ratio control.
- Soot washer swivel fittings and drain valves.
- Stack economizer for high pressure steam.
- Digester gas operation.
- Alarm horn or bell with silence switch.
- Special indicating lights.

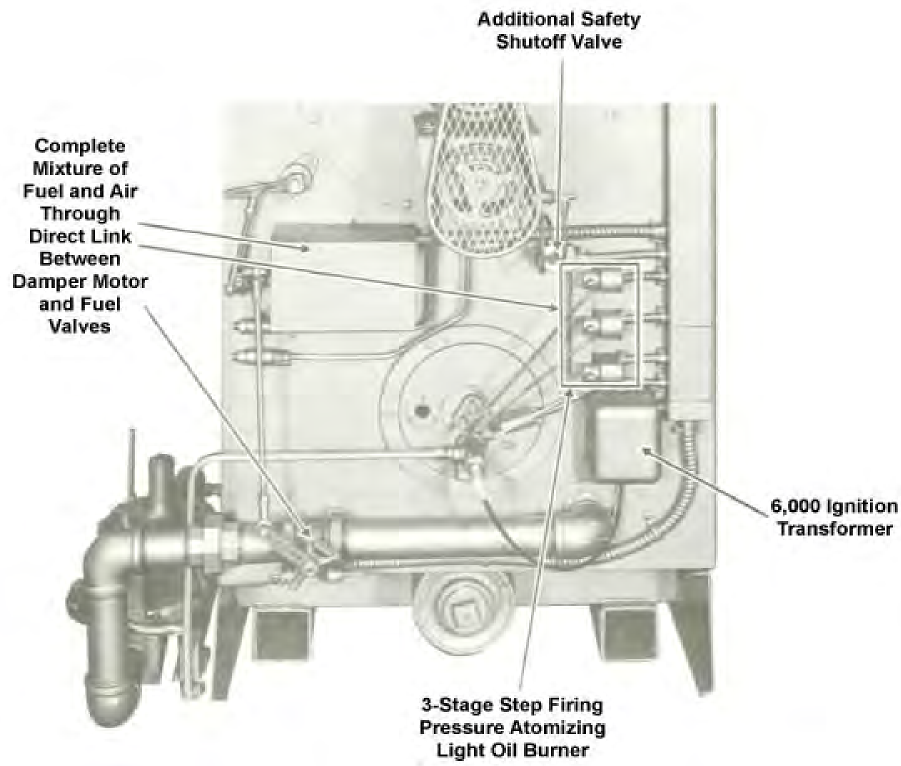

FIGURE 1-5. **Model 4 Boiler: Light Oil and Gas Fired**

CHAPTER 2

The Pressure Vessel and Connections

2.1 — Overview

This chapter is devoted primarily to the waterside care of the pressure vessel, boiler aspects, and piping considerations.

The operator must familiarize himself with this chapter before attempting to place the unit into operation.

Waterside care is of prime importance. The subject of water supply and treatment cannot adequately be covered in this manual. The services of a feedwater consultant should be obtained and their recommendations followed.

Water treatment is a must and has an important bearing on the type of service your boiler provides. This is true for both steam and hot water boilers. It is essential to boiler life and length of service. Constant attention to this area will pay dividends in the form of longer life, less down time, and prevention of costly repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove these accumulations is described later in this chapter.

Feedwater equipment should be checked and ready for use. See that all valves, piping, boiler feed pump, and receiver are installed in accordance with prevailing codes and practices.

If the boiler is to be used for temporary heat, as for example in new construction, properly treated water must be used. Failure to do so can be detrimental to the boiler.

Boilers, as part of a hot water system, require proper circulation and the system must be operated as intended by its designer to avoid severe, possibly damaging, stresses occurring to the pressure vessel. Refer to Section 2 - 3, *Water Requirements*, of this chapter.

2.2 — Construction

All Cleaver-Brooks boilers are built to ASME Code requirements and may be identified by the Code symbol stamped on the pressure vessel: {S} indicates power boilers, {H} indicates heating boilers.

Heating boilers are defined as low pressure steam boilers for operation at pressures not exceeding 15 psi and/or hot water boilers operating at pressures not exceeding 160 psi and/or temperatures not exceeding 250°F: and manufactured to the ASME heating boiler Code.

Power boilers are steam boilers designed for pressures in excess of 15 psi or high temperature water boilers operating in excess of 250°F, and manufactured to the ASME power boiler Code.

2.3 — Water Requirements

2.3.1 — Hot Water Boiler

Requirement	Description
Air Removal	All Cleaver-Brooks hot water boiler outlet connections include a dip tube which extends into the top drum. This dip tube reduces the possibility of any air (which may be trapped at the top of the drum) entering into the system. Any oxygen or air that may be released in the boiler will collect or be trapped at the top of the drum and will find its way out of the boiler through the air vent tapping. This tapping, on the top center line of the drum should be piped into the expansion or compression tank.
Continuous Flow	It is required that the system be piped and the controls arranged so that there will be water circulation through the boiler under all operating conditions. The minimum circulation is 1/2 to 1 gallon per minute per boiler horsepower. Constant circulation through the boiler eliminates the possibility of stratification and results in more even water temperature to the system. Constant circulation is mandatory for a boiler equipped with an internal coil.
Multiple Boiler Installation	When multiple boilers of equal or unequal sizes are used, care must be taken to insure adequate flow through each. If balancing cocks or orifice plates are used, a significant pressure drop (for example, 3 to 5 psi) must be taken across the balancing device to determine required flow rates. If care is not taken to insure adequate flow through the boilers, this can result in a wide variation of firing rates between them.
Pressure Drop	There will be a pressure drop of less than 9 feet head (1 psi - 2.31 ft. hd.) through all standardly equipped Cleaver-Brooks boilers operating in any system which has more than the 20° F temperature drop. This drop will vary with other boiler sizes. Consult factory for specific information.

Requirement	Description
Pressure	The design of the system and the usage requirements will often dictate the pressure exerted upon the boiler. Some systems are pressurized with air or with an inert gas, such as nitrogen. Caution must be exercised to make sure that the proper relationship of pressure to temperature exists within the boiler so that all of its internal surfaces are fully wetted at all times. It is for this reason that the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in **Figure 2-1**.
Minimum Boiler Water Temperature	If the temperature of the flue gas is reduced to the dew point, the condensed water can cause corrosion in the fireside of the boiler and the breeching. This condensation problem is more severe on the unit which operates intermittently or because it is oversized for the actual load. This is not a matter which can be controlled by boiler design, since an efficient boiler extracts all the possible heat from the combustion gases. This problem can be minimized by maintaining an adequate boiler water temperature. For greatest protection, a minimum return water temperature of 150º F is recommended, with outlet temperature at 170º F minimum.

NOTE: Fire a cold unit slowly to avoid undue stressing of pressure vessel parts.

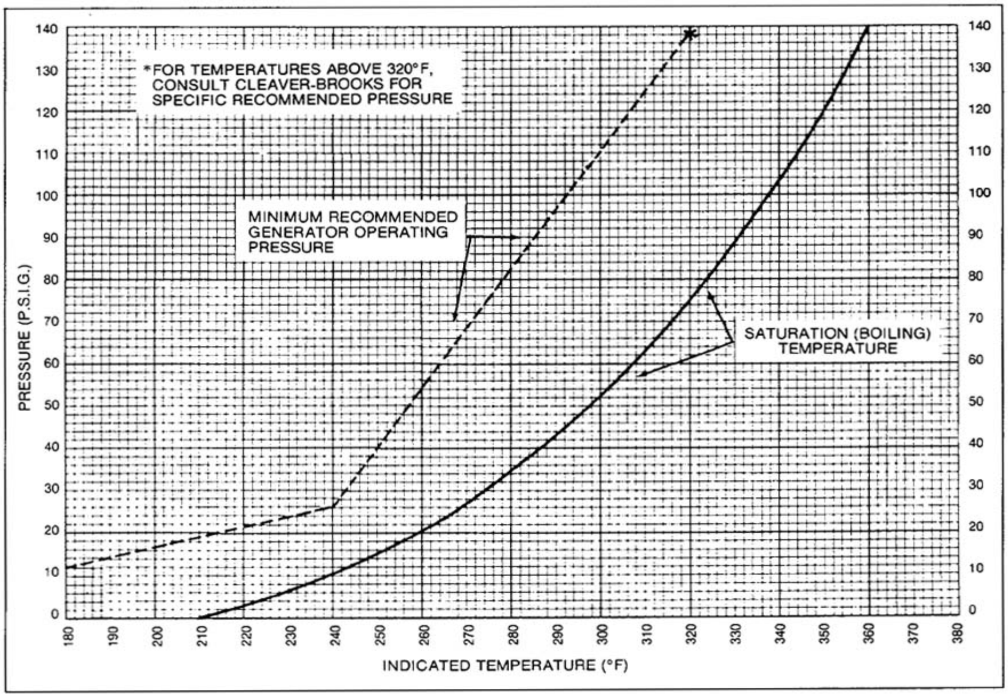

FIGURE 2-1. **Pressure/Temperature Chart for Hot Water Generators**

NOTE: When initially firing a newly installed boiler or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to cutting in.

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2.3.2 — Steam Boiler

Requirement	Description
Feed Pump Operation	Make certain that all valves in the water feed line are open BEFORE turning on the pump motor to prevent possible damage to the feed pump mechanism. After opening valves, momentarily energize the feed pump motor to establish correct pump rotation. With correct rotation, close the boiler feed pump entrance switch. The pump should shut down when the water level reaches the proper level. **NOTE:** Prior to operating a pump, carefully check alignment of flexible coupling if one is used on the pump. A properly aligned coupling will last a long time and provide trouble-free mechanical operation. Feedwater pumps must have adequate capacity to maintain water level under all operating conditions. Check feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

2.4 — Water Treatment

Maximum effectiveness and long trouble-free life of pressure vessels at the lowest cost consistent with good engineering and operating practice are functions of properly treated boiler feedwater. The recommendations of a water consultant or a reliable water treating company must be followed rigidly to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment in general are:

1. Prevention of hard scale deposits or soft sludge deposits which impair the rate of heat transfer and can lead to overheated metal and costly down time and repairs.
2. Elimination of corrosive gases such as oxygen and carbon dioxide in the supply or boiler water.
3. Prevention of intercrystalline cracking or caustic embrittlement of boiler metal.
4. Prevention of carryover and foaming.

The accomplishment of these objectives generally require proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, amount of make-up water needed, plant operating practices, etc. These treating methods include filtering, softening, de-mineralizing, derating and pre-heating. After treatment involves chemical treatment of the boiler water.

Because of the variables involved, no one “boiler compound” can be considered a “cure-all” nor is it advisable to experiment with homemade treating methods. Sound recommendations and their employment should be augmented by a periodic analysis of the feedwater, boiler water, and condensate.

The internal or waterside surfaces of the pressure vessel should be inspected with sufficient frequency to determine the presence of any contamination, accumulations of foreign matter, of corrosion and/or pitting. If these conditions are detected the water consultant or feedwater treating company should be consulted for advice on corrective action.

It is recommended that a properly sized water meter be installed in the raw water make-up line to accurately determine the amount of raw water admitted to the boiler (steam or hot water) to aid the water treatment program in maintaining proper waterside conditions.

The general feeling exists that a hot water boiler does not require water treatment, but this is a false assumption. The recommendations of a reliable water treating company or a water consultant should be followed rigidly. Even though these generally operate on a closed system and blowdown is seldom practiced, the need remains to be alert to system water losses. A water meter is recommended for water make-up lines.

2.5 — Cleaning

2.5.1 — Hot Water and Steam Piping

Steam and water piping systems connected to the boiler may contain oil, grease or foreign matter. These impurities must be removed to prevent damage to pressure vessel heating surfaces. On steam systems the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make up so that an accumulation of unwanted materials or corrosion does not occur. Follow the advice of your water treating company.

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On hot water systems, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult water treatment companies for recommendations, cleaning compounds and application procedures.

2.5.2 — Pressure Vessel

The waterside of the pressure vessel must be kept clean from grease, sludge and foreign material. Such deposits if present, will not only shorten the life of the pressure vessel and interfere with efficient boiler operation and functioning of control or safety devices, but might quite possibly cause unnecessary and expensive re-work, repairs and down time.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned it is possible that:

1. Cleaning has been inadequate.
2. Partial or total system is involved.
3. Conditions may prevent adequate cleaning of piping.

The installation and operating conditions to which the boiler will be subjected must be considered and the cleaning of the waterside of the pressure vessel must be provided during the course of initial start-up.

The pressure vessel waterside must be inspected on a periodic basis. This will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection must be made three months after initial starting and at regular six month intervals thereafter. The frequency of further periodic inspections will however depend upon the internal conditions found.

If any unwanted conditions are observed, your water consultant or water treating company must be contacted for recommendations.

Any sludge, mud or sediment found must be flushed out. The effectiveness of the blowdown practiced on steam boilers will be verified and scheduling or frequency of blowdown may have to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces must be removed promptly by a boil-out with an alkaline detergent solution.

NOTE: Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code.

2.6 — Boil-Out of a New Unit

The internal surfaces of a newly installed boiler may have oil, grease or other coatings for various reasons beyond the manufacturer's control. These coatings must be removed since they lower the heat transfer rate and could cause overheating of heating surfaces. Before boiling out procedures may begin, the burner must be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

Your water consultant or water treating company will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unselected, the following information may be of assistance.

Suggested procedure for boiling out new units prior to initial firing is as follows:

1. Tri-sodium phosphate and caustic soda are suggested chemicals for cleaning of boilers. One pound of each chemical should be used for every 50 gallons of water. See **Table** below for boiler water capacity.

Boiler Model	**Water — Gallons**		**Water — Weight**	
	Normal (Steam)	**Flooded**	**Normal**	**Flooded**
1500	79	109	656	905
2000	79	109	656	905
2500	104	144	863	1195
3000	104	144	863	1195
3500	129	176	1071	1461
4000	129	176	1071	1461
4500	155	212	1287	1760
5000	155	212	1287	1760
6000	180	244	1494	2025

2. When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water, stirring at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.

⚠ Caution

Use of a suitable face mask, goggles, rubber gloves, and protective garments is strongly recommended when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing.

3. An overflow pipe should be attached to one of the top drum openings and routed to a safe point of discharge. A water relief or safety valve tapping is usually used.
4. Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate these valves. Use care in removing and re-installing valves.

NOTE: Refer to Chapter 5, Section 5 - 10 for valve installation instructions.

5. All valves in the piping leading to or from the system must be closed to prevent cleaning solution from getting into the system.
6. Fill pressure vessel with clean water until top of tube openings in upper drum are covered. Add the cleaning solution and then fill to the top.
7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least 5 hours. Do not produce steam pressure.
8. Allow a small amount of fresh water to enter boiler to create a slight overflow that will carry off surface impunities.
9. Continue boiling and overflow until water clears.
10. Stop the burner and drain boiler using caution that the hot water is discharged with safety.
11. Remove cover plate in upper drum and inspection plugs in lower drum and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect surfaces and if not clean, repeat the boil-out.
13. After closing openings and re-installing safety or relief valve(s), fill the boiler and fire until water is heated to at least 180º F to drive off any dissolved gases which might otherwise corrode the metal.

The above procedure may be omitted in the case of units previously used or known to be internally clean, however, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

On a steam system the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make up so that an accumulation of unwanted materials or corrosion does not occur. Follow the advice of your water treating company.

On a hot water system chemical cleaning of the entire system is generally necessary and the entire system should be drained after treatment. Consult a water treatment company for recommendations, cleaning compounds and application procedure.

2.7 — Washing Out

2.7.1 — Hot Water Boiler

In theory, a hot water system and boiler that has been initially cleaned, filled with treated water, and with no make-up water added will require no further cleaning or treatment. However, since the system (new or old) may allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If there is any doubt then the pressure vessel waterside should be inspected no later than 3 months after initially placing the boiler into operation and periodically thereafter as indicated by conditions observed during inspections.

2.7.2 — Steam Boiler

No later than 3 months after initially placing the boiler into operation and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature, handhole cover or closure plate in the upper drum and handhole covers in the lower drum removed and internal waterside surfaces inspected for corrosion, pitting, or formation of deposits.

2.7.3 — Flushing of Pressure Vessel Interior

Upon completion of inspection, the pressure vessel interior should be flushed out as required with a high pressure hose. If deposits are not fully removed by such flushing, this may require immediate consultation with your water consultant or feedwater treatment company, and in extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

These inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel wash-out periods. Subsequent inspections will indicate the effectiveness of the water treating program as well as the suitability of the intervals between washouts. The feedwater consultant or water treatment company service should include periodic pressure vessel inspection and water analysis.

2.8 — Blowdown - Steam Boiler

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that a lowering of the concentration in the boiler water occurs.

Solids are present in the feedwater even though this water is treated prior to use with external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of these processes are in themselves capable of removing all substances and regardless of their high efficiency, a small amount of encrusting solids will be present in the boiler water.

Solids become less soluble in the high temperature of the boiler water and tend to crystallize and concentrate on heating surfaces. Internal chemical treatment is, therefore, required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer valve and acts as an insulation barrier. This retards heat transfer, which not only results in lower operating efficiency and consequently higher fuel consumption, but, more importantly can cause overheating of boiler metal.

This can result in tube failures or other pressure vessel metal damage causing boiler down time and costly repairs.

Scale is caused primarily by calcium and magnesium salts and silica. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate along with organic materials to maintain these precipitates or "sludge" in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale, but as the boiler water boils off as relatively pure steam, the remaining water is thicker with the solids. If this concentration is permitted to accumulate, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of this concentration requires the use of boiler water blowdown.

2.8.1 — Types of Blowdown

There are two principal types of blowdown: intermittent manual blowdown and continuous blowdown.

2.8.1.1 — Intermittent Blowdown

Manual or sludge blowdown is necessary for the operation of the boiler regardless of whether or not continuous blowdown is employed.

The blowdown tapping is located in the bottom drum. In addition to lowering the dissolved solids in the pressure vessel water, blowdown also removes a portion of the sludge which accumulates in the lower drum.

Equipment generally consists of a quick opening valve and a shut-off valve. These, along with the necessary piping, are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

2.8.1.2 — Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping and is the continuous removal of concentrated water.

The surface blow-off opening, located in the rear head of the upper drum, is slightly below the working water level for the purpose of skimming surface sediment, oil or other impurities from the surface of the pressure vessel water.

A controlled orifice valve is used to allow a continual — yet controlled — flow of concentrated water.

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with test analysis.

The flow control valve and piping are generally provided by others. All piping must be to a safe point of discharge.

2.8.2 — Frequency of Intermittent Blowdown

When continuous blowdown is utilized, intermittent blowdown is primarily used to remove suspended solids or sludge. The continuous blowdown removes sediment and oil from the surface of the water along with a prescribed amount of dissolved solids.

When surface or continuous blowdown is not utilized, manual blowdown is used to control the dissolved or suspended solids in addition to the sludge.

In practice, the valve(s) of the bottom blowdown are opened periodically in accordance with an operating schedule and/or chemical control tests. From the standpoint of control, economy and results, frequent short blows are preferred to infrequent lengthy blows. This is particularly true when suspended solids content of the water is high. With the use of frequent short blows a more uniform concentration of the pressure vessel water is maintained.

In cases where the feedwater is exceptionally pure, or where there is a high percentage of return condensate, blowdown may be employed less frequently since less sludge accumulates in the pressure vessel. When dissolved and/or suspended solids approach or exceed pre-determined limits, manual blowdown to lower these concentrations is required.

It is generally recommended that steam boilers be blown down at least once in every eight hour period, but this may vary depending upon water and operating conditions. The blowdown amounts and a schedule should be recommended by a water treating company or a water consultant.

A hot water boiler does not normally include a tapping for surface blowdown but does have a drain opening in the lower drum. Blowdown is not commonly practiced with a hot water system, however may be necessary depending upon the condition of system, variable water and make-up. The need remains to be alert to system water losses and corresponding amount of raw water make-up. A water meter with a small flow rate is recommended for water make-up lines.

2.8.3 — Manual Blowdown Procedure

Blowdown is most effective at a time when generation of steam is at the lowest rate since feedwater input then is also low, providing a minimum dilution of the boiler water with low concentration feedwater.

Make sure blow-off piping, and tank, if used, are in proper operating condition and discharge vents clear of obstruction, and that waste is piped to a point of safe discharge. The valve installation must be in accordance with applicable codes.

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Two slow opening valves or tandem valves may be used. Valves will vary depending upon pressure involved and make or manufacture.

If a quick opening valve and a globe type or slow opening valve are in combination, the former is normally opened first and closed last with blowing down accomplished with the globe or slow opening valve. If seatless valves are installed follow the manufacturer's recommendations.

When opening the second or down stream valve, crack it slightly to allow the lines to warm up, then continue opening slowly.

The length of each blow should be determined by actual water analysis. Lowering the water in the gauge glass approximately 1/2" is often acceptable as a guide to adequate blow, however, this should not be interpreted as a rule since water analysis procedures should prevail. If the glass cannot be viewed by the party operating the valve, another operator should watch the glass and direct the valve operator.

Close the downstream (slow opening) valve first and as fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly.

A blow-off valve must not be left open and the operator must never leave until the blowdown operation is completed and the valves closed.

2.9 — Periodic Inspection

Insurance regulations or local laws will require a periodic inspection of the pressure vessel by an authorized inspector. Sufficient notice is generally given to permit removal from service and preparation for inspection.

When shutting down, the load should be reduced gradually and the pressure vessel cooled at a rate that avoids damaging temperature differential that can cause harmful stresses. Vessels should not normally be drained until all pressure is relieved again to prevent uneven contraction and temperature differentials. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces. Some heat, however, may be desirable to dry out the interior of the boiler.

If the internal inspection is being made at the request of an authorized inspector, it is well to learn from him whether he desires to observe the conditions prior to cleaning or flushing of waterside surfaces.

Handhole openings are located in the drum heads. These openings provide access and permit waterside inspection of the drum.

The handhole plates should be tightened securely to prevent leakage. Always use a new gasket when resealing. Make sure that seating surfaces are clean. Snugging the nut after a warm-up period will help provide a tight seal.

Some Model M4W and M4S boilers have a plate in the front head of the upper drum. Special attention should be given to this plate since it is not readily visible. It can be inspected from the top of the boiler, by removing a side access panel or when the front head is swung aside.

Be certain that proper gaskets are available along with any other items needed to place the unit back into operation after inspection.

Have available information on the boiler design, dimensions, generating capacity, operating pressure or temperature, time in service, defects found previously and any repairs or modifications. Also have available for reference records of previous inspections.

Be prepared to perform any testing required by the inspector including hydrostatic.

After proper cooling and draining of vessel, flush out the waterside with a high pressure water hose. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion and leakage.

The fireside surfaces should also be thoroughly cleaned so that metal surfaces, welds, joints, etc. plus any previous repairs can be readily checked. See **Section 2.10**.

Be sure that steam valves, system valves, (hot water) feedwater valves, blow-off valves, all fuel valves, valves to expansion tanks, and electrical switches are shut off prior to opening inspection cover or removing plugs. Flashlights rather than extension cords are recommended as a safety factor. Cleaners should preferably work in pairs.

Clean out the low water cut-off piping, the water level controls and cross connecting piping. Replace water gauge glass and clean out water cocks and try cocks.

Also check and clean drain and blowdown valves and piping.

Check all water and steam piping and valves for leaks, wear, corrosion and other damage. Replace or repair as required.

2.10 — Fireside Cleaning

Soot and non-combustibles are effective insulators and if allowed to accumulate will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can be very moisture absorbent and may attract moisture to form corrosive acids which will deteriorate fireside metal.

Clean out should be performed at regular and frequent intervals, depending upon load, type and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer can be used as a guide to clean out intervals, since an accumulation of soot deposits will raise the flue gas temperature.

All oil fired units are equipped with water washing devices for the convection surfaces. See separate section pertaining to water washing.

In extreme cases, soot or other combustion deposits may be present in the furnace area. These will have to be removed by brushing or scraping. Entry to this area is gained through the access door. Brush-out or vacuum any loosened deposits.

Inspect the refractory and repair or maintain as outlined in the refractory section.

The vent connection stack should be cleaned at regular intervals. Commercial firms are available to perform this work. The stack should be inspected for damage and repaired as required.

The fireside should be thoroughly cleaned prior to
any extended lay-up of the boiler. Depending upon circumstances, a protective coating may be required.

2.11 — Water Washing - Fireside (Oil Fired Unit)

An oil fired boiler has water washing lances located in the passageway between the convection tube wall and the furnace tube wall on both sides of the boiler. See **Figures 2-2** and **2-3**. Their purpose is to provide a means of washing away any soot that may have built up on the tube wall surfaces. The frequency of water washing depends upon operating conditions. Boilers with long operating runs at high fire and with efficient flame will require less frequent cleaning than those with frequent cycling, prolonged low fire operation, improperly adjusted combustion, etc.

A periodic log of stack temperatures determined through use of a stack thermometer will alert the operator to the need for cleaning. A marked increase in temperature over an established level indicates a loss in efficiency and heat transfer caused by soot deposits.

