



MODEL *FLX*
PACKAGED BOILER



12,500,000 to 25,000,000 BTU/hr
Hot Water
Fuel: Light Oil, Gas or Combination

Manual Part No. 750-364

09/2013

MODEL FLX PACKAGED BOILER

Operation, Service, and Parts Manual

12,500,000 to 25,000,000 Btu/hr
Fuel: Light Oil, Gas or Combination



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DO NOT OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS YOU FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

DO NOT ALLOW OTHERS TO OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS THEY FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

FAILURE TO FOLLOW ALL APPLICABLE WARNINGS AND INSTRUCTIONS MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH.

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warnings may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic burner operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is of extreme importance. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.

The services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices are essential.

The operation of this equipment by the owner and his or her operating personnel must comply with all requirements or regulations of his insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

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CHAPTER 1

GENERAL DESCRIPTION

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A. General

This manual applies to Cleaver-Brooks FLX Model boilers (hot water) in sizes ranging from 12,500,000 to 25,000,000 Btu/hr input.

Fuel Series

700- Gas

100-No.2 Oil

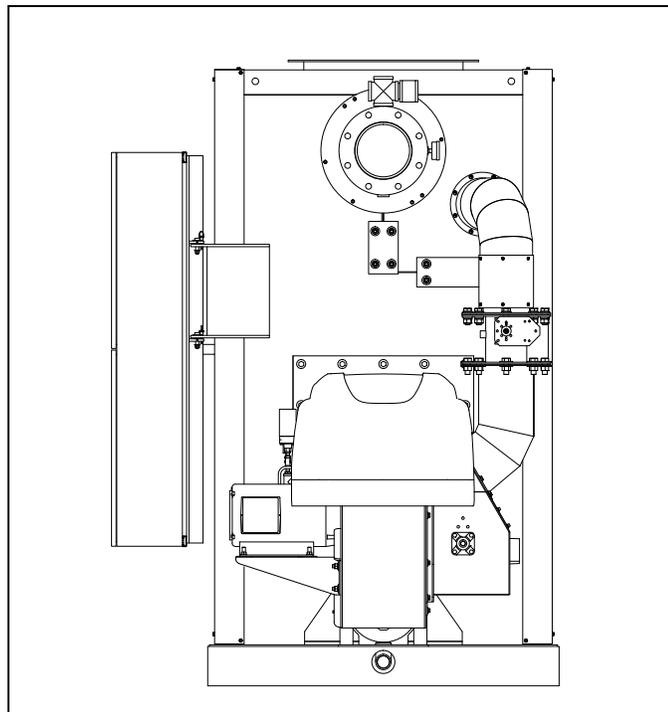
200 - Combination Gas & No.2 Oil

Design Pressure

30, 60, 125, or 160 psig hot water

CAUTION

The care taken in placing the boiler into initial service is vital to continuous, reliable operation. If the boiler is to be used for temporary heat (for example in new construction), properly treated water must be used. Failure to do so can be detrimental to the boiler.



B. The Boiler

The Cleaver-Brooks Model FLX is a five-pass steel boiler with flexible watertubes formed and arranged so as to direct the flow of combustion gases through the boiler. The pressure vessel conforms to Section I or IV of the ASME code. The pressure vessel consists of the formed tubes, the external downcomer, and the top and bottom drums to which they connect. The heated area of the pressure vessel is contained within a gas tight insulated casing that is composed of removable formed steel panels.

The boiler and related equipment installation are to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained, etc. All boilers in the FLX series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

The Model FLX boiler is a packaged watertube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, refractory, and appropriate boiler trim.

Hot water is commonly used in heating applications with the boiler supplying water to the system at 180 °F to 220 °F. The operating pressure for the Model FLX 1250-2500 is 30 psig to 160 psig.

Boilers are defined according to design pressure and operating pressure. Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler. Typically, the safety valves are set at or below design pressure. Operating pressure is the pressure of the boiler at which it normally operates. The operating pressure usually is maintained at a suitable level below the setting of the pressure relieving valve(s) to prevent their frequent opening during normal operation.

The type of service that your boiler is required to provide has an important bearing on the amount of waterside care it will require.

CAUTION

Waterside care is of prime importance. For specific information or assistance with your water treatment requirements, contact your Cleaver-Brooks service and parts representative. Failure to follow these instructions could result in equipment damage.

Feedwater equipment should be checked before use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Strict attention to water requirements is essential to proper boiler operation and length of service, and 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 accumulations is described in Chapter 3.

The operator should be familiar with this manual in its entirety before attempting to place the unit into operation.

C. Construction

Hot water boilers designed for 250°F at 160 psig or less are constructed in accordance with Section IV, Heating Boilers, of ASME Code. Hot water boilers designed for operating temperatures above 250°F are constructed in accordance with Section I of ASME Code.

D. Hot Water Controls (All Fuels)

1. Water Temperature Gauge: Indicates the boiler internal water temperature.
2. Water Pressure Gauge: Indicates the internal pressure of the boiler.
3. Operating Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.
4. High Limit Temperature Control: Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop burner at a preselected temperature above the operating control setting. The high limit temperature control is equipped with a manual reset.
5. Modulating Temperature Control: Senses changing boiler water temperature and transmits the information to change the burner firing rate when the manual-automatic switch is set on Automatic.
6. Low Water Cutoff: Breaks the circuit to stop burner operation if the water level in the boiler drops below safe operating point, activating low-water light and optional alarm bell if burner is so equipped.

7. Auxiliary Low Water Cutoff (Optional): Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.
8. Safety Valve(s): Prevent buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid over-tightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange-connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.



Only properly certified personnel such as the relief valve manufacturer's certified representative can adjust or repair the boiler relief valves. Failure to follow these instructions could result in serious personal injury or death.

CHAPTER 2

Profire EV/LNEV Burner

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A. Description

The Profire EV Series burners are designed to operate with gas, light oil, or a combination. All burners feature ignition by spark-ignited gas pilot flame. With either fuel, the burner operates with full modulation. A switch permits changeover from automatic fully modulated firing to manually set firing at any desired rate between minimum and maximum. Additional safeguards assure that the burner always returns to the minimum firing position for ignition.

EV Series burners are designed for automatic, unattended operation except for periodic inspection and maintenance. After selecting the proper overload settings for the starter, the rest of the control panel components require little attention except for occasional cleaning.

B. Combustion Air Handling System

The combustion air handling system consists of two major components:

Damper assembly - A rotary damper regulates the combustion air volume and is positioned by a modulating motor. The damper is normally almost closed in the low fire

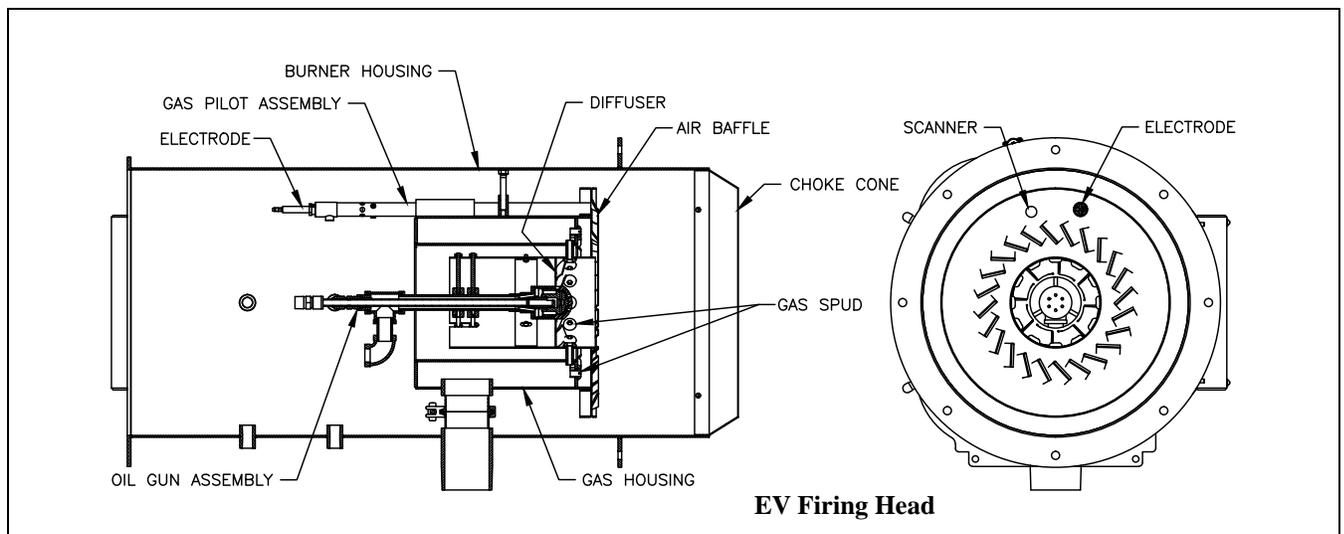
position and opens as the burner drives toward a high fire position.

Motor driven impeller - The diameter of the impeller determines available air pressure and the width determines air capacity in cubic feet per minute. Alternate motor-impeller combinations are available for 50 cycle or 60 cycle power and for firing against either moderate or high furnace pressure. All standard impellers are sized for up to 2,000 ft. altitudes. Alternate impeller wheels are available. For higher altitudes, motor and impeller combinations are determined at the factory.

C. Firing Head

Access to the firing head is provided by swinging open the impeller housing. For low NOx systems, disconnect the FGR duct.

An internal gas pilot is standard on all burners. Pilot gas pressure is adjusted at the pilot pressure regulator.



D. Oil System

EV Series burners use compressed air for atomization. Atomizing air is independent of combustion air. The system is supplied with a separate compressor module for mounting near the burner.

3-Way Solenoid Valve

Metered oil enters the common port of the 3-way solenoid valve. During shutdown, pre- and post-purge, the valve is de-energized (N.C. port closed) and all metered fuel oil returns to the storage tank. When the valve is energized, metered oil is directed to the nozzle through the N.C. port.

Nozzle Assembly

The nozzle assembly consists of four main parts: body, compression spring, swirler, and tip. The swirler is held against the nozzle tip by the compression spring. The nozzle body has inlet ports for air and oil lines. Metered fuel oil enters the nozzle body and flows through a tube to the swirler. Oil is forced from the core of the swirler to the side ports where it meets with the atomizing air. Atomizing air enters and passes through the nozzle body to grooves in the swirler, where it mixes with fuel oil. Air/oil passes through grooves and out of the nozzle orifice in a cone of atomized oil. Proper velocity and angle of the fine spray ensures good mixing with

the combustion air, providing quiet starts and excellent combustion efficiency. During pre- and post-purge, the nozzle tip is purged with air. This prevents afterdrip or baked-on residue

Oil Strainer

Prevents foreign matter from entering the burner oil system.

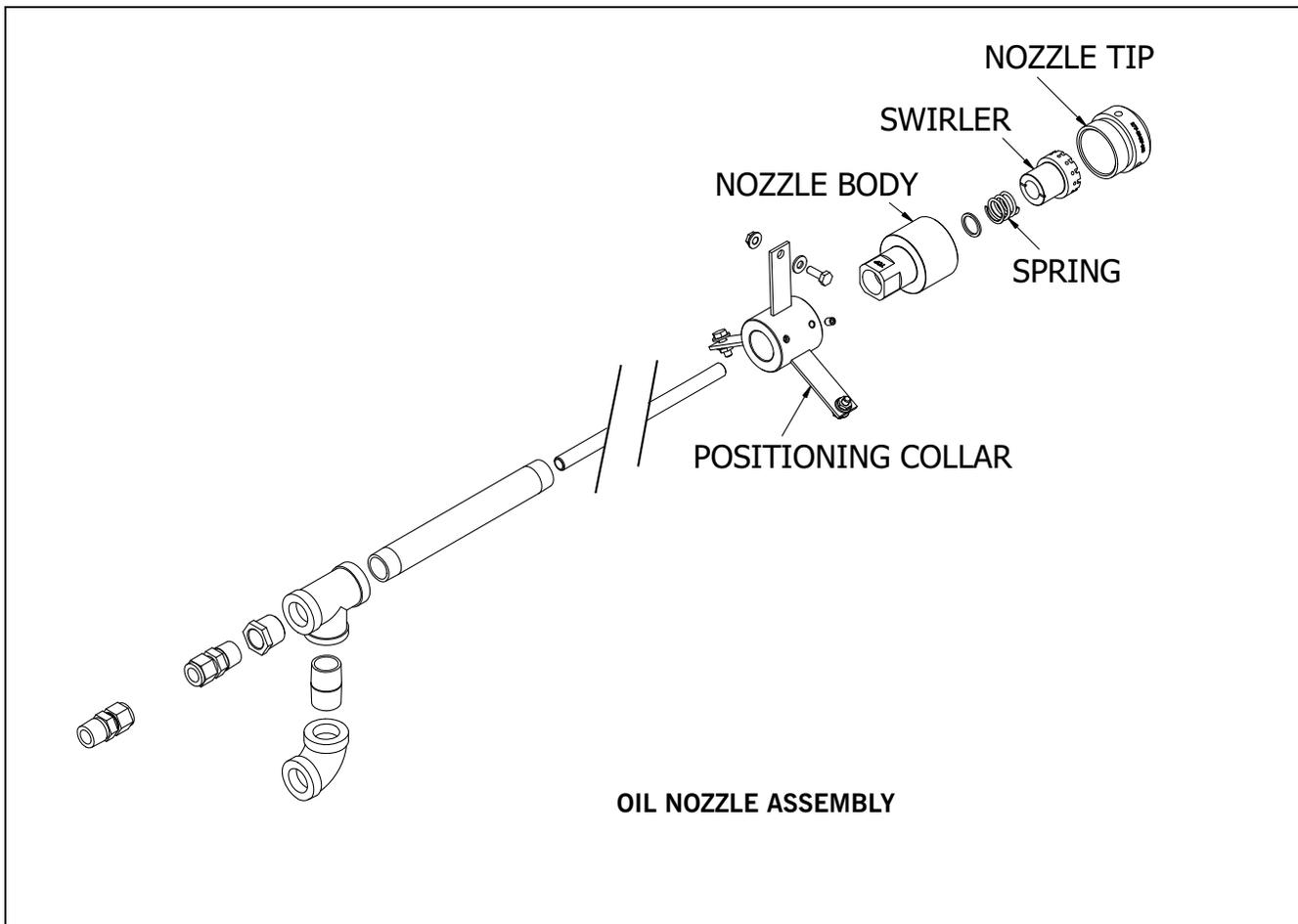
Atomizing Air Proving Switch

Pressure actuated switch contacts close when sufficient atomizing air pressure is present. The oil valve will not open unless switch contacts are closed.

