

CLEAVER-BROOKS

Model 5 Boiler

Operation and Maintenance Manual



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Model 5

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General Description and Principles of Operation

1.1 — Introduction

The Cleaver-Brooks Model 5 Boiler is a packaged steel boiler consisting of a pressure vessel, oil or gas burner, burner controls, forced draft fan, air control damper, and associated components.

The pressure vessel (see Chapter 2) is constructed in accordance with the ASME Boiler and Pressure Vessel Code.

This chapter covers Model 5 boilers designed for high or low pressure steam or hot water generation with fuel input ranging from 1,500,000 to 6,000,000 BTU/Hr.

1.2 — The Boiler

The Model 5 Boiler is a watertube construction with welded membrane waterfalls arranged so that the products of combustion travel the length of the furnace, reverse direction, then pass between the furnace waterwalls and the convection waterwalls. Complete combustion takes place in the furnace.

The boiler and any related equipment installed by others are to be in compliance with the regulations of the Canadian Standards Association. Installation should also conform to provincial and local codes governing such equipment. Prior to installation the proper authorities having jurisdiction are to be consulted, permits obtained, etc. The Model 5 boilers comply, when equipped with optional equipment, to Factory Insurance Association (FIA), Factory Mutual (FM), or other insuring underwriters' requirements.

1.3 — The Burner

The type of fuel used by the boiler determines the series classification. These are:

Series 100	Light Oil (No. 2) only
Series 200	Light Oil (No. 2) or Gas
Series 700	Gas only



Boilers equipped to burn oil and gas include equipment for each distinct fuel. Since the burner uses only one type of fuel at a time, a gas/oil selector switch is incorporated in combination units.

All Model 5 boilers have the burner assembly attached to the front head and readily accessible for inspection and maintenance.

Oil burners are of the high pressure atomizing types. Gas burners are of the high radiant annular entry type. Gas burners are ignited by a gas pilot which is spark-ignited. Burners using light oil fuel only are normally spark-ignited. Combination gas/oil burners use a gas pilot for ignition of both fuels.

The burner is fully modulating when firing gas and operates at two burning rates when firing oil (high fire and low fire). The burner and its components are described in detail later in this manual.

Combustion air is provided by a centrifugal blower located in the front head. Combustion air delivery to the burner is under control of the damper motor. The same motor regulates the flow of gas fuel through a linkage system connected to the gas butterfly valve or by actuating switches that energize the oil valves. Fuel input and air are thus properly proportioned for most efficient combustion.

And electronic safety control regulates the sequence of operation and in conjunction with a flame detector monitors the flame to shut the burner down in the event of flame loss. Other safety controls shut the burner down under low water conditions or excessive steam pressure/water temperature.

1.4 — Electrical System

The burner control circuit operates on 115 volt, single phase, 60 Hz (or 50 Hz when equipped) alternating current. The forced draft fan motor is generally operated on 3 phase service at the available main power supply voltage.

The operating limit and other interlock devices wired into the circuitry provide safe operation of the burner and protect against incorrect operating techniques.

The major electrical components included in the standard control system consist of a programming control, limit and operating pressure or temperature controls, low water cutoff, damper motor, fuel valve(s), and motor starter.

The sequence of burner operation from startup through shutdown is governed by the programming control in conjunction with the operating, limit, and interlock devices. This programmer contains a timer that energizes or de-energizes other controls at the proper time.

The same control monitors the flame to confirm gas pilot operation prior to allowing main fuel valves to open. The ignition of low fire flame on a spark-ignited oil burner must likewise be confirmed. The control will shut the burner down in the event of a flame loss or as a result of action by a safety interlock.

The safety interlocks include combustion and air proving equipment and — depending on insurance company requirements — controls that prove the presence of adequate fuel pressure.

In addition to the standard basic controls supplied, other devices may be required to meet specific requirements of an insurance carrier or local code. Refer to the wiring diagram furnished with the burner to determine the specific controls in the

burner and limit control circuits. The function of individual components is outlined in this chapter and the electrical sequence is covered in Chapter 3.



FIGURE 1-1. Model 5 Boiler

1.5 — Controls and Components

The term 'control' covers components including, but not limited to, electrical controls or those monitored by the programming control. The operator must become familiar with the individual functioning of all controls, whether or not outlined, to enable understanding of the boiler's operation.

Boilers having optionally ordered features may have control components not listed here. For information on control components, refer also to the electrical wiring diagram furnished with the boiler.

The actual controls furnished with a given unit will depend on the type of fuel and whether it is a hot water or steam boiler.

1.5.1 — Programming and Flame Safeguard Control

Automatically programs each starting, operating, and shutdown period in conjunction with operating, limit, and interlock devices. This includes, in a timed and proper sequence, the operation of the blower motor, ignition system, fuel valve(s), and the damper motor. The sequence includes air purges prior to ignition and upon burner shutdown.



The flame detector portion of this control monitors both oil and gas flames and provides protection in the event of loss of a flame signal.

The control recycles automatically during normal operation or following a power interruption. It must be manually reset following a safety shutdown caused by loss of flame. Included is an internal checking circuit effective on every start, which causes a safety lockout in case anything cause the flame relay to hold in during this period.

The Programming and Flame Safeguard Control contains the following major components:

Component	Description
Master Relay	Energized when all the limit and operating controls and switches are closed to start program sequencing and to energize the forced draft fan motor.
Flame Relay	Energized when the flame detector senses a suitable flame. When de-energized by a flame loss it routes control circuit through the lockout switch.
Safety Lockout Switch (SS)	Trips following loss of flame, ignition failure, or failure of the flame relay to remain in its de-energized position during the programmer's checking period. Causes de-energizing of fuel valve(s) followed by an air purge and shutdown.
Timer	Actuates to open and close switching contacts in a nonadjustable timed program to sequence the burner's operation through all the functions necessary to operate the burner.
Flame Detector	An ultraviolet radiation sensitive detector that monitors gas or oil pilot and energizes the programmer's flame relay in response to a flame signal. It continues to monitor main flame (oil or gas) after expiration of pilot proving period. An infrared sensitive detector is used in place of ultraviolet in some instances.

1.5.2 — Burner Switch

A manually operated start/stop switch used for directly starting and stopping burner operation.

1.5.3 — Forced Draft Fan Motor

Directly drives a forced draft fan to provide combustion air. Also referred to as blower motor. On oil fired units an oil pump is driven from this motor by a V-belt.

1.5.4 — Forced Draft Fan Motor Starter

Energizes forced draft fan (blower) motor.

1.5.5 — Damper Motor

A two-position or fully modulating motor that positions the air damper through a linkage system to provide proper air-fuel ratio under low fire to high fire conditions. Shaft rotation of the damper motor actuates one or more auxiliary switches (see **1.5.6 — Damper Positioning Switch - Manual/Automatic**). On gas fired equipment it also operates, through linkage, a gas butterfly valve. The motor is powered from a transformer that reduces control circuit voltage to 24 VAC. The motor is powered to the open position and spring returned to closed position.

1.5.6 — Damper Positioning Switch - Manual/Automatic

A three-position switch or potentiometer for manually setting high fire to low fire rate or establishing a circuit through the high/low fire control for automatic operation.

1.5.7 — Auxiliary Switch(es)

Actuated by damper motor shaft rotation. All boilers have a switch that serves as a low fire switch and which must be in a closed position before ignition can take place. Oil fired boilers have additional switches that control oil solenoid valves for high fire operation. All boilers have an additional switch to prove damper opening during pre-purge.

1.5.8 — Gas/Oil Switch

Toggle switch used to manually select circuitry for either gas or oil firing.

1.5.9 — Ignition Transformer

Provides high voltage spark for ignition electrode of gas pilot or light oil burner ignition.

1.5.10 — Operating Limit Control: Pressure (Steam Boilers) or Temperature (Hot Water Boilers)

Breaks a circuit to stop burner operation on a rise of boiler pressure or temperature above a selected setting.

1.5.11 — High Limit Control: Pressure (Steam Boilers) or Temperature (Hot Water Boilers)

Breaks a circuit to stop burner operation at a preselected pressure or temperature above the Operating Limit Control setting. This control must be manually reset to restore the circuit.

1.5.12 — High-Low Fire Control: Oil

A pressure or temperature control which, when placed into the circuit by proper setting of the damper positioning switch, makes or breaks the circuit to the damper motor. The burner will operate at either high or low fire rate according to load requirements.

1.5.13 — Modulating Control: Gas

A pressure or temperature control which, when placed into the circuit by proper setting of the damper positioning switch, modulates the burner according to load requirements.

1.5.14 — Low Water Cutoff/Pump Control: Steam Boilers

A float operated control responding to water level in the boiler as seen in the gauge glass. It performs two distinct functions:

1. Stops firing of the burner if the water level drops below a pre-determined operating point. In addition, there is an auxiliary low water cutoff that requires manual reset to start the burner after a low water shutdown.
2. Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.

1.5.15 — Low Water Cutoff: Hot Water Boilers

Breaks a circuit to stop burner operation if the water level in the boiler drops below a safe operating point.



1.5.16 — Water Level Glass: Steam Boilers

For visually determining water level. Assembly includes water gauge glass, gauge glass shutoff cock, and try cocks.

1.5.17 — Water Gauge glass Drain Valve: Steam Boilers

Provided to flush the gauge glass.

1.5.18 — Pressure Gauge: Steam

Indicates boiler's internal pressure.

1.5.19 — Temperature/Pressure Gauge: Hot Water

A compound gauge that indicates the boiler's internal water temperature and water pressure.

1.5.20 — Safety or Relief Valve



Warning

Only the manufacturer or manufacturer's representative should adjust or repair safety and relief valves.

Safety valve(s) are used on steam boilers to relieve the generator of pressures higher than the designed pressure or the pressure designated by the purchaser. Relief valve(s) are used on hot water generators for the same purpose.

Installation of safety and relief valves and their escape and drain piping must conform to ASME code requirements.

1.5.21 — Combustion Air Proving Switch

A pressure sensitive switch, actuated by air pressure, whose contacts close to prove sufficient pressure of combustion air from the forced draft fan.

1.5.22 — Oil Pump

Draws oil from the supply tank and delivers it under pressure to the burner nozzles. The pump contains an integral adjustable pressure regulator and rotary filter. The pump is driven by a V-belt connected to the blower rotor.

1.5.23 — Oil Burner Pressure Gauge

Indicates the fuel pump discharge pressure to nozzle.

1.5.24 — Fuel Oil Valves

Electrically operated to open in a controlled sequence to allow oil flow from the pump to the burner nozzles. The function of the valves is described in the oil fuel flow section later in this chapter.

1.5.25 — Fuel Oil Shutoff Cock

Manually shuts off oil supply to the burner.

1.5.26 — Low Oil Pressure Switch

Switch contacts open when fuel oil pressure drops below selected pressure. Switch will interrupt the limit circuit upon loss of sufficient fuel oil pressure for correct combustion.

1.5.27 — Air Damper

Controls the amount of combustion air admitted to the burner in proper proportion to fuel input for efficient combustion from high to low firing rates.

1.5.28 — Gas Pilot Valve

A solenoid valve energized to open during ignition period to admit fuel to pilot. It is closed after main flame is established. The sequence of energizing and de-energizing is determined by the programming control.

1.5.29 — Gas Pilot Pressure Regulator

For adjusting gas pressure to a value that assures a satisfactory pilot.

1.5.30 — Main Gas Valve

An electrically actuated control valve energized through the sequence of the program relay to admit main flame gas through the butterfly valve to the burner.

1.5.31 — Gas Butterfly Valve

Butterfly disc is operated through connecting linkage to regulate rate of gas flow to the burner.

1.5.32 — Gas Pilot Shutoff Cock

For manually opening or closing the pilot gas supply.

1.5.33 — Main Gas Cock

For manually opening or closing the main fuel gas supply upstream of the main gas valves.

1.5.34 — Main Gas Pressure Regulator

Reduces incoming gas pressure to provide a constant downstream pressure at a level selected to produce a steady dependable flame yielding highest combustion efficiency.

1.5.35 — Low Gas Pressure Switch

Pressure actuated switch that is closed whenever main gas line pressure is above a preselected pressure. Should the pressure drop below this setting the switch contacts will open causing main gas valve(s) to close.

1.5.36 — High Gas Pressure Switch

Pressure actuated switch that is closed whenever main gas line pressure is below a preselected pressure. Should the pressure rise above this setting the switch contacts will open causing main gas valve(s) to close.



1.5.37 — Test Cocks

Allow testing for leakage across main gas valve.

1.5.38 — Optional Gas Train

Insurance requirements may necessitate additional equipment and controls for operation of the gas fired burner. In addition to the items listed above, the following components may be included:

- Additional Main Gas Cock
- Additional Main Gas Valve
- Main Gas Line Vent Valve: A normally open solenoid valve for venting gas, should any be present, in main gas line when main gas valves are de-energized. Vent valve closes when main gas valves are energized.

1.6 — Automatic Ignition

Gas burners and oil burners on combination units are ignited by an interrupted type gas pilot. Some insurance regulations require that light oil burners (Series 100) be ignited with a gas pilot, although normally this model uses spark ignition.