A flexible hose from the building water supply should be attached to the hand operated valve on the lance. Do not use boiler feedwater. In the event permanent piping or tubing is provided instead of a hose, a suitable swivel joint must be installed to allow rotation of the lance. A shutoff valve at the supply point is recommended.

Remove the drain caps or fully open valves in the drain piping — depending upon installation. If drain piping is not provided, the use of a drain hose is suggested. If the boiler is situated adjacent to a drain it may be possible to merely let the discharge wash water run into it. Thoroughly wet the floor first to aid in floating away soot.

Bring the boiler up to its approximate operating pressure or temperature before washing. With the burner in low fire, open one lance valve and rotate the lance in an arc that assures washing panel surfaces. Note the reference mark on the lance to indicate location of spray holes. Continue rotating back and forth until drain water runs clear. Opening and closing the valve to obtain frequent, short sprays provides better results than a steady flow.

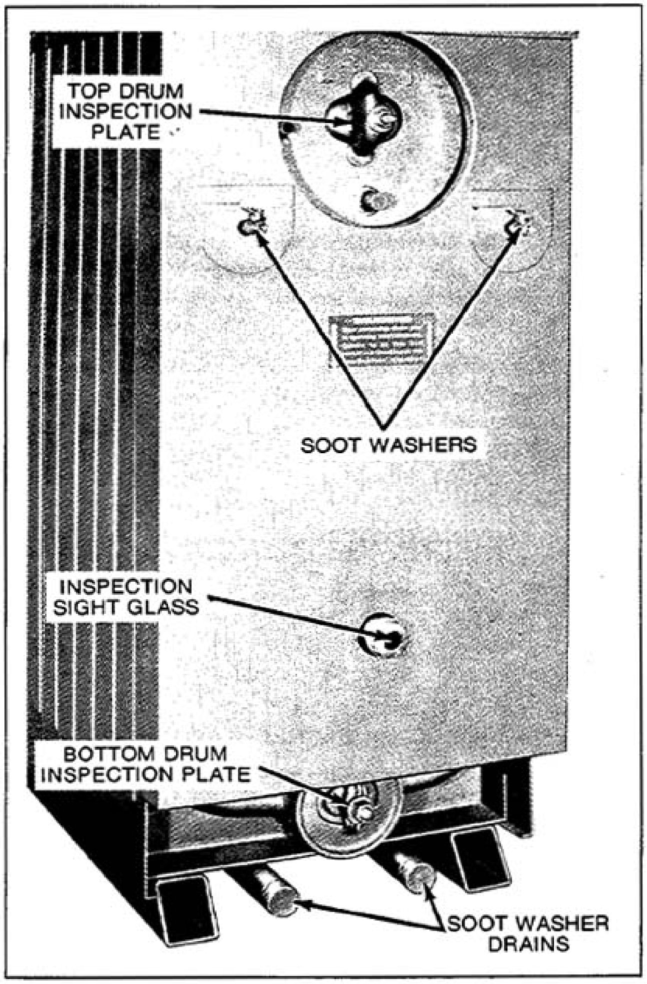

FIGURE 2-2. **Steam Boiler Rear View**

Care must be taken to be sure that water is draining away at approximately the same rate as its input to avoid flooding or entering the furnace.

When drain water is clear, repeat the process in the other bank. After washing, the close the lance valve and when draining stops, shut the drain valves or replace caps.

To be sure that all moisture is evaporated, continue firing for at least 45 minutes after washing so that the convection area is thoroughly dried. During this drying period the burner may be cycled to the high fire position.

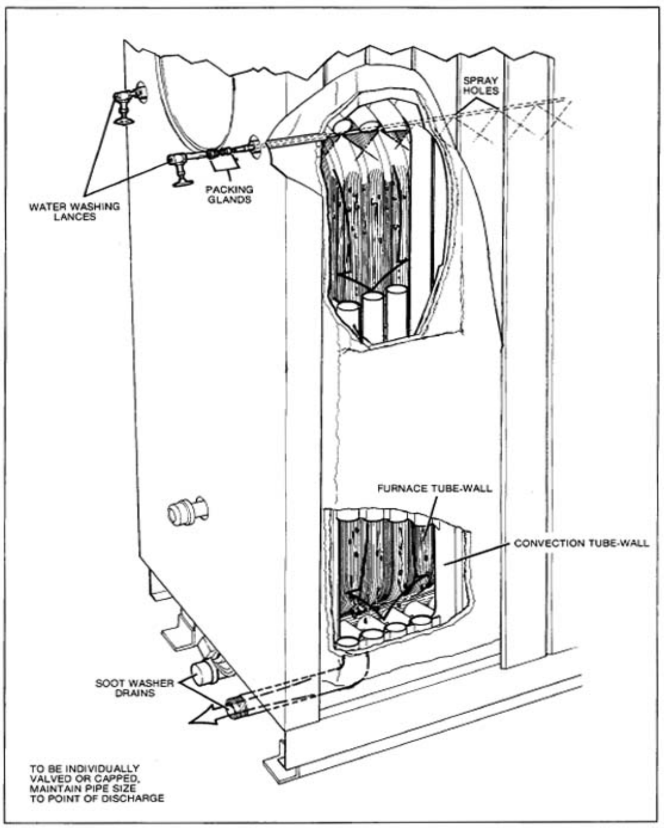

FIGURE 2-3. Water Washing Detail

The front end of the water drain troughs on the under side of the drum are equipped with capped openings. These openings enable the trough to be flushed with a hose, if necessary, to remove any accumulation. When doing this, make sure that the drains are open and that water is draining away.

2.12 — Preparation for Extended Lay-Up

A boiler used for heating or seasonal loads or for stand-by service may have an extended period of non-use. Special attention must be given so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

There are two methods of storage — wet or dry. Your water consultant or feedwater treating company can recommend the better method, depending upon circumstances in a particular installation. Section VII of the ASME Code also contains information relating to laying up a boiler.

2.12.1 — Dry Storage

Dry storage is generally employed when the boiler will be out of service for some time or when freezing temperatures may occur. In this method, the boiler must be thoroughly dried, since any moisture will cause corrosion. Both waterside and fireside surfaces must be clean of all scale and deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture absorbing material, such as quicklime or silica-gel, on trays inside the drums and furnace. These trays should not be completely filled with the material, so that the corrosion liquid gathered in them does not overflow onto the boiler surfaces. Refractories should be brushed clean and wash-coated. fireside surfaces may be sprayed or coated with an anti-corrosive material. All openings to pressure vessel must be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection must be made and the absorption materials renewed.

Care must be taken to remove all of the moisture absorbing material before any attempt is made to refill the boiler. Serious damage can result otherwise. As a precaution it is recommended that warning signs be conspicuously posted. These signs could be similar to the following:

Important

Moisture absorption material has been placed in the waterside and furnace areas of this boiler. This material must be removed before any water is placed in the boiler and before the burner is fired. Inspect periodically and replace with fresh and/or regenerated materials.

2.12.2 — Wet Storage

Wet storage is generally used for a boiler held in standby condition or in a case where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must be taken to protect metal surfaces. Variables preclude definite recommendations, however, it is suggested that after the vessel is drained and cleaned that it be refilled to overflowing with treated water. If deaerated water is not available, the boiler should be fired to boil the water for a short period of time. Additional chemicals may be suggested by the water consultant to minimize corrosion. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used for this purpose. fireside surfaces must be thoroughly cleaned and refractories should be wash-coated. It is advisable, if feasible, to occasionally circulate the water to prevent stratification and to insure that fresh inhibitor is in contact with all the surfaces. If additional chemicals are added for this idle period, more frequent blowdowns may be required when the boiler is returned to service to rapidly reduce the chemical composition to normal operating levels.

During storage, steps should be taken to protect the exterior components from the possibility of rust or corrosion. These parts should be coated with a rust inhibitor and protected from moisture and condensation. Operating controls, regulators, valves, etc. should be drained and dried. Electrical equipment should likewise be protected. Keeping the control circuit energized may prevent condensation from forming in the control cabinet or on the flame safeguard control.

2.13 — Lifting and Moving the Boiler

The boiler should be lifted by lifting lugs provided on the top or be a forklift suitable for lifting and moving heavy equipment.

> **NOTE:** The boiler should not be moved by pushing, prying, or pulling on any part of the casing or burner windbox. It may be moved on special "rollers" designed for the weight of the equipment. Refer to the shipping weight and operating weight information in the table below.

The boiler must be installed on a non-combustible floor. If the floor is not level, piers or a raised pad slightly larger in length and width than the boiler base dimensions will make the boiler installation and leveling easier.

The boiler must be installed so that all components remain accessible for inspection, cleaning, or maintenance. Field installed piping and electrical connections must be arranged so as to avoid interfering with removal of the casing or opening the front windbox/burner.

Boiler Weights:

Boiler Size	Hot Water		Steam	
	Dry Weight	Operating Weight	Dry Weight	Operating Weight
1500	3,100	3,758	3,100	3,758
2000	3,100	3,758	3,100	3,758
2500	3,700	4,556	3,700	4,566
3000	3,700	4,556	3,700	4,566
3500	4,100	5,175	4,100	5,175
4000	4,100	5,175	4,100	5,175
4500	4,700	5,991	4,700	5,991
5000	4,700	5,991	4,700	5,991
6000	5,400	6,900	5,400	6,900

⚠ Caution

In order to avoid damage to the unit, lifting or moving the boiler should only be done by experienced personnel suitably equipped for moving heavy equipment.

⚠ Warning

The boiler must not be installed on combustible flooring.

2.14 — Boiler Room

Boiler Room Ambient Conditions	
Relative humidity	≤ 85% non condensing
Ambient temperature range	0º C to 50º C/32º F to 122º F
Storage temperature range	-40º C to 60º C/-40º F to 140º F
Combustion air temperature	0º C to 50º C/ 32º F to 122º F

The boiler room must comply with all building codes and regulations. An adequate supply of combustion air and sufficient ventilation are required for safe and proper operation. Clean combustion air is required for optimum combustion efficiency and boiler operation (minimum of 10 cfm per boiler horsepower is required). Dust and airborne contaminants will adversely affect burner performance and could impact heat transfer. Do not store chemicals in the boiler room or other products that emit corrosive gasses. Under no circumstance should the boiler be operated when a negative pressure (vacuum) exists. We recommend a slightly positive condition at all times. The location of boiler room air supply dampers should provide cross flow ventilation. The recommended size of the openings should be verified.

Make-up air openings may be fixed or may include a motorized drive for open/close operation. If the openings furnished include an electrical drive, check the burner electrical wiring diagram for interface connections. The burner must not be operated if the air dampers are closed.

When placing the boiler, ensure adequate service and maintenance space is provided. If the soot washers will be utilized, allow ample space for their removal from the rear of the boiler.

Observe proper clearances above and around the boiler.

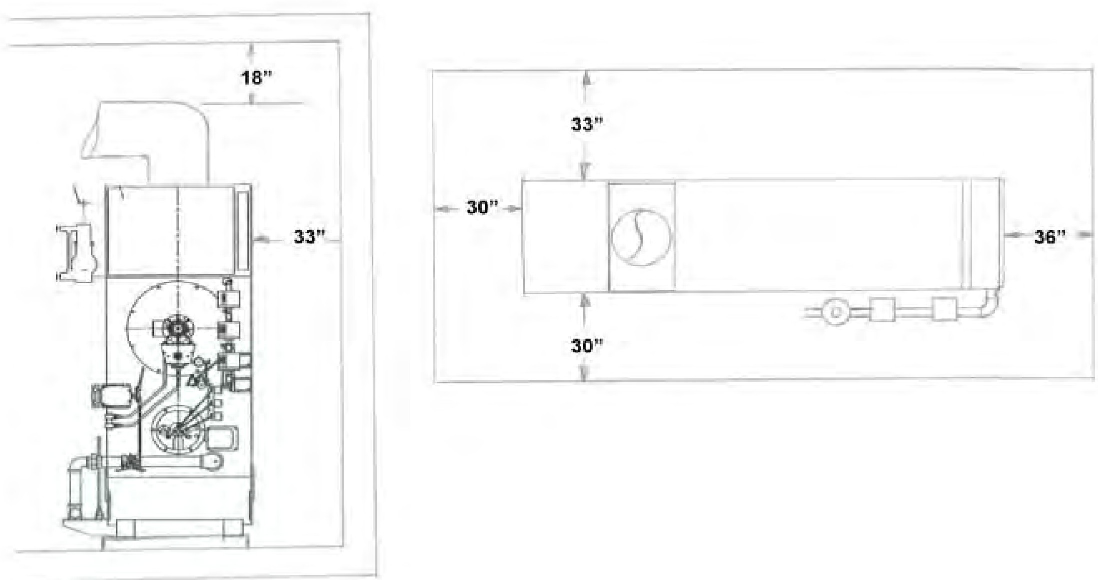

FIGURE 2-4. **Model 4 Minimum Clearances**

2.15 — Flue Gas Connection

The flue gasses from the Model 4 boiler shall be removed via a gas-tight, temperature and corrosion resistant flue gas pipeline. Only flue gas systems approved and tested by the relevant region or province are to be connected to the Model 4 boiler. Refer to the flue (stack) manufacturer for proper installation and sealing instructions.

Proper installation of flue gas exhaust venting is critical for the efficient and safe operation of the boiler. Boilers are divided into four categories based on the pressure and temperature produced in the exhaust stack and the likelihood of condensate production in the vent.

- Category I: A boiler which operates with a "non-positive" vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.
- Category II: A boiler which operates with a "non-positive" vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

- Category III: A boiler which operates with a “positive” vent pressure and with a vent gas temperature that avoids excessive condensate production in the vent.
- Category IV: A boiler which operates with a “positive” vent pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

NOTE: For additional information on boiler categorization, see the latest edition standard of the National Fuel Gas Code, or in Canada, the latest edition of CGA Standard B149 Installation Code for Gas Burning Appliances and Equipment, or applicable provisions of local building codes.

The Model 4 boiler should be considered a Category III boiler. Depending on the application, the specifying engineer may have selected alternative category venting as deemed appropriate.

Warning

Contact the manufacturer of the vent material if there is any question about the boiler categorization and suitability of a vent material for application on a Category III vent system. Using improper venting materials can result in injury, death, or property damage.

NOTE: During winter months, check the vent cap and make sure no blockage occurs from buildup of snow (where applicable). Condensate can freeze on the vent cap. Frozen condensate on the vent cap can result in a blocked flue condition.

Boiler Room Air Supply	
Supply (area) and location of combustion air supply for the boiler.	**a.** Two (2) permanent air supply openings in the outer walls of the boiler room are recommended. Locate one (1) at each end of the boiler room, preferably below a height of 7 feet. This allows air to sweep the entire length of the boiler. **b.** Air supply openings can be louvered for weather protection, but they should not be covered with fine mesh wire as this type of covering has poor air flow qualities and is subject to clogging with dust or dirt. **c.** A vent fan in the boiler room is not recommended as it could create a slight vacuum under certain conditions and cause variations in the quantity of combustion air. This would result in unsatisfactory or unsafe burner performance. **d.** Under no circumstance should the total area of the air supply be less than one square foot. **e.** Size the opening by using the formula: Area (ft^2) = CFM/FPM
Amount of air required, cubic feet per minute (CFM)	**a.** Combustion Air: Maximum Bhp x 8 CFM per Bhp **b.** Ventilation Air: Maximum Bhp x 2 CFM per Bhp or A total of 10 CFM per Bhp up to 1000 feet elevation. Add 3% more per each 1000 feet of added elevation.
Acceptable air velocity in the Boiler Room, feet per minute (FPM)	**a.** From floor to 7 feet in height - 250 FPM **b.** Above 7 feet in height - 500 FPM **c.** Duct from air supply to boiler - 1000 FPM
An example of a size 250 (60 Bhp)	ft^2 = 10 CFM(60)/500 FPM ft^2 = 600/500 = 1.2 square feet of opening

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2.16 — Vent Stack

Generally, a vent stack layout should have been designed for the installation by the project engineer. However, one should verify the layout to ensure proper draft will be available and that the breeching and layout are in accordance with the project requirements. Stacks that are too tall, without appropriate draft control, may cause combustion instability at various firing rates. Improperly sized common breeching, with multiple connected units, may cause drafting and combustion issues.

For multiple boiler installations, the common breeching should increase in size between boilers. If an exhaust fan has been installed, ensure that the draft sensor has been located in the common breeching for all units and not between the boilers. It is recommended that for multiple units a manual damper for each boiler be utilized.

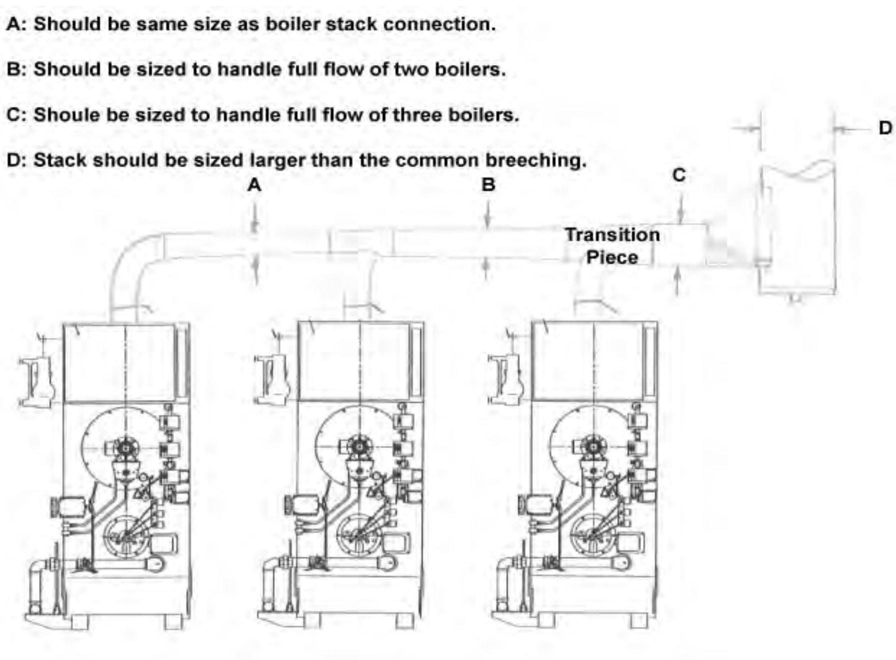
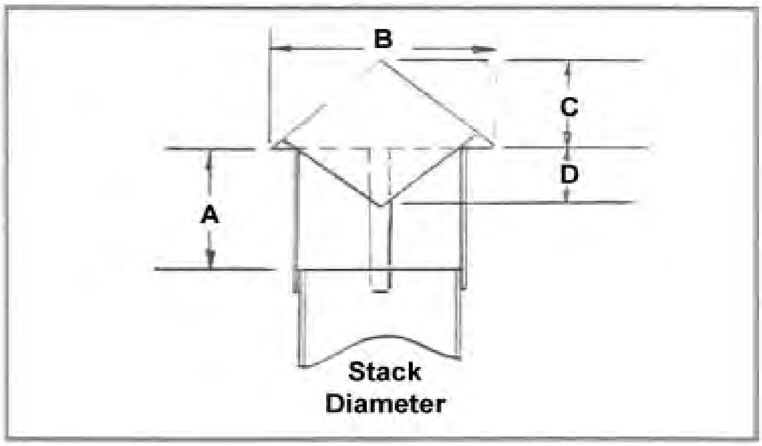


FIGURE 2-5. Breeching Increase in Size Between Boilers

Stack termination must be in accordance with local codes. If not equipped, a ran cap as shown in Figure 2-6 should be utilized to minimize the ingress of water.



Stack Diameter	A in inches	B in inches	C in inches	D in inches
10"	8	20	5	5
12"	9	24	6	6
16"	12	32	8	8
20"	15	40	10	10
24"	18	48	12	12

FIGURE 2-6. **Rain Cap Detail**

2.17 — Gas Piping

2.17.1 — Gas Pressure Requirements

For proper and safe operation, each Model 4 boiler requires stable gas pressure at the required flow. The minimum inlet supply pressure must be as noted in the following tables relative to gas type and fuel train size. Gas pressure should be measured when the burner is firing, using a manometer at the upstream test port of the gas valve. For a multiple unit installation, gas pressure should be set for a single unit first, then the remaining units should be staged on to ensure that pressure droop is not more than 1" W.C. and never below the required pressure. Fluctuating gas pressure readings could be indicative of a faulty supply regulator or improper gas train size to the boiler.

Natural Gas Pressure Requirements - Standard Size Gas Train

Boiler Size	Standard Gas Train Size (inches NPT)	Supply Pressure to Gas Train Regulator (inches W.C.)	Max. (W.C.)	Required Fuel Flow (SCFH)
1500	1.5	4.4	27.7	1500
2000	1.5	8.4		2000
2500	1.5	12.9		2500
3000	1.5	17.1		3000
3500	2.0	11.3		3500
4000	2.0	13.6		4000
4500	2.0	12.2		4500
5000	2.0	16.8		5000
6000	2.0	21.5		6000

NOTE: For altitude above 1000 feet, contact the local Cleaver-Brooks representative. Natural Gas @ 1000 Btu/cu.ft., specific gravity @ 0.65.

Natural Gas Pressure Requirements - Non-Standard Size Gas Train				
Boiler Size	Standard Gas Train Size (inches NPT)	Min. Supply Pressure to Gas Train Regulator (inches W.C.)	Max. (W.C.)	Required Fuel Flow (SCFH)
1500	2.0	2.3	27.7	1500
2000	2.0	4.8		2000
2500	2.0	6.5		2500
	2.5	5.7		2500
3000	2.0	9.0		3000
	2.5	6.8		3000
	3.0	6.0		3000
3500	2.5	9.7		3500
	3.0	7.1		3500
4000	2.5	11.8		4000
	3.0	8.5		4000
4500	2.5	9.8		4500
	3.0	5.6		4500
5000	2.5	12.9		5000
	3.0	7.1		5000
	4.0	5.6		5000
6000	2.5	17.5		6000
	3.0	10.0		6000
	4.0	7.9		6000

NOTE: For altitude above 1000 feet, contact the local Cleaver-Brooks representative. Natural Gas @ 1000 Btu/cu.ft., specific gravity @ 0.65.

Propane Gas Pressure Requirements - Standard Size Gas Train				
Boiler Size	**Standard Gas Train Size (inches NPT)**	**Supply Pressure to Gas Train Regulator (inches W.C.)**	**Max. (W.C.)**	**Required Fuel Flow (SCFH)**
1500	1.5	6.7	27.7	600
2000	1.5	10.5		800
2500	1.5	13.3		1000
3000	1.5	17.0		1200
3500	2.0	14.3		1400
4000	2.0	16.5		1600
4500	2.0	14.8		1800
5000	2.0	16.4		2000
6000	2.0	19.6		2400

NOTE: For altitude above 1000 feet, contact the local Cleaver-Brooks representative. Natural Gas @ 2500 Btu/cu.ft., specific gravity @ 0.65.

Propane Gas Pressure Requirements - Non-Standard Size Gas Train				
Boiler Size	**Standard Gas Train Size (inches NPT)**	**Min. Supply Pressure to Gas Train Regulator (inches W.C.)**	**Max. (W.C.)**	**Required Fuel Flow (SCFH)**
1500	2.0	5.9		600
2000	2.0	9.0		800
2500	2.0	10.8		1000
	2.5	10.5		1000
3000	2.0	13.8		1200
	2.5	12.9		1200
	3.0	12.6		1200
3500	2.5	13.6		1400
	3.0	12.6	27.7	1400
4000	2.5	15.8		1600
	3.0	14.5		1600
4500	2.5	13.8		1800
	3.0	12.1		1800
5000	2.5	14.8		2000
	3.0	12.5		2000
	4.0	12.0		2000
6000	2.5	18.0		2400
	3.0	15.0		2400
	4.0	14.1		2400

NOTE: For altitude above 1000 feet, contact the local Cleaver-Brooks representative. Natural Gas @ 2500 Btu/cu.ft., specific gravity @ 0.65.

A manually operated shutoff valve and pressure regulator are provided as standard. If dirt particles are present in the gas supply, it may be necessary to install an approved gas filter. Please inquire with the local gas supply company.

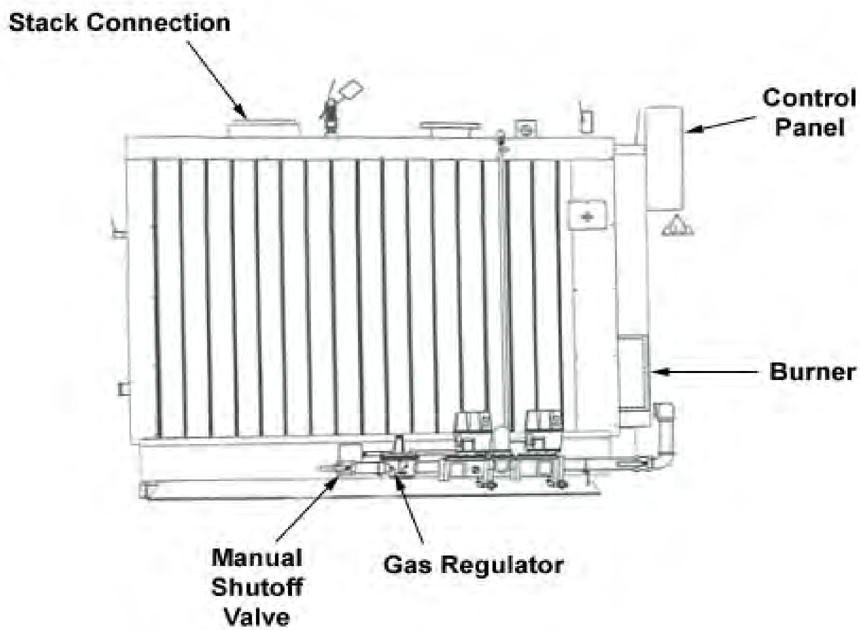


FIGURE 2-7. Typical Gas Train

If building supply gas pressure is greater than 1 psig (27.8" W.C.), and upstream regulator with overpressure protection and proper gas venting will be required and must be piped to a safe point of discharge. For multiple boiler installations, a dedicated gas pressure regulator is required for each boiler to ensure consistent gas pressure at the boiler.