Oil Metering

Fuel oil under nominal pressure in the circulating loop flows to the adjustable positive displacement (volumetric metering unit). Oil metering is accomplished by changing the piston stroke by means of an eccentric shaft and pin assembly. The pistons reciprocate in a rotor assembly, turning in a hardened steel sleeve having oil inlet and discharge slots. During each revolution the pistons go through the following cycle:

Inlet Cycle. The piston is at the bottom dead center position. At this position, the cavity between the top of the piston and the outside diameter of the rotor fills with oil.



Discharge Cycle. (180° from inlet cycle) The piston is at the top dead center position. At this position, the oil is forced out of the discharge port to the nozzle. The piston stroke length is determined by the position of the eccentric shaft and plate. The piston adjustment plate is positioned by an adjustable eccentric shaft. The eccentric shaft is positioned by the modulator through adjustable linkage. Counterclockwise rotation of the eccentric shaft increases the piston stroke (more oil delivered to nozzle); clockwise rotation decreases the amount of oil delivered. When the eccentric shaft is stationary, at any position, the stroke of the pistons remains constant delivering a constant volume of oil regardless of viscosity.

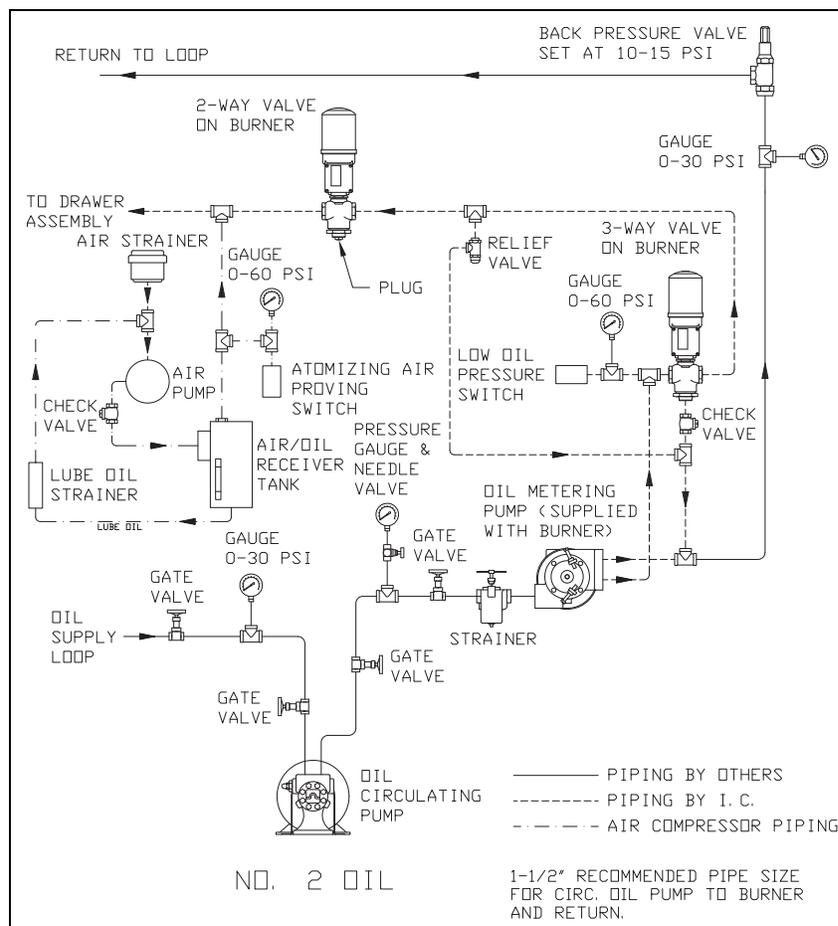
Separate Compressor Module

EV burners have a burner mounted oil metering unit and a separate compressor module. The system functions as follows:

Air is supplied by a positive displacement rotary vane compressor. This provides a constant volume of atomizing air regardless of pressure. The compressor module includes motor, air-oil reservoir tank, air filter, and lube oil cooling coil. Air enters the compressor through the filter. The air flows from the compressor into the air-oil separating and reservoir tank. Filtering material and baffles separate the lube oil from the compressed air. The tank air pressure forces

lubricating oil from the tank to the compressor to lubricate bearings and vanes. A sight glass indicates the level of lubricating oil in the air/oil reservoir. Lubricating oil must be visible in the gauge glass at all times. Air compression heat is absorbed in part by the flow of lube oil, creating a hot oil mist. The air/oil mist is cooled by a coil assembly. Lube oil is also cooled before entering the compressor.

Fuel is delivered to the positive displacement metering pump at 10 to 15 psi. Metered oil is delivered to the common port of a 3-way solenoid valve for transfer to the burner nozzle through the normally closed port or back to the storage tank through the normally open port. During pre- and post-purge, metered oil is returned to the tank. During normal firing, all metered oil is delivered to the nozzle. Air enters a rotary vane compressor through an air cleaner where it is compressed to atomizing pressure. Air flows from the compressor to an air/oil tank which serves the multiple purpose of dampening air pulsation, lube oil mist recovery, lube oil and atomizing air storage. The compressor rotor is cooled and lubricated continuously by oil under pressure from the air/oil tank. Oil vapor is extracted by a mist eliminator in the upper section of the tank. Atomizing air from the upper tank section is delivered to the nozzle at a constant volume. Air pressure increases as the burner firing rate increases. Atomizing pressure may be adjusted by the needle valve located on the air-oil pump. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering



pump is controlled by the modulating motor through adjustable linkage (or by independent actuator if parallel positioning).

E. Gas System

Gas is introduced into the combustion zone from a circular manifold through multiple ports in the manifold. Firing rate is determined by the size and number of ports, by manifold pressure, and by combustion zone pressure. The firing rate is regulated by a rotary, butterfly-type throttling valve at the manifold inlet. The valve is actuated by an adjustable linkage from the modulating motor. Depending upon specific requirements, one or two safety shutoff motorized main gas valves are provided for installation in the gas train upstream of the butterfly valve. Safety shutoff gas valves are wired into the programming control to automatically open and close at the proper time in the operating sequence.

Main Gas Train Components

Depending upon the requirements of the regulating authority, the gas control system and gas train may consist of some or all of the following items:

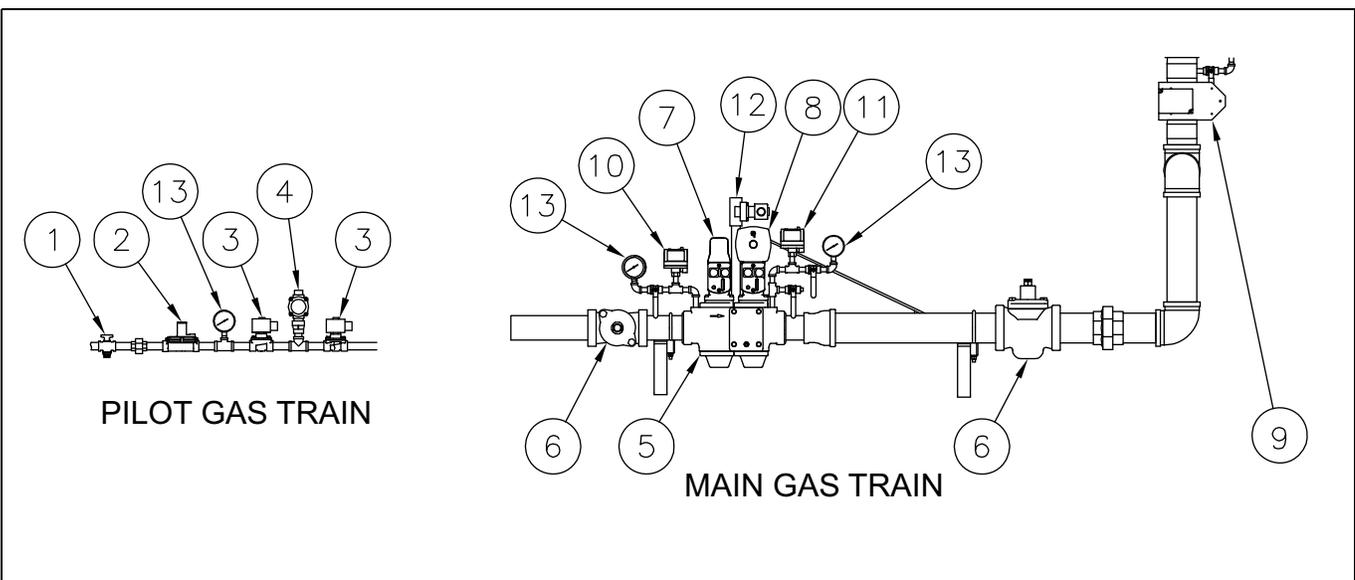
Operation

Metered gas flows through the main gas shutoff cock, through the pressure regulator to the automatic gas valves and butterfly valve to the gas manifold.

The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor (or by independent actuator if parallel positioning). The air control damper is positioned simultaneously by the modulating motor (or by independent actuator if parallel positioning).

The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high

Item	Description
1	Pilot manual shutoff cock
2	Pilot gas pressure regulator
3	Pilot safety shutoff valve (2)
4	Pilot vent valve
5	Safety shutoff valve
6	Manual shutoff valve (2)
7	Gas valve actuator with proof of closure
8	Gas valve regulating actuator
9	Metering valve
10	Low gas pressure switch
11	High gas pressure switch
12	Vent valve
13	Pressure gauge (4)



gas pressure switches must be closed to prove proper gas pressure.

A normally open vent valve, if required, is located between the two automatic gas valves. This valve is shut when the automatic gas valves are open. When the automatic valves are closed, the vent valve is open for venting gas to the outside, should any be present.

F. Installation

Locate the burner properly. The burner is designed for operation with the blast tube level. Do not tilt the burner up or excessively downward. Installation of the refractory oven or combustion cone, shipped with the burner. Allow enough clearance at the rear of the burner to allow the housing to swing open for service and maintenance. Boilers operating with combustion pressures above atmospheric pressure must be sealed to prevent escape of combustion products into the boiler room. The burner mounting flange is designed to provide for a seal. The face of the boiler and burner flange must be sealed with a rope gasket (not supplied with the burner). Make sure the dry oven and burner blast tube are concentric. For maximum safety, it is recommended that boilers not operating under pressure should also be sealed.

Typical Oil Supply Loop

Continuous oil circulation must be supplied to the burner at a rate of 50 percent greater than the high fire burning rate. The oil circulating pump should be located as close as possible to the storage tank to keep suction lines short and minimize suction loss. Pipe line sizes indicated on the following oil piping schematics are of ample size to reduce pressure losses. If heating of the fuel oil is required, the lines must be large enough to prevent restriction of flow through any cold spots in the system. Note that the supply line is approximately 20 inches or higher above the burner metering pump inlet to help eliminate air problems. Above that is an adjustable, spring-loaded back pressure valve that sets approximately 10 to 15 PSI on the circulating loop. The return line to the tank is connected at the discharge port of the back pressure valve. Since air rises to the highest point, it will rise from the supply entrance and pass through the back pressure valve to the return line and on to the tank. Metered oil is pumped (by the metering pump) to the common port of a 3-way valve. With the 3-way valve de-energized, the metered oil returns to the tank through the back pressure valve and return line. When the 3-way valve is energized, metered oil is passed on to the burner oil nozzle and atomized by air from the compressor. The proper strainers, check valves, vacuum, and pressure gauges, etc. should be installed as indicated. All lines should be pressure tested after installation.

Oil Circulating Loop Operation

An oil circulating pump provides continuous oil circulation to the circulation loop. A back pressure valve holds 10 to 15 psi

on the loop system. With the oil supply line connected only to the oil metering pump inlet, all oil must pass through the pump. During pre-purge, unmeted oil flows through a bypass section of the oil metering pump. Metered oil passes through the metering section to a de-energized 3-way oil valve (common port). Both unmeted and metered oil must pass through the back pressure valve and return to an oil storage tank. The oil metering pump will only meter oil. It will not serve as a circulating pump. At trial for main flame (main fuel), the 3-way oil valve is energized admitting metered oil to the nozzle for atomization and fast smooth ignition. Unmeted oil continues to flow through the bypass section of the oil metering pump and returns to an oil storage tank.

Circulating Oil Pump

A circulating oil pump is required to deliver fuel oil from the storage tank to the burner at a minimum of 150% of the maximum burner firing rate. The excess oil allows a margin for piping error, viscosity changes in the fuel oil, and circulating pump wear. Correct pipe sizing is determined by circulating rate, not burner capacity. Install the pump as close to the supply tanks as possible. Suction lift should be as low as possible. Maximum suction of 15" Hg vacuum is good practice for either light or heated heavy oil. The strainer should be installed in the suction line just ahead of the circulating pump to prevent foreign material from entering the pump. Locate the strainer so it may be easily cleaned.

Back Pressure Valve

A back pressure valve, similar to Watson McDaniel type "R," needs to be installed on the return line. This valve must be installed in an upright vertical position. Before installing the valve, be sure to blow out the pipe line, removing all dirt, pipe scale and sediment. This type of valve is actuated by the system pressure which enters the body beneath the main valve. Valve loading is provided by a spring that can be adjusted to the desired set pressure.