The gas pilot flame is ignited automatically by an electric spark. Fuel for the pilot is supplied from the utility mains or from a tank (bottle) supply. Flow rate (flame size) is regulated by a pressure regulator. The burner is designed to have combustion air flow into and mix with the pilot gas stream to provide a suitable flame.

At the beginning of the ignition cycle, as governed by the programming control, the pilot gas solenoid valve and ignition transformer are simultaneously energized. The ignition transformer supplies high voltage for the igniting spark, which arcs between the single electrode within the pilot tube and the wall of the tube itself. The gas pilot solenoid and transformer are de-energized after main flame is ignited.

On Series 100 boilers having spark ignition, the low fire oil nozzle is ignited by a spark arcing between two electrodes supplied with high voltage from the ignition transformer. At the beginning of the ignition cycle, as governed by the programming control, the low fire oil solenoid valve and ignition transformer are simultaneously energized. The ignition transformer is de-energized after low fire is established and proven.

1.7 — Combustion Air

Air for the combustion of fuel (also called 'secondary air') is furnished by the forced draft fan mounted in the wind box. In operation, air pressure is built up in the entire wind box and forced through a diffuser plate for a thorough mix with the fuel for proper combustion.

The output of the fan is automatically throttled by regulating the air damper. This controls the supply of combustion air to ensure a correct ratio of air to fuel at all firing rates.

1.8 — Oil Fuel Flow

Oil-fired Model 5 boilers are equipped with a belt-driven fuel pump that draws fuel oil from a storage tank. The pump has a greater capacity than the maximum burning rate. All oil not delivered to the burner nozzles is returned to the storage tank.

The pump has an integral pressure regulator that can be adjusted to provide the necessary atomizing pressure to the burner nozzles. This pressure is read on the oil pressure gauge.

Oil flow to the burner is controlled by four solenoid valves. The oil flows through a primary or safety shutoff valve into a manifold block. This valve and the low fire valve are energized simultaneously by the programming control and when opened allow flow of oil to the low fire nozzle.

As the damper motor moves to high fire position, cams close switches to energize, in sequence, the intermediate and then the high fire oil valve. The purpose of the intermediate valve is to make the change from low to high fire smoother by balancing the oil input with the increasing flow of air through the opening damper.

High fire rating of the burner is obtained when all three nozzles are firing, assuming proper oil pressure and normally sized nozzles.

1.9 — Gas Fuel Flow

Metered gas from the utility supply flows into the burner's gas piping through a main gas shutoff cock, through a pressure regulator where the pressure is reduced to the pressure suitable to the burner's requirements, through an electrically operated main gas valve, through a butterfly gas valve to the burner. Gas required for pilot operation is taken from this line, normally prior to the main gas shutoff cock.

Gas for pilot operation flows through a shutoff cock into a pressure regulator where the pilot operating pressure is established. A solenoid valve controls the flow of gas and when energized (opened) allows gas to flow to the pilot where it is mixed with combustion air. This mixture is ignited by a controlled electric spark to establish the pilot flame. The pilot burns only during the time required for main flame ignition.

At the beginning of the ignition cycle, the pilot solenoid valve is energized through circuitry in the programming control, igniting the pilot. When pilot flame is proven, the programming control energizes the electrically operated main gas valve, allowing flow through the butterfly valve to the burner. The rate of flow to the burner depends on the position of the vane in the butterfly valve. This position is mechanically controlled by the damper motor and varied in the same manner as the air damper, thus properly proportioning gas and combustion air.

The gas pressure regulator positions itself to the degree required to maintain a constant pressure on its downstream side. The regulator is set to a pressure that will prevent over-firing while still providing a sufficient volume of gas to the burner at a pressure high enough to overcome pressure loss due to friction imposed by the burner system and control valves.

Gas flows through the burner orifice ring to enter the combustion zone where it is thoroughly mixed with combustion air to produce main flame.

The main gas valve cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air.



Some insurance requirements specify two main gas valves. These are generally operated by a motorized mechanism. A normally open vent valve is placed between the gas valves to vent any gas present in the main gas line when the gas valves are de-energized. The vent valve closes when the main gas valves open.

2.1 — Overview

This chapter will primarily examine the waterside care of the pressure vessel.

The type of service that your boiler performs has an important bearing on the amount of waterside care it will require. The subject of water supply and treatment cannot be adequately covered in this manual. Nevertheless, it is of primary importance. 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.

Water requirements for both steam and hot water boilers are critical 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.

The operator should become familiar with this chapter before attempting to place the unit into operation.

The boiler, as a part of a hot water system, requires proper circulation. The system must be operated as intended by its designer to avoid severe, possibly damaging, stresses occurring to the pressure vessel.

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	<p>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 the system.</p> <p>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 tanks.</p>
Continuous Flow	<p>It is essential that the system be piped and the controls arranged so that there will be water circulation through the boiler under all operating conditions. Constant circulation through the boiler eliminates the possibility of stratification and results in more even water temperature to the system. A blend pump is included as standard on Model 5 hot water boilers.</p>
Multiple Boiler Installation	<p>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 psi to 5 psi) must be taken across the balancing device to determine required flow rates.</p> <p>If care is not taken to insure adequate flow through the boilers, wide variation of firing rate between them and possible long term damage can result.</p>
Pressure Drop	<p>There will be a pressure drop of less than 6 feet head (1 psi = 2.31 ft. hd.) through all standardly equipped Cleaver-Brooks boilers operating in any system which has more than 20° F temperature drop. this drop will vary with boiler size and temperature change. Consult factory for specific information.</p>
Pressure	<p>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 with the boiler so that all of its internal surfaces are fully wetted at all times. For this reason, the internal boiler pressure (as indicated on the water pressure gauge) must be held to the level as displayed on the Pressure-Temperature Chart for Hot Water Generators.</p> <p>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.</p>

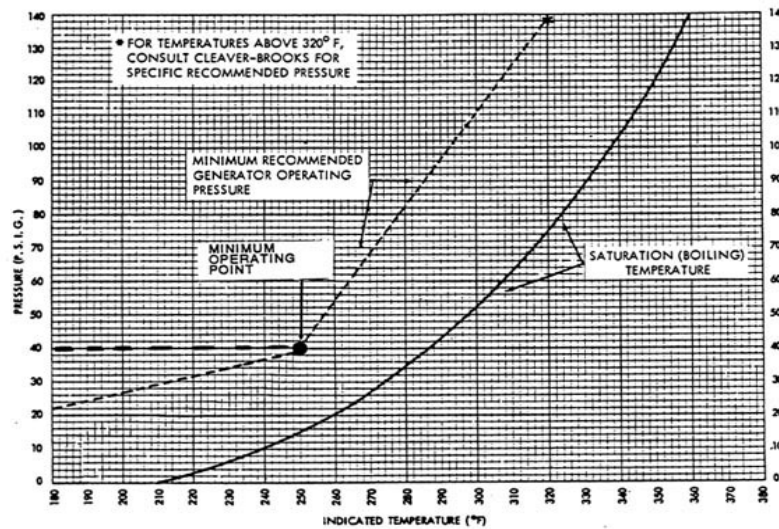


FIGURE 2-1. Pressure-Temperature Chart for hot Water Generators

2.3.2 — Steam Boiler

Requirement	Description
Feed Pump Operation	<p>Make certain that all valves in the water feed line are open BEFORE turning on the pump motor to prevent possible damage to feed pump mechanism. After opening valves, momentarily energize feed pump motor to establish correct pump rotation. With correct rotation, close boiler feed pump entrance switch. Pump should shut down when water level reaches proper level.</p> <p>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.</p>
Minimum Boiler Water Temperature Treatment	<p>The minimum recommended boiler water temperature is 180° F. If the temperature of the flue gas is reduced to the dew point, the condensed water can cause corrosion in the boiler fireside and in the breeching. This condensation problem is more severe on the unit which operates intermittently 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. However, this problem can be minimized by maintaining boiler water temperatures above 180° F.</p>

⚠ Caution

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.

 **Caution**

Fire a cold unit slowly to avoid undue stressing of pressure vessel parts. To assist in this, all hot water boilers are equipped with a minimum 10 minute low fire hold before the boiler can increase its firing rate.

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 treatment company must be followed rigidly to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment in general are:

- Prevention of hard scale deposits or soft sludge deposits, which impair the rate of heat transfer and can lead to overheated metal and costly downtime and repairs.
- Elimination of corrosive gases in the supply or boiler water.
- Prevention of intercrystalline cracking or caustic embrittlement of boiler metal.
- Prevention of carryover and foaming.

The accomplishment of these objectives generally requires proper feedwater treatment before and after introduction of 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, demineralizing, deaerating 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, or 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 hot water boilers 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.

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 free of 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 possibly cause unnecessary and expensive rework, 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:

- Cleaning has been inadequate.
- Partial or total old system is involved.
- 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, a 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 wash-out 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.

2.6 — Boil Out of a New Unit

 **Caution**

Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be approximately 70° F or as close to ambient as possible.

The internal surfaces of a newly installed boiler may have oil, grease, or other protective coatings used in manufacturing. 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 as yet unselected, the following information may be of assistance.

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

Tri-sodium phosphate and caustic soda are the suggested chemicals for cleaning of boilers. One pound of each chemical should be used for every 50 gallons of water.

1. When dissolving the chemicals, 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.

2. An overflow pipe should be attached to one or the top drum openings and routed to a safe point of discharge. A water relief or safety valve tapping is usually used.
3. 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.
4. All valves in the piping leading to or from the system must be closed to prevent cleaning solution from getting into the system.
5. Fill pressure vessel with clean water until the tops of the tube openings in the upper drum are covered. Add the cleaning solution and then fill to the top.
6. 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.
7. Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
8. Continue boiling and overflow until the water clears.
9. Stop the burner and drain the boiler using caution that the hot water is discharged with safety.
10. Remove cover plate in the upper drum and the inspection plugs in the lower drum and wash the waterside surfaces thoroughly using a high pressure water stream.
11. Inspect surfaces and if not clean repeat the boil-out.
12. After closing openings and re-installing safety or relief valve(s), fill the boiler and fire until water is heated to at least 180° 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 procedures.

2.7 — Washing Out

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.

2.7.1 — Steam 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, 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 — 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 washout 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 value 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

Intermittent manual blowdown and continuous blowdown are the two principal types.

Caution

Boiler and water column blowdown must be performed on a regular basis to ensure that concentrated solids are removed from the boiler and in order to avoid damage to the equipment.

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 shutoff 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.

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 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.

2.8.2 — Additional Considerations

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, it may be necessary depending upon the condition of the system, variable water, and make-up. The need remains to be alert to system water losses and the corresponding amount of raw water make-up. A water meter with a small flow rate is recommended for water make-up lines.

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.

2.8.3 — Bottom Blowdown

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 downstream 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 the 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.

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 the 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 tri 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.

Cleanout 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 cleanout intervals, since an accumulation of soot deposits will raise the flue gas temperature.

All oil fired units are equipped with water washing devices for convection surfaces.

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

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. 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.

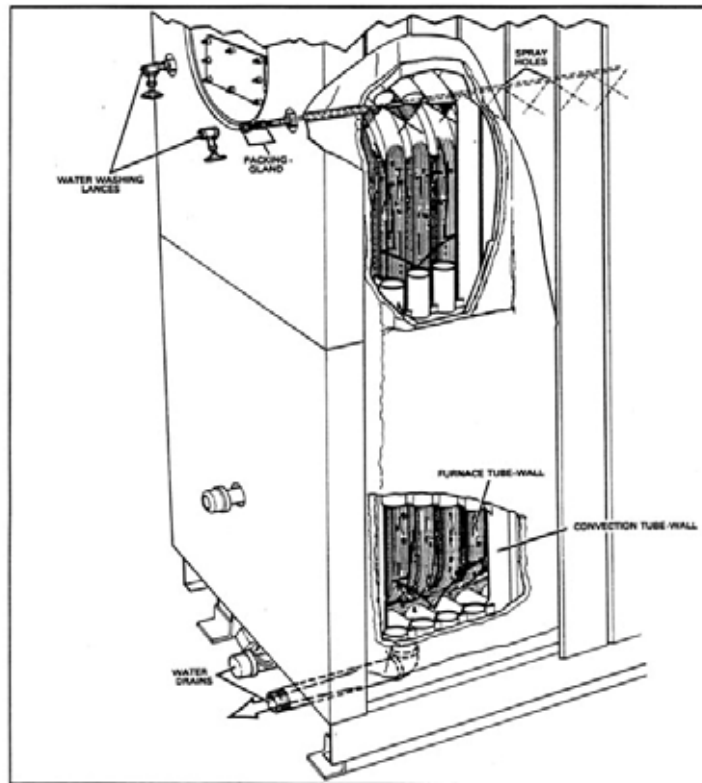


FIGURE 2-2. Water Washing Detail

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.

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, 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.

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 and 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 the 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 can 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 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.

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 Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation.

The sequences outlined in this chapter employ specific nomenclature to aid in applying the text to the wiring diagram.

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

- Boiler water is up to the 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 (optional) is on.

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

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

The sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the program relay. Chapters 5 and 6 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 Vac, 60 Hz, single-phase power.

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 the various circuits.