Drip legs are required on any vertical piping at the gas supply to each boiler so that any dirt, weld slag, or debris can deposit in the drip leg rather than into the boiler gas train. The bottom of the drip leg should be removable without disassembling any gas piping. The connected piping to the boiler should be supported from pipe supports and not supported by the boiler gas train or the bottom of the drip leg.

All gas piping and components to the boiler gas train connection must comply with NFPA 54, local codes and utility requirements as a minimum. Only gas service approved fittings, valves, or pipe should be used. Standard industry practice for gas piing is normally Schedule 40 black iron pipe and fittings.

2.17.2 — Gas Supply Pipe Sizing

For proper operation of a single unit or a multiple unit installation, we recommend that the gas pipe be sized to allow no more than 0.3” W.C. pressure drop from the source 9gas header or utility meter) to the final unit connection relative to the piping run. Greater pressure drop can be taken whenever the pipe run is lengthy or multiple unit capacities would require a larger pipe than listed in the tables. The gas supplier (utility) should be consulted to confirm that sufficient volume and normal pressure are provided to the building at the discharge side of the gas meter or supply pipe.

For installations of new boilers into an existing building, gas pressure should be measured with a manometer to ensure sufficient pressure is available. A survey of all connected “gas using devices” should be made. If appliances other than the boiler or boilers are connected to the gas supply line, then a determination must be made of how much flow (CFH =cubic feet per hour) will be demanded at one time and the pressure drop requirement when all appliances are firing. Where possible, it is highly recommended that the gas line service the boiler only.

The total length of gas piping and all fittings must be considered when sizing the gas piping. Total equivalent length should be calculated from the utility meter or source to the final boiler gas inlet connection. As a minimum guideline, the following gas piping tables should be used. The data in these tables is from the NFPA 54 source book, 2006 edition.

To verify the input of each gas firing appliance connected to the gas piping, obtain the Btu/hr input of each appliance and divide this input by the calorific value of the gas that will be utilized. For example, a size 4000 unit with 4,000,000 Btu/hr input divided by the calorific value of 1060 will result in a required CFH flow of 3,774 at sea level. And we have measured that the single boiler is approximately 20 feet from the gas supply meter/header source. With a measured gas supply pressure of 10” W.C. we find that a supply pipe size of 3” should be used as a minimum to connect to the boiler gas train.

Gas Line Capacity - Schedule 40 Metallic Pipe							
Pipe Size							
Nominal	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	1.049"	1.380"	1.610"	2.067"	2.469"	3.068"	4.026"
Length in Feet	** Maximum Capacity in Cubic Feet of Gas Per Hour (CFV)						
10	514	1,060	1,580	3,050	4,860	8,580	17,500
20	363	726	1,090	2,090	3,340	5,900	12,000
30	284	583	873	1,680	2,680	4,740	9,660
40	243	499	747	1,440	2,290	4,050	8,290
50	215	442	662	1,280	2,030	3,590	7,330
60	195	400	600	1,160	1,840	3,260	6,640
70	179	368	552	1,060	1,690	3,000	6,110
80	167	343	514	989	1,580	2,790	5,680
90	157	322	482	928	1,480	2,610	5,330
100	148	304	455	877	1,400	2,470	5,040
125	131	269	403	777	1,240	2,190	4,460
150	119	244	366	704	1,120	1,980	4,050
175	109	209	336	648	1,030	1,820	3,720
200	102	185	313	602	960	1,700	3,460
** Fuel: Natural Gas							
** Inlet Pressure: Less than 2.0 psi							
** Pressure Drop: 0.30" W.C.							
** Specific Gravity: 0.60							

Gas Line Capacity - Schedule 40 Metallic Pipe							
Pipe Size							
Nominal	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	1.049"	1.380"	1.610"	2.067"	2.469"	3.068"	4.026"
Length in Feet	** Maximum Capacity in Cubic Feet of Gas Per Hour (CFV)						
10	678	1,390	2,090	4,020	6,400	11,300	23,100
20	466	957	1,430	2,760	4,400	7,780	15,900
30	374	768	1,150	2,220	3,530	6,250	12,700
40	320	657	985	1,900	3,020	5,350	10,900
50	284	583	873	1,680	2,680	4,740	9,600
60	257	528	791	1,520	2,430	4,290	8,760
70	237	486	728	1,400	2,230	3,950	8,050
80	220	452	677	1,300	2,080	3,670	7,490
90	207	424	635	1,220	1,950	3,450	7,030
100	195	400	600	1,160	1,840	3,260	6,640
125	173	355	532	1,020	1,630	2,890	5,890
150	157	322	482	928	1,480	2,610	5,330
175	144	296	443	854	1,360	2,410	4,910
200	134	275	412	794	1,270	2,240	4,560
** Fuel: Natural Gas							
** Inlet Pressure: Less than 2.0 psi							
** Pressure Drop: 0.50" W.C.							
** Specific Gravity: 0.60							

Gas Line Capacity - Schedule 40 Metallic Pipe									
Pipe Size									
Nominal	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	0.622"	0.824"	1.049"	1.380"	1.610"	2.067"	2.469"	3.068	4.026
Length in Feet	** Maximum Capacity in Cubic Feet of Gas Per Hour (CFV)								
10	1,510	3,040	5,560	11,400	17,100	32,900	52,500	92,800	189,000
20	1,070	2,150	3,930	8,070	12,100	23,300	57,100	65,600	134,000
30	869	1,760	3,210	6,590	9,880	19,000	30,300	53,600	109,000
40	753	1,520	2,780	5,710	8,550	16,500	26,300	46,400	94,700
50	673	1,360	2,490	5,110	7,650	14,700	23,500	41,500	84,700
60	615	1,240	2,270	4,660	6,980	13,500	21,400	37,900	77,300
70	569	1,150	2,100	4,320	6,470	12,500	19,900	35,100	71,600
80	532	1,080	1,970	4,040	6,050	11,700	18,600	32,800	67,000
90	502	1,010	1,850	3,810	5,700	11,000	17,500	30,900	63,100
100	462	954	1,710	3,510	5,260	10,100	16,100	28,500	58,200
125	414	836	1,530	3,140	4,700	9,060	14,400	25,500	52,100
150	372	751	1,370	2,820	4,220	8,130	13,000	22,900	46,700
175	344	695	1,270	2,601	3,910	7,530	12,000	21,200	43,300
200	318	642	1,170	2,410	3,610	6,960	11,100	19,600	40,000
500	192	401	717	1,470	2,210	4,250	6,770	12,000	24,400
1000	132	275	493	1,010	1,520	2,920	4,650	8,220	16,800
1500	106	221	396	812	1,220	2,340	3,740	6,600	13,500
** Fuel: Natural Gas									
** Inlet Pressure: 2.0 psi									
** Pressure Drop: 1.0 psi									
** Specific Gravity: 0.60									

Gas Line Capacity - Schedule 40 Metallic Pipe									
Pipe Size									
Nominal	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	0.622"	0.824"	1.049"	1.380"	1.610"	2.067"	2.469"	3.068	4.026
Length in Feet	** Maximum Capacity in Cubic Feet of Gas Per Hour (CFV)								
10	2,350	4,920	9,270	19,000	28,500	54,900	87,500	155,000	316,000
20	1,620	3,380	6,370	13,100	19,600	37,700	60,100	106,000	217,000
30	1,300	2,720	5,110	10,500	15,700	30,300	48,300	85,400	174,000
40	1,110	2,320	4,380	8,990	13,500	25,900	41,300	75,100	149,000
50	985	2,060	3,880	7,970	11,900	23,000	36,600	64,800	132,000
60	892	1,870	3,520	7,220	10,300	20,300	33,200	58,700	120,000
70	821	1,720	3,230	6,640	9,950	19,200	30,500	54,000	110,000
80	764	1,600	3,010	6,180	9,260	17,800	28,400	50,200	102,000
90	717	1,500	2,820	5,800	8,680	16,700	26,700	47,100	96,100
100	677	1,420	2,670	5,470	8,200	15,800	25,200	44,500	90,300
125	600	1,250	2,360	4,850	7,270	14,000	22,300	39,500	80,500
150	544	1,140	2,140	4,400	6,590	12,700	20,200	35,700	72,900
175	500	1,050	1,970	4,040	6,060	11,700	18,600	32,900	67,100
200	465	973	1,830	3,760	5,640	10,900	17,300	30,600	62,400
500	283	593	1,120	2,290	3,430	6,610	10,300	18,600	38,000
1000	195	407	897	1,380	2,360	4,550	7,240	12,000	26,100
1500	156	327	616	1,270	1,900	3,650	5,820	10,300	21,000
** Fuel: Natural Gas									
** Inlet Pressure: 3.0 psi									
** Pressure Drop: 2.0 psi									
** Specific Gravity: 0.60									

Gas Line Capacity - Schedule 40 Metallic Pipe									
Pipe Size									
Nominal	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
Actual I.D.	0.622"	0.824"	1.049"	1.380"	1.610"	2.067"	2.469"	3.068	4.026
Length in Feet	** Maximum Capacity in Cubic Feet of Gas Per Hour (CFV)								
10	3,190	6,430	11,800	24,200	36,200	69,700	111,000	196,000	401,000
20	2,250	4,550	8,320	17,100	25,600	49,300	78,600	139,000	283,000
30	1,840	3,720	6,790	14,000	20,900	40,300	64,200	113,000	231,000
40	1,590	3,220	5,880	12,100	18,100	34,900	55,600	98,200	200,000
50	1,430	2,880	5,260	10,800	16,200	31,200	49,700	87,900	179,000
60	1,300	2,630	4,800	9,860	14,800	28,500	45,400	80,200	164,000
70	1,200	2,430	4,450	9,130	13,700	26,400	42,000	74,300	151,000
80	1,150	2,330	4,260	8,540	12,800	24,700	39,300	69,500	142,000
90	1,060	2,150	3,920	8,050	12,100	23,200	37,000	65,500	134,000
100	979	1,980	3,620	7,430	11,100	21,400	34,200	60,400	123,000
125	876	1,770	3,240	6,640	9,950	19,200	30,600	54,000	110,000
150	786	1,590	2,910	5,960	8,940	17,200	27,400	48,500	98,900
175	728	1,470	2,690	5,520	8,270	15,900	25,400	44,900	91,600
200	673	1,360	2,490	5,100	7,650	14,700	23,500	41,500	84,700
500	384	802	1,510	3,100	4,650	8,950	14,300	25,200	51,500
1000	264	551	1,040	2,130	3,200	6,150	9,810	17,300	35,400
1500	212	443	834	1,710	2,570	4,940	7,880	13,900	28,400
** Fuel: Natural Gas									
** Inlet Pressure: 5.0 psi									
** Pressure Drop: 3.5 psi									
** Specific Gravity: 0.60									

2.17.3 — Gas Header

For multiple installations, a single common gas header is recommended with individual takeoffs for each boiler. Boiler gas manifold piping should be sized based on volume requirements and lengths between each boiler and fuel main header. With the total input, find the length of run from the source and determine what size header will be needed for the flow of all units firing and refer to the previous tables for pipe size.

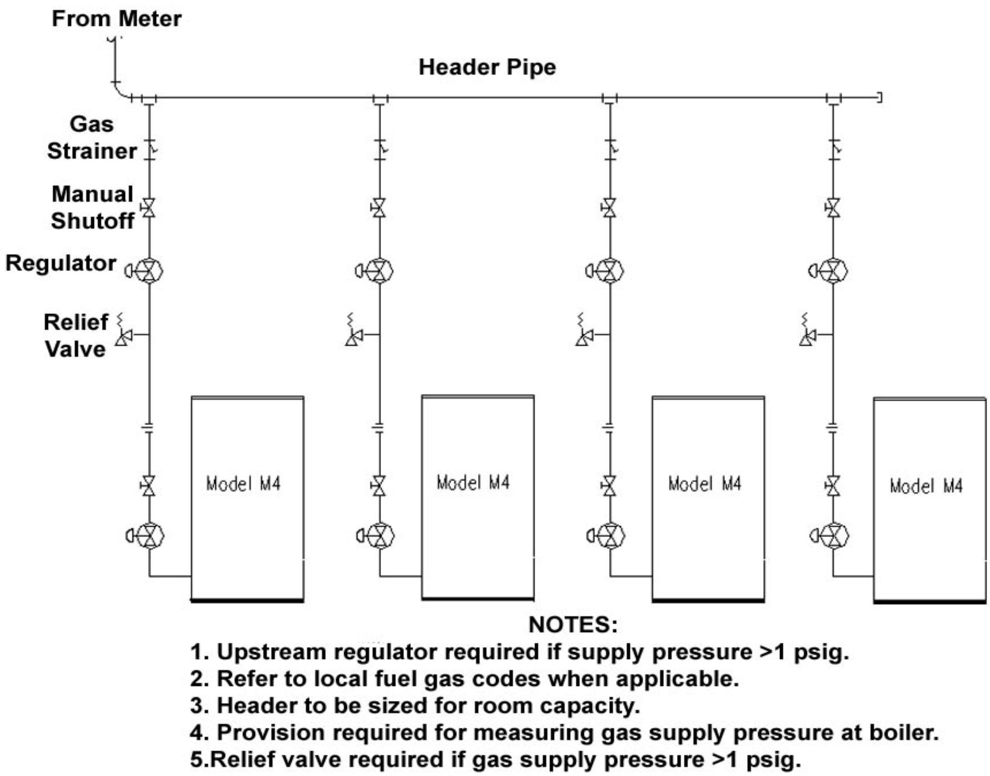


FIGURE 2-8. **Typical Gas Header Piping**

Before starting the unit, all piping must be cleaned of all debris to prevent its entrance into the boiler gas train. Piping should be tested as noted in NFPA 54 and the boiler must be isolated during any tests.

2.18 — Oil Piping

For units equipped to fire No. 2 oil (Model 10 and Model 200), it is important to understand that the fuel oil atomization process is mechanical, that is, it is pressure atomized. The standard pump supplied will develop the required pressure for proper pressure atomization and as such, requires sufficient oil flow. Consequently, the oil lines must be sized to handle the required flow.

As standard, the oil pump is belt driven from the blower motor, but as an option, a remote oil pump assembly may have been provided. Regardless of the oil pump drive, both types are of the mechanical pressure atomizing design. Therefore, the oil suction line size must be sized for 125 gph. The table below lists the firing capacity of the various sized units.

Model 4 Oil Firing rate	
Boiler Size	**Oil Flow @ High-Fire (GPH)**
1500	10.7
2000	14.3
2500	17.9
3000	21.4
3500	25.0
4000	28.6
4500	32.7
5000	35.7
6000	42.8

NOTE: If the oil supply is below the level of the pump, the suction lift capacity of this pump is 12” W.C. vacuum and must not be exceeded. If the oil lines are above the pump, the maximum inlet pressure may not exceed 3 psig.

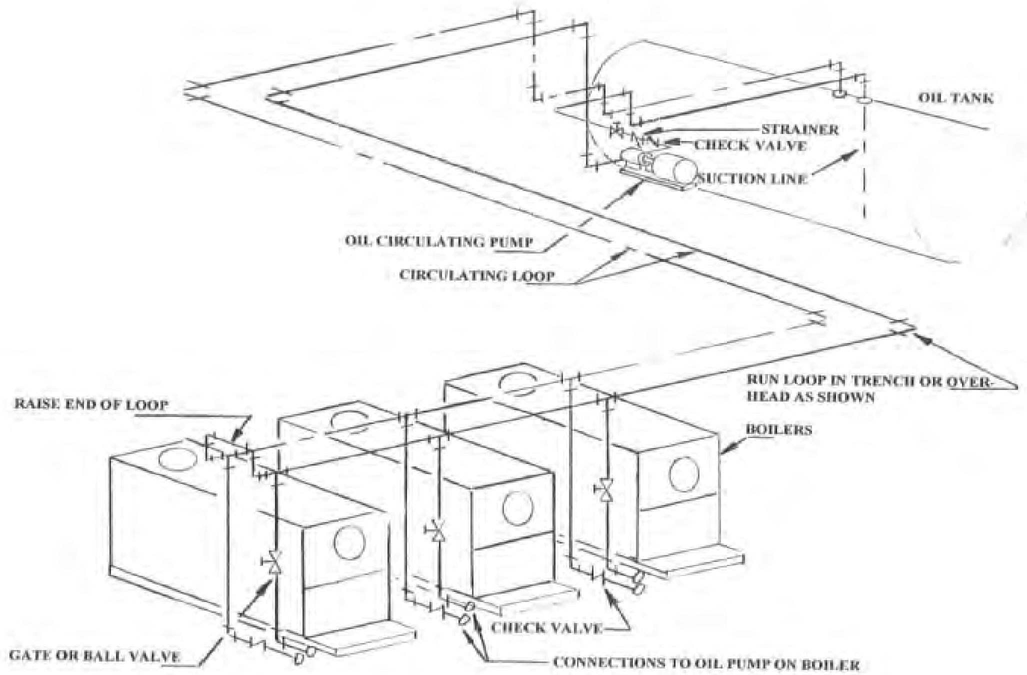


FIGURE 2-9. Installation of Light Oil Circulating Pump

Figure 2-9 shows the installation of a light oil transfer pump used for a multiple (or single) boiler installation. This is the preferred method over the pressurized supply lines or small storage tanks in the boiler room, and may be employed if the oil supply has not been furnished.

The suction line between the tank and the circulation pump should be tested for 24 hours under 100 psig air pressure to ensure that it is tight before it is covered. One oil pump is usually installed if oil is the standby fuel. If oil is the primary fuel, two pumps should be installed in parallel. If two pumps are used, or if gate valves are installed in the discharge line, the pumps should be equipped with safety relief valves.

The oil loop from the circulating pump to the boiler pump and back to the oil tank should be located in a trench, if possible. If it is necessary to locate the loop over the boilers, a check should be made to ensure that the pumps on the boilers can withstand the suction pressure imposed by the height of the loop.

NOTE: Per NFPA standards, the pressure imposed on the suction side of the boiler oil pump may not exceed 3 psig. Therefore, a pressure reducing valve may be required.

The layout has a number of advantages over high pressure supply lines or small storage tanks:

- Minimum pressure required in the oil supply line.
- Minimum amount of oil storage is required in the boiler room.
- No float switches, pressure regulators or relief valves required, other than noted above.
- Oil cannot spill out of vents or overflows that are required on other systems.

2.19 — Boiler Connections

Local codes and project specifications must be observed for all interface connections of steam and water line piping connections. Those requirements must be adhered to and inspected by the authority having jurisdiction for the installation. We are only noting the location of the connections for reference, along with other recommendations not conflicting with code or specification requirements. Refer to the Dimensional diagram for connection locations and sizes and Chapter 1 for information about connections.

A pressure relief valve (Safety Valve) provided with the boiler, must be installed in the opening provided in the upper drum. The valve must be mounted directly to the boiler without any intervening shutoff devices. Use pipe sealing compound and observe the following:

- Use only flat jawed wrenches on the flats of the valve, do not use a pipe wrench.
- Do not use a pipe threaded into the outlet connection of the valve to turn the valve in.
- Avoid tightening which can distort the valve’s seating ability.
- Valve must be mounted in the vertical position for proper operation.
- Do not paint, oil, or add any type of coating to the interior parts of the valve. A relief valve does not require any type of lubrication to operate.
- Discharge piping must be properly supported so that no strain is imposed on the valve.

- Discharge must be piped safely if the discharge of the valve will be into an area where workers might be scalded.
- If discharge piping extends greater than 12 feet, use 1/2” diameter larger for each 12 feet in length.
- Avoid all 90º bends, if possible. Avoid piping that will create a backpressure and accumulation of foreign material around the valve seat area.
- If discharge terminates outdoors where it can be subjected to freezing, ensure appropriate measures prevent the discharge pipe from freezing.
- Each discharge pipe should have a 3/8” or 1/2” open drain at its lowest point when using a drip pan.

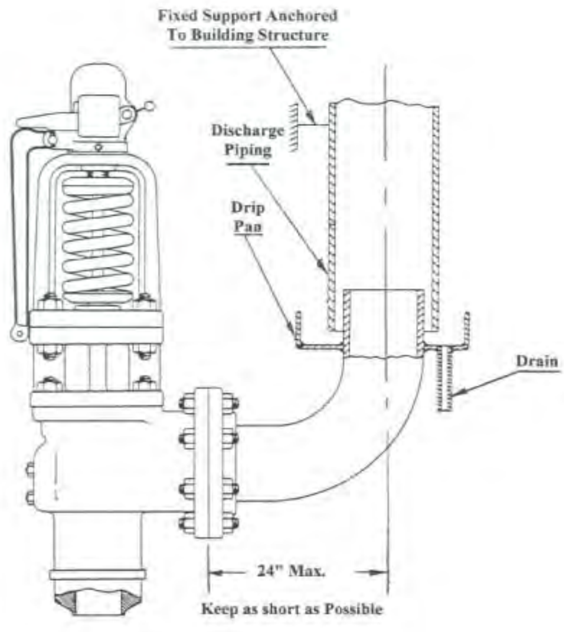


FIGURE 2-10. **High Pressure Safety Valve Drip Pan**

Safety Valve Outlet Size - Steam Standard						
Boiler Size	SAFETY VALVE SETTING					
	15 PSIG STEAM			150 PSIG STEAM		
	Valves Required	Outlet Size (in)**	Valve Capacity	Valves Required	Outlet Size (in)**	Valve Capacity
1500	1	2.0	3161 lbs/hr	1	1.0	1651 lbs/hr
2000	1	2.0	3161 lbs/hr	1	1.25	2585 lbs/hr
2500	1	2.0	3161 lbs/hr	1	1.25	2585 lbs/hr
3000	1	2.0	3161 lbs/hr	1	1.25	2585 lbs/hr
3500	1	2.0	3161 lbs/hr	1	1.50	4240 lbs/hr
4000	1	2.50	4676 lbs/hr	1	1.50	4240 lbs/hr
4500	1	2.50	4676 lbs/hr	1	1.50	4240 lbs/hr
5000	1	2.50	4676 lbs/hr	1	1.50	4240 lbs/hr
6000	1	3.0	6941 lbs/hr	1	2.0	6596 lbs/hr

** Valve size, capacity, and quantity may be different for non-standard valve settings. Check the DD for specific valve setting, size, and type.

Relief Valve Outlet Size - Hot Water						
Boiler Size	RELIEF VALVE SETTING					
	30 PSIG WATER			140 PSIG WATER*		
	Valves Required	Outlet Size (in)**	Valve Capacity	Valves Required	Outlet Size (in)**	Valve Capacity
1500	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr
2000	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr

Relief Valve Outlet Size - Hot Water						
2500	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr
3000	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr
3500	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr
4000	1	2.0	3,495,000 Btu/hr	1	1.0	3,728,000 Btu/hr
4500	1	2.50	6,215,000 Btu/hr	1	1.0	3,728,000 Btu/hr
5000	1	2.50	6,215,000 Btu/hr	1	1.25	5,827,000 Btu/hr
6000	1	2.50	6,215,000 Btu/hr	1	1.25	5,827,000 Btu/hr

* 140 PSIG is the standard relief valve setting.

** Valve size, capacity, and quantity may be different for non-standard valve settings. Check the DD for specific valve setting, size, and type.

Connection to the main steam header (steam boiler) is made at the nozzle projecting from the upper drum. The ASME Code requires a suitable stop valve to be installed between the boiler and the main steam header if multiple boilers are connected to the same header. This valve should be as close as possible to the boiler (allow expansion) to facilitate venting and pressure testing. A suitable rated gate valve is recommended for this purpose. A stop valve may have been supplied as an option with the boiler package as a shipped loose item.

For a hot water boiler, the system supply connection is located on the upper drum and the system return connection is located at the rear of the lower drum. Isolation valves should be used to avoid having to drain the system to permit a waterside inspection of the boiler. Additionally, an air vent valve should be piped into the air vent tapping or this should be piped to an expansion tank. Hot Water Boilers require proper over pressure to prevent the boiler water flashing to steam.

Feedwater (steam boilers only) is introduced through the tapping in the rear head of the upper drum. A stop valve and check valve are optional equipment and may have been provided as shipped loose items.