To adjust the set pressure, remove the top cap, loosen the brass locknut and adjust the pressure with the steel setscrew. By increasing the compression on the spring, screwing down the screw, you increase the set pressure within the limits of the spring range. Reversing the setscrew lowers the set pressure.

Adjust to 10-15 PSI for No.2 oil systems. When the desired pressure is reached, tighten the locknut and replace the top cap and gasket.

Gas Piping

Gas service and house piping must supply the quantity of gas demanded by the unit at the pressure required at the burner gas train inlet. All piping must be in strict accordance with applicable codes, ordinances, and regulations of the supplying utility. In the absence of other codes, piping should be in accordance with the following standards: "National Fuel

Gas Code" NFPA No. 54, ANSI No. Z 223.1 (for Canada, the Canadian Gas Association (CGA) B149 and Canadian Standards Association (CSA) B140 codes shall prevail).

Gas train components upstream of the butterfly valve are shipped loose. These components should be mounted by the installer as close to the butterfly valve as practical. Normally, the control train is ordered to suit a particular code or insurance regulation, such as Underwriters Laboratories Inc., CGA, or Factory Mutual.

Arrange gas piping at the burner so that the burner is accessible for servicing without disassembly.

The gas pilot supply line must be connected upstream of the main gas regulator. If a reducing bushing is required between the house piping and the burner piping, it should be close to the burner shut-off valve.

The gas piping must be internally clean and free of foreign material. Before using in service, a leak test must be performed.

Installation Checklist

All burners are carefully assembled and tested at the factory, but before being placed in service, all connectors should again be checked for looseness caused during shipment.

Check:

- Electrical terminals in the control panel and on all electrical components.
- Pipe fittings and unions.
- Tubing connections.
- Nuts, bolts, screws.

Before operating pumps, metering heads and compressors, make certain that reservoirs are properly filled with the specific lubricant. Open all necessary oil shut-off valves. Do not run compressors, pumps, or metering units without oil.

Before connecting electrical current to any component, be sure the supply voltage is the same as that specified on component nameplates.

Before burner operation, be sure all motors are rotating in the correct direction.

Before firing, make sure that the refractory flame cone is properly sealed to the burner mounting flange and the boiler front plate.

Make certain that the operator in charge is properly instructed in the operation and maintenance procedures

Caution

Before opening the gas shutoff valves, read the regulator instructions carefully. Open the shutoff valve slowly to allow inlet pressure to build up slowly in the regulator until it is fully pressurized. Opening the shutoff valve quickly will damage the regulator.

Do not exceed the regulator pressure ratings.

Caution

Lubricating oil is drained from the air/oil tank before shipment. Before attempting to start the burner, add oil to the recommended level.

G. FGR System - Low NOx Applications

LNEV burners are equipped with an FGR (flue gas recirculation) valve to lower the NOx emissions. An actuator is provided to adjust the FGR valve position throughout the firing range on gas. Follow the steps below to adjust combustion while using FGR:

Make sure the FGR valve is in the nearly closed position.

Start the burner and hold at low fire until the boiler is at the proper operating pressure or temperature.

With an analyzer in the stack, adjust the FGR amount to obtain sub 30 ppm NOx levels.

NOTE: Do not adjust the burner below 20 ppm. Unstable combustion and high CO emissions will result.

Monitor O₂ and CO levels during this process. The introduction of FGR into the combustion chamber will lower the flue O₂ levels. Too much FGR may induce high levels of CO in the flue gas. It may be necessary to adjust the O₂ to proper low fire values.

Once the low fire setting is complete, continue throughout the firing range, adjusting the FGR at each point, to obtain the proper NOx values. Verify the values modulating back to low fire, and adjust accordingly.

H. Burner Maintenance

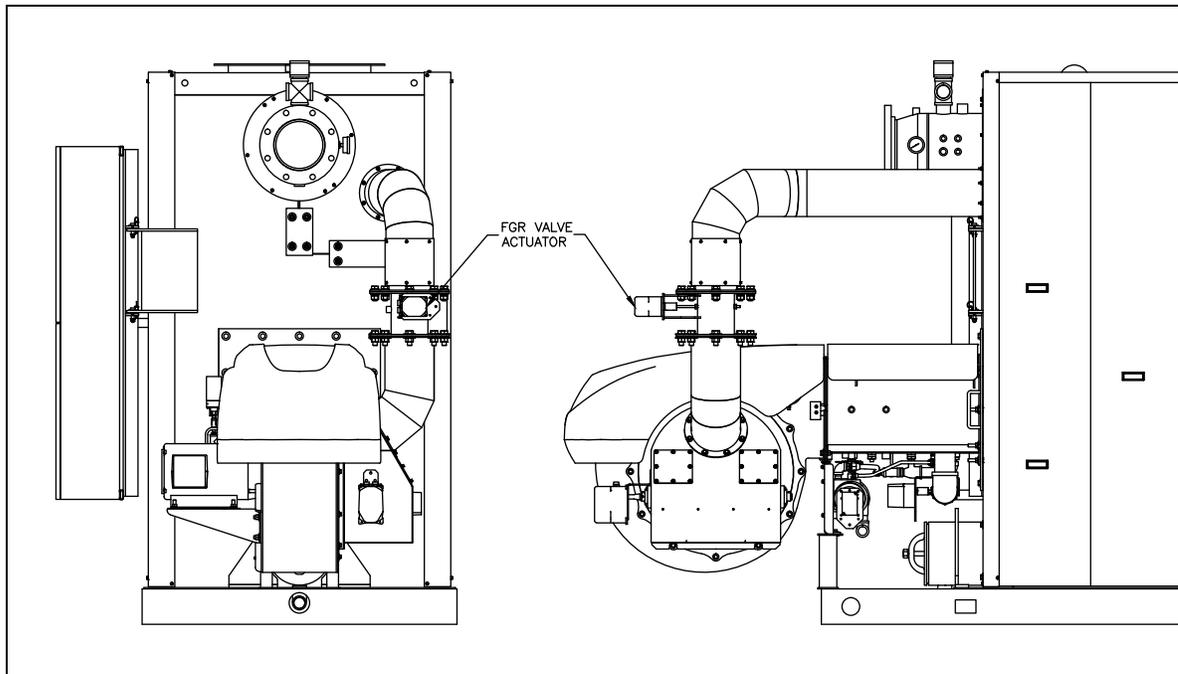
Impeller and Inlet Cone

Proper clearance between the impeller and the inlet housing set at 3/8" nominal. Adjust the inlet cone so it is centered in the inlet of the impeller and tighten the bolts. There should be no contact between the inlet cone and the impeller. Inserting

a bar through the impeller blade and using it as a lever will only damage the blade and also void the impeller warranty.

Firing Head Inspection

Remove the bolts that secure the burner housing to the fan housing and swing the housing open for access to the firing head. Inspect the flame scanner lens to be sure it is clean. Inspect the lead wire to the ignition electrode. It must be firmly attached and the insulation should be clean and free of cracks. The oil nozzle should be inspected periodically



depending on the grade of oil burned and the cleanliness of the environment.

Pilot and Ignition Electrode

The ignition transformer requires little attention other than making sure the ignition wire is firmly attached to the transformer and the electrode. Be sure the wire insulation is in good condition and not grounded. Failure to keep the ignition electrode clean and properly set can cause faulty operation. The pilot assembly is supported by a socket in the diffuser and gas inlet tube. No adjustment is required except proper positioning of the electrode wire.

Flame Scanner

The scanner must be clean. Even a small amount of contamination will reduce the flame signal. Wipe the scanner lens with a clean soft cloth.

Oil Nozzle

Successful burner operation requires using the proper nozzle tip and keeping the orifice clean. Standard nozzle tips furnished on the burners are of a special emulsifying type which delivers a spray of extreme fineness and at an angle which insures proper mixing with the air stream. Unsatisfactory performance and loss of efficiency can result from the use of nonstandard nozzle tips. If the burner flame becomes stringy or lazy, it is possible that the nozzle spring is not properly in place or the nozzle is clogged. This problem is usually indicated by an abnormally high reading on the atomizing air pressure gauge on the air-oil tank. To remove the nozzle:

1. Disconnect the oil and air tubes to the nozzle assembly.
2. Loosen the three 1/4" screws holding the nozzle spider bracket to the diffuser.

3. Withdraw the nozzle and bracket assembly.

To clean the nozzle tip and swirler:

1. Unscrew the tip from the nozzle body. Use care not to distort the tube.
2. Hold the nozzle body in a vise or use two wrenches, one on the body and one on the tip.
3. Disassemble the nozzle tip.
4. Carefully clean all parts in solvent and reassemble the nozzle.

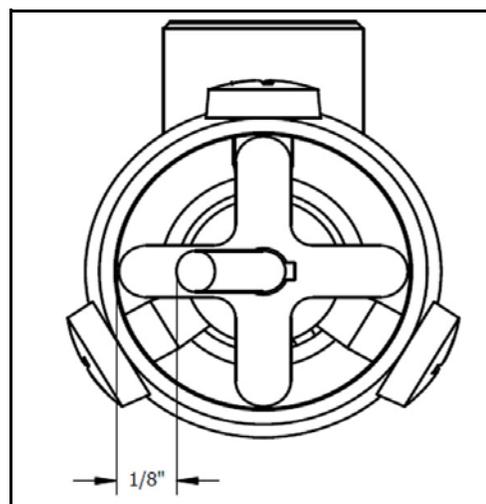
To insure proper atomizing, the tip must be screwed in tightly with the swirler seating spring pressing the swirler tight against the nozzle tip. Turn the swirler a few times to be sure it fits snugly in the nozzle and the spring is pressing the two parts firmly together. When reinstalling, be sure the nozzle is centered with the proper distance from the diffuser.

Caution

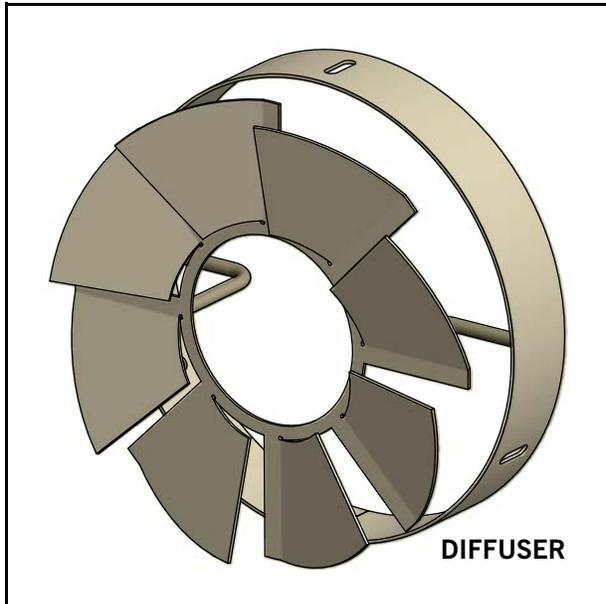
Do not attempt to use wire or a sharp metal tool to clean the nozzle orifice as this will distort the fine orifices and ruin the nozzle. Use a sharp pointed piece of soft wood.

Diffuser

The diffuser is factory set and does not require attention under normal operating conditions. If fouled with carbon, the diffuser should be removed for cleaning:



PILOT ELECTRODE GAP



1. First remove the electrode leads, the gas pilot assembly, air and oil tubes before you attempt to remove the diffuser.
2. Remove the three screws holding the diffuser to the blast tube and slowly pull the diffuser along the blast tube towards the firing head.
3. Clean all carbon from the diffuser vanes and reinstall in reverse order of disassembly.
4. When reinstalling, be sure the diffuser is centered with the proper distance.

Burner Mounting Inspection

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Periodic inspection is important. Replace the gasket if necessary. Inspect the burner head for signs of discoloration. A change the head color paint might indicate gas leakage between the dry oven and the boiler refractory.

Fuel Oil System - Fuel Oil Circulating Pump

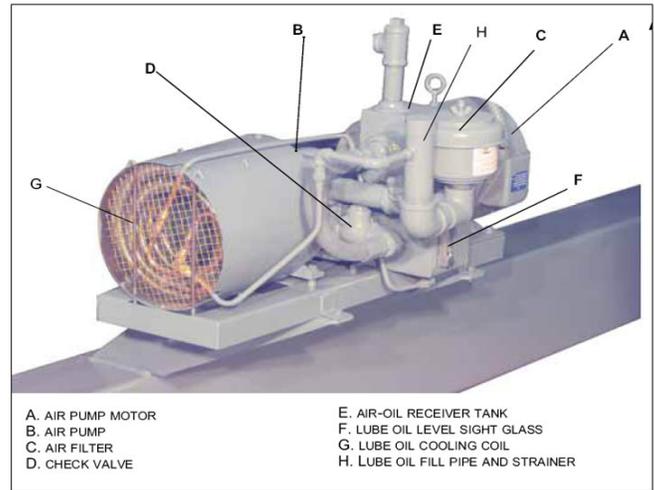
Failure of the circulating pump to deliver sufficient oil may be due to one of the following reasons:

- Insufficient fuel oil in the storage tank.
- Suction line or check valve clogged.
- Air leaks or air traps in the suction line. If the line has a high point at which an air trap can occur, the line must be changed.
- Oil strainer clogged (line strainer or burner strainer).
- Suction line piping too small (see Chapter 2).
- Pump rotating in wrong direction.
- Three-phase pump motor operating on single-phase because of fuse failure.

Low voltage applied to pump motor.

AIR COMPRESSOR

The air pump itself requires little maintenance. However, the life of the pump is dependent upon a sufficient supply of clean cool lubricating oil. The oil level in the air-oil tank must be observed closely. Lack of oil will damage the pump making replacement necessary. Disassembly or field repairs to the pump are not recommended.