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

Circuit	Components
Limit Circuit	<ul style="list-style-type: none"> • 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) • High Gas Pressure Switch (HGPS)
Fuel Valve Interlock Circuit	<ul style="list-style-type: none"> • Main Gas Valve Auxiliary Switch (MGVAS) • Oil Valve Auxiliary Switch (OVAS), optional
Blower Motor Start Circuit	<ul style="list-style-type: none"> • Blower Motor Starter (BMS)
Running Interlock Circuit	<ul style="list-style-type: none"> • Blower Motor Starter Interlock (BMSI) • Combustion Air Proving Switch (CAPS)
Low Fire Proving Circuit	<ul style="list-style-type: none"> • Low Fire Switch (LFS)
Pilot Ignition Circuit	<ul style="list-style-type: none"> • Gas Pilot Valve (GPV) • Ignition Transformer (IT) • Gas Pilot Vent Valve (GPVV), if provided
Flame Detector Circuit	<ul style="list-style-type: none"> • Flame Detector (FD) • Main Fuel Valve Circuit • Main Gas Valve (MGV) • Main Gas Vent Valve (MGVV), if provided • Oil Valve (OV) • Main Fuel Valve Light (FVL)

Circuit	Components
Firing Rate Circuit	<ul style="list-style-type: none"> • Damper Motor Transformer (DMT) • Modulating Damper Motor (MDM) • Manual-Automatic Switch (MAS) • Manual Flame Control (MFC) • Modulating Control (MC) <p>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 in this table.</p>
High Fire Proving Circuit	<ul style="list-style-type: none"> • High Fire Switch (HFS)
Running Interlock and Limit Circuit	<ul style="list-style-type: none"> • 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 combined 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. LDL is an option which must be ordered.

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. Opening the damper motor allows a flow of purging air through the boiler prior to the ignition cycle.

On almost all boilers the circuitry will include a high fire switch (HFS). The purpose of the 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.

The controls wired into the “running interlock circuit” must be closed within 10 seconds after the start sequence. In the event any of the 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.

3.3.2 — Ignition Cycle

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

NOTE: 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.

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 lockout will occur.

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

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized and the main fuel valve light (FVL) in the panel is lighted. 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 the pilot flame is extinguished.

NOTE: Depending upon the requirements of the regulatory body, insurer, 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.

Warning

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could result in serious injury or death.

NOTE: 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 flame loss sequence (Section 3.4) for description of action.

3.3.3 — Run Cycle

With main flame established, the program relay releases the modulating damper motor (MDM) from its low fire position to control by either the manual flame control (MFC) or the modulating control (MC), depending upon the position of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

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 (MDM). The air damper and fuel valves 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 manual-automatic 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. Excess air flow subjects the pressure vessel metal and refractory to undesirable conditions.

The burner starting cycle is now complete. 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 ready 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 lockout 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.

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. Failure to follow these instructions could cause damage to the equipment.

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 previous “Caution” notice.)

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 or 15 seconds later. The flame detecting circuit will respond to de-energize the main fuel valve circuit within 2 to 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 previous “Caution” notice.)

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 2 to 4 seconds to de-energize the fuel valve circuit and shut off the 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 previous “Caution” notice.)

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. Costly down time 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, a safety device 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 is recommended to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame.

Starting and Operating Instructions

4.1 — General Preparation for Initial Startup (All Fuels)

Instructions in this chapter assume that installation is complete and that all electrical, fuel, water, and vent stack connections have been made.

The operator should be familiar with the burner, boiler, and all controls and components. To quickly locate and identify the various controls and components mentioned in the following paragraphs, refer to callout photographs and the contents of Chapter 1. Adjustment of the major components are given in Chapter 5 and this should be reviewed prior to firing. The wiring diagram should also have been studied along with the sequence explained in Chapter 3.

It is recommended that these starting instructions be reviewed thoroughly until they are understood before attempting to operate the boiler, rather than performing each operation as it is read for the first time.

Verify supply of fuel and proper voltage. Check for blown fuses or fusetrons, open circuit breakers, dropped-out 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 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 it can be closed.

 **Caution**

Prior to firing, make certain the discharge piping from safety or relief valves and discharge piping from all blowdown or drain valves 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 motor starter. 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, make a final pre-startup inspection, especially checking for any loose or incomplete piping or wiring or any other situation that might present a hazard.

4.2 — Control Settings: Steam and Hot Water

See Chapter 5 for adjustment instructions for the following controls.

Inspect the operating limit control for proper setting:

- The pressure control on a steam boiler should be set slightly above the highest desired steam pressure, but at least 10 percent lower than the setting of the safety valves.
- The temperature control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the high limit control for proper setting:

- The pressure control on a high pressure steam boiler 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 on a low pressure steam boiler may be 2 or 3 lbs. above the operating limit setting but must not exceed safety valve setting.
- The temperature control on a hot water boiler should be 5 to 10 degrees above the operating limit temperature control setting.

Inspect the modulating control for proper setting.

This control must be set and adjusted so that the modulating motor returns to low fire position before the operating limit control opens. It is further desirable to have its low point setting somewhat below the cut in setting of the limit control so that the burner operates in low fire position for a brief period on each start rather than immediately driving to a high fire position.

NOTE: The settings of all the above controls may require some readjustment after the boiler is started and running of a short period. The scale settings on the controls are relatively accurate, but are principally for use as guides. Final adjustment should be based on and agree with the reading of the steam pressure gauge or the water temperature thermometer.

Inspect the low water cutoff and pump control as well as the auxiliary low water cutoff. Normally no adjustment is required since these controls are preset by the original manufacturer. Check for freedom of float movement. Float movement can be verified by observing the level of the water in the gauge glass when the water supply has been cut off either by the stopping of the feed pump or by the closing of a valve, and the restarting of the pump or opening of the valve when water is drained from the pressure vessel. The importance of proper functioning of low water controls cannot be over-emphasized. Make sure that the control and the piping are plumb.

The settings of controls relating to fuel, either oil or gas, are covered in subsequent sections.

In the event the boiler is equipped with optional control devices not listed here, be certain to ascertain that their settings are correct. If additional information is required see your local Cleaver-Brooks representative or contact Cleaver-Brooks.

On initial startup or whenever the boiler is placed into operation from a “cold” start, the manual-automatic selector switch should be set at “manual” and the manual flame control set at “close.” After the boiler is in operation and thoroughly warmed, the selector switch should be turned to “automatic,” so that the burner firing rate may be controlled by the modulating control in accordance with load demands.

Close all power entrance switches (supplied by others).

4.3 — Gas Pilot

The gas pilot should be checked for satisfactory performance prior to initial firing. Follow the pilot flame adjustment instructions given in Chapter 5.

On initial starting attempts, several efforts might be required to accomplish bleeding time of pilot line. While checking pilot adjustment observe whether pilot flame is extinguished promptly when burner switch is opened. Lingering flame is indicative of a leaking gas pilot valve and a condition requiring correction before proceeding.

4.4 — Oil Burner Startup (100 and 200 Series)

4.4.1 — Preparation for Initial Firing

Verify that the driving belt for the oil pump is in place. Temporarily close the oil shutoff valve.

On a 200 Series boiler, set the gas/oil selector switch to “Oil.” Close the main gas cock and open the pilot gas cock.

4.4.2 — Oil Flow

1. 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.

2. Manually hold in the blower motor starter until the oil pump picks up and circulates oil. The oil flow may be verified when the pressure gauge indicates a steady pressure reading of 200 psi (approximately). If no pressure shows on the gauge after a few moments, stop the pump and prime the suction line.

3. Continue this procedure until oil flow is established.

A vacuum (or compound pressure - vacuum) gauge installed in the oil suction line 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 pumping system.

4. Check that the damper positioning switch is set at “low.”
5. Turn the burner switch to “on.” The blower motor will start and oil pressure will be indicated on the gauge. The timer in the programming control will begin.

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.

6. Check for ignition spark. When the “Ignition Trial” light appears on the CB70, 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.
7. With evidence of a good spark (or gas pilot) and proper oil pressure, the unit is ready to be fired. Turn the burner switch to “off.” The programmer will complete its cycle and stop. Reset the safety switch in the event the programmer locked out prior to the burner switch being turned off.
8. 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.

4.4.3 — Initial Start Up and Firing

1. Set the damper position switch to “low.”
2. Open the manual fuel oil valve.
3. Turn the burner switch to “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 rechecking burner and pilot adjustments.

4. 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.

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

Hot water boilers must have a continuous flow of system water through the vessel during the warmup period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.

6. As a 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.
7. After the unit is thoroughly warmed, make a combustion analysis test 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 the burner be allowed to fire at maximum rate sufficiently long enough to achieve desired results.

Refer to Section 4.5 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.

4.5 — Gas Burner Startup (200 and 700 Series)

4.5.1 — Preparation for Initial Firing

1. Close the main gas cock and open the pilot gas cock.
2. On a 200 series boiler, set the gas-oil selector switch to “gas.” Although not mandatory, it is suggested that the oil pump belt be removed during periods of extended gas firing.
3. Check the linkage attached to the butterfly valve to ensure 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 new installations 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 5.6 of Chapter 5 for information on pressures and flow rates.
6. Check to ensure the damper positioning switch is set to “low.” Turn the burner switch to “on.” The blower motor will start and the programming control timer will begin.

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. Check for ignition spark and gas pilot. When the “Ignition Trial” appears on the CB70, the ignition transformer and gas pilot valve are energized. The gas pilot flame may be viewed through the sight glass on the rear door.
8. The main burner will not light since the main gas shutoff cock is closed. When the programmer indicates “Flame On,” determine that the main gas valve opens when energized. Yellow showing on the stem of the motorized valve will indicate that it is closed.
9. As soon as valve action is confirmed, turn the burner switch off and let the 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, the unit is ready to be fired. Reset the safety switch in the event the 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.

4.5.2 — Initial Startup and Firing

Depending upon the type of fuel being burned, the applicable previous sections of this chapter should be reviewed for preliminary instructions.

1. Set the damper positioning switch to “close or low.”
2. Turn the burner switch “on” and when the programmer indicates “Flame On,” slowly open the main gas cock. The main flame should ignite unless there is air present in the line. In this event, turn the burner switch “off” and allow the programmer to run through its normal shutdown cycle. Several efforts may be necessary to “bleed” air from the line.
3. On an ignition failure, the blower will continue running to purge the burner 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.

4. When the main flame is established observe that it is extinguished promptly when the burner is shut down. The burner will normally continue to burn for a second or two after shutdown due to the gas remaining downstream of the shutoff valve. If the flame continues to burn for a longer period, or during blower motor spin down, immediately turn the burner switch “off” and close the main gas cock.
Investigate and correct the cause of valve leakage before relighting the burner. The main gas valve is tight seating providing 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.
5. When flame is established, leave the burner in low fire position for approximately 30 minutes or until the boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.
 - a) A hot water boiler must have a continuous flow of system water through the vessel during the warmup period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.
 - b) For gas, if flame at low fire setting is insufficient to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the manual flame control in one point increments to no higher than the midpoint between close and open. Operate at this increased fuel input rate for a period of time until an increase is noted in pressure or temperature. Sustained operation of the boiler should never be maintained when the manual control is set beyond midpoint.
6. After the unit is thoroughly warmed, turn the manual flame control to high fire. At this point, make a combustion analysis with instruments and fuel flow regulated as required. Refer to adjustment procedures in Chapter 5. After making the high fire adjustment, manually position the burner over the range from high to low fire stopping at intermediate points analyzing combustion gases and adjusting as required.
To properly perform this testing and adjusting, it is necessary that the burner be allowed to fire at maximum rate sufficiently long enough to achieve desired results.
7. The main gas pressure regulator and the pilot gas regulator 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.

Refer to Section 4.6 of this chapter for normal starting operating and shutdown information.

4.6 — Normal Operation: All Fuels

4.6.1 — Start Up

1. Check water level and supply. Fill the steam boiler to center of the gauge glass.
2. Check settings of all operating controls. Check all reset and lockout mechanisms.
The programmer should show “Standby.”
3. On a combination fuel unit (Series 200) set the fuel selector switch for the appropriate fuel.
4. Turn the burner switch “on.” Observe action of the burner and controls to assure proper functioning.
5. Allow the boiler to run at low fire until properly warmed up before allowing the burner to go to high fire.
Low fire hold will prevent hot water boilers going to high fire for a minimum of 10 minutes.

4.6.2 — Operating

Normal operation should be with the manual-automatic switch set at “auto” and under the control of the modulating pressure or temperature control or the high-low fire control. If operated in manual position the pressure vessel metal and refractory are subjected to undesirable conditions.

With the switch set at “auto,” the burner will operate on a modulating basis according to the load demand.

The burner will continue to operate until the operating limit pressure or temperature 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 shutdown such as motor overload, flame outages, tripped circuit breakers, blown fuses, or through other interlock devices in the circuitry.

When the burner is shut down normally, by either the operating limit control or by manually switching the burner off, the load demand light (optional) no longer glows.

Shutdown through conditions causing safety or interlock controls to open will actuate the annunciation feature of the CB70 programmer. The cause of this type of shutdown will have to be located, investigated and corrected before operation can be resumed. Refer to the “troubleshooting” section in the CB70 manual, CB18-6367.