> **NOTE:** these valves are required per code and must be piped to the boiler from a suitable make-up water source. The check valve should be nearest to the boiler. If an electrically operating feedwater valve is provided as an option, refer to the valve cut sheet for piping requirements. A stop and check valve are still needed regardless of the electrically operated valve.

Hot Water Boilers: A drain connection is located on the bottom drum near the rear. Pipe a suitable drain valve, full size of the drain connection to a safe point of discharge. This is not a periodic blow-down valve, strictly to be used for draining the boiler.

Steam Boilers: For draining the boiler or for periodic bottom blowdown, a tapping is located on the bottom drum centerline at the rear. Connect an approved valve to this tapping and pipe to a safe discharge area or, if furnished, a blowdown separator.

> **NOTE:** For high pressure boilers or as local codes or specification may dictate, one quick opening and slow opening valve shall be installed to the bottom drum drain connection. The valve closest to the drum shall be the quick open type. (These valves may have been provided as an option from Cleaver-Brooks, and normally are shipped loose.)

For steam boilers a surface blowoff tapping is located in the rear head of the upper drum. If provided, surface blowoff valves may have been provided as an option. If not, it is recommended that a metering valve be piped to this tapping to remove surface solids and the control of TDS in the boiler.

> **NOTE:** A qualified boiler and piping installer should make all boiler piping connections.

2.20 — Electrical Connections

A qualified electrician or service technician must make the electrical connections to the boiler in accordance with local electrical and building codes. It is recommended that Emergency Power Disconnect switches be located at each entry into the boiler room. Make sure that all external wiring to and from the boiler control panel is properly identified and marked. This is to ensure that if burner power is disconnected, other power sources are known and marked, which remain active within the panel, even though the burner power has been disconnected.

2.21 — Wiring Diagrams

Refer to the actual wiring diagram for the boiler that was provided. If the drawing is not available, contact your local authorized Cleaver-Brooks representative to obtain a copy.

CHAPTER 3 Sequence of Operation

3.1 — Overview

This chapter outlines the electrical sequencing of various controls through the pre-purge, ignition, run, and shutdown cycles of the burner.

The program relay establishes the sequence of operation and directs the operation of all other controls and components to provide an overall operating sequence.

> **NOTE:** The make or model of the program relay provided will vary depending upon job specifications. the following sequence applies regardless of the make or model. Please refer to the manufacturer's bulletin for specific information.

In the schematic type wiring diagram provided for the boiler, the grounded (common) side of the power supply is shown as a vertical line on the right side of the diagram. All inductive components (coils, solenoids, transformers, lights, etc.) are connected to it. The hot side of the power supply is shown as a vertical line on the left side of the electrical schematic. All the inductive components are connected to it through switches or contacts that permit the component to function when required.

Abbreviations for the various electrical components are listed in **Section 3.2**. The sequences outlined in this chapter employ these designations to aid in applying the text to the wiring diagram.

For an explanatory booklet on schematic wiring diagrams, request Cleaver-Brooks Bulletin C17-4095.

The burner and control system are in starting condition when the following conditions exist:

- Boiler water is up to correct level, closing the low water cutoff switch.
- The low water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cutoff setting.
- All applicable limits are correct for burner operation.
- The load demand light glows.

All entrance switches are closed and power is present at the line terminals of:

- Blower and motor starter.
- Oil pump motor starter (if provided).

These sequences do not attempt to correlate the action of the fuel supply system or feed-water system except for the interlock controls that directly relate to the action of the program relay. **Chapter 4** and **Chapter 5** contain operating instructions and specific information on setting and adjusting the controls.

3.2 — Circuit and Interlock Controls

The burner control circuit is a two-wire system designed for 115 volt, single phase, 60 Hz, alternating current.

The electrical portion of the boiler is made up of individual circuits with controls that are wired in a manner designed to provide a safe workable system. The program relay provides connection points for the interconnection of these various circuits.

The controls used vary depending upon the fuel — oil or gas — and the specific requirement of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. The circuits and controls normally used in these circuits are listed in the next table and referred to in the following sequence of operation.

Circuit	Components
Limit Circuit	• Burner Switch (BS) • Operating Limit Control (OLC) - pressure or temperature • High Limit Control (HLC) - pressure or temperature • Low Water Cutoff (LWCO) • Gas-Oil Selector Switch (GOS) - combination burner only • Low Gas Pressure Switch (LGPS) 200 & 700 Series only • High Gas Pressure Switch (HGPS) 200 & 700 Series only • Fuel Valve Interlock Circuit • Main Gas Valve Auxiliary Switch (MGVAS)
Blower Motor Start Circuit	• Blower Motor Starter (BMS)
Running Interlock Circuit	• Blower Motor Starter Interlock (BMSI) • Combustion Air Proving Switch (CAPS)
Low Fire Proving Circuit	• Low Fire Switch (LFS)
Pilot Ignition Circuit	• Gas Pilot Valve (GPV) • Ignition Transformer (IT) • Gas Pilot Vent Valve (GPVV) if provided
Flame Detector Circuit	• Flame Detector (FD) • Main Fuel Valve Circuit • Main Gas Valve (MGV) • Main Gas Vent Valve (MGVV) if provided • Oil Valve (OV) • Auxiliary Switches (AS-1) (AS-2) Model 100 & 200 only • Main Fuel Valve Light (FVL)

Circuit	Components
Firing Rate Circuit	• Damper Motor Transformer (DMT) • Modulating Damper Motor (MDM) • Damper Motor (DM) • Damper Positioning Switch (DPS) • Manual-Automatic Switch (MAS) • High-Low Fire Control (HLFC) • Manual Flame Control (MFC) • Modulating Control (MC) To comply with requirements of insurance underwriters such as Factory Mutual (FM), Industrial Risk Insurers (I.R.I.), or others, additional interlock devices may be used in addition to those identified above.
High Fire Proving Circuit	• High Fire Switch (HFS)
Running Interlock and Limit Circuit	• Low Oil Pressure Switch (LOPS) • High Oil Pressure Switch (HOPS) • Auxiliary Low Water Cutoff (ALWCO)

3.3 — Sequence of Operation - Oil or Gas

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

The following sequence occurs with power present at the program relay (PR) input terminals and with all other operating conditions satisfied:

3.3.1 — Pre-Purge Cycle

When the burner switch (BS) is turned "on," and controls wired in the "limit" and "fuel valve interlock" circuits are closed and no flame signal is present, the "blower motor start circuit" is powered, energizing the blower motor starter (BMS). The load demand light (LDL) turns on. When firing oil, the low oil pressure switch (LOPS) must be closed to indicate that sufficient fuel supply pressure exists.

At the same time, the program relay signals the modulating damper motor (MDM) to open the air damper. The damper begins to open and drives to its full open or high fire position. This allows a flow of purging air through the boiler prior to the ignition cycle.

On certain boilers the circuitry will include a high fire switch (HFS). The purpose of this switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle. In this instance, the “high fire proving circuit” is utilized. If proof of high fire position is not required the timer will not stop but will continue its cycle.

The controls wired into the “running interlock circuit” must be closed within 10 seconds after the start sequence. In the event any of these controls are not closed at this time, or if they subsequently open, the program relay will go into a safety shutdown.

At the completion of the high fire purge period, the program relay signals the modulating damper motor (MDM) to drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete the “low fire proving circuit.” The sequence will stop and hold until the modulating damper motor (MDM) has returned to the low-fire position and the contacts of the low fire switch (LFS) are closed. Once the low fire switch is closed, the sequence is allowed to continue.

The ignition trial cannot be started if flame or a flame simulating condition is sensed during the pre-purge period. A safety shutdown will occur if flame is sensed at this time.

3.3.2 — Ignition Cycle

The ignition transformer (IT) and gas pilot valve (GPV) are energized from the appropriate pilot ignition terminal.

> **NOTE:** An oil fired burner may be equipped with a spark pilot rather than a gas pilot. The ignition sequence of both is identical.

The pilot flame must be established and proven by the flame detector (FD) within a 10 second period in order for the ignition cycle to continue. If for any reason this does not happen, the system will shut down and safety lock-out will occur.

> **NOTE:** Depending upon the requirements of the regulatory body, insurance, or fuel being burned, either the 10 or 15 second pilot ignition terminal may be used. Both provide the same function but differ in time interval allowed for proving main flame ignition. Refer to the boiler wiring diagram.

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized. The main fuel valve light (FVL) in the panel turns on. The main flame is ignited and the trial period for proving the main flame begins. It lasts 10 seconds for light oil and natural gas. At the end of the proving period, if the flame detector still detects main flame, the ignition transformer and pilot valve are de-energized and pilot flame is extinguished.

> **⚠ Caution**
>
> If the main flame does not light, or stay lit, the fuel valve will close. The safety switch will trip to lock out the control. Refer to the flame loss sequence section for description of action. The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart it.

3.3.3 — Run Cycle

With main flame established, power is transferred to the damper motor positioning switch and releasing the burner from low-fire position is subject to the following conditions:

- With damper positioning switch in the “low” position, the damper motor is powered to maintain the motor in the low-fire position.
- With damper positioning switch in the “high” position. the damper motor is powered to drive the motor to the high-fire position.
- With damper positioning switch in the “auto” position, power is routed through the high-low fire control to either low-fire or high-fire as the load demands.
- On an oil fired unit, the opening of the damper motor actuates switches which in turn energize the intermediate and high-fire solenoid valves, increasing the size of the fire to the high-fire rate. Closing of the motor de-energizes the high-fire valves, reducing the flame to the low-fire rate.
- On a gas fired unit, the opening of the damper motor actuates through linkage, the disc in the butterfly valve to allow a greater flow of gas, increasing the size of the flame to high-fire rate. Closing of the motor decreases gas flow to a low-fire rate.
- On a modulating gas fired unit, with the manual automatic switch (MAS) set at automatic, subsequent modulated firing will be at the command of the modulating control (MC) which governs the

position of the modulating damper motor. The air damper and the cam controlled metering valve are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

NOTE: Normal operation of the burner should be with the switch in the automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual position at other than low-fire, the damper will not be in a closed position thus allowing more air than desired to flow through the boiler. This subjects the pressure vessel metal and refractory to undesirable conditions. The effectiveness of nozzle purging is lost on a No. 5 or No. 6 oil burner.

This is the end of the burner starting cycle. The (LDL) and (FVL) lights on the panel remain lit. Demand firing continues as required by load conditions.

3.3.4 — Burner Shutdown Post Purge

The burner will fire until steam pressure or water temperature in excess of demand is generated. With modulated firing, the modulating damper motor (MDM) should return to the low-fire position before the operating limit control (OLC) opens. When the limit control circuit is opened, the following sequence occurs:

- The main fuel valve circuit is de-energized, causing the main fuel valve (MGV) or (OV) to close. The flame is extinguished. The control panel lights (LDL) and (FVL) are turned off. The blower motor continues to run to force air through the boiler for the post purge period.
- The blower motor start circuit is de-energized at the end of the post purge cycle and the shutdown cycle is complete.

The program relay is now in readiness for subsequent recycling, and when steam pressure or water temperature drops to close the contacts of the operating control, the burner again goes through its normal starting and operating cycle.

3.4 — Flame Loss Sequence

The program relay will recycle automatically each time the operating control closes or after a power failure. It will lock out following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the pre-purge period.

The control will prevent start-up or ignition if limit circuit controls or fuel valve interlocks are open. The control will lock out upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit. The CB-20 control will recycle in an attempt to correct the shutdown situation (if it is self-correcting).

⚠ Caution

The lockout switch must be manually reset following a safety shutdown. The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart.

3.4.1 — No Pilot Flame

The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately de-energized and the pilot valve closes, the reset switch lights and lockout occurs immediately.

The blower motor will continue to operate. The flame failure light and the alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

3.4.2 — Pilot But No Main Flame

When the pilot flame is proven, the main fuel valve circuit is energized. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 seconds later. The flame detecting circuit will respond to de-energize the main fuel valve circuit within 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

3.4.3 — Loss of Flame

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay will trip within 4 seconds to de-energize the fuel valve circuit and shut off fuel flow. The reset switch lights and lockout occurs immediately. The blower motor continues operation. The flame failure light and alarm bell (optional) are energized 10 seconds later.

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

If the burner will not start, or upon a safety lockout, the troubleshooting section in the operating manual and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the manual and this bulletin. Knowledge of the system and its controls will make troubleshooting much easier in the event it is necessary. Costly downtime or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember that this is a safety device and for the most part it is doing its job when it shuts down or refuses to operate. Never attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay to see that a safety lockout will occur under conditions of failure to ignite either pilot of main flame, or from loss of flame is recommended.

To assure that the system is in low-fire position prior to ignition, the low fire switch (LFS) must be closed to complete an interlock circuit to terminal 14. The timer will stop until the damper motor has returned to the low-fire position and the contacts of the low fire switch are closed.

NOTE: The ignition trial cannot be started if for any reason the flame relay pulls in during the pre-purge. The timer will complete its revolution and lock out at the start position.

3.4.4 — Ignition Period

3.4.4.1 — Dial at "Pilot and Ignition"

Spark Ignited Oil Fired Burner — The ignition transformer is energized from terminal 5. The low fire solenoid valve is energized from terminal 6, which is jumpered to terminal 7 (main fuel valve). With combustion air, ignition spark and oil present, the low-fire flame is ignited. When flame is detected, flame relay 2K is energized.

Gas Pilot Ignited Oil or Gas Fired Burner — The ignition transformer and the gas pilot solenoid valve are energized from terminal 5. With combustion air, ignition spark and gas present, the pilot flame is established. When flame is detected, flame relay 2K is energized.

The pilot flame must be established and proven within a 10 second period in order for the ignition cycle to continue. If for any reason this has not happened, the system will shut down and safety lock-out will occur.

⚠ Caution

The cause for loss of flame or any other unusual condition must be investigated and corrected before attempting to restart.

3.4.4.2 — Dial at "Main Burner"

Spark Ignited Burner — Terminal 7 is now powered. The main fuel valve (LFOV), already opened, will continue to be energized from this terminal when terminal 6 is de-energized at the end of the main flame proving period.

Gas Pilot Ignited Burner — Main gas valve(s) (gas fired unit) or the low fire solenoid valve (oil fired unit) is energized from terminal 7. Main flame is ignited.

I.R.I. regulations, or others, require two main gas valves with a vent valve between them. As the main gas valves are simultaneously energized and open, the normally open vent valve is also energized and closes.

After a 10 second trial period for the proving of main flame, power is removed from terminal 5, de-energizing the ignition transformer and the gas pilot valve. The gas pilot flame is extinguished.

If for any reason the main flame does not light or remain burning, relay 2K will drop out and cause the fuel valve(s) to close. The program lockout switch will trip to lock out the control. Refer to flame loss sequence Section E for description of action.

> **⚠ Caution**
>
> The cause for loss of flame or any other unusual condition must be investigated and corrected before attempting to restart.

3.4.5 — Run Cycle

With the main flame established, terminal 11 is powered (from terminal 10) transferring power to the damper motor positioning switch and releasing burner from low-fire position subject to following conditions:

- With the damper positioning switch in the "low" position, the damper motor terminal W is powered to hold the motor in the closed, or low-fire position.
- With the switch in the "high" position, damper motor terminal B is powered to drive the motor to the high-fire position.
- With the switch in the "auto" position, power is routed through the high-low fire control to either the low fire or the high fire terminal of the damper motor as the load demands.
- On an oil fired unit, the opening of the damper motor actuates switches which in turn energize the intermediate and high fire solenoid valves, increasing the size of the fire to the high-fire rate. Closing of the motor de-energizes the high fire valves, reducing the flame to the low-fire rate.
- On a gas fired unit, the opening of the damper motor actuates, through linkage, the disc in the butterfly valve to allow a greater flow of gas, increasing the size of the flame to high-fire rate. Closing of the motor decreases gas flow to a low-fire rate.

3.4.6 — Burner Shutdown

3.4.6.1 — Dial at "Post Purge"

The burner will fire until steam pressure or water temperature in excess of demand is generated. With the high-low fire control properly adjusted, the damper motor should return to the low-fire position before the operating limit control opens. When the limit control circuit is opened, the following sequence occurs:

- Relays 1K, 3K and 4K drop out. The main fuel valve(s) is de-energized and closes. Flame is extinguished and flame relay 2K drops out. The blower motor continues to force air through the boiler in a post-purge period. The timer begins rotating.
- Power is removed from terminal 11, breaking the circuit to the damper motor. The motor returns to the low-fire position if it is not already in that position.

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. The timer stops as it reaches its original position.

The control is now in readiness for subsequent recycling and when steam pressure or water temperature drops to close the contacts of the operating control, the burner again goes through its normal starting and operating cycle.

3.5 — Flame Loss Sequence

The CB-20 and CB-40 programmers recycle automatically each time the operating control closes or after a power failure. Both will lock out following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the pre-purge period.

Both controls will prevent start-up or ignition if the pre-ignition or air flow interlocks open. The CB-20 control will recycle in an attempt to correct the shutdown situation (if it is self-correcting). The CB-40 control will lock out upon any abnormal condition affecting fuel or air supervisory controls.

The lockout switch must be manually reset following a safety shutdown. A short cool down period is necessary before the switch button can be depressed and operation resumed.

⚠ Caution

The cause for loss of flame or any other unusual condition must be investigated and corrected before attempting to restart.

3.5.1 — No Pilot Flame

The pilot flame must be ignited and proven within a 10 second period after the ignition cycle begins — terminals 5 and 6 energized. The flame is proven by the pull-in of relay 2K. If 2K is not energized within this period, the fuel valve circuit (terminal 7) will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately de-energized and the pilot valve closed.

The blower motor will continue to operate. The timer will stop after a short period of operation. Approximately 30 seconds after the ignition circuit is interrupted, the lockout switch (LS) will trip. Master relay 1K is de-energized. The flame failure light and the alarm belt (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position, the timer and blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

3.5.2 — Pilot But No Main Flame

If the pilot flame is proven, the main fuel valve circuit is energized from terminal 7. The pilot flame will be extinguished 10 seconds later. The flame detecting circuit will break within 4 seconds to drop out the flame relay 2K. The main fuel valve circuit is de-energized to stop the flow of fuel. The blower motor continues to run.

The lockout switch will trip approximately 30 seconds later and relay 1K will be de-energized. The flame failure light and alarm bell (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position, the timer and blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

3.5.3 — Loss of Flame

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay 2K will trip within 4 seconds to de-energize the fuel valve circuit and shut off fuel flow. The blower motor continues operation. Approximately 30 seconds later the lockout switch will trip to de-energize master relay 1K. The flame failure light and alarm bell (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position, the timer and blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

If the burner will not start, or upon a safety lockout, the troubleshooting section in the operating manual and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent. Familiarity with the programmer and other controls in the system can be obtained by studying the contents of the manual and this bulletin. Knowledge of the system and its controls will make troubleshooting much easier in the event it is necessary. Costly downtime or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember that this is a safety device and for the most part it is doing its job when it shuts down or refuses to operate. Never attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame is recommended.

3.6 — Optional Equipment Sequence: Day-Night Operation

3.6.1 — Day-Night Operation

Steam boilers with a maximum design pressure of 150 psi may be equipped with a dual set of operating limit and high-low fire controls and wired for both high pressure and low pressure operation. This enables the boiler to be operated at a lower pressure during “off” load hours, but at a somewhat reduced output dependent upon the lower steam pressure and the steam nozzle size.

For “night” operation the day-night selector switch (D-NS) is positioned at “night”. This places the limit circuit under the control of the secondary operating limit and high-low fire controls which are set at a lower pressure than the primary controls. The burner will operate normally to maintain the lower pressure.

3.6.2 — Indicator Lights and Alarm System

Indicator lights provide visual information on the operation of the boiler as follows:

- Flame Failure
- Load Demand

- Fuel Valve (valve open)
- Low Water

In addition, an alarm bell is provided to ring under conditions of flame failure or low water.

The load demand light glows during the period that the unit is operating. When the operating limit control opens and the burner proceeds into a normal shutdown, the circuit to the load demand light is broken and the light extinguished.

The fuel valve light glows whenever the main fuel valves — oil or gas — are energized. It does not indicate the operation of the gas pilot valve.

The low water light glows whenever boiler water is below normal operating level. This condition also energizes an alarm relay, causing the alarm bell to sound to audibly notify the operator.

The flame failure light is energized from terminal 9 of the programmer control and glows whenever a safety lockout of the control occurs. This would be upon failure to ignite the pilot, upon failure to light the main flame or upon loss of flame. The alarm bell also rings. The safety switch must be manually reset to extinguish the light and silence the alarm.

⚠ Caution

The cause for loss of flame or any other unusual condition must be investigated and corrected before attempting to restart.

CHAPTER 4

Starting and Operating Instructions

4.1 — General Preparation for Initial Start-Up (All Fuels)

The instructions in this chapter assume that complete installation has been made and that all electrical, fuel, water, and vent stack connections are completed.

It is expected that the operator has familiarized himself with the burner, boiler, and all components. To quickly locate and identify the various controls mentioned in the following paragraphs, refer to callout photographs and the contents of **<Color>Chapter 1**.

Chapter 5 contains adjustment procedures and this must be reviewed prior to actual firing. The wiring diagram also must have been studied.

Verify supply of fuel and proper voltage. Check for blown fuses or fusetrons, open circuit breakers, tripped overloads, etc. Check reset of all starters and controls having manual reset features. Check the lockout switch on the programmer and reset if necessary. The timer dial setting should be at the black dot.

The boiler should be filled with water to the proper operating level using water of ambient temperature. Make sure that treated feedwater is available and used. In heating applications the entire system should be filled and vented. Refer to **Chapter 2** for water requirements.

On a steam boiler the try-cocks should be left open to vent air displaced during filling. The top cock may be left open until steam vapor appears and then closed.

⚠ Caution

Prior to firing make certain the discharge piping from safety or relief valves and discharge piping from all blowdown or drain valve is piped to a safe point of discharge so that emission of hot water or steam cannot possibly cause injury to personnel or damage to property. Check to see that lines from any gas vents are properly installed.

Inspect all linkage for full and free movement of the damper and also of the butterfly gas valve on gas fired burners.

Check for proper rotation of blower motor by momentarily closing the burner switch. Rotation is counterclockwise when viewed from front of boiler.

⚠ Caution

Remove the oil pump belt before checking motor rotation.

Before operating boiler feed pump, if used, be sure all valves in the line are opened or properly positioned.

For safety's sake make a final pre-start-up inspection, especially checking for any loose or incompleted piping or wiring or any other situation that might present a hazard.

4.2 — Control Settings (All Fuels)

Inspect operating limit control for proper setting. The pressure control on a steam boiler should be set slightly above highest desired steam pressure, but 10% lower than the setting of the safety valve(s). The temperature control on a hot water boiler should be set slightly above highest desired water temperature and within the limits of the pressure vessel.

Inspect high limit control. On a high pressure steam boiler this should be set approximately 10 lbs. above the operating limit pressure control setting, if feasible, or midway between operating limit pressure and safety valve setting. The setting can be 2 or 3 lbs. on a low pressure steam boiler. On a hot water boiler, the temperature control should be 5° to 10° above operating limit temperature control setting.

Inspect the high-low fire control for proper setting which should be slightly lower than that of the operating limit control.

Adjustment procedures for these controls is covered in Chapter 5.

Inspect the low water cutoff. Check for freedom of float and verify that control is functioning properly.

Set damper positioning switch at "low". Leave burner switch "off" but close all other power entrance switches (supplied by others).

4.3 — Oil Burner Start-Up (100 and 200 Series)

4.3.1 — Preparation for Initial Firing

1. Verify that the driving belt for the oil pump is in place. Temporarily close the oil shutoff cock.
2. On a 200 series boiler, set the gas/oil selector switch to "Oil". Close main gas cock and open pilot gas cock.
3. Open all valves in the oil suction line and oil return line. The line from the storage tank to the pump should be filled with fuel. Short suction lines may be filled by use of the fuel pump. Long suction lines and those of large diameter pipe should be filled by priming or other means.
4. Place the damper positioning switch at "low". Place the test switch of the programming control in the "test" position. This will stop the timer during the low-fire purge of the pre-purge.
5. Turn the burner switch "on" to start the burner motor and the oil pump. When the pump picks up and circulates oil, the flow will be indicated on the pressure gauge which should show a steady reading of 200 psi (approx.).
6. If no pressure shows on the gauge after a few moments, stop the pump and prime the suction line. Continue this procedure until oil flow is established.

If a vacuum (or compound pressure-vacuum) gauge is installed in the oil suction line, it will reveal the tightness of the system. Its readings should be observed and recorded for future guidance. Refer to **Section 5.6** of **Chapter 5** for further information on the oil piping system.

7. After the oil flow is established, return the test switch to "NORM". The timer will resume rotating.

   The damper will open for the pre-purge period and allow a flow of air through the fireside area of the pressure vessel. The damper motor will return to the low-fire position after this pre-purge is completed. The low fire switch must be closed for action to continue.

8. Now check for ignition spark. When the "pilot ignition" legend appears on the timer dial, the ignition transformer is energized. An electric spark should be visible when viewed through the rear door sight glass. If the unit has a gas pilot, its flame can be seen.

   The main burner will not light, since the oil shutoff valve is closed.