Compressor Lube Oil

Lubricating oil must be visible in the sight glass at all times. There is no specific level required as long as oil is visible. Do not operate if oil is not visible.

Oil with proper viscosity must be used. SAE 20 detergent is recommended, although SAE 10 detergent is also permissible.

When adding oil, remove the cover from the fill pipe and add oil through the conical strainer in the pipe with the unit running.

The oil and its container should be clean. Although there is a strainer in the lube oil line, its purpose is to remove any unwanted materials rather than to act as a filter for unclean oil.

⚠ Caution

Oil must NEVER be added unless the pump is in operation and the strainer screen is in place. Failure to follow these instructions could result in equipment damage.

Oil Strainer and Cooling Coil

Air pressure from the pump forces lubricating oil from the tank through a cooling coil to the pump. The oil lubricates the pump bearings and also provides a seal and lubrication for the pump vanes.

The cooled oil flows to the pump through the strainer in the filler pipe. It is possible to visually verify oil flow during operation by removing the filler cap and checking the flow. If necessary, the strainer may be cleaned during operation.

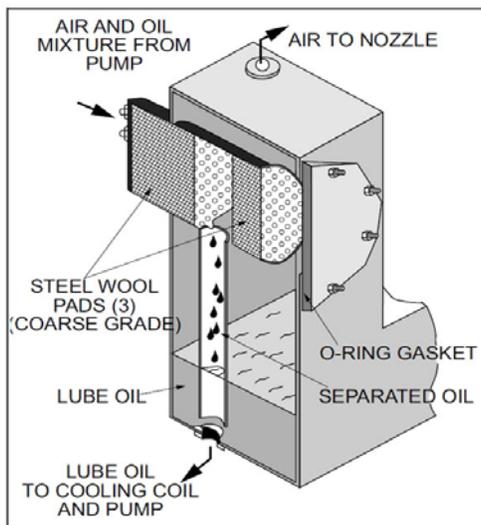
In the event it is necessary to clean the strainer during operation, clean it and replace immediately. It can be cleaned by immersing in solvent and blowing it dry with compressed air. Do not operate without the strainer any longer than necessary, and never add new oil unless the strainer is in place. A spare strainer basket can be obtained, if desired, and used on a rotating basis while the other is serviced.

Air-Oil Tank

Pads of steel wool are used in the air-to-oil tank as a filtering medium to separate the lube oil from the compressed air.

The pads play a very important role and should be replaced semi-annually. It is also important that a proper grade of steel wool be used. Only No. 3 coarse grade American steel wool or equivalent (CB919-124) should be used. Three pads are required. When replacing the wool, insert two pads into the cylinder. Alternate the grain of the pads. Install the spacer with its stub end toward the opening and fit one pad over the stub. Be careful not to overly compress the wool and be sure that it is fluffed out to fill all available space. Improper packing can cause high oil consumption. After the last pad is in place, slip the retainer screen onto the cylinder. Be sure to fit an o-ring gasket under the cover so that a tight seal is obtained.

Follow previous instructions for oil replacement.



Air-Oil Tank

Air Cleaner

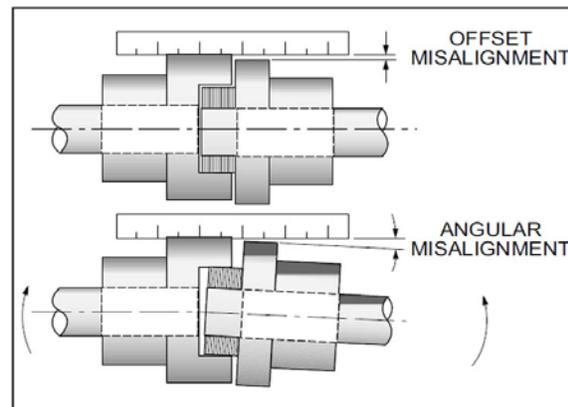
Never operate the air pump without the air cleaner in place. The cleaner itself must be periodically checked and its element flushed and cleaned semi-annually.

Flexible Coupling Alignment

Alignment of the pump and motor through the flexible coupling is extremely important for trouble free operation. Check the coupling alignment semi-annually and replace the coupling insert as required. Keep the coupling guard in place.

The most commonly used tools for checking alignment are a small straightedge and a thickness gauge.

The coupling must be checked for both parallel (offset) alignment and angular (gap) alignment. Parallel misalignment exists when shaft axes are parallel but not concentric. Angular misalignment is the reverse situation, with shaft axes concentric but not parallel.



Checking parallel alignment, both horizontal and vertical, can be accomplished by laying a straightedge across the coupling halves and checking with a thickness gauge to obtain the amount of misalignment. The check should be done on the top of the coupling and at 90 degrees. A useful aid is to hold a flashlight behind the straightedge so that any gap can readily be seen.

Shim stock of appropriate thickness and area is then used under either the feet of the pump or the motor to establish parallel alignment. A tolerance of .008" is a permissible limit.

After parallel alignment is established, check for angular alignment, which is done by checking the gap between coupling halves. The coupling should have a minimum gap of 1/16" and a maximum of 3/32".

Set the spacing between the halves at one point by using a thickness gauge and then rotate the coupling slowly to be sure that clearance at that point remains the same through 360 degrees of rotation. Adjust to obtain proper gap by loosening the hold-down bolts and shifting either the pump or the motor as required. Generally, a slight tapping on either the front or

rear legs is all that is needed to obtain lateral adjustment. Rear legs may require shimming for vertical correction.

Tighten the hold-down bolts after adjustments are made and recheck the alignment.

Calipers can also be used to check angular alignment. Measure the overall distance of the outer ends of the coupling halves at 90° intervals. Shift the pump or motor, as required, so that the ends of the coupling are the same distance apart at all points. The coupling will then have proper angular alignment.

Remember that alignment in one direction may alter alignment in another. Re-check both angular and parallel alignment procedures after making any alteration.

A properly aligned coupling will last longer and will provide trouble-free mechanical operation.

Air Compressor Replacement

Use the following procedures when replacing the pump. Be sure to tag the motor leads if disconnected to simplify re-connection.

Dismantling:

1. Lift out the two front cylinder pins that hold the screen, and remove the screen.
2. Disconnect the flared nut on tubing "A" (behind screen) and lift tubing "A" high enough to prevent drainage of lubricating oil from the tank.
3. Disconnect the flared nut at the orifice fitting.
4. Remove the two sheet metal screws that hold the cylinder in place. One screw is located at the top rear of the cylinder, the other is at the bottom front.
5. Remove the entire heat exchange assembly, consisting of the cylinder, the finned tubing, and the oil line "B".
6. Remove the fan from the air pump.
7. disconnect the flexible air line from the lube tank.
8. Remove the coupling guard by pushing in on both sides until it clears the clamp.
9. Loosen the clamp at the rear of the tank and remove the tank with copper tubing "B" attached.
10. Leave the rear pump bracket (coupling end) in place to aid in realignment of the replacement pump. Do this by removing the two capscrews that extend through the bracket into the pump housing. Temporarily leave the front bracket attached to the pump.
11. Remove screws holding the front bracket to the base and lift off the pump with its attachments. Note the location of the pipe fittings and brackets prior to removing for installation on the replacement pump. If piping is dismantled, be sure that the check valve is re-installed so that the gate swings toward the pump.

Reassembly:

Reassemble in reverse order. With the rear pump bracket left in place, realignment and spacing between the pump shaft and the motor shaft is greatly simplified.

There should be approximately 7/8" space between the two shafts. Place the coupling insert between the coupling halves prior to reassembly. Check that both shafts rotate freely.

Refer to the previous section on coupling alignment instructions.

If shims were used originally under either pump brackets or motor feet, be sure that they are correctly re-installed.

When re-installing the fan, slide the hub on the pump shaft so that it is bottomed. Tighten the setscrew and capscrews. If the fan blades were removed from the hub, be sure that the side of the blade marked "Blower" faces the hub when reassembling. When tightening the coupling halves or the fan hub, tighten the setscrews against the key first, then tighten the setscrew against the shaft. Clean or remove any dust or grime from the blades prior to re-installing.

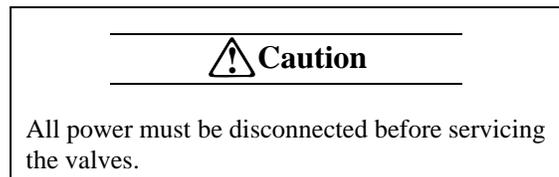
When replacing the retainer screen, a slight force may be required to push the cooling coil into the air cylinder so that the pins may be fitted into place.

Be sure that all piping connections are tight.

If the motor was replaced or if motor leads were disconnected, be sure that pump rotation is proper before starting operation. The air pump should rotate in a clockwise direction, as viewed from the drive shaft end.

Keep the motor and other components free from dust and dirt to prevent overheating and damage. Motor lubrication should follow manufacturer's recommendations.

GAS SYSTEM



Motorized Main Gas Valves

Should the valve fail to operate, check for voltage at the valve. Make certain that the main shutoff cock is closed prior to testing. The actuator is not field repairable nor should it be disassembled. Replace the actuator if the valve fails to operate. After replacement, cycle the valve with the fuel shutoff to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operation.

Solenoid Valves

A slight hum from the solenoid is normal when the coil is energized. Should the valve fail to operate, check that there is voltage at the valve coil. If there is no voltage at coil, check for loose wiring connections. If there is proper voltage at the valve coil and the valve still fails to open, replace the coil. Refer to manufacturer's bulletin for correct procedure in coil replacement.

Should it become necessary to replace the complete valve, be sure that the flow is in the direction of the arrow on the body.

Test for gas leaks and check valve action several times to ensure proper operation before attempting to relight the burner.

Electrical System - Electric Motors

Motor supply voltage must not vary more than 10 percent from nameplate ratings. At initial startup and at least once a year thereafter, check the motor current with a meter while the burner is in high fire position. If the reading exceeds the nameplate rating plus service factor, determine the cause and correct it immediately. In dusty locations, clean the motor regularly to assure adequate cooling. Lubricate in accordance with the manufacturer's instructions.

Extended Shutdown

When shutting down the burner for an extended period of time, the operator should use the following general guidelines to protect the burner from its surrounding elements. This will add to the operating life of the burner.

1. Turn the main electrical disconnect switch to the burner to "OFF."
2. Close all main fuel valves.
3. If the burner operates in a damp environment, cover it with plastic to protect all electrical components from moisture. Remove the flame safeguard control and store in a dry atmosphere.

CHAPTER 3

Pressure Vessel Care

A. General	3-1
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A. GENERAL

This chapter is devoted primarily to the waterside care of the pressure vessel.

Proper water supply and treatment are essential to boiler life and length of service. Proper water treatment will pay dividends in the form of longer life, less downtime, and prevention of costly repairs.

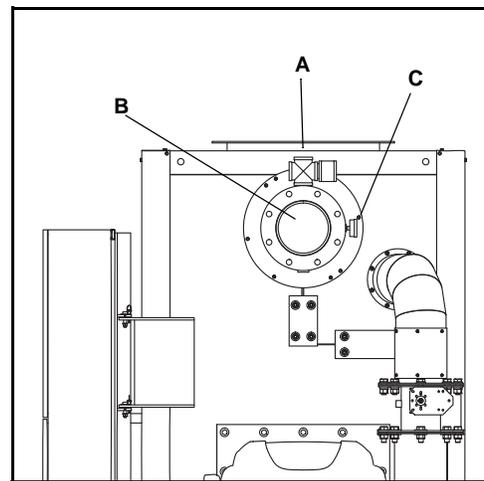
Hot water boilers require proper circulation. The system must be operated as intended by its designer in order to avoid the possibility of thermal shock with severe stress to the pressure vessel.

Although it is of prime importance, the subject of water supply and treatment cannot adequately be covered in this manual. For specific information or assistance with your water treatment requirements, contact your local Cleaver-Brooks authorized representative.

B. WATER REQUIREMENTS

Air Removal

The hot water outlet (Figure 3-1) is located in the top drum of the boiler. This location reduces the possibility of released air (which is trapped at the top of the drum) from entering the system. Any air (or oxygen) that may be released in the boiler will collect at the top of the upper drum, where it will escape through the air vent tapping (Figure 3-1). The tapping must be



A. VENT TAPPING
B. HOT WATER OUTLET
C. TRIDICATOR (TEMP AND PRESSURE)

Figure 3-1: Upper Drum (Hot Water)

properly piped to the expansion tank or a stand pipe and air bleeder to remove gases that collect at the top of the drum.

Continuous Flow

The system must 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 within the unit.

Refer to Table 3-1 for the maximum gpm circulation rate of boiler water in relation to full boiler output and temperature differential between supply and return.

MODEL NO.	Temperature Differential Between Supply and Return									
	$\Delta T = 10\text{ }^\circ\text{F}$	$\Delta T = 20\text{ }^\circ\text{F}$	$\Delta T = 30\text{ }^\circ\text{F}$	$\Delta T = 40\text{ }^\circ\text{F}$	$\Delta T = 50\text{ }^\circ\text{F}$	$\Delta T = 60\text{ }^\circ\text{F}$	$\Delta T = 70\text{ }^\circ\text{F}$	$\Delta T = 80\text{ }^\circ\text{F}$	$\Delta T = 90\text{ }^\circ\text{F}$	$\Delta T = 100\text{ }^\circ\text{F}$
FLX-1250	2010	1005	670	503	403	335	287	251	223	201
FLX-1450	2350	1175	784	587	470	392	336	294	261	235
FLX-1650	2680	1340	895	670	535	447	383	335	298	268
FLX-1850	3012	1506	1005	753	603	502	430	377	335	301
FLX-2100	3350	1675	1120	838	670	558	479	419	372	335
FLX-2500	4020	2010	1340	1005	805	670	575	502	448	402

Table 3-1: Maximum Flow Rates for Hot Water Boilers

NOTE: To avoid fireside condensation, return water temperature must be $> 140^\circ\text{F}$.