4.6.3 — Shutdown

When the operating limit control setting is reached to open the circuit or if the burner switch is turned “off,” the following sequence occurs:

- The fuel valve(s) is de-energized and flame extinguished. The programmer continues operation and the blower motor continues running to force air through the furnace in the post-purge period.
- At the end of the programmed post-purge period, the blower motor is de-energized. The programmer has returned to its original starting position “standby.” The unit is ready to restart.

Caution

It is advisable to check for tight shutoff of fuel valves. Despite precautions and strainers, foreign material in either new or renovated fuel lines may lodge under a valve seat preventing tight closure. This is especially true in new installations. Promptly correct any conditions causing leakage.

4.7 — Control Operational Test and Checks

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 the 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 modulating control for desired operating pressure range. See Chapter 5 for instructions on the adjustment of controls.

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 through the action of the operating limit control.

1. Observe the thermometer to verify the desired settings at the point of cutout and again when the burner restarts.
2. Return the manual automatic switch to “automatic” and check the modulating control for the desired temperature range. See Chapter 5 for instructions on the adjustment of the controls.
3. Observe the ignition and programming control operations to make sure that they are correct.
4. Check the proper operation and setting of the low water cutoff (and pump operating control, if used).
5. Proper operation of the flame failure device should be checked at time of starting and at least once a week thereafter.
6. Check for tight shutoff of all fuel valves.
7. Despite precautions and strainers, foreign material may lodge under a valve seat preventing tight closure. Promptly correct any conditions causing leakage.

Refer to adjustment procedures and maintenance instruction given in Chapter 5.

5.1 — Overview

While each boiler is tested for correct operation before shipment from the factory, variable conditions such as burner characteristics of the fuel used and operating load conditions may 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 down time 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 of daily, weekly, monthly, and yearly maintenance activities provides a valuable guide and aids in obtaining economic and extended length of service from Cleaver-Brooks equipment.

This chapter details adjustment and inspection procedures plus specialized maintenance where required. It cannot cover all of the phases involved in a complete maintenance program.

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” feature does not relieve the operator from responsibility, but rather frees 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.

Being alert to an unusual noise, improper gauge reading, leaks, etc. can make the operator aware of a developing malfunction and prompt corrective action that may prevent extensive repairs or unexpected down time. Any steam, water, or fuel leaks should be repaired as soon as they are noticed. These 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 analysis 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 down time 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

The water level control has 2 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.

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 with this feature.

Low water cutoff devices are generally set by the original manufacturer and 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 previously established levels, check for reasons and correct, repair, or replace the device as required.

The need to periodically check water level controls cannot be over emphasized. Most instances of major boiler damage are the result of operating with low water.

On steam boilers 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.

In addition and at the same time, remove the pipe plugs from the column, tees or crosses to make sure 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 the life of the equipment.

Water level controls normally function for long periods of time which may lead to laxity in testing on the assumption that normal operation will continue indefinitely. Testing of the controls, especially on steam boilers, should be followed on a definite planned schedule. The control's operation may be checked by 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 SHUTDOWN THE BURNER IMMEDIATELY. Repair or replace the control at once.

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

On a hot water boiler it is impractical to perform daily and monthly maintenance of the low water cutoff devices. However, it is essential to remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean the float ball, internal moving parts, and the bowl housing. Also check any cross connecting piping to make certain that it is clean and free of obstruction. It is not practical to blowoff or drain the low water cutoff devices, 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.

5.4 — Water Gauge Glass

A blowdown cock is provided on the lower gauge glass fitting and a daily blowdown is recommended. The glass should be removed every 3 months and checked, while cool, for etching, thinning, or damage. If any defects are found, replace the glass immediately to avoid the possibility of breakage in service. Do not over tighten water gauge glass fittings. Check try cocks and gauge cocks for freedom of operation and clean as required. Proper alignment of gauge glass cocks is essential to prevent mechanical strain on the glass.

5.5 — Operating Controls

The following instructions apply to those controls considered standard, or normally provided as optional. Space prevents listing other controls or variations of those listed that may be included in the circuitry due to job specifications or insurance carrier requirements. If instructions are needed for particular controls not listed here, please request them from the CleaverBrooks Service Department.

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 recalibration. 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 readjust control settings 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 contact 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 material such as sandpaper on the contact 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.

5.5.1 — Setting and Adjusting

The Model 5 boiler is designed to withstand considerable change in steam pressure or water temperature, however, good operating practice with any boiler is to avoid thermal shock caused by 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. Model 5 hot water boilers are equipped with a minimum low fire hold of 10 minutes to assist in preventing rapid heating or thermal shocking.

Normal operation of the burner should be with the damper positioning switch in the “auto” position. This allows the burner to automatically shift from one firing rate to another in accordance with load requirements.

5.5.2 — Burner Operating Controls: Gas

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 shutdown.
- The burner will operate at low fire for a brief period on each start during normal operation.

- eliminates frequent burner on-off cycling.

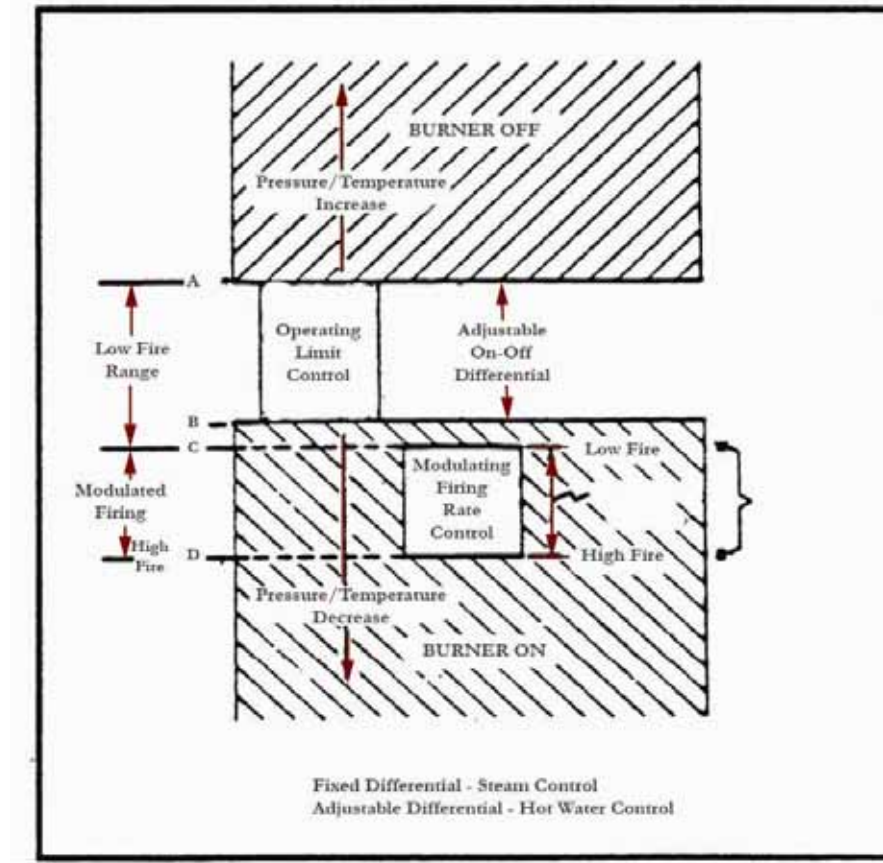


FIGURE 5-1. Operating and Modulating Control Actions

Figure 5-1 depicts a typical relationship of the setting of the operating limit control and the modulating control. Please note that this is not drawn to any scale. The burner will be “on” whenever the pressure or temperature is below point B and “off” whenever pressure or temperature is above point A.

The distance between points A and B represents the “on-off” differential of the operating limit control.

In normal operation, the burner will shut down whenever the pressure or temperature reaches setting A. The switch in the operating limit control will open. As the pressure or temperature drops back to B, the switch makes and the burner will restart. The modulating control will be calling for the modulating motor to be in a low fire position at this point. If the load exceeds this low fire input, the modulating control will respond to increase the firing rate proportionately as pressure or temperature falls toward the point D. The modulating motor will stop at any intermediate point between C and D whenever the fuel input balances the load requirement. As the load requirement changes, the firing rate will change accordingly. This is referred to as modulated firing.

Point D represents the maximum firing rate of the burner. In the event pressure or temperature drops while the burner is firing at its maximum input, this is indicative that the load exceeds the generating rate of the boiler.

Although a gap is shown between B and C, these points may well coincide if required by load conditions. When set as shown, the burner will be in a low fire position upon a restart and will fire at that rate for a short period of time before falling pressure or temperature requires an increase in the firing rate. From this illustration it can be seen that this desirable objective will not be attained if setting C overlapped point B. In that event, upon a restart, the burner would drive to a higher firing position immediately after main flame was proven, and the brief period of low heat input would not occur. Actual settings will, of course, depend greatly upon load conditions which will affect the amount of differential permitted the operating limit control and to the gap, if any, between B and C.

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. The size of the flame may be manually and gradually increased to build up pressure or temperature. If the burner is not under manual control on a cold start, it will immediately move to high fire as soon as the program control releases the circuit that holds the burner in low fire during ignition. The modulating control will be calling for higher fire and the burner will move to that position as rapidly as the damper motor can complete its travel. This rapid heat input can subject the pressure vessel metal and refractory to undesirable conditions. A 10 minute low fire hold is incorporated to slow this rapid heat input.

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 percent 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 be reset to provide maximum utilization of the modulating firing system.

To accomplish this, and assuming that air/fuel combustion ratios have been set, make approximate adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

To properly set the modulating control, carefully adjust it under load conditions, until the load is maintained with the burner firing at a steady rate. The firing rate at that point may be full high fire or slightly less, depending upon the relationship of the boiler size to the load.

When the modulating control is set in this manner and if the burner is in full high fire, the scale setting of the modulating pressure control on a steam boiler will have a reading that indicates the low point of the modulating range. This fixed differential range is described later in this section. The scale setting of the modulating temperature control on a hot water boiler will have a reading that indicates the midpoint of the modulating range. This is also described later.

The operating limit control should now be adjusted and its differential established. See directions later in this section for the mechanics of adjusting. In an installation that does not require a very close control of steam pressure or water temperature, this adjustable differential should be set as widely as conditions permit, since this will provide less frequent burner cycling.

The high limit control provides a safety factor to shut the burner off in the event the operating limit control should fail to do so. The setting of this control should be sufficiently above the operating limit control to avoid nuisance shutdowns. The setting, however, must be within the limits of the safety valve settings and preferably not exceed 90 percent of the valve setting. The control requires manual resetting after tripping.

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 approximately one-half minute required for damper motor travel from low to high fire, may allow pressure or temperature to drop below desirable limits.

5.5.3 — Pressure Controls: Steam Boiler (Oil)

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.

Basically, 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 control settings should not cause a boiler to operate at or in excess of the safety valve setting. Control settings that do not exceed 90 percent of the safety valve pressure are recommended. Operation of the boiler very close to maximum valve setting may cause slight leakage of the valve. Continued leakage through the valve will cause erosion to its components and necessitate early replacement. Therefore, the steam pressure control should be adjusted to operate the boiler at the lowest pressure required to satisfy the load demand.

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 de-energizes the damper motor, causing 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 drum 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 energize the damper motor 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 the control to close and the burner to drive to high fire.

5.5.4 — Temperature Controls: Hot Water Boiler (Oil)

The temperature controls that serve as the operating limit control and as the high-low fire control are equipped with an adjustable differential setting. Basically 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 the 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 — 190° F

Operating Limit Control

Open — 180° F

Close — 170° F

High-Low Fire Control

Open — 170° F (low fire)

Close — 165° 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° 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 165° setting. As temperature increases during high fire rate, the burner will be switched back to low fire when the control opens at 170°.

If temperature increases during low fire, the burner will shut down when the operating limit setting of 180° is reached. When temperature drops back to 170°, the operating limit will close to restart the burner. The unit will fire at its low rate unless temperature continues to drop to 165°, 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 they will prevent the burner from shutting down while in high fire or from immediately going to high fire upon restarting.

5.5.5 — Operating Limit Pressure Control (Steam)

(Honeywell L404A)

Set “cut out” (burner off) pressure on the main scale using the large adjusting screw. 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 percent of the safety valve setting.

5.5.6 — High Limit Pressure Control (Steam)

(Honeywell L404C)

Set “cut out” (burner off) pressure on scale using adjusting screw. The control will break a circuit to shut off the burner when pressure reaches this point. The setting should be sufficiently above the operating limit pressure control to avoid nuisance shutdowns, and preferably not exceed 90 percent of the 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.

5.5.7 — High-Low Fire Control (Steam)

(Honeywell L404A)

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.

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.

5.5.8 — Modulating Pressure Control (Steam)

(Honeywell L91A)

Turn adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between this point and a higher point equal to the modulating range of the particular control.

- In 0 - 15 psi controls the range is 1/2 lb.
- In 5 - 150 psi controls the range is 5 lbs.
- In 10 - 300 psi controls the range is 12 lbs.

NOTE: To prevent burner shutdown at other than low fire setting, adjust modulating pressure control to modulate to low fire before operating limit pressure control shuts off burner.

5.5.9 — Operating Limit Temperature Control (Hot Water)

(Honeywell L4008A)

Set “cut out” (burner off) temperature on scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw.