9. With evidence of a good spark (or gas pilot) and proper oil pressure, the unit is ready to be fired. Turn burner switch to "off". The programmer will complete its cycle and stop. Reset the safety switch in the event programmer locked out prior to the burner switch being turned off.

10. Review the sequence of operation given in **Chapter 3** for a complete description of the action that takes place during a starting and operating cycle.

4.3.2 — Initial Start-Up and Firing

1. Set damper position switch to "low." Open the manual fuel oil cock. Turn burner switch "on." After the pre-purge period the burner will light and operate at its low fire rate.

   In some instances on initial firing, air may be trapped in the fuel lines, preventing ignition until it is completely expelled and replaced by fuel oil. It may be possible for the burner to go through several cycles until all lines are filled with oil. If ignition does not then occur, do not repeat unsuccessful lighting attempts without re-checking burner and pilot adjustments.

On an ignition failure the blower will continue running to purge the boiler of any unburned fuel vapors before stopping. After ignition failure wait a few moments before re-setting safety switch.

⚠ Caution

The burner and control system is designed to provide a pre-purge periods of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system in any way that might circumvent this feature.

2. When flame is established leave the burner in low-fire position for approximately 30 minutes or until boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.

   A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.

3. As normal pressure or temperature is approached at low-fire, turn the damper positioning switch to "high". Observe the burner as it progresses to high-fire position. There possibly may be air trapped in the high fire oil lines and it may be necessary to operate the burner for several cycles to assure that these lines become filled with oil. Failure of oil to flow through the high fire nozzles promptly may cause the increased combustion air to extinguish the low fire flame.

4. After the unit is thoroughly warmed, a combustion analysis test should be made with instruments and fuel flow and/or air flow regulated as required. Refer to adjustment procedures in **Chapter 5**. To properly perform this test and adjustment, it is necessary that burner be allowed to fire at maximum rate sufficiently long enough to achieve desired results.

   Refer to **Section E** of this chapter for normal firing operating and shutdown sequences.

⚠ Caution

It is advisable to check for tight shutoff of fuel valves. Review **Section 5.11** in **Chapter 5**.

4.4 — Gas Burner Start-Up (200 and 700 Series)

4.4.1 — Preparation for Initial Firing

1. Close main gas cock and open pilot gas cock.
2. On a 200 series boiler, set the gas-oil selector switch to "gas". Although not mandatory, it is suggested that oil pump belt be removed during periods of extended gas firing.
3. Check the linkage attached to the butterfly valve to insure that it has free movement and that all connections and set screws are tight. The linkage was set at the factory but if adjustment is required, see **Section 5.7** in **Chapter 5**.
4. Verify the presence and availability of gas. On a new installation, representatives of the gas utility should be present when gas is first turned into the system to supervise purging of the new gas line unless they have already done so.

5. Determine that sufficient gas pressure exists at the entrance to the gas train. This can be noted by installing a gas pressure test gauge in the line. Refer to **Section 5.7** of **Chapter 5** for information on pressures and flow rates.
6. Check to insure that damper positioning switch is set to “low”. Turn burner switch to “on”. The blower will start and the programming control timer will begin rotating.

   The damper will open for the pre-purge period and allow a flow of air through the fireside area of the pressure vessel. The damper motor will return to the low-fire position after this pre-purge period is completed. The low fire switch must be closed for action to continue.
7. Now check for ignition spark and gas pilot. When the legend “pilot ignition” appears on the timer dial, the ignition transformer and gas pilot valve are energized. The gas pilot flame may be viewed through the rear sight glass.
8. The main burner will not light since the main gas shutoff cock is closed. When the timer dial indicates “main burner” determine that the main gas valve opens when energized. In the case of a diaphragm valve, the click of its solenoid will indicate that it is energized. The valve will not actually open since there is no gas pressure available. During normal operation the position of the diaphragm valve may be determined by observing the flag in the window on top of the valve which shows black when the valve is closed and yellow when opened. In the case of a motorized valve, yellow showing on the stem indicates that the valve is closed.
9. As soon as valve action is confirmed, turn the burner switch off and let programmer finish its cycle. Check to see that the gas valve has closed.
10. With evidence of a good pilot and operating main gas valve, unit is ready to be fired. Reset the safety switch in the event programmer locked out prior to the burner switch being turned off.
11. Review the sequence of operation given in **Chapter 3** for a complete description of the action that takes place during a starting and operating cycle.

4.4.2 — Initial Start-Up and Firing

1. Set damper positioning switch to “low”. Turn the burner switch “on” and when the timer dial indicates “main burner”, slowly open the main gas cock. Main flame should ignite unless there is air present in the line. In this event, turn the burner switch “off” and allow programmer to run through its normal shutdown cycle. Several efforts may be necessary to “bleed” air from the line.

2. On an ignition failure, the blower will continue running to purge the boiler of any unburned fuel vapors before stopping. After ignition failure wait a few moments before resetting the safety switch.

> **⚠ Caution**
>
> The burner and control system is designed to provide a pre-purge period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system in any way that might circumvent this feature.

3. When main flame is established observe that it is extinguished promptly when burner is shut down. Burner will normally continue to burn for a second or two after shutdown due to the gas remaining downstream of the cutoff valve. If flame continues to burn for a longer period, or during blower motor spin down, immediately turn burner switch "off" and close main gas cock. Investigate and correct the cause of valve leakage before re-lighting the burner. The main gas valve is tight seating provided nothing prevents tight closure. Foreign material may be present in either new or renovated gas lines unless adequate care is taken in cleaning, purging and providing a suitable strainer.
4. When flame is established leave the burner in low-fire position for approximately 30 minutes or until boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.

   A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.
5. After normal pressure or temperature is approached at low fire, turn the damper positioning switch to "high". Observe the burner as it progresses to "high" fire position. In the event the butterfly gas valve movement is not properly coordinated with the air damper, it is possible that increased secondary air may extinguish the low fire flame. After the unit is thoroughly warmed and running in high fire, a combustion analysis should be made, with instruments, and fuel flow and/or air flow regulated as required. Refer to the adjustment procedures in **Chapter 5**. To properly perform this analysis and adjustment it is necessary that burner be allowed to fire at maximum rate and sufficiently long enough to achieve desired results.
6. The main gas pressure regulator, the pilot gas regulator and the diaphragm-type main gas valve have a vent opening which must be free from obstructions for proper operation of the device. Local codes or insurance requirements may require discharge piping to the outside of the building. Make sure that this piping is not obstructed.
7. Refer to **Section 4.5** of this chapter for normal starting, operating and shutdown information.

4.5 — Normal Operation (All Fuels)

4.5.1 — Start-Up

1. Check water level and supply. Fill a steam boiler to center of gauge glass.
2. Check setting of all operating controls. Check all reset and lockout mechanisms.

   Programmer timer dial should be at the black dot.

   On a combination fuel unit (Series 200) the fuel selector switch should be set for the appropriate fuel.
3. Turn burner switch “on”. Observe action of burner and controls to assure proper functioning.
4. Allow boiler to run at low fire until properly warmed up before allowing burner to go to high fire.

4.5.2 — Operating

Normal operation should be with the damper positioning switch set at “auto” and under the control of the high-low fire control.

With the switch set at “auto”, burner will operate on a high-low firing basis according to the load demands.

The burner will continue to operate until the operating limit pressure or temperature setting is reached, unless:

- Burner is manually turned “off.”
- Low water condition is detected by low water level control.
- Current or fuel supply is interrupted.

Pressure of combustion air drops below minimum level.

> **NOTE:** There can be other reasons for shutdowns such as motor overload, flame outages, tripped circuit breakers, blown fusetrons, or through interlock devices in the system.

4.5.3 — Shutdown

When the operating limit pressure or temperature control opens due to pressure or water temperature increase, or if the burner switch is turned “off”, the following sequence occurs:

- The fuel valve is de-energized and flame extinguished. The timer resumes operation and the blower motor continues running to force air through the furnace during the post purge period.
- At the end of the post purge the blower motor is de-energized. The timer has returned to its original position and stops.

Refer to **Chapter 3** for timing sequence.

Unit is ready to re-start.

CHAPTER 5

Adjustment and Maintenance

5.1 — Overview

While each boiler is tested for correct operation before shipment from the factory, variable conditions, such as burning characteristics of the fuel used and operating load conditions, require further adjustment after installation to assure maximum operating efficiency and economy. Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts and setscrews to be sure that no damage or mis-adjustments occurred during shipment and installation.

A well planned maintenance program avoids unnecessary downtime or costly repairs, promotes safety and aids boiler code and local inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained, recording daily, weekly, monthly and yearly maintenance activities. This provides a valuable guide and aids in obtaining economies and length of service from Cleaver-Brooks equipment.

Even though the boiler has electrical and mechanical devices that make it automatic or semi-automatic in operation, these devices require systematic and periodic maintenance. Any “automatic” features do not relieve the operator from responsibility, but rather free him of certain repetitive chores, providing him time to devote to upkeep and maintenance.

Good housekeeping helps maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust or repair the boiler and its related equipment. The boiler room should be kept free of all material and equipment not necessary to the operation of the boiler or heating system.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of an improper condition, permitting prompt corrective action that may prevent extensive repairs or unexpected downtime. Any steam, water or fuel leaks should be repaired as soon as they are noticed. Leaks are wasteful as well as hazardous. Include in the program preventive maintenance measures such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc.

The air-fuel ratio should be checked often since this will alert the operator to losses in combustion efficiency which do not produce visible flame changes. Variations in fuel composition from one time to another may require readjustment of the burner. A combustion analyzer should be used to adjust fuel input for maximum operating efficiency and economy.

5.2 — Periodic Inspection

Insurance regulations or local laws require a periodic inspection of the pressure vessel by an authorized inspector.

Chapter 2 contains information relative to this inspection.

Inspections of this type are usually, though not necessarily, scheduled for periods of normal boiler downtime such as an off-season. This major inspection can often be used to accomplish maintenance, replacements or repairs that cannot easily be done at other times. This also serves as a good basis for establishing a schedule for annual, monthly or other periodic maintenance programs.

While this inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the operator an excellent opportunity for detailed inspection of all components of the boiler including piping, valves, pumps, gaskets, refractory, etc. Comprehensive cleaning, spot painting or repainting and the replacement of expendable items should be planned for and taken care of during this time. Any major repairs or replacements that may be required should also, if possible, be coordinated with this period of boiler shutdown.

Replacement spare parts, if not on hand, should be ordered sufficiently prior to shutdown.

Cleaver-Brooks boilers are designed, engineered and built to give long life and excellent service on the job. Good operating practices and conscientious maintenance and care will obtain efficiency and economy from their operation and contribute to long years of performance.

5.3 — Water Level Controls and Waterside of Pressure Vessel

The need to periodically check water level controls and the waterside of the pressure vessel cannot be over-emphasized. Most instances of major boiler damage are the result of operating with low water or the use of untreated (or incorrectly treated) water.

Always be sure of the boiler water level. The water column should be blown down routinely. Check samples of boiler water and condensate in accordance with procedures recommended by your water consultant. Refer to **Sections 2.8** and **2.9** in **Chapter 2** for blowdown instructions and internal inspection procedures.

A typical water level control is mounted in the water column and has float actuated mercury switches. One switch is connected to the burner limit circuit and will stop the burner if a low water condition occurs. On a steam boiler the other switch is connected to the feedwater circuit to energize a water pump or feeder valve to maintain water at the proper operating level.

Usually, the control is of the automatic reset type and will remake the limit circuit when the water level is restored. Some applications require that a control be equipped with a manual reset mechanism that must be manually reset before the burner can be restarted. This is usually accomplished with the use of a second or auxiliary control that has this feature.

Since low water cutoff devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low water cutoff or point of pump cut-in or cut-out. If a low water device should become erratic in operation or if its setting changes from previous established levels, check for reasons and correct, repair or replace as required.

These controls normally function for long periods of time which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

The controls' operation may be checked by:

1. Stopping the water supply to the boiler while the burner is operating at low fire. While under constant attendance allow the water to lower at a normal rate. If a control does not break the circuit to stop the burner at the proper point, then SHUT DOWN THE BURNER IMMEDIATELY.
2. Do not restart until all cross connecting piping is checked for obstructions. Also check the float bowl. If these are clean, repair or replace the control.
3. Repeat the above test to insure proper operation prior to returning the boiler to service.

   On a steam boiler, the head mechanism of the low water cutoff device(s) should be removed from the bowl at least once a month to check and clean the float ball, the internal moving parts, and the bowl or water column.
4. Remove the pipe plugs from the tees or crosses and make certain the cross connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance. Determine that piping is vertically aligned after shipment and installation and throughout life of equipment.

A scheduled blowdown of the water controls on a steam boiler should be maintained.

It is impractical to blowdown the low water cutoff devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require make-up and additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangement usually makes it impractical to perform daily and monthly maintenance of the low water cutoff devices, it is essential to remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float ball, internal moving parts, and the bowl housing. Also check the cross connecting piping to make certain that it is clean and free of obstruction.

5.4 — Water Gauge Glass

A broken or discolored glass must be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use "loose packing" which could be forced below the glass and possibly plug the valve opening.

1. Close the valves when replacing the glass. Slip a packing nut, a packing washer, and packing ring onto each end of the glass.

2. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.
3. If the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by cracking the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.
4. Check try cocks and gauge cocks for freedom of operation and clean as required. It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

A blowdown cock is provided on the lower gauge glass fitting and a daily blowdown is recommended.

5.5 — Operating Controls

In general, when adjusting controls check to see that they are level, especially those containing mercury switches. On temperature sensing controls make sure that the bulb is properly bottomed in its well. Make sure that connecting tubing is not kinked or damaged.

Controls are carefully calibrated during their manufacture and do not normally require re-calibration. The dial settings are generally quite accurate although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading and to re-adjust control setting to agree with these readings. This is predicated, however, on pressure gauges and thermometers being accurate.

Most of the operating controls require very little maintenance beyond occasional inspection. Examine tightness of electrical connections. Keep controls clean. If any dust accumulates in the interior of the control, remove with a low pressure air hose taking care not to damage the mechanism.

Examine any mercury tube switches for damage or cracks: this condition, indicated by a dark scum over the normally bright surface of the mercury, may lead to erratic switching action. Make certain that controls of this nature are correctly leveled using the leveling indicator if provided. Piping leading to various controls actuated by pressure should be cleaned if necessary. Covers should be left on controls at all times.

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts and maintenance of these is a requirement. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Do not use files or abrasive materials such as sandpaper on the contact

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points since this only wastes the metallic silver with which the points are covered. Use a burnishing tool or a hard surface paper to clean and polish contacts. Replacement of the contacts is necessary only if the silver has worn thin.

Thermal relay units (overloads) are of the melting alloy type and when tripped, the alloy must be given time to resolidify before relay can be reset. If overloads trip out repeatedly when motor current is normal, replace them with new overloads. If this condition continues after replacement, it will be necessary to determine the cause of excessive current draw.

Power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits and standard one-shot fuses are not recommended.

5.5.1 — Setting and Adjusting

Burner controls properly set to match load demands will provide operational advantages and achieve the following desirable objectives:

- The burner will be operating in low fire position prior to shut down.
- The burner will operate at low fire for a brief period on each start during normal operation.
- Eliminates frequent burner on-off cycling.

Normal operation of the burner should be with the damper positioning switch in the “auto” position rather than either “low” or “high”. This allows the burner to automatically shift from one firing rate to the other in accordance with load requirements.

When firing a cold boiler, it is recommended that the burner be kept under manual flame control until normal operating pressure or temperature is approached. If the burner is not under manual control on a cold start, it will immediately move to high fire.

The Model 4 boiler is designed to withstand considerable change in steam pressure or water temperature, however, good operating practice with any boiler is to avoid rapid and frequent variations. Therefore, it is advantageous to set the controls so that the burner is in low-fire position before shutdown and so that it does not immediately go to high fire upon a restart.

Any control setting must not cause the boiler to operate at or in excess of the safety valve setting. Settings that do not exceed 90% of the valve setting are recommended, with lower settings greatly desirable if load conditions permit. Avoid having the operating pressure too near the valve set pressure, because the closer the operating pressure is to the valve pressure, the greater the possibility of valve leakage. Continued leakage, however slight, will cause erosion and necessitate early valve replacement. The control settings on a hot water boiler must be within the temperature and pressure limits of the boiler.

Ideally, the burner operating controls should be set under actual load conditions. Often, especially on new construction, the boiler is initially started and set to operate under less than full load requirements. As soon as possible thereafter the controls should he reset to provide maximum utilization of the firing system.

In the setting of these controls, consideration must be given to the time required for a burner restart. Upon each start, there is a pre-purge period of some length, plus the fixed time required for the proving of the pilot and main flame. This, plus the time required for damper motor travel from low to high fire, may allow pressure or temperature to drop below desirable limits.

5.5.2 — Pressure Controls - Steam Boiler

The pressure controls that serve as the operating limit control and as the high-low fire control are equipped with an adjustable differential setting. See the following portion of this section for adjustment procedures.

The switch in the control opens when the steam pressure reaches a pressure equal to the main scale setting and closes at a pressure equal to that shown on the main scale, MINUS the amount of differential.

In an installation that does not require very close control of the steam pressure, the differential setting should be adjusted to its maximum, since this will provide less frequent burner cycling.

The high-low fire control should be set to open at 5 to 10 psi lower than the operating limit setting. The suggested setting on a low pressure steam boiler is 2 to 3 psi. The differential setting on this control may be set low, to give quite close control of steam pressure. In any case, the control should be adjusted so that it opens and causes the burner to go to low fire at a pressure below the limit control opening point. When the pressure controls are properly set, the burner will maintain steam pressure within narrow limits.

On a rise in steam pressure, the high-low fire control opens its contacts and the damper motor returns to low-fire position. The burner continues to operate at low fire rate. If steam pressure drops, the control will again close to complete the circuit and return the burner to high fire. If steam pressure continues to rise, the boiler will remain at low fire rate. Should the boiler pressure reach the set point of the operating limit control, its contacts will open to turn off the burner. When boiler pressure drops, the operating limit control contacts close, causing the burner to restart. It is desirable to have the high-low fire control adjusted so that the burner does not immediately go to high fire upon start, but rather operates at low for a brief period before decreasing steam pressure causes control to close and the burner to drive to high fire.

5.5.2.1 — Operating Limit Pressure Control (Steam) (Honeywell L404A)

1. Set “cut-out” (burner off) pressure on the main scale using the large adjusting screw.
2. Set differential on the short scale turning the small adjusting screw until the indicator points to the desired difference between cut-out and cut-in pressures. The “cut-in” (burner on) pressure is the cut-out pressure MINUS the differential. The cut-out pressure should not exceed 90% of the safety valve setting.

5.5.2.2 — High Limit Pressure Control (Steam) (Honeywell L404C)

1. Set “cut-out” (burner off) pressure oil scale using adjusting screw. The control will break a circuit to shut off burner when pressure reaches this point.
2. The setting should be sufficiently above the operating limit pressure control to avoid shutdowns, and preferably not exceed 90% of safety valve setting. This control requires manual resetting after tripping on a pressure increase. To reset, allow boiler pressure to return to normal and then press the reset button.

5.5.2.3 — High-Low Fire Control (Steam) (Honeywell L404A)

1. Set the “cut-out” pressure — the point at which the burner will return to low fire — on the main scale using the large adjusting screw. This setting should be sufficiently below the cut-out setting of the operating limit control so that the burner will return to the low fire position prior to shutting off at the operating limit.
2. The “cut-in” pressure — the point at which the burner drives to high fire — is set on the differential scale. This setting is equal to the cut-out pressure MINUS the amount of the differential. It should be adjusted so that it is sufficiently below the burner “on” pressure of the operating control so that the burner when starting will operate briefly at the low fire position prior to advancing to high fire.

5.5.3 — Temperature Controls - Hot Water Boiler

The temperature controls that serve as the operating limit control and as the high-low fire control are equipped with an adjustable differential setting. The switch in the control opens when the water temperature reaches a temperature equal to the dial setting and closes at a temperature equal to the dial setting MINUS the amount of differential. See following portion of this section for instructions on control adjustment.

In an installation that does not require very close control of the water temperature, the differential setting should be adjusted as widely as possible since this will provide less frequent burner cycling.

The operating limit temperature control should be set slightly above the highest desired water temperature and within the limits of the pressure vessel. The high limit control should be set 5 to 10 degrees above the operating limit temperature control setting. The high-low fire control should be adjusted so that it is below the burner "on" temperature of the operating control.

Relative settings of the temperature controls are as follows:

- High Limit Control
Open – 200°F
- Operating Limit Control
Open – 190°F
Close – 180°F
- High-Low Fire Control
Open – 180°F (Low Fire)
Close – 175°F (High Fire)

With settings similar to these, the following operational sequence occurs. On a rise in boiler water temperature, the high-low fire control opens its contacts at 170 degrees F to de-energize the damper motor and place the burner in its low fire range.

If temperature decreases during low fire, the burner will return to high fire as soon as the high-low fire control closes at its 175 degree setting. As temperature increases during high fire rate, the burner will be switched back to low fire when the control opens at 180 degrees.

If temperature increases during low fire, the burner will shut down when the operating limit setting of 190 degrees is reached. When temperature drops back to 180 degrees the operating limit will close to restart the burner. The unit will fire at its low rate unless temperature continues to drop to 175 degrees, at which time the high-low fire control will close to move the burning rate to high fire.

The settings listed are typical and will vary according to job requirements. However, setting the controls with these relations to each other is desirable, since this will prevent the burner from shutting down while in high fire or from immediately going to high fire upon restarting.

5.5.3.1 — Operating Limit Temperature Control (Hot Water) (Honeywell L4008A)

1. Set “cut-out” (burner off) temperature on scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw.
2. The “cut-in” (burner on) temperature is the cut-out temperature MINUS the differential. The differential is adjustable from 5 to 30 degrees F. Differential is adjusted by rotating the wheel on the back of the snap switch.

5.5.3.2 — High Limit Temperature Control (Hot Water) (Honeywell L4008E)

1. Set the “cut-out” (burner off) temperature on scale using adjusting screw. This control will break the circuit and lockout on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. On 30 lb. hot water generators the setting is not to exceed 240º F.
2. The control requires manual resetting after tripping on a temperature increase. To reset allow water temperature to drop below the cut-out setting, less differential, and then press the manual reset button.

5.5.3.3 — High-Low Fire Control (Hot Water) (Honeywell L4008A)

1. Set the “cut-out” temperature — the point at which the burner will return to low fire — on the indicating dial. This setting should be sufficiently below the cut-out setting of the operating limit temperature control so that the burner will return to the low-fire position prior to shutting off at the operating limit.
2. The “cut-in” temperature — the point at which the burner drives to high fire — is set on the differential scale. This setting is equal to the cut-out temperature MINUS the amount of the differential. It should be adjusted so that it is sufficiently below the burner “on” temperature of the operating control so that the burner when starting can operate briefly in the low-fire position prior to advancing to high fire.

5.5.4 — Combustion Air Proving Switch

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of the combustion air. Since the pressure of the combustion air is at its minimum value when the damper is full open, the switch should be adjusted under that situation. It should be set to actuate under a condition of minimum pressure, but not too close to that point to cause nuisance shutdowns.

The test switch in the programmer will stop the timer only during the low fire period of the pre-purge or during the pilot ignition period. To stop the timer during the high fire portion of pre-purge, it is necessary to do the following:

5.5.4.1 — CB-20

1. Turn off both the burner switch and the main power.
2. Remove the programmer from its base.
3. Check the instruction manual for the control and locate the position of contact M3A.
4. Carefully work a narrow strip of paper between the contact points. An alternate method is to insert a thin wood wedge between the timer cam and the spring leaf for this contact.
5. Use extreme care not to bend or damage the contacts.

⚠ Caution

Line voltage is present at most contacts.

6. Reinstall the control and restore main power.

5.5.4.2 — CB-40

1. Remove the purge extender or the purge extender jumper. See the instruction manual for details.
2. Turn the burner switch on. The blower motor and the timer will start (provided the low water control and limit controls are made). The timer will stop after a few seconds. The damper motor will drive to its open position and stop there.
3. Attach a test lamp or volt meter from switch terminal W to ground. Turn the adjustment screw until this circuit is broken. Then add a half turn or so to the adjusting switch to remake the circuit.
4. Turn the burner switch off. Remove the paper slip or wood wedge from the CB-20 relay.
5. Replace the purge extender or purge extender jumper on a CB-40 relay.

6. With the programmer returned to operating condition, turn the burner switch on and observe whether unit cycles normally.

   If the air switch is not adjusted to make within its allotted time, the CB-20 control will keep recycling. The CB-40 control will lock out and require manual resetting to restart.

5.5.5 — Low Gas Pressure Switch

1. Turn adjusting screw until indicator on scale moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this value. The control should be finally adjusted to prevent operation with low gas pressure, but should not be set at a value close enough to normal operating pressure to cause unnecessary shutdowns. When setting this control consideration must be given to the fact that gas line distribution pressure may decrease under some conditions and it is advisable that the control does not cut out unnecessarily.
2. The switch must be manually reset after tripping on a drop of gas pressure below the cut-out setting. To reset allow gas pressure to rise and press the manual reset button.