⚠ CAUTION

In order to avoid damage to the equipment, a circulating pump should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running.

It is recommended that the system circulating pumps be kept running, even though the heat users do not require hot water. The relief device or bypass valve will allow continuous circulation through the boiler and will help prevent rapid replacement of boiler water with “cold” zone water.

⚠ CAUTION

The operator should determine that a circulation of water exists through the boiler before initial firing or when firing after the unit has been drained and refilled. A reduced circulation of water or no water circulation through the boiler when the burner is operating may result in damage to the equipment.

System Pressure

The design of the system and the usage requirements often will dictate the pressure exerted upon the boiler. Some systems are pressurized with nitrogen. Caution must be

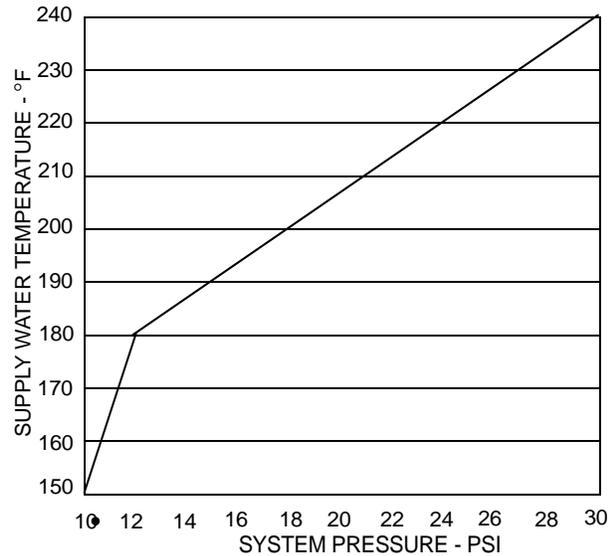


Figure 3-2: Minimum System Operating Pressure

exercised to make sure that the proper relationship of pressure to temperature exists within the boiler so that all of its internal surfaces are fully wetted at all times. It is for this reason that the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in Figure 3-3.

It is advisable to install a thermometer in the return line to indicate return water temperature. With the return water temperature and the supply water temperature to the system known, the temperature differential will be established. Knowing the flow rate, the operator easily can detect any excessive load condition and take appropriate corrective action.

Minimum Boiler Outlet Water Temperature

The minimum recommended operating boiler outlet water temperature is 150°F. When water temperatures lower than 150°F are used, the combustion gases are reduced in temperature to a point where the water vapor in the gases condenses. A result of condensation is that fireside corrosion occurs in the boiler and breeching. The condensation problem is more severe on a unit that operates intermittently or is oversized for the actual load. This is not a matter that can be controlled by boiler design, since an efficient boiler extracts all the possible heat from the combustion gases.

Note: In order to maintain a minimum outlet water temperature of 150°F the low limit of the Operating Temperature Control should be set at least 10° higher.

If the operating water temperature going to the system must be lower than 150°F, the operating boiler outlet water temperature should still be held to a minimum of 150°F. Mixing valves are used to reduce the supply temperature going to the system.

Note: The minimum return water temperature through the boiler is 140°F (150°F on #2 Oil).

CAUTION

Three-way valves and system controls should be installed or set so that the boiler cannot be bypassed. A reduced circulation of water or no water circulation through the boiler when the burner is operating may result in damage to the equipment.

Multiple Boiler Installations

When multiple boilers of equal or unequal size are installed, care must be taken to ensure proportional flow through the boilers. Proportional flow can best be accomplished by use of balancing valves and gauges in the supply line from each boiler. If balancing cocks or orifice plates are used, a significant pressure drop (for example, 3-5 psi) must be taken across the balancing device to accomplish proportional flow.

Variations in water temperature and firing rates will result if care is not taken to ensure proportional flow through the boilers. In extreme cases, differences in firing rates could result in a net header water temperature below the desired temperature.

C. WATER TREATMENT

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

The objectives of water treatment in general are to:

1. Prevent hard scale and soft sludge deposits that inhibit heat transfer and that could lead to overheated metal and costly downtime and repairs.
2. Eliminate corrosive gases in the supply or boiler water.

To accomplish these objectives, the boiler requires proper water treatment before and after introduction of water into the unit. The selection of pretreatment processes depends upon the water source, its chemical characteristics, the amount of makeup water needed, system operation practices, etc.

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. A sound treatment program should include a periodic analysis of the water in the system.

Table 3-1: FLX Water Chemistry

Parameter	Limit
pH	8.3 - 10
Chloride	30 mg/liter
Oxygen	0.1 mg/liter
Specific Conductivity	3500 μmho/cm
Total Hardness	<10 ppm

D. USING GLYCOL

Before glycol is added, the system must be cleaned and flushed. Correct glycol selection and regular monitoring of the concentration and stability of the glycol solution in use are necessary to ensure adequate long-term freeze protection, including protection from the effects of corrosion due to glycol degradation.

Typically, ethylene glycol is used for freeze protection but other alternatives exist. All glycols tend to oxidize over time in the presence of oxygen, and when heated form aldehydes, acids, and other oxidation products. When inadequate levels of water treatment buffers and corrosion inhibitors arise, the water-glycol pH may fall below 7.0 (frequently reaching 5) and acid corrosion results within the boiler and system piping. Therefore, when pH levels drop below 7.0 due to glycol degradation, the only corrective measure is to drain, flush, repassivate, and refill with a new inhibited glycol solution.

Here are Cleaver-Brooks' recommended guidelines when using glycol with a FLX Boiler.

1. Maximum allowable antifreeze proportion (% volume):
 - 60% antifreeze (glycol)
 - 40% water
2. Maximum allowable boiler outlet flow temperature: 1120 C (2350 F).
3. Minimum water circulation through the boiler:
 - a.) Independent from the hydraulics of the heating system, a constant water circulation is required. Requires a dedicated boiler pump if in a primary/secondary loop arrangement. Minimum circulation as noted below whether the boiler is firing or in stand-by.
 - b.) In installations with more than one boiler, the compliance with the minimum water circulation is for all boilers.
 - c.) Recommend minimum continuous GPM flow rate through the boiler corresponding to a 40 degree F system drop for outlet temperatures to 240 degrees F.
4. Minimum over-pressure at the boiler:
 - a.) For operating temperatures up to a maximum of 1120 C (2350 F), an over-pressure of a minimum of 2.75 bar (40 psig) is required.
5. Expansion Tank
 - a.) Nitrogen pressurizing blanket preferred.
6. Process boilers should be sized so that continuous duty does not exceed 80% of the maximum rating. Operating at rating for short periods is acceptable.
7. Standard tube attachment will be used.
8. It is the end user's responsibility to routinely monitor the condition of the system fluid. Frequent analyses during

the first six months of operation and semi-annual checks thereafter are recommended.

CAUTION

Excessive use of inhibitors can create precipitation of solids causing reduced circulation and heat transfer.

E. CLEANING

Although it may be necessary to clean the system, information in this chapter deals primarily with cleaning the boiler under isolated conditions.

System piping connected to the boiler may contain oil, grease, or other foreign matter. These impurities must be removed to prevent damage to the heating surfaces of the pressure vessel. Chemical cleaning generally is necessary in this case and the entire system should be drained after cleaning. Consult your local Cleaver-Brooks authorized representative for recommended cleaning compounds and application procedures. For information on Boilout, see Section G, in this chapter.

Pressure Vessel

Cleaning of the waterside of the pressure vessel should be done during the course of initial installation. The waterside of the pressure vessel must be cleansed of grease, sludge, and foreign material. Such deposits will shorten the life of the pressure vessel and interfere with the efficient operation and function of control or safety devices. In addition, deposits might cause unnecessary and expensive rework, repairs, and downtime.

The pressure vessel and the hot water system represent in effect, a closed system. Although individual components of the system may already have been cleaned, it is possible that:

1. The cleaning was not adequate.
2. An old system was partially or totally involved.
3. Conditions may have prevented an adequate cleaning of the piping.

Therefore, it is recommended that the entire system be cleaned, after installation of all components is completed. The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal the true internal conditions and will serve as a check against conditions indicated by chemical analysis of the boiler water. An inspection should be performed 3 months after the initial start up, then at regular 6, 9, or 12 month intervals thereafter. The frequency of periodic inspections will depend upon the internal conditions found, the particular installation, and the operating conditions that the boiler is subjected to.

If any deterioration or unusual conditions are observed, contact your local Cleaver-Brooks authorized Representative for recommendations.

F. BOILOUT

Any oil, grease, or other contamination found to be present on waterside heating surfaces should be removed promptly by boiling out the unit with an alkaline detergent solution.

Note: Before boiling out, the burner must be ready for firing. Refer to CHAPTER 2 - Profire EV/LNEV Burner.

There are several chemicals suitable for boilout. One combination often used is soda ash (sodium carbonate) and caustic soda (sodium hydroxide) at the rate of 3 to 5 pounds each per 1,000 pounds of water, along with a small amount of laundry detergent added as a wetting agent.

If the system is to be cleaned with the boiler, consider the additional water content of the system in determining the amount of chemical required. The water capacity of Cleaver-Brooks FLX Boilers is listed in Table 3-2.

Boilout Procedure

1. Prepare the boiler for firing by taking the standard precautions. Check for any situations that might present a hazard.
2. Remove upper and lower drum handhole covers and inspect all internal waterside surfaces. Remove debris and wash all internal surfaces, including tubes. It may be necessary to use a high pressure hose or a wash out lance to flush out inaccessible areas. Reinstall the lower drum handhole cover. (Use standard service gaskets during the boilout procedure.)
3. The relief valve(s) must be removed before adding the boilout solution so that neither the solution nor the contaminants that it may carry can come in contact with the valve(s). Use care in removing, handling, and reinstalling these valves.

Note: For relief valve installation information, refer to Chapter 7, Section E. "Controls."

4. Replace the regular gauge glass with a temporary gauge glass that can be discarded after the cleaning (steam boilers).
5. An overflow pipe should be connected to one of the top boiler openings and routed to a safe point of discharge. A relief valve tapping is usually used for this purpose. The overflow connection to the boiler should incorporate a tee fitting for adding cleaning solution to the boiler.

6. Fill the unit with clean water to a point just below the access port in the upper drum. It is important that the water used for the filling process is at a temperature of 70°F or above.
7. Add the boilout solution using a chemical pump.



The chemicals used in this procedure are corrosive to eyes and skin. Always refer to the Material Safety Data Sheet to ensure that the proper safety equipment and precautions are present. Failure to heed this warning could result in serious personal injury or death.

8. Reinstall the upper handhole cover.
 9. Continue to fill the boiler until it is full (indicated by flow from the overflow connection).
 10. Recheck the burner, gauge glass, pressure gauge, feedwater supply and the position of all valves. Make sure that all water feeding and level indicating apparatus are in proper working condition.
 11. Fire the boiler intermittently at the burners lowest fire rate until the water reaches the boiling point. The water should be held at this temperature for at least five hours.
- Note: Do not produce pressure in the boiler.**
12. Throughout the entire process, each blow-down point or valve should be blown at least once every two hours. The total amount of water blown from all points each time should be approximately one-half gauge glass, this amount being equally divided among the various manual blowdown points and continuous blowdown system. Blow the surface and/or continuous blow-down points first, followed by the other blowdown points lower on the boiler. After each blowdown cycle, the water level should be brought back to full. If the total alkalinity in the cleaning solution falls to a level below 3000 ppm, it may be necessary to add additional solution, using a chemical pump.
 13. Allow a small amount of fresh water to enter the boiler in order to create a slight overflow that will carry off surface impurities. Continue to boil and overflow until the water clears.
 14. It is difficult to provide specific recommendations regarding the duration of the cleaning process. In general, a period of 18 to 36 hours will prove sufficient to internally clean the water-side of the boiler. The

condition of the water blown from the boiler is the best indicator as to whether the cleaning process is complete.

15. Discontinue firing, and allow the water to cool. After letting the water cool to 120°F or less, drain the boiler.



Be sure to drain the hot water to a safe point of discharge to avoid the possibility of scalding, serious personal injury or death.

16. Remove the drum handhole cover, and wash the waterside surfaces thoroughly, using a high pressure water stream. Direct the water stream into each individual tube. If possible, this washing should be done from the bottom up. A wash out lance is available from your local Cleaver-Brooks authorized representative.
17. Inspect the waterside surfaces. If they are not clean, repeat the boilout procedures.
18. Replace the handhole covers (using new gaskets) and reinstall the relief valve(s).

Note: Refer to Chapter 7, Section E, “Controls” for information regarding proper installation of relief valves.

19. If the boiler is to be put into service immediately, fill the boiler with clean, treated water and fire the burner until the water has been heated to at least 180°F to drive off any dissolved gases that might otherwise corrode the metal.
20. If the boiler is not to be put into immediate service, refer to the section on boiler layup procedures in this chapter.

G. WASHING OUT

Depending on system integrity, feedwater quality, or operating conditions, the water side of the boiler may need to be washed out on occasion.

In theory, a hot water system and boiler that have been initially cleaned, filled with clean, treated water, and with no makeup water added, will require no further cleaning or treatment. However, minor system leaks may allow the admission of additional water or air into the boiler.

Boiler Size	1250	1450	1650	1850	2100	2500
Water Capacity (US gal.) HW	306	335	513	558	800	912

Table 3-2: Water Capacity

Introduction of raw (untreated) makeup water or air to a hot water boiler may lead to pitting, corrosion, or formation of sludge, sediment, or scale on the pressure vessel waterside.

The waterside condition of steam boilers can be likewise affected by feedwater quality, load demands, operating conditions, or blowdown practices.

The waterside of a hot water or steam boiler should be cleaned and inspected no later than three months after the boiler is put into service. Subsequent cleaning of waterside surfaces should be performed as indicated through periodic inspection.