The “cut in” (burner on) temperature is the cut out temperature minus the differential. The differential is adjustable from 5° to 30° F. Differential is adjusted by rotating the wheel on the back of the snap switch.

5.5.10 — High Limit Temperature Control (Hot Water)

(Honeywell L4008E)

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. 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.

5.5.11 — Low Fire Hold Timer

Set timer at a minimum of 10 minutes to a maximum of 30 minutes. This control prevents the boiler modulating or going to high fire before the timer runs out to help minimize thermal shock.

5.5.12 — System Low Pressure Control

Set normally for 35 psi by setting the “cut out” (burner off) pressure on scale using adjusting screw. The control will break a circuit to shut off burner when pressure falls to this point.

5.5.13 — High-Low Fire Control (Hot Water)

(Honeywell L4008A)

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.

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.

5.5.14 — Modulating Temperature Control (Hot Water)

(Honeywell T991A)

Turn knob on front of case until pointer indicates desired set point temperature. This is the center point of a proportional range. The control has a 3° to 30° differential and may be adjusted to vary the temperature range within which modulating action is desired. With cover off, turn adjustment wheel until pointer indicates desired range.

NOTE: To prevent burner shutdown at other than low fire setting, adjust modulating temperature control to modulate to low fire before operating limit temperature control shuts off burner.

5.5.15 — Control Operational Test (Oil)

The operating limit control may be checked by observing the burner shut-off and restarting points. With a light load it may be necessary to manually set the burner at the high fire rate to obtain burner shutdown. With a heavy steam load the header valve can be throttled to allow pressure buildup. Make any necessary adjustments to obtain cut out at the desired point.

Note the setting at which burner restarts and adjust differential setting if necessary.

Allow pressure or temperature to build up and set the “high-low” fire control to obtain turndown at the desired setting. Check the point at which the burner returns to high fire and adjust control differential if required.

Observe the ignition and programming control operation to be sure that these are proper.

Refer to Section 5.10 of this chapter for information on flame safety check and place the burner through these tests.

The low water cutoff, and pump operating control, if used, should also be checked for proper operation. Refer to Section 5.3 of this chapter for information relative to testing this control.

5.5.16 — Combustion Air Proving Switch

(Honeywell C645A)

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of 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.

5.5.17 — 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.

Replacement of internal components, other than the plug-in amplifier, is not practical or recommended. A spare control is suggested and this should be rotated periodically so that each unit will be placed into operation at least every 90 days. A periodic safety check procedure should be established to test the complete safeguard system at least once a month or more often. This test should verify safety shutdown on loss of flame and also fuel valve tightness.

Caution

When replacing the 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.

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.

5.5.18 — Low Gas Pressure Switch

(Honeywell C437A)

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 finely 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.

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.

5.5.19 — High Gas Pressure Switch

(Honeywell C437B)

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.

This switch must be manually reset after tripping on rise of gas pressure above the cut out setting. To reset, allow gas pressure to drop and press the manual reset button.

5.5.20 — Low Oil Pressure Switch (Optional)

This control prevents burner from igniting or stops its operation when the oil pressure drops below a set 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. Adjust the “high” knob to a point slightly below the normal operating oil pressure. 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.

5.6 — Oil Burner

5.6.1 — Overview

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.

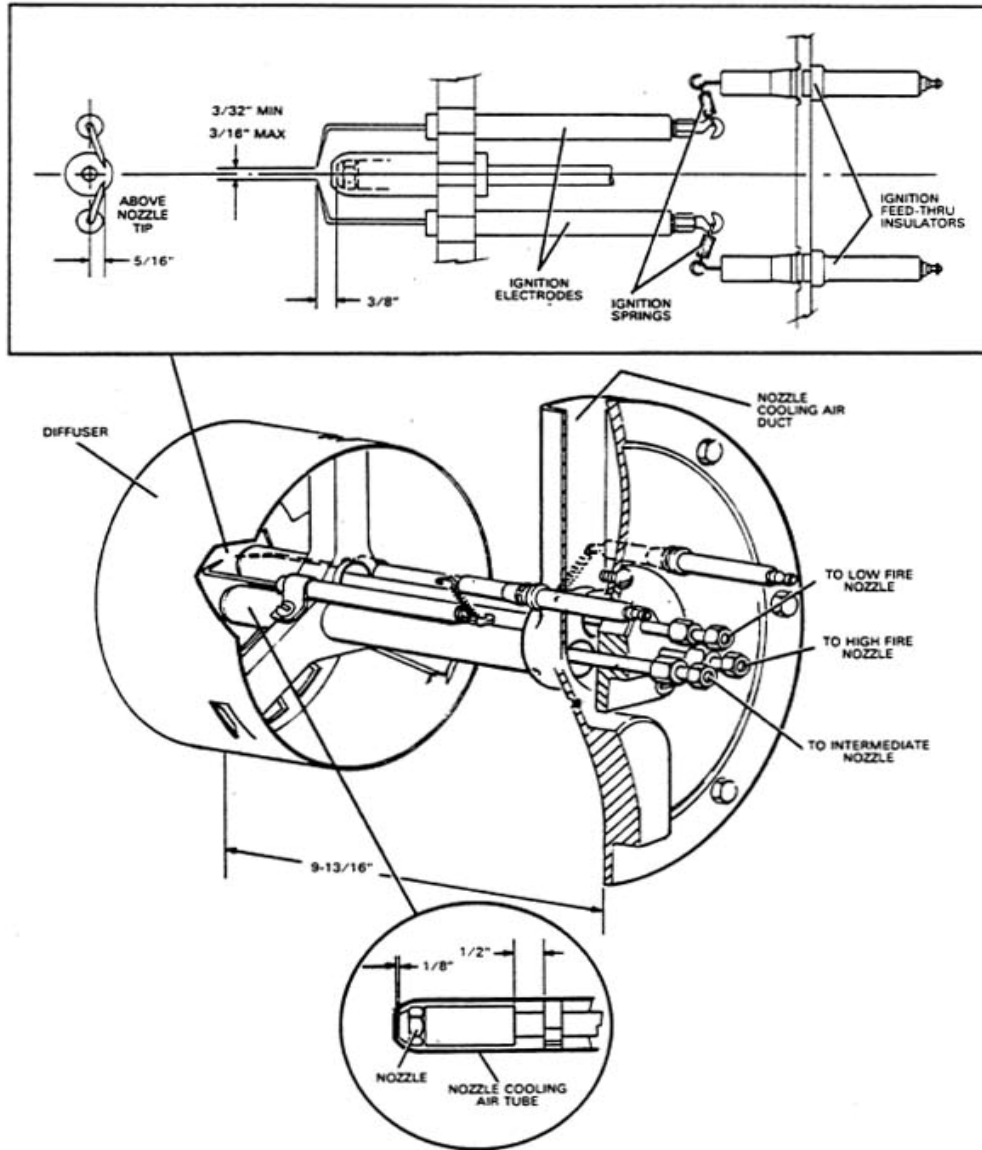


FIGURE 5-2. Oil Burner Drawer: Spark Ignition

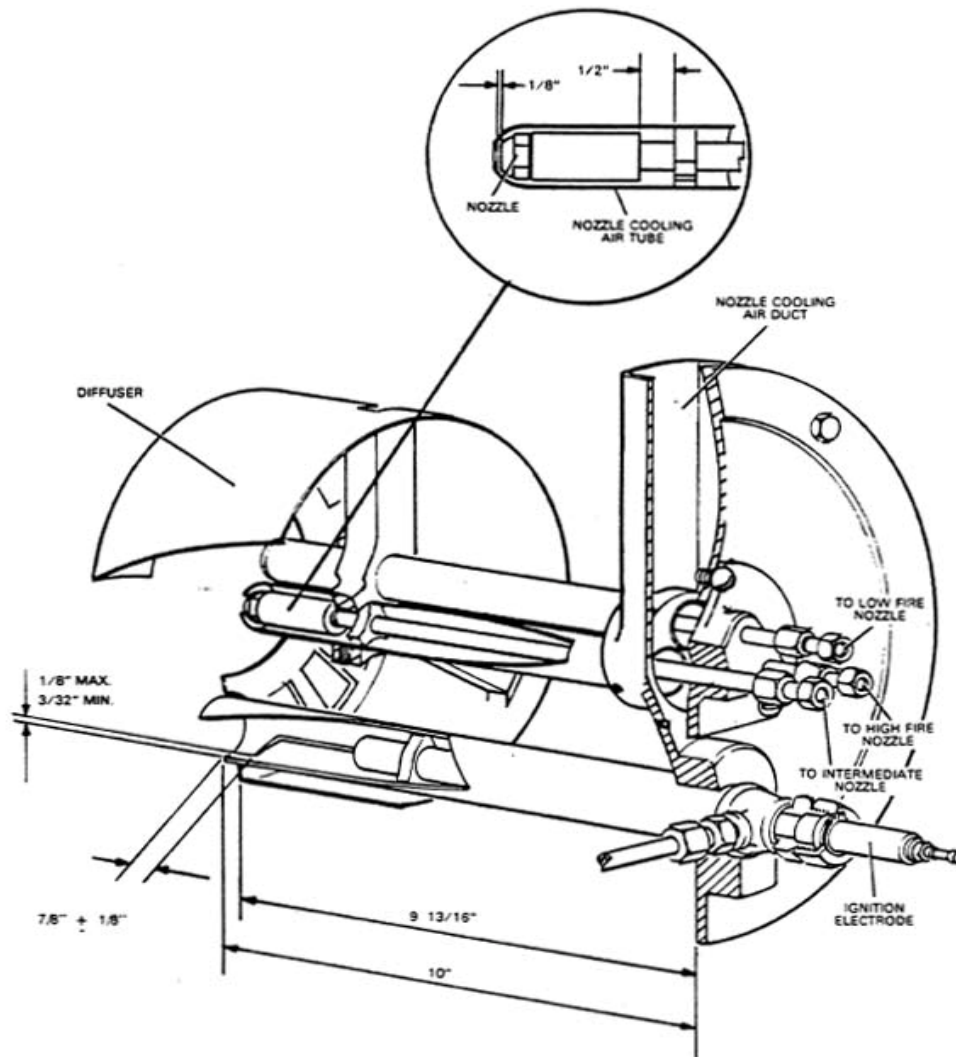


FIGURE 5-3. Burner Drawer: Gas Pilot Ignition

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 an unusually 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.

5.6.2 — 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.

5.6.3 — Burner Nozzles

Efficient oil burner operation requires clean nozzles. The nozzles furnished on the Model 5 burner 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 Figure 5-4 for proper location of nozzles.

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	30° HV	899-93	2.5	60° PLP	899-162	2.5	60° PLP	899-162	200 PSI	10.7
2000	3.5	30° HV	899-29	3.5	60° PLP	899-37	3.5	60° PLP	899-37	188 PSI	14.3
2500	4.5	30° HV	899-31	4.5	60° PLP	899-32	4.5	60° PLP	899-32	180 PSI	17.9
3000	5.0	30° HV	899-33	5.0	60° PLP	899-34	5.0	60° PLP	899-34	210 PSI	21.4
3500	5.5	30° HV	899-109	5.5	60° PLP	899-74	5.5	60° PLP	899-74	238 PSI	25.0
4000	7.5	30° HV	899-83	7.0	60° PLP	899-63	7.0	60° PLP	899-63	197 PSI	28.6
4500	7.5	30° HV	899-83	7.5	60° PLP	899-38	7.5	60° PLP	899-38	225 PSI	32.7
5000	7.5	30° HV	899-83	8.3	60° PLP	899-40	9.5	60° PLP	899-42	217 PSI	35.7
6000	7.5	30° HV	899-83	9.5	60° PLP	899-42	10.5	60° PLP	899-44	267 PSI	42.8

FIGURE 5-4. Nozzle Sizes, Location, and Firing Rate

NOTE: Nozzle size is rating at 100 psi oil pressure. Flow rate increases with pressure. Multiply boiler size by 1000 to obtain maximum input BTU/HR.

The capacity stamped on the side of the 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 is approximately 200 psi. Oil pressure is adjusted by the regulator in the fuel oil pump and final pressure setting may be slightly higher or lower. 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.

5.6.4 — Ignition System

Maintain the proper gas dimensions of the ignition electrode(s) for best ignition results. Figures 5-2 or 5-3 show 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 the electrode wiped clean if any carbon 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.

5.6.5 — 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 combination fired units it is an acceptable practice to remove the belt when gas is being used for extended periods, although it is not absolutely necessary to do this. If left connected, oil will merely be circulated back to the tank. However, the pump and belt life will be extended if the belt is removed.

5.6.6 — Oil Pump

The oil pump has a built-in strainer of the self-cleaning knife 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.

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 removed pumps be returned to the factory for complete reconditioning rather than replacement of individual parts.

If the oil supply is below the level of the pump, a vacuum gauge installed at the suction port of the pump 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 installed in the pump bypass port may be used to determine that the head of oil is not too great. If the head pressure is over 10 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.

As an initial startup 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.

5.6.7 — 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 adjust met 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 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 (CO₂), oxygen (O₂), and carbon monoxide (CO) in the flue gas. Efficiency is measured by the

percentage of CO₂ present in the flue gas. The ideal setting from a standpoint of efficiency is reached when there is no measurable percentage of oxygen 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. Excess air of 15 to 20 percent is considered normal. A CO₂ range of 12 to 13 percent 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.