5.5.6 — High Gas Pressure Switch

1. Turn adjusting screw until indicator on scale moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure but should not be set at a value close enough to normal operating pressure to cause unnecessary shutdowns.
2. This switch must be manually reset after tripping on a rise of gas pressure above the cut-out setting. To reset allow gas pressure to drop and press the manual reset button.

5.5.7 — Low Oil Pressure Switch (Optional)

This control prevents burner from igniting or stops its operation when the oil pressure is below a preset point. The control contains a single-pole, single-throw mercury switch which closes on a pressure rise. Pressure settings are made with the knobs on the face of the control. The “low” setting indicates the point at which switch action takes place on a pressure drop. Initially set this knob to the bottom of the scale.

1. Adjust the “high” knob to a point slightly below the normal operating oil pressure.
2. Then set “low” knob somewhat lower, but not less than 150 psi. The burner will operate as long as oil pressure exceeds the lower setting.

5.5.8 — Programming Control

This control requires no adjustment, nor should any attempt be made to alter contact settings. The contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Do not use abrasive materials. The control cabinet door should be closed during normal operation.

The manufacturer's bulletin also contains troubleshooting information.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth, moistened with detergent if necessary. The UV sensing tube within the flame detector is not field replaceable. If the flame detector is replaced be sure to properly connect the blue lead to the F terminal and the white lead to the G terminal. Reversing the leads even momentarily may destroy the UV tube.

Replacement of internal components, other than the plug-in amplifier is neither practical nor recommended.

⚠ Caution

When replacing a control or cleaning contacts, be sure to open the main power supply switch, since the control is "hot" even though the burner switch is off.

A periodic safety check procedure should be established to test the complete safeguard system at least once a month or oftener. Tests should verify safety shutdown and a safety lockout upon failure to ignite the pilot, upon failure to ignite the main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. These tests will also verify fuel valve tightness.

5.5.8.1 — Checking Pilot Flame Failure

1. Close the gas pilot shutoff cock. Also shut off the main fuel supply.
2. Turn the burner switch "on". The pilot system will be energized at the end of the pre-purge period. Since there is no pilot flame to be detected, the pilot valve will be de-energized and the main fuel valves will not be energized.
3. Check to see that there is an ignition spark but no flame. The programmer will complete its cycle during which time the lockout switch will trip on a safety lockout.

4. Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Reopen the gas pilot shutoff cock and reestablish main fuel supply.

5.5.8.2 — Checking Failure to Light Main Flame

1. Leave the gas pilot shut off cock open.
2. Shut off the main burner fuel supply.
3. Turn the burner switch on. The pilot will light upon completion of the pre-purge period. The main fuel valve(s) will be energized but there should be no flame. Relay 2K should drop out within 4 seconds after main burner ignition trial ends. The safety switch should trip and lock out about 30 seconds after end of the ignition trial.
4. Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Re-establish the main fuel supply.

5.5.8.3 — Checking Loss of Flame

1. With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame. Relay 2K should drop out within 4 seconds after flame is extinguished. The blower motor runs during the post purge. The lockout switch will trip approximately 30 seconds later de-energizing master relay 1K.
2. Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Re-establish main fuel supply.

5.5.9 — Control Operational Test

Proper operation of the various controls should be verified and tested when the boiler is initially placed into service or whenever a control is replaced. Periodic checks should be made thereafter in accordance with a planned maintenance program.

The operating limit control may be checked by allowing steam pressure or water temperature to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner shutoff point. If load is heavy, the header valve can be closed or throttled until the pressure increases.

1. Observe the steam gauge to check the cutoff pressure as the operating limit control shuts the burner down.
2. Open the header valve to release steam pressure or vent steam and check the cut-in setting as the burner restarts.

3. Check the high-low fire control for desired operating pressure range.
4. Water temperature, on a hot water boiler that may be operating at less than full load, may be raised by manually increasing the firing rate until the burner shuts down thru the action of the operating limit control. Observe the thermometer to verify the desired setting at the point of cutout and again when burner restarts. Check the high-low fire control for the desired operating temperature range.
5. Observe the ignition and programming control operations to make sure that they are correct. Check the proper operation and setting of the low water cutoff (and pump operating control, if used).
6. Proper operation of the flame failure device should be checked at time of starting and at least once a week thereafter. Refer to previous section for information on flame safety checks.
7. Check for tight shutoff of all fuel valves. Despite precautions and strainers, foreign material may lodge under a valve seat preventing tight closure. Promptly correct any conditions causing leakage.

5.6 — Oil Burner

5.6.1 — General Information

There are relatively few adjustments that can be made to the burner drawer, however, a check should be made to see that all components are properly located and that all holding devices such as setscrews properly tightened. **Figures 5-1** and **5-2** cover typical burner drawers and show pertinent dimensions.

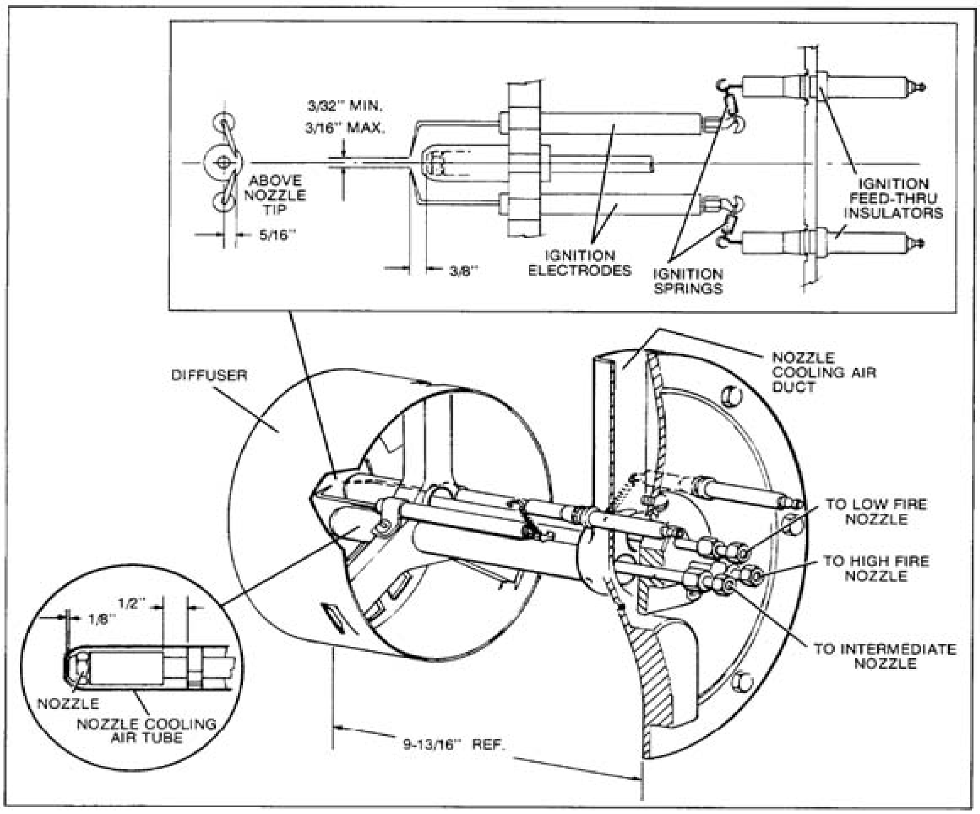

FIGURE 5-1. Oil Burner Drawer - Spark Ignition

The burner drawer should be periodically inspected for evidence of damage due to improperly adjusted combustion. The air cooling tubes surrounding the nozzles should be inspected occasionally for any carbon residue or any clogging that might be caused by unusual dusty or lint-laden atmosphere. The setting of the oil nozzle in relation to the opening in the cooling tube is important and should be maintained.

5.6.1.1 — Diffuser

Proper positioning of the diffuser should be maintained so that oil spray or flame does not impinge on it. Remove any carbon or other deposits if any have accumulated so that air flow pattern is not affected. Do not attempt to change the gap or angle of the fins.

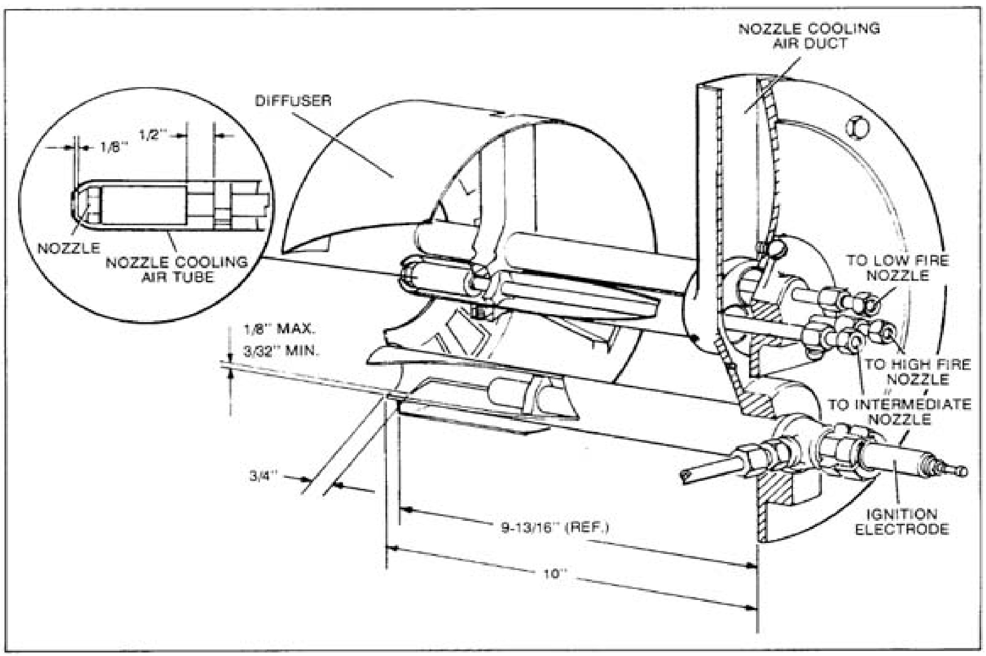

FIGURE 5-2. Burner Drawer - Gas Pilot Ignition

5.6.1.2 — Burner Nozzles

Efficient oil burner operation requires clean nozzles. The nozzles deliver a spray of extreme fineness to assure proper mixing with the air stream. If at any time the flame becomes "stringy or lazy" it is possible that one or more of the nozzles is clogged or worn. Even though the oil pressure gauge may indicate correct pressure, plugged or partially plugged nozzles will greatly reduce oil delivery.

The nozzles may be cleaned. However, if they appear worn or if they have been in service for a considerable time, it is more economical to replace them. Any cleaning should be done with a wood splinter rather than with any metal to avoid damaging the hole in the tip or the oil grooves. Check strainer and clean if necessary.

Nozzles may be of different capacities and it is extremely important that they are replaced in proper firing order. Nozzles can be identified by the capacity and spray angle stamped on them. See **Table** below for proper location of nozzles.

Nozzles Sizes, Location, and Firing Rate

Boiler Size	Low Fire Nozzle			Intermediate Nozzle			High Fire Nozzle			Oil Pressure (Approximate)	Max. Firing Rate GPH
	Size	Spray Angle	Part Number	Size	Spray Angle	Part Number	Size	Spray Angle	Part Number		
1500	2.5	300° HV	899-93	2.5	60° PLP	899-162	2.5	60° PLP	899-162	200 PSI	10.7
2000	3.5	300° HV	899-29	3.5	60° PLP	899-87	3.5	60° PLP	899-87	188 PSI	14.3
2500	4.5	300° HV	899-31	4.5	60° PLP	899-32	4.5	60° PLP	899-32	180 PSI	17.9
3000	5.0	300° HV	899-33	5.0	60° PLP	899-34	5.0	60° PLP	899-34	210 PSI	21.4
3500	5.5	300° HV	899-109	5.5	60° PLP	899-74	5.5	60° PLP	899-74	238 PSI	25.0
4000	7.0	300° HV	899-59	7.0	60° PLP	899-63	7.0	60° PLP	899-63	197 PSI	28.6
4500	7.5	300° HV	899-83	7.5	60° PLP	899-38	7.5	60° PLP	899-38	225 PSI	32.7
5000	7.5	300° HV	899-83	8.3	60° PLP	899-40	9.5	60° PLP	899-42	217 PSI	35.7
6000	7.5	300° HV	899-83	9.5	60° PLP	899-42	10.5	60° PLP	899-44	267 PSI	42.8

NOTE: Nozzle size is rating at 100 PSO oil pressure. flow rate increases with pressure. Multiply Boiler Size by 1000 to obtain maximum input BTU/HR.

The capacity stamped on side of nozzle represents delivery rate with oil pressure at 100 psi. Since the burner is designed to use considerably higher atomizing oil pressures, the capacity of the nozzle is greatly increased. Do not assume that undersized nozzles are installed on the basis of nozzle marking compared to the burner input.

The oil pressure required for full burner input ranges from approximately 180 to 267 psi depending on boiler size. Oil pressure is adjusted by the regulator in the fuel oil pump. If smoke occurs at open damper, the pressure should be adjusted downward to clear the fire. See the later section covering oil burner combustion adjustment.

5.6.1.3 — Ignition System

Maintain the proper gap and dimensions of the ignition electrode(s) for best ignition results. **Figure 5-1** or **5-2** shows the correct settings.

Inspect electrode tips for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the insulators of the electrodes and the feed through insulators for evidences of cracks or chipping. If any are present replace the items, since this can cause grounding of ignition voltage. Carbon is an electrical conductor, so it is necessary to keep the insulating portion of electrode wiped clean if any is present. Ammonia will aid in removing carbon or soot.

Check ignition cables for cracks in the insulation. Also see that all connections between transformer and electrodes are tight.

5.6.2 — Oil Pump

The oil pump has a built-in strainer of the self-cleaning knife type that normally requires no servicing, however, any other strainers or filters in the suction line must be cleaned periodically.

Problems attributed to the pump can generally be traced to other causes such as broken or restricted fuel lines, lack of fuel, clogged filters, stuck or closed valves, a high vacuum or even an excessive head of oil. Improperly sized suction and return lines will cause problems.

The pressure gauge reveals that the pump gears are pumping and building up a steady even pressure to deliver oil to the nozzles and at the pressure to which the integral regulator has been set. Collapse of the nozzle spray below the set limit can indicate worn internal parts, although these units are designed to give long periods of operation without undue wear. If this situation is verified, it is generally advisable to replace the pump. It is recommended that the removed pump be returned to the factory for complete reconditioning rather than field replacement of individual parts.

If the oil supply is below the level of the pump, a vacuum gauge can be installed at the suction port of the pump as this is helpful in checking the condition of the suction line and aids in pinpointing problems. Normally a vacuum reading should not exceed 10". Vacuums higher than this can lead to problems in oil separation or in erratic or declining delivery. Excessive readings can indicate restrictions such as kinked or clogged lines, sticking or closed valves, or even a frozen oil line. If there is no reading, look for air leaks in the lines, valve fittings, or pump. On gravity fed installations a vacuum gauge should read zero. If not, this is evidence of restrictions being present.

If the oil supply is above the level of the pump, a pressure gauge can be installed in the pump bypass port for use in determining that the head of oil is not too great. If the head pressure is over 3 psi, damage or seal leakage can occur. A pressure reducing valve should be installed in this instance.

Seal leakage may also be caused by restrictions in the return line.

In an initial start-up a pump noise in the form of a whine may be noticed. This is a condition that results from air in the oil line and should cease as soon as the pump is able to clear the line of air. If the condition persists after a long period of operation, it may indicate a leak in the suction line.

5.6.2.1 — Oil Pump Belt

The V-belt driving the oil pump requires no servicing and no preservatives or dressing compounds should be used. Belts normally stretch with use and proper tension should be maintained. Do not apply excessive tension since this can result in damage to the pump shaft bearings.

On a 200 series boiler, it is recommended that the belt be removed when gas is used for an extended period as this will prolong the life of the pump and belt.

5.6.3 — Combustion Adjustment: Oil

Each boiler is adjusted prior to shipment from the factory, however circumstances caused by shipment, installation, or operating load conditions may require further adjustment to assure maximum operating efficiency and economy. Periodic rechecks of adjustments and settings are also recommended.

The burner system should be adjusted on the basis of a combustion efficiency analysis after the unit has been in operation sufficiently long enough to assure a warm boiler.

Proper air-fuel ratio should be established by the use of a combustion gas analyzer. This instrument measures the content by percent of carbon dioxide (CO_2), oxygen (0_2) and carbon monoxide (CO) in the flue gas. Efficiency is measured by the percentage of $C0_2$ present in the flue gas. The ideal setting from a standpoint of efficiency is reached when no measurable percentage of oxygen is present. It is, however, more practical to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure or burning properties of oil. 15 to 20 percent excess air is considered normal. A $C0_2$ range of 12 to 13% is desirable. The burner should never be operated with an air-fuel ratio that indicates a detectable percentage of carbon monoxide.

Turn the burner to high fire and let it operate at this rate for several minutes. Observe the color and size of the flame. Color alone is a poor means of determining efficiency, although it can serve as a guide for tentative setting. If smoke or haze is visible additional combustion air is required. If the flame is overly bright, rumbles or emits sparks, the amount of combustion air will have to be reduced.

Take a sample of flue gas with an instrument known to be in good working order and determine $C0_2$ reading. Based on this analysis, make any required adjustments to increase or decrease the air and/or oil flow.

Recheck low fire to determine whether it was affected by high fire adjustments. If so, additional linkage adjustment may be required.

5.7 — Gas Burner

5.7.1 — General Information

Relatively few adjustments can be made to the burner drawer, however, a check should be made to see that all components are properly located and that all holding devices such as setscrews are properly tightened. Periodically inspect the burner drawer for evidence of damage due to improperly adjusted combustion.

Check the gas pilot electrode for proper setting (see **Figure 5-2**) and also for any cracks in the porcelain insulator. Cracks can cause grounding of ignition voltage. Check the tip of electrode for signs of pitting and dress as required. Check the ignition cable for insulation cracks. See that all connections between transformer and electrode are tight.

5.7.2 — Gas Pilot Flame Adjustment

The size of the gas pilot flame is regulated by adjusting the gas flow through the pilot gas regulator. The flame must be sufficient to ignite the main flame and to be seen by the flame detector but an extremely large flame is not required. An overly rich flame can cause sooting of the flame detector. Too small a flame can cause ignition problems.

To check the pilot flame, visually observe it through the rear sight port. A flame that encircles approximately one-half of the diffuser is satisfactory. To control the flame size, make the necessary adjustment to the gas pilot regulator.

A preferred method of setting a flame is to obtain a micro-amp reading of the flame signal. This can be measured with a good quality micro-ammeter or a suitable multi-meter with a zero to 25 micro amp DC rating.

The meter is connected to a jack in the amplifier of the flame safeguard control. Use a meter connecting plug harness (Cleaver-Brooks 884-72). Connect the plus (red meter lead) to the red tab of the harness and the minus (black meter lead) to the black tab before inserting the plug in the meter jack.

1. To measure and adjust the pilot, turn the damper switch to low. Fully open the pilot shut-off cock. Close the cock in the main gas line.
2. Connect the micro-ammeter as outlined above.
3. Turn burner switch on. Let the burner go through the normal pre-purge cycle. When the ignition area of the timer dial is opposite the index notch, set the timer switch to the TEST position to stop the timer. Relay 2K should pull in when the pilot ignites.
4. If the pilot flame is not established within ten seconds, turn off the burner switch. Repeat the lighting attempt.

> **NOTE:** On an initial starting attempt, portions of the fuel lines may be empty and require “bleeding” time. It is better to accomplish this with repeated short lighting trial periods with intervening purge periods than to risk prolonged fuel introduction. If the pilot does not light after several attempts, check all components of the pilot system.

5. When the pilot flame is established, remove the flame detector from the burner plate. The pilot flame can then be observed thru this opening.

> **⚠ Caution**
>
> Keep eyes sufficiently away from the sight tube opening and wear a protective shield or suitable glasses. Never remove the flame detector while the main burner is firing.

6. To make the final adjustment, slowly close the gas pilot regulator until the flame can no longer be seen through the sight tube. Then slowly open the regulator until a flame providing full sight tube coverage is observed.

   This adjustment must be accomplished within the time limit of the safety switch or approximately 30 seconds after the detector is removed. If the control shuts down, allow several moments for the thermal element in the safety switch to cool and then manually reset it. Replace the detector and repeat from step 3.

7. When a suitable flame is obtained, replace the detector. Observe the reading on the micro-ammeter. The reading should be between two and five micro-amps and the reading must be steady. If the reading fluctuates, recheck the adjustment. Make sure that the flame detector is properly seated and that the lens is clean.
8. Reset the timer switch from the TEST position to the NORM position.
9. If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.
10. The micro-amp reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in step 7. If there are any deviations, refer to the troubleshooting section in the technical bulletin.
11. The gas burner housing surrounding the diffuser plate should be periodically checked for any signs of damage that might be caused by an improperly adjusted burner or by a poor seal to the refractory. Routine maintenance should include this resealing which can be done with a mixture of refractory cement and insulating pulp. Use care not to clog or obstruct the holes in the face of the gas housing.
12. The diffuser should be positioned as shown in **Figure 5-2**. Do not attempt to change the gap or angle of the fins.

5.7.3 — Gas Pressure and Flow Information

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields highest combustion efficiency at rated performance yet prevents overfiring. Once this optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency.

Minimum Net Regulated Gas Pressure for Rated Boiler Output (Required at Gas Train Entrance)

Boiler Size	Gas Train Size	Standard Train	F.M. Approved Train	FIA (IRI) Train
1500	[a]1-1/2 þ2	3.3 W.C 2.1 W.C.	3.5 W.C. 2.1 W.C.	4.3 W.C. 2.2 W.C.
2000	[(1)]1-1/2 þ2	6.4 W.C. 4.1 W.C.	6.8 W.C. 4.1 W.C.	8.2 W.C. 4.4 W.C.
2500	[(1)] 2 þ2-1/2	5.3 W.C. 4.7 W.C.	5.3 W.C. 4.7 W.C.	5.7 W.C. 5.0 W.C.
3000	[(1)] 2 þ2-1/2	7.4 W.C. 6.4 W.C.	7.4 W.C. 6.4 W.C.	8.1 W.C. 6.9 W.C.
3500	[(1)] 2 þ2-1/2	8.6 W.C. 7.3 W.C.	8.6 W.C. 7.3 W.C.	9.4 W.C. 7.8 W.C.
4000	[(1)] 2 þ2-1/2	10.1 W.C. 8.6 W.C.	10.1 W.C. 8.6 W.C.	11.1 W.C. 9.4 W.C.
4500	[(1)] 2 þ2-1/2	8.3 W.C. 6.3 W.C.	8.3 W.C. 6.3 W.C.	9.7 W.C. 7.3 W.C.
5000	[(1)] 2-1/2 þ3	9.8 W.C. 6.9 W.C.	9.8 W.C. 6.9 W.C.	9.8 W.C. 6.9 W.C.
6000	[(1)] 2-1/2 þ3	13.1 W.C. 9.8 W.C.	13.1 W.C. 9.8 W.C.	13.1 W.C. 9.8 W.C.

a. Standard Size Train

5.7.3.1 — Pressure

The gas supplied must provide not only the quantity of gas demanded by the unit, but must also be at a pressure high enough to overcome the pressure loss due to the frictional resistance imposed by the burner system and the control valves.

The pressure required at the entrance to the burner train (downstream of the regulator) for rated boiler output is termed “net regulated pressure”. The gas pressure regulator must be adjusted to achieve this pressure to assure full input.

The pressure requirement varies with boiler size, altitude, and type of gas train.

The pressures listed are based on 1000 BTU/CU. FT. natural gas and elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor.

Gas Pressure Altitude Factors

Altitude Feet Above Sea Level	**Correction Factor**
1000	1.04
2000	1.13
2500	1.18
3000	1.22
4000	1.33
5000	1.44
6000	1.57
7000	1.70
8000	1.84
9000	2.01

5.7.3.2 — Gas Flow

The volume of gas flow is measured in terms of cubic feet and is determined by a meter reading. The gas flow rate required for maximum boiler output depends on the heating value (BTU/CU. FT.) of the gas supplied. The supplying utility can provide this information.

To obtain the required number of cubic feet per hour of gas, divide the heating value (BTU/CU. FT.) into the required burner input (BTU/HR.).

Burner Input Requirements

Model Size	Maximum BTU/Hr.
1500	1,500,000
2000	2,000,000
2500	2,500,000
3000	3,000,000
3500	3,500,000
4000	4,000,000
4500	4,500,000
5000	5,000,000
6000	6,000,000

5.7.3.3 — Pressure Correction

The flow rate outlined in the previous section is figured on a "base" pressure which is usually atmospheric or 14.7 psi.

Meters generally measure gas in cubic feet at "line" or supply pressure. The pressure at which each cubic foot is measured and the correction factor for this pressure must be known in order to convert the quantity indicated by the meter into the quantity which would be measured at "base" pressure.