In order to thoroughly wash out the waterside of the pressure vessel, the handhole covers at the ends of the upper and lower drums must be removed. The interior surfaces of the drums

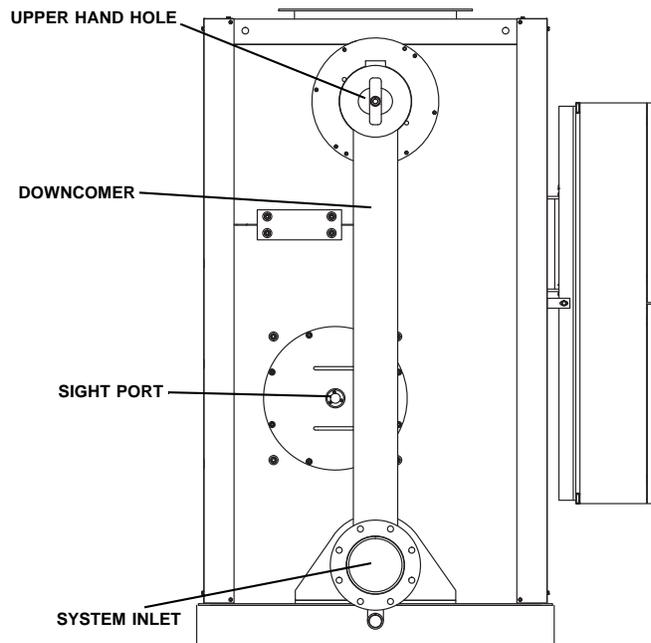


Figure 3-3: Rear Panel (Hot Water Boiler)

should be washed with a high pressure hose. Tubes should be cleaned by directing a high pressure stream of water into the end of each tube, first from the bottom, and then from the top drum.

Note: A washout lance for this purpose is available from your local Cleaver- Brooks authorized representative.

Control and water column connections on steam boilers should be checked for accumulated deposits, and cleaned as required.

After waterside cleaning has been completed, replace the handhole covers, using new gaskets.

Note: Handhole cover gaskets are installed dry; that is, without application of a sealing compound.

H. PERIODIC INSPECTION

Insurance regulations or local codes and good maintenance will require that the pressure vessel be inspected periodically by an authorized inspector. Sufficient notice is generally required to allow removal of the boiler from service and preparation for inspection. An internal inspection may be required before cleaning or flushing.

Have the following information available for the inspector: boiler design, dimensions, generating capacity, operating pressure and temperature, time in service, defects found previously, and any repairs or modifications made to the unit. Reference records of previous inspections also should be available. Be prepared to perform any testing required by the inspector, including a hydrostatic test.

When shutting down a boiler, the load should be reduced gradually and the pressure vessel should be cooled at a rate that avoids a temperature differential that can cause harmful stresses. Normally, all pressure should be relieved before a vessel is drained in order to prevent uneven contraction and temperature differential that can cause tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces.

Note: Check to see that system valves, all fuel valves, expansion tank, and electrical switches are shut off prior to opening the handholes or the burner access door. After proper cooling and draining of the vessel, flush out the waterside with a high pressure water stream. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion or leakage.

Fireside surfaces also should be cleaned so that metal surfaces, welds, joints, tube fittings, and any previous repairs can be readily checked.



To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight

is recommended during an internal inspection.

Fireside Inspection

Access for inspection of the firing chamber, or furnace, is gained through the hinged burner door. Inspection of the upper pass requires removal of the side casing panels and second and fourth pass cover plates. Refer to Chapter 7, Section C, "Fireside Cleaning," for information regarding outer and inner casing removal.

Fireside tube surfaces should be checked for corrosion or accumulation of soot. Use a vacuum cleaner and wire brush to remove light corrosion or soot.

Localized, heavy corrosion on fireside tube surfaces may indicate a leaking tube or ferrule connection. If a tube or tube ferrule leak is indicated, the source of the leakage must be found and repaired before putting the boiler back in service. A leak from a tube-to-drum connection may require removal and reseating of the tube. A heavily corroded or leaking tube must be replaced in order to assure continued reliable operation of the boiler. Information regarding tube replacement can be obtained from your local Cleaver-Brooks authorized representative.

Waterside Inspection

Check all water piping and valves for leaks, wear, corrosion, and other damage. Replace or repair the piping and valves as necessary. Inspection covers at one end of the upper and lower drums provide access to the interior of the drums for visual inspection or washout. The interior surfaces of the drums should be examined for any sign of corrosion or accumulation of deposits.

I. PREPARATION FOR EXTENDED LAYUP

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. The procedures outlined in this section are designed to allow a boiler to be kept off line for any period of time without damage to the unit. Special care must be taken so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion. Operating boilers can be protected from corrosion and scale by applying various chemical treatments and monitoring the system on a regular basis. However, boilers that are taken off line, even for short intervals, are susceptible to oxygen attack. Boiler drums and/or tubes may sustain pitting type damage during either wet or dry layup if proper precautions are not taken.

Oxygen solubility at ambient (off-line) temperatures can be many times that of normal boiler operating temperatures. The higher the oxygen concentration, the greater the oxygen corrosion potential. Problems also can occur as a result of improper shutdown procedures, where settled solids can dry in a hard, adherent deposit.

Care must be taken to prevent fireside corrosion, especially when firing oil that contains sulfur. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation during cooling. Moisture and any sulfur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid can be serious. An acid solution could eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

Too many conditions exist to lay down definite rules for individual installations. In general, there are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better method based on the circumstances of your particular installation. Regardless of the method employed, the boiler should be thoroughly cleaned and inspected prior to storage. With either method, common sense dictates a periodic recheck of fireside and waterside conditions during layup to meet the requirements of special or job site conditions.

Preparing The Boiler For Layup

To prepare a boiler for layup, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, exposed drum surfaces, and refractory.

CAUTION

The insulating refractory covering the top of the bottom drum must be protected from damage when work is being done in the boiler furnace area. Damage to the insulation may eventually cause damage to the boiler itself.

Generally, a good brushing will clean fireside surfaces. Use a wire brush for metal surfaces and a soft bristle brush for the refractory. Sweep away or vacuum any accumulation.

To prevent condensation from forming in the control cabinet, keep the control circuit energized. For extended layup periods, especially where high humidity or large swings in ambient temperature occur, the flame safeguard control should be removed and stored in a dry atmosphere.

It is recommended that the burner air inlet be blocked to prevent the flow of warm, moist air through the boiler.

CAUTION

A label should be affixed to the burner advising that the air inlet has been blocked. Failure to remove the air inlet block when attempting to operate the burner may result in damage to the equipment.

Dry Storage

Dry storage generally is used for boilers that are to be out of service for some time or for boilers that might be subjected to freezing conditions. With the dry storage method, the boiler must be thoroughly dried because any moisture would cause corrosion. Drying can be accomplished by the use of a small stove or heater.

Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, and other combustion products as soon as possible after shutdown.

All openings to the pressure vessel, such as handholes or inspection ports, should be closed tightly. Feedwater and system valves should be closed. Dampers should be closed to prevent air from reaching the fireside surfaces.

Steps must be taken to eliminate moisture by placing moisture-absorbing materials on trays inside the boiler. Two moisture-absorbing materials are: quick-lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume). As soon as the material is in place, close all boiler openings and blank all connections.

WARNING

Materials described in this section may be considered hazardous under the U.S. Occupational Safety and Health Act of 1970. Material Safety Data Sheets should be obtained and understood prior to the use of these products to avoid the possibility of serious personal injury or death.

Wet Storage

Note: It is always best to consult with a water treatment specialist before proceeding with extended layup.

Wet storage is used when the boiler will be out of service for shorter periods of time, when a boiler is held in standby conditions, or in cases where dry storage is not practical. The boiler held in wet storage can be brought back into service more quickly than one held in dry storage. However, the possibility of freezing temperatures must be considered. Again, take care to protect metal surfaces. Because of the number of variables, it is difficult to offer definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and refilled to overflowing with treated water.

If deaerated water is not available, the unit should be fired to boil the water for a short period of time in order to drive off oxygen in the water.

Tightly close all connections and apply a small positive pressure to compensate for the vacuum that will develop as the unit cools to room temperature. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen often is used to pressurize the vessel.

The boiler water should be tested weekly as long as the unit is in storage. Additional chemicals may be required to prevent internal corrosion. If more chemicals are added, it is desirable to circulate the boiler water for a short time by means of an external pump.

Contact your local Cleaver-Brooks authorized representative for water treatment chemicals or assistance.

CHAPTER 4

Sequence Of Operation

A. General	4-1
B. Circuit And Interlock Controls	4-1
C. Sequence Of Operation - Oil Or Gas.	4-2
D. Flame Loss Sequence	4-3

Note: For complete startup and operating information refer also to the manual included with the boiler's control system.

A. GENERAL

Chapter 4 outlines the electrical sequencing of various controls through the pre-purge, ignition, run, and shutdown cycles of the burner.

The C-B Hawk controls are an integrated system combining the functions of a Programmable Logic Controller (PLC) for firing rate control with a Flame Safeguard (FSG, also called here *program relay*) for flame supervision and burner sequencing.

Note: Details of the boiler operating sequence will vary depending upon the installation. The following sequence is intended as a general illustration. Please refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation.

Abbreviations for the various electrical components are given throughout this chapter. These abbreviations reflect the nomenclature employed in C-B boiler wiring diagrams. For abbreviations not found in this chapter, see also document C23-3862 Electrical Nomenclature.

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 temperature control and high limit temperature control are below their cutoff settings.
- All applicable limits are correct for burner operation.
- The load demand indicator 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 described here do not directly involve the fuel supply or feedwater systems except for those interlock controls capable of interrupting the program relay.

Chapters 5 and 6 contain further operating instructions and specific information on setting and adjusting the controls.

B. CIRCUIT AND INTERLOCK CONTROLS

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 vary depending upon the fuel used and upon the specific requirements of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. A typical control circuit and operating sequence are described in this chapter.

Limit Circuit

- Burner switch (BS)
- Operating limit control (OLC) - pressure or temperature
- High limit control (HLC) - pressure or temperature
- Low-water cutoff (LWCO)
- Auxiliary low water cutoff (ALWCO)
- Gas-oil selector switch (GOS) - (Combination burner only)
- Low gas pressures switch (LGPS)
- High gas pressure switch (HGPS)

Fuel valve (Pre-ignition) interlock circuit

- Main gas valve auxiliary switch (MGVAS)
- Oil valve auxiliary switch (OVAS)

Blower Motor Starter Circuit

- Blower motor starter (BMS)

Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)

Pilot Ignition Circuit

- Gas pilot valve (GPV)
- Ignition transformer (IT)
- Gas pilot vent valve (GPVV) (if provided)

Flame Detector Circuit

- Flame detector (FD)

Main fuel valve circuit

- Main gas valve (MGV)
- Main gas vent valve (MGVV) (if provided)
- Oil valve (OV)
- Main fuel valve light (FVL)

Firing Rate Circuit

Boiler firing rate is controlled by the PLC, which sends individual modulation signals via Modbus to actuators for air, fuel, and FGR (if provided).

An auto/manual switch on the touchscreen HMI allows operator control of firing rate.

To comply with requirements of insurance underwriters such as Factory Mutual (FM), Industrial Risk Insurers (IRI) or others, additional interlock devices may be used in addition to the circuits mentioned in Section B.

Running Interlock and Limit Circuit

- Low oil pressure switch (LOPS)
- High oil pressure switch (HOPS)

C. SEQUENCE OF OPERATION - OIL OR GAS

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

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

Pre-Purge Cycle - When the burner switch (BS) is turned “on,” and 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.

At the same time, the program relay signals the PLC to drive the air damper actuator to its full open or high fire position. Opening the damper allows a flow of purging air through the boiler prior to the ignition cycle.

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 PLC to drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the sequence will stop and hold until the damper actuator has returned to the low fire position and the low fire relay (LFR) is closed.

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.

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

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: 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.

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 deenergized and pilot flame is extinguished.

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 D) for description of action.



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 personal injury or death

Run Cycle - With main flame established, the program relay releases to modulation and enters the RUN state.

With the controls set for automatic operation, subsequent modulated firing will be based on demand, subject to the combustion curves entered into the PLC during commissioning. The air damper and fuel valves are positioned by individual actuators to provide modulated firing rates.

With the controls in manual mode, firing rate is set by the operator using the Hawk HMI.

Note: Normal operation of the burner should be with the manual-automatic switch in the automatic position. 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. The program relay remains in RUN until demand is satisfied or a limit opened.

Burner Shutdown-Post Purge - The burner will fire until steam pressure or water temperature in excess of demand is generated. With modulated firing, the actuators 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 deenergized, 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 deenergized 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.

D. 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.

Start-up or ignition will not be possible if limit circuit controls or fuel valve interlocks are open. The control will lock out upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit.



The 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.

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 deenergized 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 deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

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 then deenergized. The lockout switch must be manually reset before operation can be resumed. (Refer to the previous caution.)

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 deenergized. The lockout switch must be manually reset before operation can be resumed. (refer to the previous caution).

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, for the most part, is doing its job when it shuts down or refuses to operate. Never attempt to circumvent a safety feature.

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.

CHAPTER 5

Adjustment Procedures

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J. High Gas Pressure Switch	5-6
K. Fuel Oil Pressure and Temperature	5-7
L. Fuel Oil Combustion Adjustment	5-7
M. Low Oil Pressure Switch	5-7

Note: For combustion setup and adjustments, see the manual for the CB Hawk or other control system provided.

Each Cleaver-Brooks boiler is tested for correct operation before shipment from the factory. However, variable conditions such as burning characteristics of the fuel and operating load conditions may require further adjustment after installation to assure maximum operating efficiency and economy.

A combustion efficiency analysis made during the initial start-up will help to determine what additional adjustments are required in a particular installation.

Prior to placing the boiler into 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 has occurred, or that adjustments have not changed during shipment and installation.