Determine that the proper atomizing oil pressure exists as mentioned in the preceding section covering nozzles. In some instances, conditions may require that the oil pressure be reduced below the suggested setting if a desired flue gas analysis cannot be obtained with an open damper.

Take a sample of flue gas with an instrument known to be in good working order and determine CO₂ reading. Based on this analysis, make any required adjustments to increase or decrease air flow. See the section on air damper adjustment in this chapter.

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 — Overview

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 and also for any cracks in the porcelain insulator. Cracks can cause grounding of ignition voltage. Check the electrode tip 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 flames 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 0 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 part number 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.

To measure and adjust the pilot:

1. Turn the damper switch to low.
2. Fully open the pilot shutoff cock.
3. Close the cock in the main gas line.
4. Connect the micro-ammeter as outlined above.
5. Turn the burner switch on. Let the burner go through the normal pre-purge cycle. Relay 2K should pull in when the pilot ignites with the programmer in test.
6. If the pilot flame is not established within 10 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.

7. When the pilot flame is established, remove the flame detector from the burner plate. The pilot flame can then be observed through 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.

8. 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.
9. 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 5. See tables below for more details.

Boiler Size	Standard Train Size Ts	Manifold Pres. “ W.C. Mp	Regulated Pres. “ W.C. Rp	Train Ent Pres Tp	Housing Part No.
1500	1-1/2”	1.4	3.9	4.3	40-C-453 with 28 5/16” holes
2000	1-1/2”	2.8	7.7	8.5	
2500	1-1/2”	3.4	11.4	12.6	
3000	1-1/2”	4.6	15.7	17.3	
3500	2”	5.2	9.0	9.8	
4000	2”	5.9	11.6	12.7	
4500	2”	3.4	11.5	12.9	40-C-454 with 45 3/8” holes
5000	2”	4.2	14.6	16.3	
6000	2”	6.0	18.4	20.9	

Altitude Feet Above Sea Level	Correction Factor		Model Size	Maximum Input BTU/hr
1000	1.04		1500	1,500,000
2000	1.13		2000	2,000,000
2500	1.18		2500	2,500,000
3000	1.22		3000	3,000,000
4000	1.33		3500	3,500,000
5000	1.44		4000	4,000,000
6000	1.57		4500	4,500,000
7000	1.70		5000	5,000,000
8000	1.84		6000	6,000,000
9000	2.01			

10. When a suitable flame is obtained, replace the detector.
11. Observe the reading on the micro-ammeter. The reading should be between 2 and 5 micro-amperes 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.
12. Reset the programmer from the “test” position to the “norm” position.
13. If main flame has not been previously established, proceed to do so in accordance with instructions in Chapter 4.
14. The micro-amp reading of the main flame signal should also be rechecked. 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 of 2 to 5 micro-amperes. If there are any deviations, refer to the troubleshooting section in the technical bulletin.

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 be a poor seal to the refractory. Routine maintenance should include this resealing which can be done with a mixture of refractory cement and cement pulp. Use care not to clog or obstruct the holes in the face of the gas housing. The diffuser should be positioned as shown in Figure 5-3. do not attempt to change the gap or angle of the fins.

5.7.3 — Gas Input

To achieve rated capacity of the boiler, a sufficient volume of gas must be supplied to the burner. It must also be at a pressure high enough to overcome the pressure loss due to the frictional resistance imposed by the burner system and control valves. A pressure regulator is provided for reducing the incoming pressure to a level that produces a steady, dependable flame, yet prevents over-firing.

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

The volume, or rate, of gas input is readily measured in terms of cubic feet per hour and can be determined from a meter reading. The flow rate required for maximum boiler output is dependent upon the heating value of the gas (BTU/cu. ft.). To determine this flow rate, divide the boiler input requirement by the heating value (BTU/hr. ÷ BTU/cu. ft.). The BTU rating is shown on the boiler nameplate. The heating value of the gas is available from the gas supplier.

5.7.4 — Gas Fuel Combustion Adjustment

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

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 percent.

As shown in Figure 5-5, this is attained when there is no excess O_2 or CO . A definite percentage of excess air (O_2) 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 CO_2 .

Subject to local regulations pertaining to specific amounts of excess oxygen, it is generally recommended that CO_2 readings of between 9.5 and 10.5 percent be attained with corresponding O_2 readings of 2 to 4 percent.

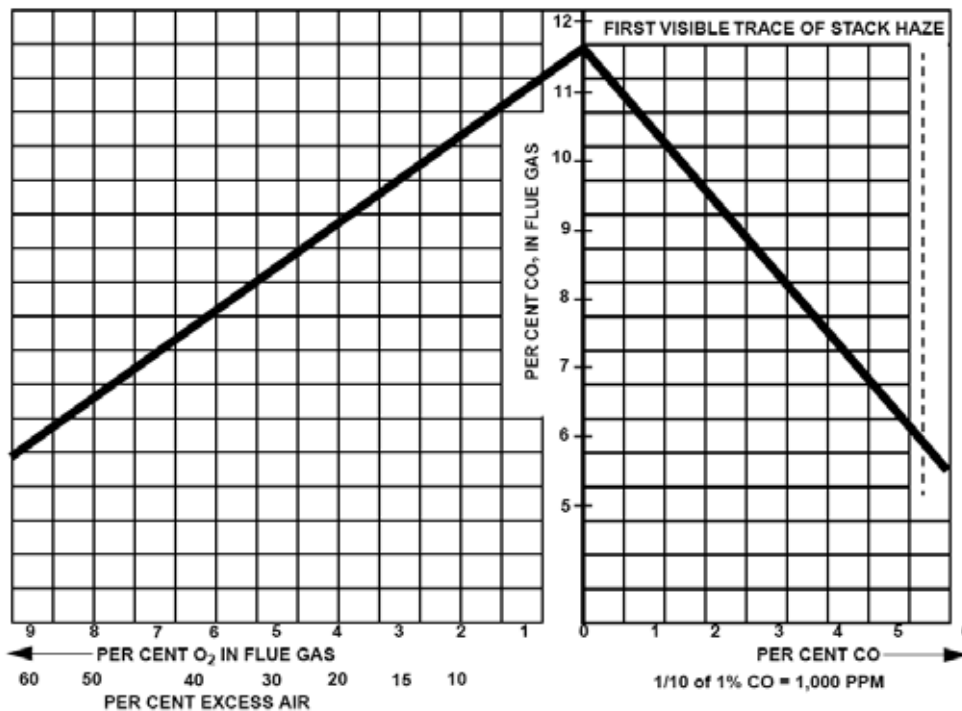


FIGURE 5-5. Flue Gas Analysis Chart for Natural Gas

From information in this chapter, determine the standard conditions of gas pressure and flow for the size of boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.

Basically, gas adjustments are made with a gas pressure regulator which controls the pressure and with the butterfly gas valve which directly controls the rate of flow.

In initially setting the linkage:

1. Back off the low fire stop screw on the butterfly valve so that the valve is closed.
2. Run the screw out to touch the arm and give it two complete turns.
3. Adjust the connecting rod so that override tension is released and so that the arm is now just touching the stop screw.
4. Tighten the lock nuts on all ball joints.

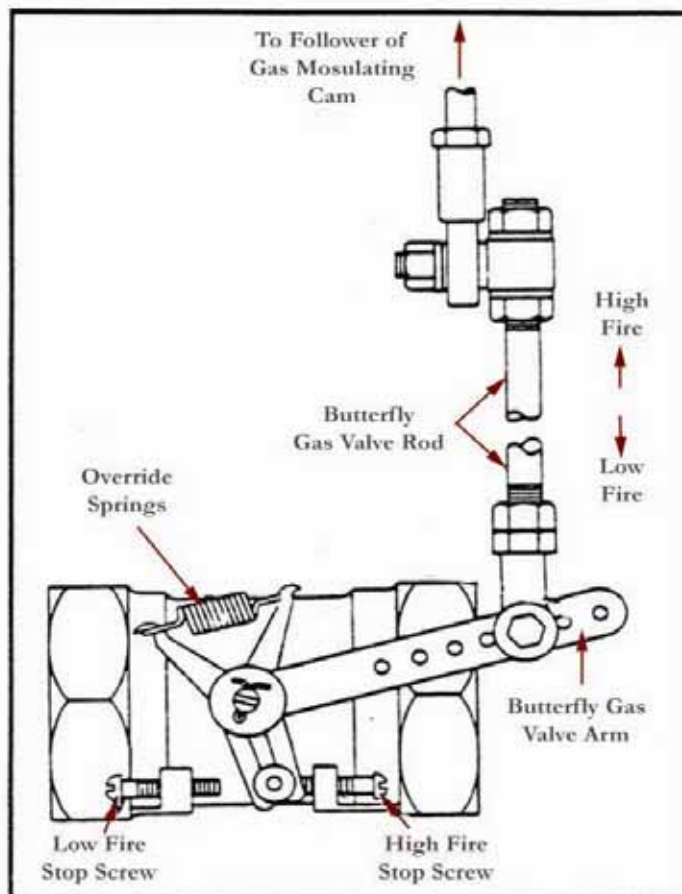


FIGURE 5-6. Butterfly Gas Valve

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

1. Turn the manual flame control switch to open.
2. 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.
3. Determine the actual gas flow from a meter reading.

4. With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be quite close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following manufacturer's directions for regulator adjustment.
5. When proper gas flow is obtained, take a flue gas analysis reading. The CO₂ should be between 9.5 and 10.5 percent and the corresponding O₂ reading should be 2 to 4 percent.

With the high fire air-fuel ratio established the gas pressure regulator needs no further adjustment.

After making certain that the air control damper and its linkage are correctly adjusted to provide the proper amount of secondary air and after adjusting the gas pressure regulator, final adjustment can be made, if necessary, to the gas modulating cam to obtain a constant air-fuel ratio throughout the entire firing range.

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. This adjustment is made to the metering cam by means of adjusting screws (Figure 5-7) which are turned out (counterclockwise from the hex-socket end) to increase the flow of fuel, and in (clockwise from the hex-socket end) to decrease it. Flow rate is highest when the cam follower assembly is closest to the jack-shaft.

1. Through the manual flame control switch, position the cam so that the adjusting screw adjacent to the end or high fire screw contacts the cam follower.
2. Make a combustion analysis at this point.
3. Adjust the cam screw as necessary.
4. Repeat this process, stopping at each adjusting screw until low fire position is reached.

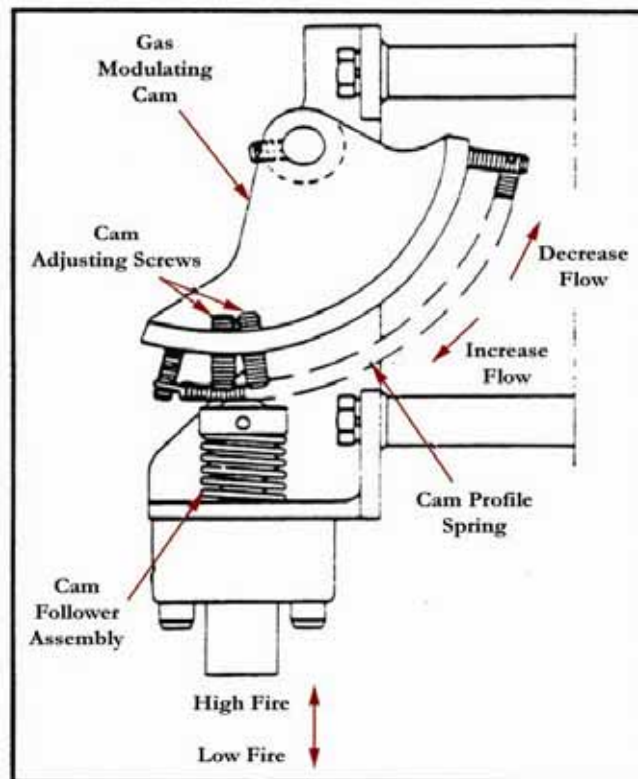


FIGURE 5-7. Gas Modulating Cam

If all screws are properly adjusted, none will deviate from the general overall contour of the cam face. It may be necessary to readjust the setting of the low fire stop screw in order to obtain the proper air-fuel ratio at low fire burning rate. To ensure that the low fire position of the butterfly valve is always the same, allow one turn of the stop screw for over-travel.

5.7.5 — 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 meter”:

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. Use the following formula to provide the required gas input for a 3 minute period:

$$\text{Input (BTU/hr) divided by Heating Value (BTU/cu. ft.) divided by 20 = gas input in cubic feet for 3 minutes}$$

5. Apply any necessary pressure correction factor to this answer to obtain the desired rate. See Section 5.7.6 for pressure correction information. See table below.

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		

6. 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.

Frequently other gas fired equipment which cannot be turned off is served by the same meter and it will not be possible to get an actual meter reading. In this event an alternate method of setting high fire fuel-air ratio using a flue gas analyzer may be used. This is done by adjusting gas flow when the air damper is approximately 90 percent open. Adjust fuel flow through the regulator and butterfly to match the available combustion air and make adjustments until the combustion efficiency described in the next section is achieved.