To express the volume obtained from an actual meter reading into cubic feet at base pressure it is necessary to multiply the meter index reading by the proper pressure factor obtained from the **Pressure Correction Factors table.**

Conversely, to determine what the meter index reading should be in order to provide the volume of gas required for input, divide the desired flow rate by the proper pressure correction factor. This answer indicates the number of cubic feet at line pressure which must pass through the meter to deliver the equivalent number of cubic feet at base pressure.

As an example: assume that a size 3000 boiler is installed at 2,000 feet above sea level; is equipped with a standard gas train; and that 1,000 BTU natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

Pressure Correction Factors

Regulator Inlet Pressure	Pressure Factor		Regulator Inlet Pressure	Pressure Factor
1 psig	1.05		9 psig	1.59
2 psig	1.11		10 psig	1.66
3 psig	1.18		11 psig	1.72
4 psig	1.25		12 psig	1.81
5 psig	1.32		13 psig	1.86
6 psig	1.39		14 psig	1.93
7 psig	1.45		15 psig	2.00
8 psig	1.52			

Pressure — Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 6.4" WC gas pressure at sea level (**Minimum Net Regulated Gas Pressure for Rated Boiler Output table**). The **Gas Pressure Altitude Factors table** indicates a correction factor of 1.13 for 2,000 feet. Multiplying these results in a calculated net regulated gas requirement of approximately 7.2" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

Flow — Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the BTU content of the gas into the burner input (**Burner Input Requirements table**) and "correct" this answer by applying the correction factor for 3 psig. (**Pressure Correction Factors table**).

$$\frac{\text{BTU/HR Input}}{\text{BTU/CU. FT.}} = \text{CFH (Cubic Feet/Hour)}$$

OR

$$\frac{3{,}000{,}000}{1{,}000} = 3000 \text{ CFH}$$

(At 14.7 lbs. atmospheric "base" pressure)

THEN

$$\frac{3000}{1.18} = 2542 \text{ CFH}$$

This is the CFH (at line pressure) which must pass through the meter so that the equivalent full input requirement of 3000 CFH (at base pressure) will be delivered.

5.7.3.4 — Checking Gas Flow

Your gas supplier can generally furnish a chart developed to determine the cubic feet/hour reading from the meter based on the number of seconds per revolution of the 10 cubic feet dial. This provides a knowledge of the flow rate after a relatively short observation period.

Lacking a chart of this nature it is possible to "clock the gas meter" as follows:

1. Turn off all other gas appliances that may be served by the meter.
2. Set burner at high fire.
3. Note meter reading and record consumption for 3 minutes.
4. The following formula will provide the required gas input for a 3 minute period:
   Input (BTU/HR) ÷ Heating Value (BTU/CU. FT.) ÷ 20 = Gas input in cubic feet for 3 minutes.
5. Apply any necessary pressure correction factor to this answer to obtain the desired rate.
6. To illustrate, using circumstances from previous example, compute as follows:
   BTU/HR ÷ BTU/CU. FT. ÷ 20 = 3 minute input in cu. ft.
   OR
   3,000,000 ÷ 1000 ÷ 20 = 150 cu. ft. (base pressure)
   150 ÷ 1.18 (pressure correction = 127 cu. ft.(line pressure)
7. If the input timed for 3 minutes does not agree with the rating indicated by the formula, adjust the gas pressure regulator to increase or decrease flow as required.

> **NOTE:** The information given in this section is for all practical purposes sufficient to set and adjust controls for gas input. Your gas supplier can, if necessary, furnish exact correction factors that take into consideration BTU content, exact base pressure, specific gravity, temperature, etc., of the gas used.

5.7.4 — Combustion Adjustment: Gas

Gas input adjustment is accomplished by increasing or decreasing the pressure of gas downstream of the pressure regulator. Any required adjustment to the regulator should be done with burner at high fire and with the gas butterfly valve wide open.

In the event linkage or regulator adjustments are required, proceed as follows. Initially set the linkage by backing out the low fire stop screw so the valve is closed. Then turn screw in two complete turns. Adjust the connecting rod so that tension is released.

It is not practical to list specific setting of the connection points or of the angles of the arms. The final setting should provide a coordinated movement of the damper and the gas valve. If the gas valve opens rapidly compared to the air damper, an overly rich fire will occur during transition between the two firing positions. This improper fuel-air ratio can cause sooting of the fireside surfaces. If it opens too slowly then the proportionally greater air flow could extinguish the flame.

Points to remember are that the motor arm must complete its full travel and that the valve arm should travel its required arc without excessive stretching of the override springs. The closer that the swivel joint in the motor arm is to the hub, the less distance it will travel. To increase the valve arm travel, move the connecting rod closer to the hub or away from it if decreased travel is required.

This low fire setting should be regarded as tentative until proper gas pressure for high fire operation is established.

After operating at low fire for a sufficient period of time to assure a warm boiler, turn the damper positioning switch to “high”. Observe the burner as it progresses toward high fire. In the event gas pressure is too low or if the butterfly valve movement is not properly coordinated with the air damper, it is possible that increased air flow may extinguish the flame. Immediately turn burner off. Determine and correct condition causing flame failure before repeating attempt.

At high-fire position, the butterfly valve should be wide open as indicated by the slot on the end of its shaft. Set and lock the high fire stop screw until it is just touching the valve arm.

Determine the actual gas flow from a meter reading as outlined in another section. If corrections are necessary to obtain the required input, increase or decrease the gas pressure by adjusting the pressure regulator. Turn its adjusting screw clockwise to increase pressure, or counterclockwise to decrease pressure.

When the high fire gas flow is established, no further adjustment of the regulator is required.

With proper gas flow, any further adjustment necessary to obtain a desirable flue gas analysis must be done with the air damper. Check all adjustments with a combustion gas analyzer.

When the high fire air fuel ratio is set, shut the burner down, relight and check low fire. It may be necessary to readjust the low fire stop screw or the linkage. To assure that low-fire position of the butterfly valve is always the same, allow a minimum of one turn of the stop screw for over-travel.

Any adjustment must not cause extensive stretching of the override springs. If linkage adjustments are made, recheck to determine that high fire is not affected.

The appearance or color of the gas flame is not an indication of its efficiency since an efficient gas flame will vary from transparent blue to translucent yellow.

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. This instrument measures the content, by percentage, of carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount or percentage of CO_2 present in the flue gas. The theoretical maximum CO_2 percentage for natural gas is approximately 11.7%. This is attained when there is no excess oxygen (O_2) or carbon monoxide (CO). A definite percentage of excess air (oxygen) is required by most local gas authorities and, of course, the burner should never be operated with an air-fuel ratio that indicates a detectable percentage of carbon monoxide.

Subject to local regulations pertaining to specific amounts of excess oxygen, it is generally recommended that CO_2 readings of between 9-1/2 and 10-1/2% be attained with corresponding 0_2 readings of 2% to 4%.

Water washing of the fireside surfaces of a gas fired boiler is usually not required. Washing lances are not provided although a gas burning boiler — Series 700 — does have provisions for their addition. If stack temperatures indicate a need for washing, lances can be ordered from your agent. However, a condition of this nature would indicate a definite maladjustment of the burner that requires attention and correction.

5.8 — Damper Motor and Auxiliary Switches

The damper motor, in addition to controlling the damper (and the gas valve linkage) contains one, or two, internal switches which serve as a Low Fire Switch and, if required, a High Fire Switch. These switches are actuated by cams attached to the shaft of the motor. They are factory set and should not normally require any adjustment.

If adjustment is required to the internal switches, loosen the locking screw on the cam assembly about one half turn. Do not remove the cam assembly.

With the motor in its fully closed position, rotate the cam counterclockwise until the switch makes an “audible click.” Adjust the cam so that the slow-rise portion of the lobe engages the switch lever to operate the switch. This gives a switching differential of approximately 10°.

The Low Fire Switch (LFS) used on all boilers must be closed to complete programmer circuitry that assures that the damper is in the low-fire position before ignition takes place. The switch opens when the damper motor drives to open during pre-purge and closes when it returns to low-fire position on completion of pre-purge. The switch, therefore, must be actuated just prior to the damper reaching its closed position.

The High Fire Switch (HFS), when required, is used to prove that the air damper opens during the pre-purge. Its terminals should make when the damper is nearly open and just before the timing of the programmer returns the motor to low-fire position.

5.8.1 — Oil Valve Switches

Attached to the damper motor is an auxiliary control containing two switches.

The first switch (left hand side) is used for the intermediate oil valve. The right-hand switch is used for the high fire oil valve.

The following directions are based on adjusting the switch prior to its attachment to the damper. While particularly useful during replacement, they will also serve as a guide for final adjustment.

1. BEFORE attaching the switch to the mounting bracket, depress the scale lock and rotate the scale so that the zero mark of the outer scale on the silver scale is at the index mark.
2. Release the scale lock. Remove the thumb nut and the top set of cams.

3. Loosen both cam locking screws on the remaining set of cams. Align the two cam lobes so that only the operational cam (silver colored) will cause switch lever movement. Tighten the differential cam screw.

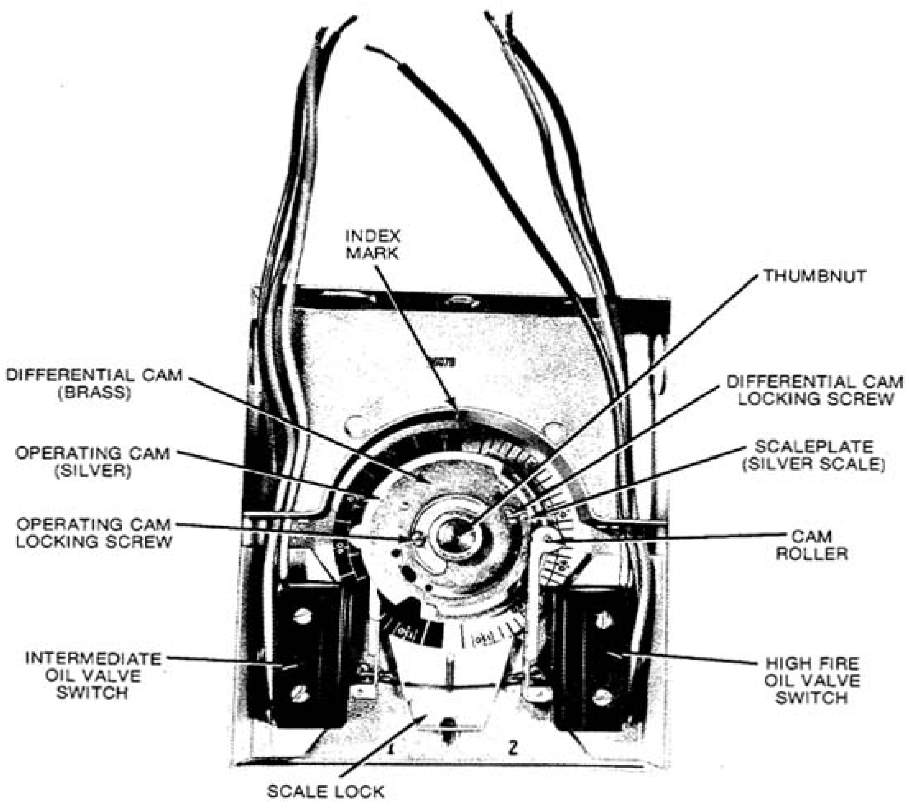

FIGURE 5-3. Damper Motor Auxiliary Switch

4. The switching action desired is for the normally open leads (red and blue) to close as the motor travels from low to high fire. Using the index mark as a reference point, push the scale lock down and turn the scale counterclockwise approximately 10° (motor stroke is 90°). Release the scale lock.
5. Turn cam until the cam roller of the switch lever is exactly over the outer corner of the operational cam lobe. A slight movement of the cam at this point should produce an audible click in the switch. Tighten the operational cam's locking screw.

6. No cam differential is desired between the make and the break of the contacts, so be sure that the differential cam lobe (brass colored) and the operational cam lobe are aligned so that the differential cam has no effect on the switch.
7. Place the second set of cams on the shaft. Make sure that the operational cam's locking screw is on the opposite side of the shaft of the switch the cam is to operate (when the scale plate is set at zero).
8. Adjust the cam lobes as described in step 3.
9. Depress the scale lock. Turn the cam so that the cam roller of the No. 2 switch lever is exactly over the outer corner of the operational cam lobe when the scale indicates 60°. Replace and tighten thumb screw.
10. Connect the red and blue leads to the oil valve circuit as shown on the wiring diagram. The yellow lead is not required and its end should be insulated to prevent short circuits.
11. Check the operation of the switches under actual operating conditions. Make any necessary cam adjustments to insure that the oil valves open at the desired point.

The variables involved may require adjustment of the cams under operating conditions. The point of valve actuation is directly related to the amount of damper travel on a particular burner. The first switch should be actuated to close midway between low and high fire. This causes the intermediate oil valve to open and the second nozzle to fire, providing an increased firing rate for a smoother changeover between the low and high fire rates and vice versa. As the air damper moves towards the high-fire position, an increasing amount of air is allowed into the boiler. The valve should open in approximately mid range of the air input but definitely at a point where sufficient air is present so that there is no incomplete combustion or smoke. The positioning of the cam must be guided while observing the fire or stack when the valve opens. If smoke or haze is noticed, reposition cam to slightly retard valve opening.

The second oil valve switch should be actuated just as the damper reaches its open position. Based upon a combustion analysis, a damper position linkage adjustment may be required to provide more or less air at this point.

5.9 — Air Damper Adjustment

The arms and connecting rod that transmit motion from the damper motor to the air damper (and to the gas butterfly valve on a gas fired unit) are set at the factory and should not normally need further adjustment.

If adjustments are required, or to aid in determining the position of linkage in event of replacement, the following factors should serve as guides.

- The damper motor should be able to complete its full travel range of 90 degrees. A restriction can cause damage.
- Initial adjustment is done with the motor in its closed or unpowered condition. The power end of the shaft will be in its most counterclockwise position.
- Secure the motor arm approximately 60 degrees below the horizontal centerline.
- The slot on the end of the damper shaft indicates the position of the damper blade.
- It is not practical to list specific setting of all of the connections or of the damper arm angle, since adjustment conditions must exist to meet combustion requirements or load conditions.
- The closer the swivel joint in the motor arm is to the hub, the less distance it will travel.
- The amount of damper opening increases when its connecting joint is closer to the hub. To decrease opening, move the ball joint away from the hub.
- Final adjustments should result in a coordinated movement of the damper and damper motor.

Normally, at low fire the damper blade is cracked slightly open. With the burner firing at its low rate, hold the damper shaft securely with pliers and loosen the setscrew on its arm. Manually close damper until a slight haze appears and then open until it clears. Tighten setscrews and for reference purposes mark the position of the shaft slot to indicate approximate low fire damper setting.

Turn the damper positioning switch to “high” and observe the burner as it progresses to high fire, to be sure that air flow is coordinated with fuel flow.

Too much air can extinguish the flame and damper travel must be regulated accordingly. When high-fire position is reached again observe the flame appearance. If it is hazy then more air is required. Determine approximate setting by following the procedure outlined in the previous paragraph to obtain a haze-free fire. Again, make a reference mark showing the open position.

NOTE: As pointed out in the sections pertaining to combustion adjustment, color is a poor indication of flame efficiency and should be used only for tentative adjustment. final adjustments should be made based upon stack analysis and with proper fuel input.

With the limits of low fire and high fire damper travel determined from reference marks, adjustment can now be made to the connecting rod connections.

Periodically check for proper adjustment. Check tightness of setscrews to prevent slippage. Occasionally oil swivel joints with a graphite or silicone type lubricant.

5.10 — Safety Valves

The safety valve is a very important safety device and deserves attention accordingly.

The purpose of the valve(s) is to prevent pressure buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and Code required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening as this can distort the seats. Use only flat jawed wrenches on the flats provided. When installing a flange connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

A drip pan elbow or a flexible connection between the valve and the escape pipe is recommended. The discharge piping must be properly arranged and supported so that its weight does not bear upon the valve.

Do not paint, oil, or otherwise cover any interior or working parts of the safety valve. A valve does not require any lubrication or protective coating to work properly.

Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency of testing, either by the use of the lifting lever or by raising the steam pressure, should be based on the recommendation of your boiler inspector, and/or the valve manufacturer, and in accordance with Sections VI and VII of the ASME Boiler and Pressure Vessel Code.

Avoid excessive operation of the safety valve as even one opening can provide a means of leakage. Safety valves should be operated only often enough to assure that they are in good working order. When a pop test is required, raise the operating pressure to the set pressure of the safety valve, allowing it to open and reseat as it would in normal service.

Do not hand operate the valve with less than 75% of the stamped set pressure exerted on the underside of the disc. When hand operating, be sure and hold the valve in an open position long enough to purge accumulated foreign material from the seat area and then allow the valve to snap shut.

Frequent usage of the safety valve will cause the seat and disc to become wire drawn or steam cut. This will cause the valve to leak and necessitate downtime of the boiler for valve repair or replacement. Repair of a valve must be done only by the manufacturer or his authorized representative.

Avoid having the operating pressure too near the safety valve set pressure. A 10% differential is recommended. An even greater differential is desirable and will assure better seat tightness and valve longevity.

Steam is expensive to generate and, for the sake of economy, wastage should be avoided whenever possible.

The above comments, although written primarily for a safety valve on a steam boiler, are largely applicable to a relief valve on a hot water boiler. It is imperative that the discharge piping be properly supported to avoid valve distortion and that this piping is directed to a safe point of discharge.

5.11 — Motorized Gas Valve

1. Should the valve fail to operate, check its operation by applying test leads of the proper voltage to terminals 1 and 2 of the actuator. Make certain that the main shutoff cock is closed prior to testing. If the actuator falls to operate, it must be replaced. The actuator is not field repairable nor should it be disassembled.
2. To remove the actuator, loosen the two 5/32” allen setscrews that hold the actuator collar to the valve bonnet.
3. After replacement, cycle the valve with the fuel shutoff to determine that it opens and closes. If the valve has a visual indicator, observe the colored indicator: yellow — shut; red — open.

The auxiliary switch normally used as a valve closed indication switch is replaceable as a component.

5.12 — Solenoid Valves: Gas Pilot/Fuel Oil/Vent Valves

Foreign matter between the valve seat and seat disc can cause leakage. Valves are readily disassembled, however, care must be used during disassembly to be sure that internal parts are not damaged during the removal and that reassembly is in proper order.

A low hum or buzzing will normally be audible when coil is energized. If valve develops loud buzzing or a chattering noise check for proper voltage and clean plunger assembly and interior plunger tube thoroughly. Do not use any oil. Make sure that plunger tube and solenoid are tight when reassembled. Take care not to nick, dent or damage the plunger tube.

Coils may be replaced without removing the valve from the line. Be sure to turn off power to the valve. Check coil position and make sure that any insulating washers or retaining springs are reinstalled in proper order.

5.13 — Refractory

The Model 4 Boiler is shipped with completely installed refractory. This consists of the burner tile, access door arid a bed covering the lower drum.

The refractory should be checked for evidence of shipping damage and repairs made prior to initial firing.

Periodic inspection will keep the operator informed of the condition of refractory. Normal maintenance requires little time and expense and prolongs operating life. Frequent washcoating of all surfaces is recommended. High temperature, air-dry type mortar diluted with water to the consistency of light cream is used for this purpose. Coating intervals will vary with service and are best determined by inspection.

Face all joints or cracks by applying mortar with a trowel or finger tip. Do this as soon as cracks are detected. It is normal for refractories exposed to hot gases to develop thin “hairline” cracks. This is caused by expansion and contraction. Cracks up to 1/8 inch across may be expected to close at high temperatures. If there are any that are relatively large (1/8 to 1/4 inch) clean them and fill with high temperature bonding mortar.

Refractory, under normal conditions, will last for considerable periods before replacement is necessary.

In the event of spalling of the furnace floor, remove affected area and replace with a mix made from regular Furnas-Crete (Kaiser).

The burner tile is a precast special shape, and replacements can be ordered from your Cleaver-Brooks representative. Installation is generally done by working from inside of furnace and through the access door. Dry fit all the segments and chip to fit, if necessary. Reinstall, using proper refractory cement. Make sure that all joints are tight and coated with cement. Mix insulating cement with refractory mortar and work the mixture into the crevices formed by the back of the tile and the boiler tube panel. It is important that a good tight seal be attained between the burner housing and the brick. Make sure that the insulating material is in place and cement all joints and crevices. Periodically check the seal and repack as required.

5.14 — Fuel Changeover Maintenance

A boiler that is equipped to burn either oil or gas is often run for extended periods on either one of these fuels. To insure that the alternate fuel system is in working order, it is suggested that the burner be changed over for a short run on a periodic basis such as monthly. This preventive maintenance will permit checking of fuel valves and controls to determine their standby readiness. Circulation of oil through the system on a unit primarily firing gas is beneficial to the pump.

5.15 — Forced Draft Fan

Rotation of the fan is counterclockwise when viewed from front of burner. If motor is ever replaced be sure that rotation is proper when motor leads are reconnected. Remove the oil pump belt before testing for motor rotation. Occasionally check to see that fan is securely tightened on motor shaft. A retaining washer on the end of motor shaft holds the fan in the proper position and there should be no rubbing or contact with the air inlet. If the boiler is installed in a dusty location check the vanes for deposits of dust or dirt; buildup of such deposits can cause a decrease in air capacity or lead to an unbalanced fan condition.

5.16 — Furnace Access and Fireside Cleaning

The entire windbox is attached to a davit and can be swung aside from the boiler. A bolted panel is provided for furnace inspection or access.

To swing front head:

1. Remove access casing panels and insulation on both sides of boiler.
2. Disconnect the fuel lines at unions or other piping connections.

> **⚠ Caution**
>
> Make certain that the fuel supply — oil and/or gas — is properly shut off prior to disconnecting.

3. Disconnect the sight tube cooling line.
4. Disconnect pressure control lines on a steam boiler. Remove the remote bulbs from the water controls on a hot water boiler.
5. Unbolt the windbox from the burner flange.
6. Swing the windbox assembly on its davit.

> **⚠ Caution**
>
> Check for interference for field installed wiring or piping.

7. Remove bolting from access panel.
8. Reassemble in reverse order. Check the condition of the gasketing on the access panel and on the burner flange and replace if necessary. Restore the fuel supply and check the tightness of all reconnected piping.
9. Before firing, remove the burner drawer and reseal the burner housing. See **Section 5.18** of this chapter.

Refer to appropriate sections in **Chapter 2** for information on cleaning of fireside and waterside boiler surfaces.

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5.17 — Lubrication

5.17.1 — Electric Motors

Manufacturers of electric motors vary in their specifications for lubrication and care of motor bearings and their recommendations should be followed.

Ball bearing equipped motors are pre-lubricated. The length of time a bearing can run without having grease added or the bearing replaced, will depend upon many factors. The rating of the motor, type of motor enclosure, duty, atmospheric conditions, humidity, and ambient temperatures are but a few of the factors involved.

Complete renewal of grease can, on some motors, be accomplished by forcing out the old grease with the new.

1. Thoroughly wipe those portions of the housing around the filler and drain plugs (above and below bearings).
2. Remove the drain plug (bottom) and free the drain hole of any hardened grease which may have accumulated.
3. With the motor not running, add new grease through the filler hole until clear grease starts to come out of the drain hole. Before replacing the drain plug run the motor for 10 to 20 minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

The lubricant used should be clean and equal to one of the good commercial grades of grease locally available. Some lubricants that are distributed nationally are:

Gulf Oil	– Precision Grease No. 2
Humble Oil	– Andok B
Texaco	– Multifak No. 2
Phillips	– 1 B + RB No. 2
Fiske Bros.	– Ball Bearing Lubriplate
Standard/Mobile	– Mobilux No. 2

NOTE: Siemens TEFC motors use a different and incompatible grease to those listed above.
For Siemens Motors: Contains re-greasable bearings. The shaft end (impeller end) requires the use of CB's high temperature auto grease system (PN 884-133) for proper lubrication.
The opposite shaft end (end opposite impeller) can be greased by the auto grease system or by hand pump, using two or three pumps every three months with a grease compatible with a high temperature aluminum complex grease.

5.17.2 — Control Linkage

Apply a non-gumming dripless high temperature lubricant, such as graphite or a silicone derivative to all pivot points and moving parts. Work lubricant in well and wipe excess. Repeat application at required intervals to maintain freedom of motion of parts.

Solenoid valves and motorized valves require no lubrication.

5.18 — Burner Housing Seal

The area between the end of the burner housing and the refractory facing of the oven must be properly sealed to avoid damage. The condition of this seal must be checked prior to placing the boiler into initial operation and periodically thereafter. Whenever the front head is swung aside, it will be necessary to reseal this area.

Resealing can be accomplished by using a half and half mixture of insulating pulp and refractory cement.

1. Remove the burner drawer and clean away as much of the old seal as possible.
2. Force the sealing mixture around the outer perimeter of the burner housing using care to make sure that the holes in the gas housing are not obstructed.

The use of a mirror can be helpful in making a proper seal.

CHAPTER 6

Troubleshooting

6.1 — Overview

This section assumes that the unit has been properly installed and adjusted and that it has been running for some time prior to the trouble listed in the heading of each section. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points under each heading are set down briefly as possible causes, suggestions or clues to simplify locating the source of trouble. Methods of correcting the trouble, once it has been identified, may be found elsewhere in this manual.