The adjustment procedures in Chapter 5 apply to standard components furnished on boilers fired with gas and/or the various grades of oil.

A. BURNER OPERATING CONTROLS

Note: Adjustments to the boiler operating controls should be made by an authorized Cleaver-Brooks Service Technician. Refer to the appropriate boiler Operation and Maintenance manual for specific information on boiler startup and operation.

The term 'controls' is used in this manual to refer to:

- The **Operating Limit** and **High Limit** controls, hardware devices which turn the boiler on and off according to their respective switch settings.
- The **Modulating** and **Flame Safeguard** controls, which provide for modulated firing and burner sequencing/flame supervision. On a standard FLX these functions are managed by an integrated control system comprising both hardware (PLC, Input/Output devices, and touch-screen HMI) and software (programming for the PLC and HMI).

The limit controls are described below; for more information see the documentation provided with the boiler control system.

Operating Limit Control: Senses pressure or temperature and automatically turns the burner on to initiate the startup sequence when required and turns the burner off to initiate the shutdown sequence when the demand is satisfied. The control must be set to initiate startup only at the low-fire position.

High Limit Control: Senses the steam pressure or hot water temperature. It is used as a safety limit to turn the burner off in the event the operating limit control fails. The high limit control should be set sufficiently above the operating limit control to avoid nuisance shutdowns, because it has a manual reset feature

When adjusting or setting controls, first be sure all control devices are securely mounted and level. With the temperature sensing control, make sure the sensing bulb is properly bottomed in its well and is secured against movement. Be sure the connecting tubing is not kinked.

The dial settings are generally accurate, although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading. Always adjust control settings to agree with pressure gauge or thermometer readings. Accurate instrument readings are required. When necessary use auxiliary test equipment to set controls.

Burner controls correctly 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.

The Hawk control system modulates the boiler firing rate according to stored combustion curves. The Firing Graph (see figure below) depicts a typical setting relationship of the operating limit control, modulating control, and the high limit control.

The burner will be “on” whenever the pressure or temperature is less than point B and “off” whenever pressure or temperature is greater than 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 rises above setting A. At that point the switch in the operating limit control will open. As the pressure or temperature drops back to B, the operating limit control closes and the burner will restart. The boiler control system will signal the actuators to be in a low-fire position. If the load demands exceed the low-fire input potential, the controls will increase the firing rate proportionately as pressure or temperature falls toward point D. The controls

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 it is referred to as modulated firing.

Point D represents the maximum firing rate of the burner, or high-fire. In the event pressure or temperature drops while the burner is firing at high-fire, it indicates that the load exceeds the capacity of the boiler.

The Firing Graph shows that point B and point C do not coincide. Extreme load conditions could require the points be closely matched.

When set as shown, with a time lag between B and C, 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.

If points B and C overlap when restart occurs, the burner would drive to a higher firing position immediately after the main flame was proven. It is therefore prudent to set the modulating control a few pounds or degrees below the operating control allowing the Low Fire to “catch the load” before releasing to modulation.

Do not operate the boiler in excess of 90% of the safety valve relief setting. The closer the operating pressure is to the safety valve relief pressure, the greater the possibility of valve leakage. Continued leakage, however slight, will cause erosion and necessitate early safety valve replacement. The control settings on a hot water boiler must be within the temperature limits of the boiler

CAUTION

NOTE: On-off cycling in excess of 8 cycles per hour will shorten the life of the combustion air motor and cause excessive wear on switch gear and pilot electrodes. It also substantially reduces fuel efficiency.

Ideally, the boiler operating controls should be set under actual load conditions. Especially under new construction conditions, 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 maximum utilization, and assuming that air/fuel combustion ratios have been set, make the required adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

Note: It is not recommended that the boiler controls be set so as to overlap the modulation range and operating control range.

Modulation settings should be adjusted 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

Note: Rapid heat input can subject the pressure vessel metal and refractory to undesirable conditions.

B. OPERATING LIMIT TEMPERATURE CONTROL

Set “cut-out” (burner off) temperature on the 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 adjusted from 5 to 30° F.



C. HIGH LIMIT TEMPERATURE CONTROL

Set the “cut-out” (burner off) temperature on scale using the adjusting screw. The control will break the circuit and lock out 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 the water temperature to drop below

the cut-out setting less differential, and then press the manual reset button.



D. LOW WATER CUTOFF DEVICES

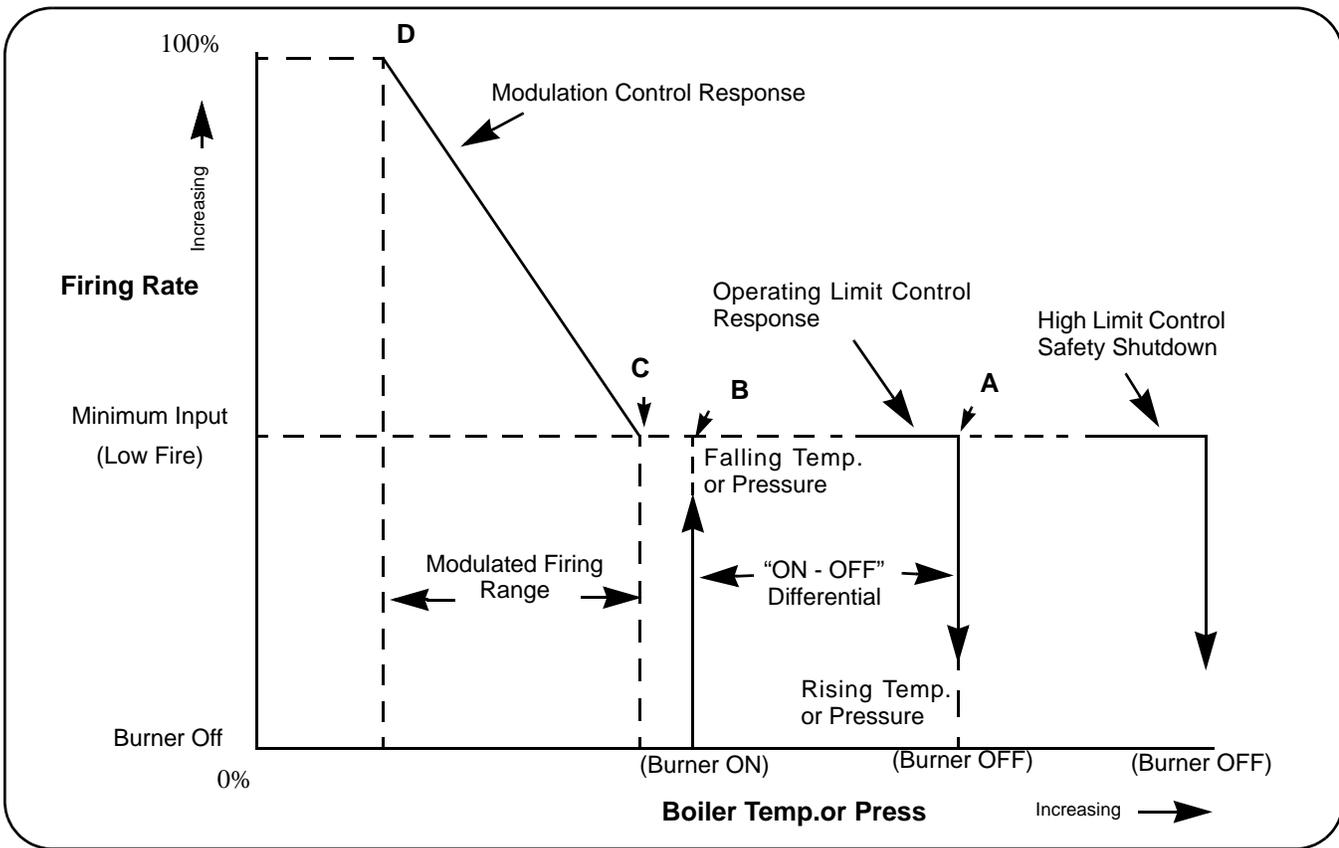
No adjustment is required since LWCO controls are preset by the original manufacturer. However, if the water level is not maintained, inspect the devices immediately and replace as required.

E. COMBUSTION AIR PROVING SWITCH (CAPS)

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 closed, the switch should be adjusted under that situation. It should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The run/test switch on the program relay should be set to TEST. Turn the burner switch on. The blower will start (provided that all limit circuits are completed) and the programmer will remain in the low-fire (damper closed) portion of the prepurge.

Slowly turn down the air switch adjusting screw until it breaks the circuit. Here the programmer will lock out and must be manually reset before it can be restarted. Add a half turn or so to the adjusting screw to remake its circuit.

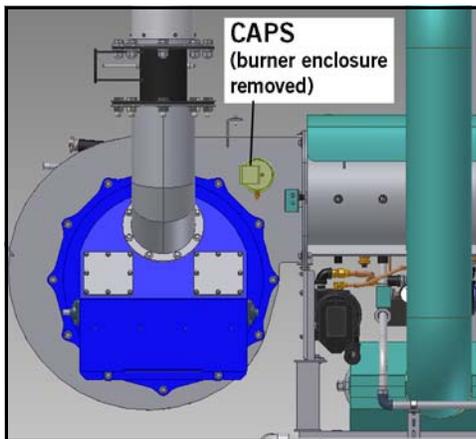


Recycle the program relay to be sure that normal operation is obtained. Return the test switch to the RUN position.

Although it is possible to visibly adjust the size of the pilot flame, it is preferable to obtain a microamp or voltage reading of the flame signal.

The correct voltage or microamp readings can be found in the information supplied with the flame safeguard system.

The program relay used may be of the type that provides message information that includes a constant flame signal of dc voltage. In this case a separate dc voltmeter is not required.



F. GAS PILOT FLAME ADJUSTMENT

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

G. GAS PRESSURE AND FLOW INFORMATION

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

Pressure

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

The pressure required at the entrance to the burner gas train for rated boiler output is termed "inlet pressure." The gas pressure regulator must be adjusted to achieve the pressure to assure full input.

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

The volume of gas flow is measured in terms of cubic feet and is determined by a meter reading. The gas flow rate required for maximum boiler output depends on the heating value (Btu/cu-ft) of the gas supplied.

Pressure Correction

The flow rate is based on a "base" pressure, which is usually atmospheric or 14.7 psia.

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 the 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 Table 5-1.

As An Example:

Assume that a 500 Flextube boiler rated for 5MMBtu/hr input is installed and equipped with a standard gas train; and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The flow requirements can be determined as follows:

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input and "correct" this answer by applying the correction factor for 3 psig (Table 5-1).

$\frac{\text{Btu/hr Input}}{\text{Btu/cu-ft}} = \text{CFH (Cubic feet/hour) Required}$

OR

$\frac{5,000,000}{1,000} = 5,000 \text{ CFH (At 14.7 lb-atmospheric base pressure)}$

THEN

$\frac{5,000}{1.18} = 4237 \text{ CFH}$

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 5,000 CFH (at base pressure) will be delivered.

Checking Gas Flow

Your gas supplier can generally furnish a gas meter flow chart from which gas flow can be determined. After a short observation period, the information aids in adjusting the regulator to increase or decrease flow as required to obtain the rating.

Final adjustment of the gas fuel is carried out by means of fine tuning the combustion settings while performing a combustion efficiency analysis.

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

H. 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.

Burner efficiency is measured by the amount or percentage of O₂ present in the flue gas. O₂ readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion is a term used to describe a condition when there is the exact amount, molecule for molecule, of air for the fuel attempting to be burned. This can be accomplished under laboratory conditions, however it's not practical to attempt to meet this condition in a boiler. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room temperature and atmospheric conditions, and to ensure the combustion is on the proper side of the combustion curve.

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion or flue gas analyzer. The appearance or color of the gas flame is not an indication

of its efficiency, because an efficient gas flame will vary from transparent blue to translucent yellow.

Most flue gas analyzers in use today measure the content, by percentage of oxygen (O_2) and carbon monoxide (CO) either by percent or parts per million (ppm). Carbon dioxide (CO_2) is not normally measured with today's flue gas analyzers, but may be displayed via a calculation.

The O_2 levels through the entire firing range of the burner, low fire to high fire should be tested. Cleaver-Brooks recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding Figure 5-3 shows the relationship between O_2 levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

One of the products of combustion is CO_2 (Carbon Dioxide). This is shown in percentage.

Another product of combustion is CO (carbon monoxide) and is shown in both percentage and parts per million (ppm). The maximum CO level standardly allowed is less than 400 ppm. However, this may change subject to local regulations.

The percent O_2 recorded on an instrument equates to percent excess air, I.E. 3% O_2 is approximately 15% excess air and 4% O_2 is approximately 20% excess air. The exact percentage of excess air is a mathematical calculation based on an ultimate fuel analysis of the fuel being fired.

It is generally recommended that O_2 readings of between 3% to 5% be attained with less than 400 ppm CO, at high fire.

Using information from Section G, determine the standard conditions of gas pressure and flow for the size 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.

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

To reach the high fire rate, manually increase in minor increments while monitoring combustion for overly rich or lean conditions.

At high fire, the gas butterfly valve should be open as wide as indicated by the slot on the end of the shaft.

Determine the actual gas flow from a meter reading. (See Section G) With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following the manufacturer's directions for regulator adjustment.

When proper gas flow is obtained, take a flue gas reading. The O_2 should be between 3% and 5% at high fire.

If the fuel input is correct, but the O_2 values do not fall within this range, the air damper settings may need to be adjusted.

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

After being 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 obtain a constant air/fuel ratio throughout the entire firing range.