5.7.6 — Pressure Correction

The flow rate outline 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 table in the previous section, **5.7.5 — Checking Gas Flow**.

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.

5.7.7 — Combustion Efficiency (Gas)

Each boiler is adjusted for proper operation prior to shipment from the factory, however, circumstances due to shipment, installation, different fuel characteristics, or operating load conditions may require further adjustment to assure maximum operating efficiency and economy.

Adjustments to obtain efficient combustion should be made after the boiler has operated for a sufficient period of time to assure a warm boiler.

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 air-fuel ratio should be established by the use of a combustion gas analyzer. This instrument measures the content, by percentage, of carbon dioxide (CO₂), oxygen (O₂), and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount or percentage of CO₂ present in the flue gas. The theoretical maximum CO₂ percentage for natural gas is approximately 11.7 percent. This is attained when there is no excess O₂ or 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 CO.

Subject to local regulations pertaining to specific amounts of excess oxygen, it is generally recommended that CO₂ readings of between 9.5 and 10.5 percent be attained with corresponding O₂ readings of 2 to 4 percent.

5.8 — 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:

- A.** The damper motor should be able to complete its full travel range of 90 degrees. A restriction can cause damage.
- B.** 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.
- C.** Secure the motor arm approximately 60 degrees below the horizontal center line.

- D. The slot end of the damper shaft indicates the position of the damper blade.
- E. It is not practical to list specific setting of all connections or of the damper arm angle, since adjustment conditions must exist to meet combustion requirements or load conditions.
- F. The closer the swivel joint in the motor arm is to the hub, the less distance it will travel.
- G. 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.
- H. 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 the 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” or “open” 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 preceding 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, using the foregoing suggestions.

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

5.9 — *Forced Draft Fan*

Rotation of the fan is counterclockwise when viewed from front of the burner. If the motor is ever replaced, be sure that rotation is proper when motor leads are reconnected. Occasionally check to see that the fan is securely tightened on the motor shaft. A retaining washer on the end of the 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, build up of such deposits can cause a decrease in air capacity or lead to an unbalanced fan condition.

5.10 — *Cam Adjustment*

The variables involved preclude specifying the position of the cam(s) by degree of angle. This especially applies to the cams for the oil valve switches and the high fire switch, since their point of actuation is directly related to the amount of damper travel on a particular burner. Damper movement may be set to a greater or lesser amount of opening depending upon job conditions and combustion needs. Cam position can best be explained by detailing the function of the switch it actuates.

From one to four switches are used depending upon the type of fuel and insurance requirements.

The low fire switch (LFS), used on all boilers, must be closed to complete programmer circuitry, thus assuring that the damper is in low fire position before ignition takes place. The switch opens when the damper motor drives to high fire during pre-purge and closes when the motor resumes its low fire position upon completion of pre-purge. The cam, therefore, must be positioned so that it actuates this switch just prior to the damper reaching its closed position.

The high fire switch (HFS) is used, when required, to prove that the air damper is opened during pre-purge. Its terminals should make when the damper is nearly open and just before the timing of the programmer de-energizes the damper motor. See wiring diagram for sequence timing of the control.

An oil fired boiler uses two switches to energize the intermediate and high fire oil valves. The first switch (AS-1) is 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 it moves towards high fire, the air damper allows an increasing amount of air into the boiler. The valve should open at approximately midrange, but definitely at a point when sufficient air is present so that there is no incomplete combustion or smoke caused by an improper air-fuel ratio. The positioning of the cam must be guided by observing the fire or stack when the valve opens. If smoke or haze is noticed, reposition cam to slightly retard the valve opening.

The second oil valve switch (AS-2) should be actuated just as the damper reaches its open position. On the basis of a combustion analysis, damper position or linkage adjustment may be required to provide more or less air at this point.


In the event of damper motor replacement, note position of cams and replace them as nearly as possible to their original position, but be sure to check for proper switch actuation, especially those controlling the oil valves. If a switch is replaced, make sure that wiring connections are correct. The low fire switch is normally closed while the others are normally open. The setscrew holding the cam should be checked occasionally for tightness.

5.11 — Fuel Valves: Gas and Pilot Main: Gas

These valves require no adjustment nor maintenance beyond normal housekeeping. Under normal conditions maintenance and trouble-free operation may be expected. Lubrication is not required.

It is advisable to check at time of the initial starting, and periodically afterwards, for tight shutoff valves. Despite precautions and strainers, foreign material may lodge under a valve seat and prevent tight closure. As explained in Section 1.7 of Chapter 1, the oil flows through a safety shutoff valve and then through individual valves to each nozzle. If the flame is not extinguished promptly on burner shutdown, it is an indication that both the safety shutoff valve and the low fire valve are leaking. A smoking condition during low fire operation will indicate that either or both of the high fire valves are leaking.

A valve may be disassembled for inspection of the seating surface or to check for foreign matter. Care must be taken during disassembly to be sure that internal parts are not damaged during the removal and that reassembly is in proper order.

 **Caution**

Never operate your boiler with a fuel or pilot valve that is known to be or suspected to be leaking.

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

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

5.12 — Flame Safeguard Check (All Series)

The flame detector should cause a safety lockout upon failure to ignite the pilot, upon failure to light the main flame, and upon loss of flame. Check each of these conditions as follows to make sure that safety lockout will occur. In the event the safety switch fails to trip and shut down the system on any of the tests, investigate the reason and, if necessary, replace the control or flame detector.

5.12.1 — Checking Gas Pilot

1. Close the gas pilot shutoff cock to prevent ignition of the pilot flame.
2. Turn the burner switch “on.”

The pilot system will be energized at the end of the pre-purge period. Since no flame is detected, the pilot valve will shut and the main fuel valve(s) will not be energized.

The programmer will complete a cycle including a post-purge and the safety switch will lockout about 30 seconds after the end of the ignition trial.
3. The safety switch must be reset after allowing a few moments for the thermal element to cool.
4. Reopen the gas pilot shutoff cock.

5.12.2 — Failure to Light Main Flame

1. Open gas pilot cock. Shut the main gas cock or the oil valve in the pump discharge.
2. Turn the burner switch “on.”
3. Relay 2K should pull in as pilot flame is detected, but the main burner should not ignite.

Relay 2K should drop out within 4 seconds after the main burner ignition period ends.
4. The safety switch should trip and lock out about 30 seconds after the ignition trial.

NOTE: If the oil burner has direct spark ignition, there will be no flame during the pilot ignition period, and relay 2K will not be energized. The safety switch will lock out approximately 30 seconds after the trial for pilot ignition.

5.12.3 — Loss of Flame

1. With the burner firing in normal operation, shut off the main fuel supply. On a gas fired unit, shut the main gas cock. On an oil fired unit, close the oil valve on the discharge side of the pump.

Within 4 seconds after the flame is extinguished, flame relay 2K will drop out, de-energizing and closing the fuel valves.

The programmer will complete its cycle including a post-purge and the safety switch will lockout about 30 seconds later.
2. The safety switch must be reset after allowing a few moments for the thermal element to cool.
3. Re-establish main fuel supply.

5.13 — Safety and Relief Valves

Valves are factory set and sealed. Change to an existing setting may only be made by the manufacturer or an approved representative.

These valves and their discharge piping must be installed to conform to all applicable codes. Discharge piping must be supported so that no strain is placed on the valve itself. Proper drainage of this piping should be provided.

Valves with a screwed inlet connection should be threaded into the tapping on the boiler using a parallel jaw wrench. Never use a pipe wrench. The wrench should be used only on the hex portion of the valve body. No undue strain should be placed on the valve during installation since such strain may cause distortion to the valve seat resulting in a leaky valve. Do not use a wrench on the valve bonnet. Do not install or remove side outlet valves by using a pipe or level bar in the outlet.

5.14 — Refractory

The Model 5 boiler is shipped with a completely installed refractory. This consists of the burner tile, rear access door, and 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 the 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 cracks that are relatively large (1/8” to 1/4”), clean them and fill with high temperature bonding mortar.

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

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

The burner tiles are precast special shapes and replacements can be ordered from your Cleaver-Brooks representative. Installation is generally done by working from inside of the furnace and through the rear access door. Dry fit all the segments and chip to fit, if necessary. Re-install using proper refractory cement. Make sure that all joints are tight and coated with the cement. Mix insulating or 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.

Periodically check the rear door refractory. Make sure that the door bolts and sealing gasket are tight.

5.15 — Lubrication

5.15.1 — Electric Motors

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

Ball bearing equipped motors are prelubricated. The length of time a bearing can run without having grease added 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, when necessary, 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.
4. Before replacing the drain plug, run the motor for 10 to 20 minutes to expel any excess grease.
5. 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:

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

5.15.2 — 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 the lubricant in well and wipe away any excess. Repeat application at required intervals to maintain freedom of motion of parts.

Solenoid valves and motorized valves require no lubrication.

5.16 — Fireside and Waterside Cleaning

Refer to the appropriate sections in chapter 2 for fireside and waterside boiler surfaces cleaning information.

6.1 — Overview

This chapter assumes that the unit has been properly installed and adjusted and that it has been running for some time prior to the problem identified by the section heading. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points displayed under each heading are possible causes, suggestions or clues to simplify locating the source of the problem. Methods of correcting the problem, 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.

6.2.1 — Burner Does Not Start

Possible Cause	Additional Considerations
Main disconnect switch open	
Blown fuses, tripped overloads, loose electrical connections.	
Combustion control safety switch requires resetting.	<ul style="list-style-type: none"> a) Refer to manufacturer's bulletin. b) Check for power between terminal 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 programming bulletin).
Limit circuit not completed - no power to programmer terminal 3 (TB 10 or 23).	<ul style="list-style-type: none"> a) Pressure of temperature is above setting of operating control. b) Water below required level. <ul style="list-style-type: none"> i) Low water light, if provided, should indicate this condition. ii) 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.	

6.2.2 — No Ignition

Possible Cause	Additional Considerations
Lack of spark.	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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 (TB 17).

Possible Cause	Additional Considerations
Low fire switch open.	a) Damper motor not closed, slipped cam, defective switch. b) Damper jammed or linkage binding.
Check interlocks and circuit to relay terminal 12.	
Timer switch (CB70) in TEST Position and timer stopped in “prepurge.”	

6.2.3 — 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. c) 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, 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 (TB 18). If not voltage, check contacts (see bulletin).

6.2.4 — 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 6.2.6).	
Defective high-low fire control.	
Binding or loose linkage, cams, setscrews, etc.	
Check appropriate relay contacts.	

6.2.5 — shutdown Occurs During Firing

Possible Cause	Additional Considerations
Loss or stoppage of fuel supply.	
Defective fuel valve, loose electrical connections.	
Flame detector weak or defective.	
Lens dirty or sight tube obstructed.	
If the programmer lockout switch has not tripped, check the limit circuit controls, interlock, or blower motor.	<ul style="list-style-type: none"> 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.
If the lockout switch has tripped:	<ul style="list-style-type: none"> 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 (CB70). e) Lockout switch malfunctioning. <ul style="list-style-type: none"> i) Stuck contacts.
Improper air-fuel ratio (lean fire).	<ul style="list-style-type: none"> a) slipping linkage. b) Damper stuck open. c) Fluctuating fuel supply. <ul style="list-style-type: none"> i) Temporary obstruction in fuel line. ii) Temporary drop in gas pressure.
Interlock device inoperative or defective.	

6.2.6 — 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 shutdown.	<ul style="list-style-type: none"> a) Check appropriate contacts (see bulletin).
Motor does not operate on demand.	<ul style="list-style-type: none"> a) Damper positioning switch in wrong position. b) High-low fire control improperly set or inoperative. c) Check appropriate contacts (see bulletin).
Motor inoperative.	<ul style="list-style-type: none"> a) Loose electrical connection. b) Faulty damper motor transformer.

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, prop-



erly 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.

CleaverBrooks

MODEL 5 PACKAGED BOILER
MANUFACTURED AT
STRATFORD, ONTARIO

MODEL NO. SERIES
SERIAL NO. MAX. WORKING PRESS. PSI
MAX. OUTPUT BTU PER HR.

MIN. SAFETY VALVE CAPACITY PER HR.
CONTROL CIRCUIT RATING 10 AMPS OR LESS 120V-1PH
SHORT CIRCUIT CURRENT RATING kA RMS SYMMETRICAL
 VOLTS MAX.
BLOWER MOTOR RATING AMPS VOLTS PH
ALTERNATING CURRENT FREQUENCY HZ.