If the burner will not start, or operate properly, refer to this troubleshooting section and to the programming relay bulletin for assistance in pinpointing problems that may not be readily apparent. Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual and the bulletin. Knowledge of the system and its controls will make troubleshooting much easier. Costly downtime or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

If an obvious condition is not apparent, check the continuity of the circuits with a voltmeter or test lamp. Each circuit can be checked and the fault isolated and corrected. Most circuitry checking can be done between appropriate terminals on the terminal boards in the control cabinet or the entrance box. Refer to the schematic Wiring Diagram for terminal identification.

6.2 — Burner Does Not Start

Possible Cause	Additional Considerations
Main disconnect switch open.	
Blown fuses, tripped overload, loose electrical connections.	
Combustion control safety switch requires resetting.	**A.** Refer to manufacturer's bulletin. **B.** Check for power between terminals L1 and L2 (terminal board 4 and 5). **C.** If relay 1K pulls in, but the blower motor does not start, check for power at programmer terminal 8 (terminal board 15). **D.** Check that appropriate relay contacts are closed (see programmer bulletin).
Limit circuit not completed — no power to programmer terminal 3 (TB10 or 23).	**A.** Pressure or temperature is above setting of operator control. **B.** Water below required level: • Low water light, if provided, should indicate this condition. • Check manual reset button, if provided, on low water control. **C.** Fuel pressure must be within settings of low pressure and high pressure switches.
Motor defective.	
If burner starts, but shuts down after a few seconds, check the air proving switch circuit.	

6.3 — No Ignition

Possible Cause	Additional Considerations
Lack of spark.	**A.** Electrode grounded or porcelain cracked. **B.** Improper electrode setting. **C.** Loose terminal on ignition cable - cable shorted. **D.** Inoperative ignition transformer. **E.** Check appropriate program relay contacts.
Spark but no flame.	**A.** Lack of fuel — no gas pressure, closed valve, empty tank, broken line, etc. **B.** Inoperative pilot solenoid or low fire oil valve. **C.** Insufficient or no voltage to gas pilot solenoid valve. Check power at relay terminal 5 (TB17)
Low fire switch open.	**A.** Damper motor not closed, slipped cam, defective switch. **B.** Damper jammed or linkage binding.
Check interlocks and circuit relay terminal 12.	
Timer switch (CB20 or CB40) in TEST position and timer stopped in “pre-purge.”.	

6.4 — Pilot Flame but no Main Flame

Possible Cause	Additional Considerations
Insufficient pilot flame.	
Gas fired unit:	**A.** Manual gas cock closed. **B.** Main gas valve inoperative. • Low or high gas pressure (reset switch if necessary)
Oil fired unit:	**A.** Oil supply cut off by obstruction, closed valve, or loss of suction. **B.** Pump inoperative, belt broken or slipping. **C.** No fuel. **D.** Inoperative solenoid valve. **E.** Check oil nozzles and lines.
Inoperative programmer.	**A.** If relay 2K does not pull in when pilot flame lights, check flame detector, contacts, and amplifier. **B.** Flame detector defective, sight tube obstructed, or detector lens dirty. **C.** If relay 2K pulls in but fuel valve isn't energized, check for voltage at terminal 7 (TB18). If no voltage, check contacts (see bulletin).

6.5 — Burner Stays in Low Fire

Possible Cause	Additional Considerations
Pressure or temperature above high-low fire control setting.	
Damper positioning switch in wrong position.	
Inoperative damper motor (see **Section 6.7**).	
Binding or loose linkage, cams, setscrews, etc.	
Check appropriate relay contacts.	

6.6 — Shutdown Occurs During Firing

Possible Cause	Additional Considerations
Loss or stoppage of fuel supply.	
Defective fuel valve, loose electrical connection.	
Flame detector weak or not operative.	
Lens dirty or sight tube obstructed.	
If the programmer lockout switch has not tripped, check the limit circuit controls, interlock, or blower motor.	**A.** The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the non-recycling interlock circuit. **B.** The light will not be energized by the opening of any control in the limit circuit.

Possible Cause	Additional Considerations
If the lockout switch has tripped:	**A.** Check fuel lines and valves. **B.** Check flame detector. **C.** Visually check appropriate timer and relay contacts, refer to program control manual. **D.** Check blower motor and all interlocks (CB40). **E.** Lockout switch malfunctioning. • Stuck contacts.
Improper air-fuel ratio (lean fire).	**A.** Slipping linkage. **B.** Damper stuck open. **C.** Fluctuating fuel supply. • Temporary obstruction in fuel line. • Temporary drop in gas pressure.
Interlock device inoperative.	

6.7 — Damper Motor Does Not Operate

Possible Cause	Additional Considerations
Damper positioning switch in wrong position.	
Linkage loose or jammed.	
Motor does not drive to open or close during pre-purge or close on burner shut-down.	**A.** Check appropriate contacts (see bulletin).
Motor does not operate on command.	**A.** Damper positioning switch in wrong position. **B.** High-low fire control improperly set or not operative. **C.** Check appropriate contacts (see bulletin).
Motor inoperative.	**A.** Loose electrical connection.

CHAPTER 7

Parts Ordering and Parts Lists

7.1 — Ordering Parts

Furnish complete information when ordering parts. When ordering parts for the boiler, be sure to include on the order:

- The boiler serial number shown on the nameplate attached to the front head.
- The Cleaver-Brooks part number and the name and description of the part required.
- The quantity required.
- The method of shipment.
- The date the material is required.

If repair parts are required for accessory equipment, such as an electric motor, pump, etc., which may not be shown, be sure to give the complete nameplate data from the item for which the parts are required.

Where to Order Parts - Repair or replacement parts should be ordered from a Cleaver-Brooks representative.

Returning Parts for Repair - Parts to be repaired should be directed to a Cleaver-Brooks representative. A purchase order or a letter authorizing repairs and giving complete details should be mailed to the representative. Prior to returning, please remove fittings or accessories from the component, properly drain and clean the part to comply with shipping regulations, and include inside of the package a packing slip identifying the part with your company's name.

To return parts for reasons other than repair or exchange, please contact the Cleaver-Brooks representative and explain the reason for the return and await permission and directions prior to returning the material.

Many controls and other components can be factory rebuilt (FR) or have a trade-in value. These items are available on an exchange basis. Consult the Cleaver-Brooks representative.

Be sure to show the serial number of the unit on all parts orders and correspondence.

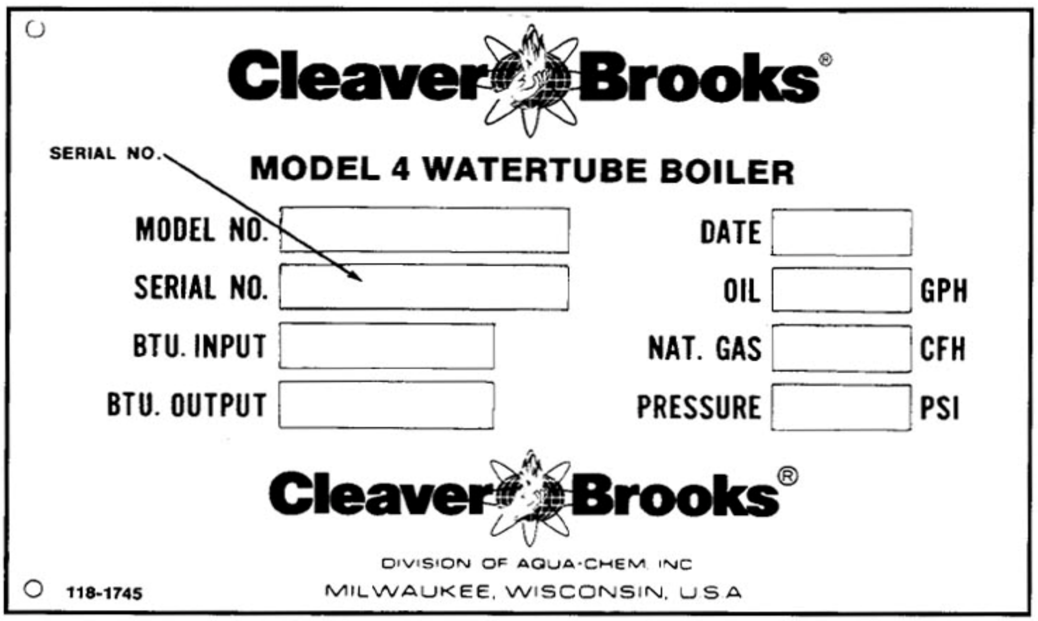

FIGURE 7-1. Boiler Nameplate

7.2 — Parts Lists

- HW = Hot Water
- LP = Low Pressure
- HP = High Pressure

Usage Column indicates parts that apply to a particular unit. If no designation is given, parts apply to all models in all horsepower ranges.

> **NOTE:** A blank space under "Usage" indicates the part is used on all sizes and series covered by this manual.

7.2.1 — Burner Parts

Part Number	Req.	Description	Usage
275-236	1	Diffuser, Series 100, Sizes 1500-2500	
275-237	1	Diffuser, Series 200 & 700, Sizes 1500-2500	
275-238	1	Diffuser, Series 100, Sizes 3000-4000	
275-239	1	Diffuser, Series 200 7 700, Sizes 3000-4000	
275-226	1	Diffuser, Series 100, Sizes 4500-6000	
275-227	1	Diffuser, Series 200 & 700, Sizes 4500-6000	
435-99	1	Electrode	Gas Pilot
435-102	1	Electrode, Right	Oil Pilot
435-103	1	Electrode, Left	Oil Pilot
94-179	2	Insulator, Ignition	Oil Pilot
82-74	2	Spring, Ignition	Oil Pilot
899-93		Nozzle, 30° HV - 2.5 GPH	
899-162		Nozzle, 60° PLP - 2.5 GPH	
899-29		Nozzle, 30° HV - 3.5 GPH	
899-87		Nozzle, 60° PLP - 3.5 GPH	
899-31		Nozzle, 30° HV - 4.5 GPH	
899-32		Nozzle, 60° PLP - 4.5 GPH	
899-33		Nozzle, 30° HV - 5.0 GPH	
899-34		Nozzle, 60° PLP - 5.0 GPH	
899-109		Nozzle, 30° HV - 5.5 GPH	
899-74		Nozzle, 60° PLP - 5.5 GPH	
899-80		Nozzle, 30° HV - 6.0 GPH	
899-59		Nozzle, 30° HV - 7.0 GPH	
899-63		Nozzle, 60° PLP - 7.0 GPH	
899-83		Nozzle, 30° HV - 7.5 GPH	
899-38		Nozzle, 60° PLP - 7.5 GPH	
899-40		Nozzle, 60° PLP - 8.3 GPH	
899-42		Nozzle, 60° PLP - 9.5 GPH	

Part Number	Req.	Description	Usage
899-44		Nozzle, 60º PLP - 10.5 GPH	
851-77		Mica, Sight Hole	
90-948		Tube, Scanner	
100-100		Nozzle, Body	
134-77		Spider, Series 100 and 200	Sizes 1500-4000
134-78		Spider, Series 100 and 200	Sizes 4500, 6000
134-79		Spider, Series 700	Sizes 1500-4000
134-80		Spider, Series 700	Sizes 4500, 6000
90-949		Tube, Nozzle Air Cooling	Short
90-950		Tube, Nozzle Air Cooling	Long
134-66		Spider, Oil Pipe	
134-81		Holder, Gas Pilot Electrode	
40-455		Sleeve, Gas Burner Housing 40-455	Sizes 1500-4000
40-454		Sleeve, Gas Burner Housing 40-454	Sizes 4500, 6000
284-129		Gas Pilot Assembly	

7.2.2 — Gaskets

Part Number	Req.	Description	Usage
32-2375	1	Gasket, Burner Drawer	
32-2376	1	Gasket, Motor Mounting Plate	
32-2377	1	Gasket, Burner Housing	
32-2447	1	Gasket, Windbox Housing	
32-2436	1	Gasket, Front Access Door	
32-2437	2	Gasket, Convection Inspection	
853-973	1	Gasket, Handhole 4” x 5”	
853-972	1	Gasket, Handhole 4” x 6”	
821-179	1	Plate, Handhole 4” x 5”	
821-275	1	Plate, Handhole 4” x 6”	
953-48	1	Yoke, Handhole	

7.2.3 — Electrical Controls and Components

Part Number	Req.	Description	Usage
		FLAME SAFEGUARD	**NOTE:** For FS6 parts information, see CB manual 750-264 (CB 120E) or 750-234 (CB 780E)
817-1257	1	High Limit Control, Temp., L4008E	281-300º F HTHW
817-700	1	Operating Limit Control, Temp., L4008A	281-300º F HTHW
817-699	1	Well Separable	281-300º F HTHW/ 240-280º F HTHW
817-1566	1	High-Low Fire Control, Temp., L6008A	281-300º F HTHW/ 240-280º F HTHW
817-1249	1	Modulating Control, Temp., T991A	281-300º F HTHW/ 240-280º F HTHW

Part Number	Req.	Description	Usage
817-1028	1	Well Separable	281-300º F HTHW/ 240-280º F HTHW
817-619	1	Low Fire Hold Control, Temp., L6008A	281-300º F HTHW/ 240-280º F HTHW/30-40# HW
817-1281	1	High Limit Control, Temp., L4008E	240-280º F HTHW
817-698	1	Operating Limit Control, Temp., L4008A	240-280º F HTHW
817-1050	1	High Limit Control, Temp., L4008E	30-40# HW
817-400	1	Operating Limit Control, Temp., L4008A	30-40# HW
817-405	1	Well Separable	30-40# HW
817-619	1	High-Low Fire Control, Temp., L6008A	30-40# HW
817-1244	1	Modulating Control, Temp., T991A	30-40# HW
817-378	1	Well Separable	30-40# HW

7.2.4 — Pilot Gas Train

Part Number	Req.	Description	Usage
825-30	1	Shutoff Cock, 1/2”	
918-356	1	Pilot Regulator	
948-197	1	Valve, Pilot Solenoid, 1/2”	
940-1582	1	Relief Valve	

7.2.5 — Main Gas Train

Part Number	Req.	Description	Usage
918-711	1	Regulator, Pressure 1-1/2”	Boiler Size 1500
918-733	1	Regulator, Pressure 2”	Boiler Size 1500
918-155	1	Regulator, Pressure 1-1/2”	Boiler Size 2000
918-716	1	Regulator, Pressure 2”	Boiler Size 2000
918-730	1	Regulator, Pressure 1-1/2”	Boiler Size 2500
918-716	1	Regulator, Pressure 2”	Boiler Size 2500
918-703	1	Regulator, Pressure 2-1/2”	Boiler Size 2500
918-547	1	Regulator, Pressure 1-1/2”	Boiler Size 3000
918-716	1	Regulator, Pressure 2”	Boiler Size 3000
918-701	1	Regulator, Pressure 2-1/2”	Boiler Size 3000
918-698	1	Regulator, Pressure 3”	Boiler Size 3000
918-650	1	Regulator, Pressure 2”	Boiler Sizes 3500-4000
918-701	1	Regulator, Pressure 2-1/2”	Boiler Sizes 3500-4000
918-698	1	Regulator, Pressure 3”	Boiler Sizes 3500-4000
918-650	1	Regulator, Pressure 2”	Boiler Size 4500
918-701	1	Regulator, Pressure 2-1/2”	Boiler Size 4500
918-718	1	Regulator, Pressure 3”	Boiler Size 4500
918-650	1	Regulator, Pressure 2”	Boiler Size 5000
918-705	1	Regulator, Pressure 2”	Boiler Size 6000

Part Number	Req.	Description	Usage
918-701	1	Regulator, Pressure 2-1/2”	Boiler Sizes 5000-6000
918-698	1	Regulator, Pressure 3”	Boiler Sizes 5000-6000
940-5810	1	Valve (Std.)	Train Size 1-1/2”
940-5812	1	Valve (Std.)	Train Sizes 2”-3”
945-139	1	Actuator (Std.)	
940-5811	1	Valve (Poc.)	Train Size 1-1/2”
940-5813	1	Valve (Poc.)	Train Sizes 2”-3”
945-143	1	Actuator (Poc.)	
817-2414	1	Low Gas Pressure (Switch or Sensor)	
817-2421	1	High Gas Pressure Switch	Models 1500-2500 FM/ IRI
817-1935	1	High Gas Pressure Switch	Model 3000 STD/FM
817-2415	1	High Gas Pressure Switch	Models 3500-4500
817-2421	1	High Gas Pressure Switch	Model 5000
817-2415	1	High Gas Pressure Switch	Model 6000
941-1946	2	Manual Shutoff Valve	Train Size 1-1/2”
941-1947	2	Manual Shutoff Valve	Train Size 2”
941-129	2	Manual Shutoff Valve	Train Size 2-1/2”
941-130	2	Manual Shutoff Valve	Train Size 3”
940-4243	1	Relief Valve	

7.2.6 — Linkage

Part Number	Req.	Description	Usage
2-47	1	Arm, Damper Shaft	
2-105	1	Arm, Damper Motor	
287-20	1	Arm, Gas Valve	
883-17	1	Ball Joint	
10-288	1	Bushing, Ball Joint	
82-83	2	Spring, Compression	Gas Valve
10-305	1	Shaft Extension	
807-376	2	Bearing, Damper	

7.2.7 — Oil Pump and Components

Part Number	Req.	Description	Usage
901-1328	1	Pump, Oil, Webster 2R626C	
809-157	1	V-Belt, 4L250	
809-255	1	V-Belt, 4L270	
29-1477	1	Flange, Oil Pump	
921-342	1	Sheave, Oil Pump, 4.7 PD-1A-7/16" Bore	
921-166	1	Sheave, Motor, 2.2 PD-1A-5/8" Bore	
921-592	1	Sheave, Motor, 2.2 PD-1A-7/8" Bore	
825-255	1	Cock, Oil Gauge Shutoff	
825-318	1	Cock, Oil Line Shutoff	

7.2.8 — Gauges and Thermometers

Part Number	Req.	Description	Usage
850-122	1	Gauge, Pressure	HW
850-407	1	Gauge, Pressure	Steam - 15#
850-122	1	Gauge, Pressure	Steam - 150#
850-400	1	Gauge, Pressure	Steam - 250# - 350#
850-952	1	Gauge, Pressure	Steam - 500#
937-624	1	Thermometer, 5", Dial, 50-300°	H.W.
937-28	1	Thermometer, Stack	

7.2.9 — Safety Valves

Part Number	Req.	Description	Usage
		Because of the many variations in pressure settings and sizes, it is impractical to list safety or relief valves. Furnish nameplate data of existing valve when ordering replacement.	

7.2.10 — Refractory

Part Number	Req.	Description	Usage
872-421	*	Refractory, Castable 2500°	*6000, 230 lbs.
			*4500-5000, 200 lbs.
			*3500-4000, 180 lbs.
			*2500-3000, 150 lbs.
			*1500-2000, 100 lbs.
872-390	*	Mortar, Bonding, Refractory, Drum, 200lbs	*6000, 50 lbs.
			*4500-5000, 50 lbs.
			*3500-4000, 25 lbs.

Part Number	Req.	Description	Usage
			*2500-3000, 25 lbs.
			*1500-2000, 25 lbs.
872-162	*	Refractory, Castable 1600º	*6000, 50 lbs.
			*4500-5000, 50 lbs.
			*3500-4000, 40 lbs.
			*2500-3000, 40 lbs.
			*1500-2000, 40 lbs.
94-380	2	Insulation, Front Wall, Upper, Short	
94-385	1	Insulation, Front Wall, Upper	
94-381	1	Insulation, Blanket, 1" thk. 2400º	
872-200	*	Insulation, Blanket, 2" thk. 1000º	*6000, 130 sq. ft.
			*4500-5000, 130 sq. ft.
			*3500-4000, 110 sq. ft.
			*2500-3000, 95 sq. ft.
			*1500-2000, 55 sq. ft.
94-377	2	Tile, Throat, Burner, Size 1500-6000	
94-378	*2	Tile, Throat, Burner, Size 1500-4000	*Sizes 1500-4000 only
94-379	*4	Tile, Throat, Burner, Size 4500-6000	*Sizes 4500-6000 only
930-138	1	Netting, Poultry, Hexagonal, 1" Mesh	
980-20	2	Superglass, Strip, 1/4" thk. 1800º	
903-245	69	Pin, Welded, Insulation, 1-3/8" lg.	
828-26	69	Retainer, Insulation	
125-263	1	Strip, Sized, 3/4" x 18-7/8" lg.	
841-1401	3	Screw, Self-Drilling, 1/2" lg.	

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7.2.11 — Motors and Impellers

SIZE	FUEL	MOTOR			HP	IMPELLER	KEY
		115V	200/230/460V				
		ODP (STD)	ODP (STD)	TEFC			
1500	100/200	894-3106	894-3108	894-3267	1.5	192-225	841-1449
	700	894-3097	894-3091	894-3703	3/4	192-225	841-1449
2000	100/200	894-3106	894-3108	894-3267	1.5	192-212	841-1449
	700	894-3098	894-3100	894-3704	1	192-212	841-1449
2500	100/200	894-3114	894-3116	894-3266	2	192-226	841-1449
	700	894-4011	894-4013	894-3705	1.5	192-226	841-1449
3000	100/200	894-3114	894-3116	894-3266	2	192-215	841-1449
	700	894-3110	894-3112	894-3706	2	192-215	841-1449
3500	100/200	894-3066	894-3068	894-3309	3	192-227	841-1451
	700	894-3110	894-3112	894-3706	2	192-218	841-1449
4000	100/200	894-3074	894-3076	894-3308	5	192-209	841-1450
	700	894-3062	894-3064	894-3707	3	192-208	841-1451
4500	100/200	894-3066	894-3068	894-3309	3	192-227	841-1451
	700	894-3062	894-3064	894-3707	3	192-227	841-1451
5000	100/200	894-3066	894-3068	894-3309	3	192-210	841-1451
	700	894-3062	894-3064	894-3707	3	192-210	841-1451
6000	100/200	894-3074	894-3076	894-3308	5	192-214	841-1450
	700	894-3070	894-3072	894-3708	5	192-214	841-1450

7.2.12 — Water Level Control Parts

Part Number	Req.	Description	Usage
100-271	1	L.W. Cutoff w/Pump Control	15# ST
817-2411	1	L.W. Cutoff w/Pump Control	150# ST
817-163	1	L.W. Cutoff w/Pump Control	250# ST
817-1649	1	L.W. Cutoff w/Pump Control	350-500# ST
817-2305	1	L.W. Cutoff	30-150# HW
817-2351	1	Probe for McD-m #750	30-150# HW
289-154	1	S.W. Cutoff Level Master	15-250# ST
817-740	1	Aux. L.W. Cutoff	15-250# ST
067-533	2	Probes for Warrick	15-250# ST
817-1020	1	Aux. LWCO	15-250# ST

Part Number	Req.	Description	Usage
067-533	3	Probes for Warrick	15-250# ST
817-1367	1	Aux. LWCO	350-500# ST
817-312	1	Aux. LWCO	Optional
817-2407	1	Aux. LWCO	Optional
817-93	1	Aux. LWCO	Optional
825-281	1	Set Water Gauge	15# ST
825-132	1	Set Water Gauge	150# ST
825-352	1	Set Water Gauge	250# ST
825-357	1	Set Water Gauge	350# ST
825-357	2	Set Water Gauge	500# ST
851-58	1	Gauge, Glass	15# ST
851-44	1	Gauge, Glass	150# ST
851-38	1	Gauge, Glass	250# ST
851-321	1	Gauge, Glass	350# ST
851-321	2	Gauge, Glass	500# ST
851-199	1	Gauge Glass - Level Master	15-250# ST
912-51	2	Rod, Gauge Glass	15# ST
912-146	2	Rod, Gauge Glass	150# ST
912-38	2	Rod, Gauge Glass	250# ST
912-85	4	Rod, Gauge Glass - Level Master	15-250# ST
830-28	*	Chain Sash	250-500# ST
941-251	1	Valve, Ball 1/4”	15-150# ST
941-318	1	Valve, Globe 1/4”	250# ST
941-1868	1	Valve, Globe 3/8”	350# ST
941-1868	2	Valve, Globe 3/8”	500# ST
941-142	1	Valve, Globe 3/4”	15-150# ST
941-1870	1	Valve, Globe 3/4”	250# ST
941-1870	2	Valve, Globe 3/4”	350-500# ST
941-402	1	Valve, Globe 1” - Level Master	15-250# ST

Part Number	Req.	Description	Usage
825-31	1	Cock, Union 1/4" Brass	15-250# ST
941-1867	1	Valve, Globe 1/4"	300-500# ST
623-116	1	Level Master Control Panel	15-250# AR
623-117	1	Level Master Control Panel	15-250# MR
623-163	1	Level Master Probe	15-250#

7.3 — Notice

The manufacturer's bulletin for the particular Flame Safe Guard and Programming Control installed on the boiler is supplied along with this operating manual. In the event that a replacement control bulletin is required, the model and form number is listed below. Order from you Cleaver-Brooks representative.

Control Model	Cleaver-Brooks Bulletin No.
CB-20	C9-767
CB-40	C9-768