INSTALL ON NONCOMBUSTIBLE FLOOR
MIN. CLEARANCE – FRONT 48", REAR 36"
SIDES 18", TOP AND FLUE PIPES 18"
ADEQUATE ACCESS MUST BE MAINTAINED FOR SERVICE
BOILERS WITH EXCHANGER REQUIRE
INCHES AT REAR FOR REMOVAL

118-1794

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
275-216	1	Diffuser, Series 100, Sizes 1500-2500	
275-217	1	Diffuser, Series 200 & 700, Sizes 1500-2500	
275-212	1	Diffuser, Series 100, Sizes 3000-4000	
275-214	1	Diffuser, Series 200 & 700, Sizes 3000-4000	
275-213	1	Diffuser, Series 100, Sizes 4500-6000	
275-215	1	Diffuser, Series 200 & 700, Sizes 4500-6000	
435-99	1	Electrode	Gas Pilot
914-258	1	Snap Ring	For 435-99
904-36	1	Grommet	For 435-99
435-100	2	Electrode	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	



Part Number	Req.	Description	Usage
899-42		Nozzle, 60° PLP - 9.5 GPH	
899-44		Nozzle, 60° PLP - 10.5 GPH	
851-77		Mica, Sight Hole	
90-948		Tube, Scanner	
100-100		Nozzle, Body	
134-77	1	Spider, Series 100	Sizes 2000-4000
134-78	1	Spider, Series 100	Sizes 5000, 6000
134-79	3	Spider, Series 200 and 700	Sizes 2000-4000
134-80	1	Spider, Series 200 and 700	Sizes 5000, 6000
90-949	1	Tube, Nozzle Air Cooling	Short
90-950	1	Tube, Nozzle Air Cooling	Long
134-66	1	Spider, Oil Pipe	
134-53	1	Holder, Gas Pilot Electrode	
459-334	3	Housing, Burner, Insulated, Oil	Sizes 2000-4000
459-335	1	Housing, Burner, Insulated, Oil	Sizes 5000, 6000
40-453	1	Gas Burner Housing	Sizes 1500-4000
40-454	1	Gas Burner Housing	Sizes 4500, 6000
57-422	1	Gas Pilot Pipe	



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	
853-214	1	Gasket, Handhole 4" x 6"	
853-972	16'	Gasket, Rope	
821-275	1	Plate, Handhole 4" x 6"	
953-48	1	Yoke, Handhole	
32-2378	1	Gasket, Gas Pipe Flange	

7.2.3 — Electrical Controls and Components

Part Number	Description	Usage
	FLAME SAFEGUARD	NOTE: For FSG parts information, see CB manual 750-264 (CB 120E) or 750-234 (CB 780E)
817-1257	High Limit Control, Temp., L4008E	281-300° F HTHW
817-700	Operating Limit Control, Temp., L4008A	281-300° F HTHW
817-699	Well, Separable	281-300° F HTHW/240-280° F HTHW
817-1566	High-Low Fire Control, Temp., L6008A	281-300° F HTHW/240-280° F HTHW
817-1249	Modulating Control, Temp., T991A	281-300° F HTHW/240-280° F HTHW
817-1028	Well, Separable	281-300° F HTHW/240-280° F HTHW, 150# ST
817-619	Low Fire Hold Control, Temp., L6008A	281-300° F HTHW/240-280° F HTHW/30-40# HW
817-1281	High Limit Control, Temp., L4008E	240-280° F HTHW
817-698	Operating Limit Control, Temp., L4008A	240-280° F HTHW



Part Number	Description	Usage
817-1050	High Limit Control, Temp., L4008E	30-40# HW
817-400	Operating Limit Control, Temp., L4008A	30-40# HW
817-405	Well Separable	30-40# HW
817-619	High-Low Fire Control, Temp., L6008A	30-40# HW
817-1244	Modulating Control, Temp., T991A	30-40# HW
817-378	Well, Separable	30-40# HW, 15# ST
817-4094	High Limit Control, Pressure	15# ST
817-4092	High Limit Control, Pressure	150# ST
817-4095	Op. Limit Control, Pressure	15# ST
817-4093	Op. Limit Control, Pressure	150# ST
817-4167	High-Low Fire Control, Pressure	15# ST
817-120	High-Low Fire Control, Pressure	150# ST
817-251	Modulating Control, Pressure	15# ST
817-204	Modulating Control, Pressure	150# ST
817-619	Control, Temperature	15# ST
817-2039	Control, Temperature	150# ST
817-2094	Steam Pressure Sensor	15# ST
817-2095	Steam Pressure Sensor	150# ST



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

Gas Pressure Regulators

CSA/FM		
GAS PRESSURE REGULATORS		
BOILER SIZE	SIZE	PART NO.
1500	1 1/2"	918-711
	2"	918-733
2000	1 1/2"	918-155
	2"	918-716
2500	1 1/2"	918-730
	2"	918-716
3000	1 1/2"	918-547
	2"	918-716
	2 1/2"	918-701
3500-4000	2"	918-650
	3"	918-698
4500	2"	918-650
	3"	918-718
5000	2"	918-650
	3"	918-698
6000	2"	918-705
	3"	918-698
7500	2"	918-161
	3"	918-521

IRI

GAS PRESSURE REGULATORS		
BOILER SIZE	SIZE	PART NO.
1500	1 1/2"	918-711
	2"	918-733
2000	1 1/2"	918-730
	2"	918-716
2500	1 1/2"	918-730
	2"	918-716
3000	1 1/2"	918-547
	2"	918-650
	2 1/2"	918-701
3500-4500	2"	918-650
	3"	918-698
5000-6000	2"	918-705
	3"	918-698
7500	2"	918-161
	3"	918-521

Gas Pressure Switches

M5 MODEL	STD	FM	IRI
1500-2500	817-2414		
3000-6000	817-2414		
1500-3000	817-1935	817-2415	
3500-4500	817-2415		
5000	817-2421		
6000-7500	817-2415		



Gas Valves

DESCRIPTION	QTY	TRAIN SIZE		
		1.5"	2"	3"
VALVE (STD)	SEE TABLE	940-5810	940-5812	
ACTUATOR (STD)			945-139	
VALVE (POC)		940-5811	940-5813	
ACTUATOR (POC)			945-143	

M5 MODEL	INSURANCE					
	CSA		FM		IRI	
	STD	POC	STD	POC	STD	POC
1500-5000	-	1	-	1	2	-
6000-7500	1	1	1	1	1	1

NOTE—WHEN STD & POC SUPPLIED MOUNT POC VALVE DOWNSTREAM OF STD VALVE

7.2.6 — Linkage

Part Number	Req.	Description	Usage
2-47	1	Arm, Damper Shaft	
2-209	1	Arm, Damper Motor	
287-20	1	Arm, Gas Valve	
883-17	1	Ball Joint	
10-288	1	Bushing, Ball Joint	
82-27	2	Spring, Over Ride	Gas Valve
882-15	1	Arm, Spring Holding	Gas Valve
287-5	1	Arm, Gas Butterfly Actuating	
807-376	2	Bearing, Damper	
313-1	1	Cam	
36-199	1	Cam Spring Guides	
82-111	1	Cam Spring	



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
850-266	1	Gauge, Pressure 0-30#	LP Steam
850-122	1	Gauge, Pressure 0-300#	HP Steam
850-1061	1	Gauge, 0-200# 60-260 deg F	50-125 lb HW
850-1038	1	Gauge, 0-300# 60-260 deg F	
850-476	1	Gauge, Oil Pressure 0-300#	
850-1051	1	Gauge, Oil Pressure 0-600#	
850-109	1	Gauge, Gas Pressure	
937-681	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
94-317	1	Tile, Top, Front	1500 - 4000
94-318	1	Tile, Top, Rear	1500 - 4000
94-319	1	Tile, Bottom, Front	1500 - 4000
94-320	1	Tile, Bottom, Rear	1500 - 4000
94-340	1	Tile, Top, Front	4500 - 6000
94-339	1	Tile, Top, Rear	4500 - 6000
94-341	2	Tile, Bottom, Front and Rear	4500 - 6000
94-335	1	Tile, Bottom, Center	4500 - 6000
94-351	1	Tile, 1/2 Top Center	4500 - 6000
94-352	1	Tile, 1/2 Top Center	4500 - 6000
94-327	1	Insulation	
872-47	1	Cement, Refractory	
872-26	15#	Cement, Insulating	
872-382	30#	Refractory, Castable	



7.2.11 — Motors and Impellers

Part No.	Req.	Description	Usage
894-3110	1	Motor, 2 HP, 115/230/1/60/3600	Single Shaft Motors For Series 700 Boilers.
894-3111	1	Motor, 2 HP, 208/3/60/3600	
894-3112	1	Motor, 2 HP, 230/460/3/60/3600	
894-3113	1	Motor, 2 HP, 575/3/60/3600	
894-3062	1	Motor, 3 HP, 115/230/1/60/3600	
894-3063	1	Motor, 3 HP, 208/3/60/3600	
894-3064	1	Motor, 3 HP, 230/460/3/60/3600	
894-3065	1	Motor, 3 HP, 575/3/60/3600	
894-3071	1	Motor, 5 HP, 208/3/60/3600	
894-3072	1	Motor, 5 HP, 230/460/3/60/3600	
894-3073	1	Motor, 5 HP, 575/3/60/3600	
894-3114	1	Motor, 2 HP, 115/230/1/60/3600	Double Ended Shaft Motors for Series 100 and 200 Boilers.
894-3115	1	Motor, 2 HP, 208/3/60/3600	
894-3116	1	Motor, 2 HP, 230/460/3/60/3600	
894-3117	1	Motor, 2 HP, 575/3/60/3600	
894-3066	1	Motor, 3 HP, 115/230/1/60/3600	
894-3067	1	Motor, 3 HP, 208/3/60/3600	
894-3068	1	Motor, 3 HP, 230/460/3/60/3600	
894-3069	1	Motor, 3 HP, 575/3/60/3600	
894-3075	1	Motor, 5 HP, 208/3/60/3600	
894-3076	1	Motor, 5 HP, 230/460/3/60/3600	
894-3077	1	Motor, 5 HP, 575/3/60/3600	
192-253	1	Impeller, 1500	
192-242	1	Impeller, 2500	
192-245	1	Impeller, 3500/4500 (700 Series)	
192-244	1	Impeller, 3500/4500 (100 & 200 Series)	
192-241	1	Impeller, 2000	
192-243	1	Impeller, 3000	
192-247	1	Impeller, 4000 (100 & 200 Series)	
192-248	1	1 Impeller, 4000 (700 Series)	
192-249	1	Impeller, 5000 (700 Series)	
192-250	1	Impeller, 5000 (100 & 200 Series)	
192-252	1	Impeller, 6000	
91-134	1	Washer, Impeller Retainer	
868-690	1	Capscrew 5/16-24 x 1-1/2"	

NOTE: Always provide Boiler Serial Number and Motor Nameplate Data when ordering a replacement motor or impeller.



7.2.12 — Water Level Control Parts

QTY	PART NO.	DESCRIPTION	USED ON
1	100-271	L.W. CUT-OFF W/PUMP CONTROL (CB271)	15# ST
1	817-2411	L.W. CUT-OFF W/PUMP CONTROL(McDM 157S-RD-MD)	150# ST
1	817-163	L.W. CUT-OFF W/PUMP CONTROL (MAG. W25)	250# ST
1	817-1649	L.W. CUT-OFF W/PUMP CONTROL (MAG. W601)	350-500# ST
1	817-2305	LOW WATER CUT-OFF (McD-M #750MR)	30-150# HW
1	817-2351	PROBE FOR McD-M #750	
1	289-991	L.W. CUT-OFF - LEVELMASTER	150#/250# ST
1	817-312	AUX. LOW WATER CUT-OFF (McDM 63-BM)	15# ST
1	817-2407	AUX. LOW WATER CUT-OFF (McDM 150S-BM)	150# ST
1	817-740	AUX. LOW WATER CUT-OFF (WARRICK E2)	250# ST
2	067-533	PROBES FOR WARRICK (TRIM PER "J" DIM)	
1	817-1367	AUX. LOW WATER CUT-OFF (MAG. B60)	350-500# ST
1	817-1020	AUX. LWCO (WARRICK E3 W/HIGH ALARM)	OPTIONAL 15-250# ST
3	067-533	PROBES FOR WARRICK(TRIM 2 PER "J",1 PER "K")	
1	817-93	AUX. LOW WATER CUT-OFF (MAG. B24)	OPTIONAL
1	825-281	SET WATER GAUGE	15 ST
1	825-132	SET WATER GAUGE	150 ST
1	825-352	SET WATER GAUGE	250 ST
1	825-357	SET WATER GAUGE	350 ST
2	825-357	SET WATER GAUGE	500 ST
1	851-56	GAUGE, GLASS	15 ST
1	851-44	GAUGE, GLASS	150 ST
1	851-38	GAUGE, GLASS	250 ST
1	851-321	GAUGE, GLASS	350 ST
2	851-321	GAUGE, GLASS	500 ST
2	912-51	ROD, GAUGE GLASS	15 ST
2	912-146	ROD, GAUGE GLASS	150 ST
2	912-38	ROD, GAUGE GLASS	250 ST
*	830-28	CHAIN SASH	250-500 ST
1	941-251	VALVE, BALL 1/4"	15-150 ST
1	941-318	VALVE, GLOBE 1/4"	250 ST
1	941-1868	VALVE, GLOBE 3/8"	350 ST
2	941-1868	VALVE, GLOBE 3/8"	500 ST
1	941-1790	VALVE, BALL 3/4"	15-150 ST
1	941-1870	VALVE, GLOBE 3/4"	250 ST
2	941-1870	VALVE, GLOBE 3/4"	350-500 ST
1	825-31	COCK, UNION, 1/4", BRASS	15-150 ST
1	941-318	VALVE, GLOBE 1/4"	250 ST
1	941-1867	VALVE, GLOBE 1/4"	350-500 ST





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