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. Standard Burner Low Fire Adjustment

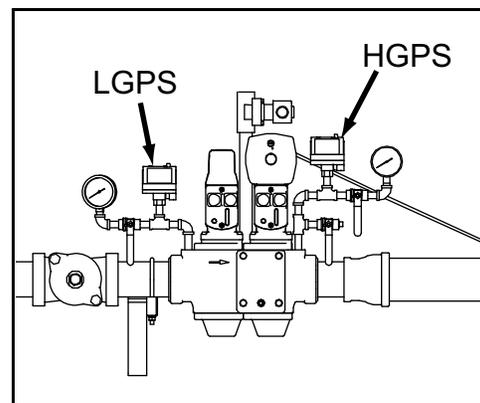
The fuel input should be adjusted using the linkage to approximately 33% of that at high fire. At low fire the O_2 flue gas reading should be between 3-5%.

If the air damper needs to be adjusted in order to provide the correct low fire air/fuel ratio, combustion must be rechecked at higher firing rates and adjusted as required.

I. LOW GAS PRESSURE SWITCH

Adjust the scale setting to slightly below the normal burning pressure. The control circuit will be broken when pressure falls below this point. Since gas line distribution pressure may decrease under some conditions, shutdowns may result if the setting is too close to normal. However, regulations require that the setting may not be less than 50% of the rated pressure downstream of the regulator.

Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored.



J. HIGH GAS PRESSURE SWITCH

Adjust the scale setting to slightly above the normal burning pressure. The control circuit will be broken when pressure exceeds the normal operating pressure. Unnecessary shutdowns may result if the setting is too close to normal; however, regulations require that the setting may not be greater than 150% of rated pressure.

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure returns to normal.

K. FUEL OIL PRESSURE AND TEMPERATURE

Variations in burning characteristics of the fuel oil may occasionally require adjustments to assure highest combustion efficiency. The handling and burning characteristics may vary from one delivery of oil to another. Therefore, it is recommended that the oil system be inspected from time to time to verify that pressures and viscosity are at the proper operating levels.

Because of variation in oils, including chemical content, source, blends, and viscosity characteristics, the temperatures and pressures listed in Chapter 5, and mentioned in the adjusting of the controls in the following paragraphs, will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. Review of the applicable maintenance instructions given in Chapter 7 will aid in maintaining an efficient fuel system.

L. FUEL OIL COMBUSTION ADJUSTMENT

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

Burner efficiency is measured by the amount or percentage of O₂ present in the flue gas. O₂ readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.

There must always be excess air in the combustion process to account for changes in boiler room conditions and to ensure the combustion is on the proper side of the combustion curve.

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. Efficient combustion cannot be solely judged by flame condition or color, although they may be used in making approximate settings. Combustion settings should be done so that there is a bright sharp flame with no visible haze.

Most flue gas analyzers in use today measure the content, by percentage, of oxygen (O₂) and in some cases, smoke. Carbon dioxide (CO₂) is not normally measured with modern gas analyzers, but may be displayed as a calculation.

The O₂ levels through the entire firing range of the burner, low fire to high fire should be tested. Cleaver-Brooks recommendations on turndown should also be followed and the turndown range of the burner should not be exceeded.

It is required to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure, temperature, or burning properties of oil. Fifteen to 20% excess air is considered reasonable. This would result in an O₂ reading of 3% to 4%, at high fire.

Final adjustment to fuel input must be made to produce a minimum of smoke. A maximum smoke spot density of a No. 2 for light oil, as measured in conformance to ASTM D 2156-63T.

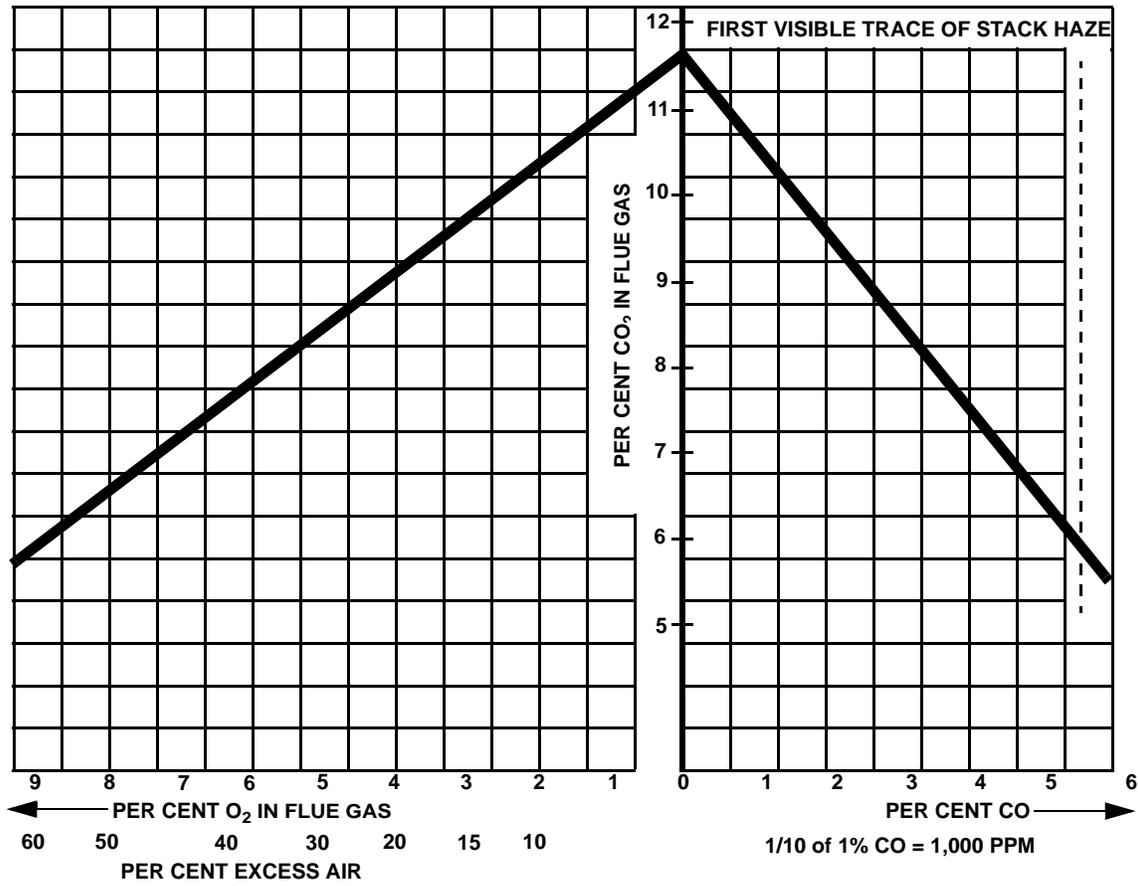
Through the use of the manual flame control, slowly bring the unit to high fire by stages while monitoring combustion for overly rich or lean conditions. At the high fire position, the air damper should be fully opened and the air and oil pressure readings should be on the order of the readings given.

M. LOW OIL PRESSURE SWITCH

The LOPS prevents burner ignition, or stops its operation, when the oil pressure is below the setpoint. Adjust the control by turning the screw on top of control case to an indicated pressure 10 psi below the established primary oil pressure setting indicated on the oil supply pressure gauge. The switch will remain in a closed position as long as the oil pressure exceeds this setting. The control normally used automatically resets when pressure is restored after a drop.

Table 5-1: Pressure correction factor

REGULATOR INLET PRESSURE (PSIG)	PRESSURE FACTOR
1	1.05
2	1.11
3	1.18
4	1.25
5	1.32
6	1.39
7	1.45
8	1.53
9	1.59
10	1.66
11	1.72
12	1.81
13	1.86
14	1.93
15	2.00



O₂ and products of combustion

CHAPTER 6

Troubleshooting

**WARNING**

Troubleshooting should be performed only by personnel who are familiar with the equipment and who have read and understand the contents of this manual. Failure to follow these instructions could result in serious personal injury or death.

**WARNING**

Disconnect and lock out the main power supply in order to avoid the hazard of electrical shock. Failure to follow these instructions could result in serious personal injury or death.

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.

Chapter 6 assumes that the unit has been properly installed and adjusted, and that it has been running for some time. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points under each heading are set down briefly as possible causes, suggestions or clues to simplify locating the source of trouble. Methods of correcting the trouble, once it has been identified, may be found elsewhere in this manual.

If the burner will not start or operate properly, the trouble shooting chapter should be referred to for assistance in pinpointing problems that may not be readily apparent.

The boiler control system has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the controls manual for specifics and suggested remedies.

Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual. Knowledge of the system and its controls will make trouble shooting much easier. Costly down-time or delays can be prevented by systematic checks of actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may

Problem	Solution
BURNER DOES NOT START	1. No voltage at program relay power input terminals. A. Main disconnect switch open. B. Blown control circuit fuse. C. Loose or broken electrical connection.
	2. Program relay safety switch requires resetting.
	3. Limit circuit not completed—no voltage at end of limit circuit program relay terminal. A. Pressure or temperature is above setting of operation control. (Load demand light will not glow.) B. Water below required level. 1). Low-water light (and alarm horn) should indicate this condition. 2). Check manual reset button, if provided, on low-water control. C. Fuel pressure must be within settings of low pressure and high pressure switches.
	4. Fuel valve interlock circuit not completed. A. Fuel valve auxiliary switch not enclosed.
NO IGNITION	1. Lack of spark. A. Electrode grounded or porcelain cracked. B. Improper electrode setting. C. Loose terminal on ignition cable; cable shorted. D. Inoperative ignition transformer. E. Insufficient or no voltage at pilot ignition circuit terminal.
	2. Spark but no flame. A. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc. B. Inoperative pilot solenoid. C. Insufficient or no voltage at pilot ignition circuit terminal. D. Too much air.
	3. Low fire switch open in low fire proving circuit. A. Damper motor not closed, slipped cam, defective switch. B. Damper jammed or linkage binding.
	4. Running interlock circuit not completed. A. Combustion air proving switch defective or not properly set. B. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

Problem	Solution
PILOT FLAME, BUT NO MAIN FLAME	1. Insufficient pilot flame.
	2. Gas Fired Unit. A. Manual gas cock closed. B. Main gas valve inoperative. C. Gas pressure regulator inoperative.
	3. Oil fired unit. A. Oil supply cut off by obstruction, closed valve, or loss of suction. B. Supply pump inoperative. C. No fuel. D. Main oil valve inoperative. E. Check oil nozzle, gun and lines.
	4. Flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.
BURNER STAYS IN LOW FIRE	1. Manual-automatic switch in wrong position.
SHUTDOWN OCCURS DURING FIRING	1. Loss or stoppage of fuel supply.
	2. Defective fuel valve; loose electrical connection.
	3. Flame detector weak or defective.
	4. Lens dirty or sight tube obstructed.
	5. If the programmer lockout switch has not tripped, check the limit circuit for an opened safety control.
	6. If the programmer lockout switch has tripped: A. Check fuel lines and valves. B. Check flame detector. C. Check for open circuit in running interlock circuit. D. The flame failure light is energized by ignition failure, main flame failure, inadequate flame signal, or open control in the running interlock circuit.

Problem	Solution
SHUTDOWN OCCURS DURING FIRING	7. Improper air/fuel ratio (lean fire). A. Slipping linkage. B. Damper stuck open. C. Fluctuating fuel supply. 1). Temporary obstruction in fuel line. 2). Temporary drop in gas pressure. 8. Interlock device inoperative or defective.
EXCESSIVE RUST ON TUBES	1. Condensation of the flue gases on cool tubes is causing rust. A Change system so return temperatures are above 120 °F or install blend pump to assure water temperatures entering boiler are above 120 °F.
	2. Open stack or condensate running down stack or breeching. A. Stack should be offset. Insulate and drain stack.
	3. Frequent cold starts. A. Reset controls for less cycling.
WATER ON BASE	1. A cold environment and/or intermittent firing may allow inner casing to heat up above the condensation temperature of the flue gasses. A. Increase temperature of the cold boiler room if possible. B. Verify insulation is in place between inner and outer casing and replace if missing. C. Reset controls for less cycling to allow boiler to run for longer periods of time to heat inner casing above condensation temperature.
	2. Cold system startup. A. Any time a boiler is started with a cold system, it will produce condensate until internal surface temperatures exceed 130 °F. Internal condensation will not be produced once a boiler has warmed up. Condensate will dry up after a short time. Limit number of cold starts.
	3. Cold return temperatures. A. Return temperatures below 120 °F. will continually produce condensation. Raise return temperatures above 120 °F.
	4. Gasket leaks allow gases to escape and condense on relatively cool base. A. Gasket may need to be replaced or inner casing not installed per instructions. Install inner casing and gasket.

CHAPTER 7

Inspection and Maintenance

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A. GENERAL

A well-planned maintenance program will help to avoid unnecessary downtime or costly repairs, promote safety, and aid boiler inspectors in performing required periodic inspections. 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 safe, economical and lengthy service from your Cleaver-Brooks equipment. It is important to realize that the frequency of inspection will depend on variable conditions such as load, fuel, system requirements, boiler environment, etc.

certain repetitive chores, thus providing more time to devote to upkeep and maintenance.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction, permitting prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks - fuel, water, steam combustion gases - should be investigated and repaired with all due consideration of the necessary safety precautions.

Preventive maintenance measures such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc., should be included in regular maintenance activities.



Shut off electrical power to the boiler when performing any service or maintenance work or work that requires removal of covers or component parts. Failure to heed this warning could result in electrical shock, serious personal injury or death.

Good housekeeping practices help maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust, or repair the boiler and 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.

Even though the boiler has electrical and mechanical devices that make it automatic or semiautomatic in operation, the devices require systematic and periodic maintenance. Any “automatic” feature does not relieve the operator from responsibility. Automatic features do free the operator of



Inspection and maintenance should be performed only by trained personnel who are familiar with the equipment. Failure to heed this warning could result in serious personal injury or death.

Insurance regulations or local codes may require a periodic inspection of the pressure vessel by an authorized inspector. Inspections are usually scheduled for periods of normal boiler downtime such as during an off season. The major inspection can often be used to accomplish maintenance, replacement, or repair tasks 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 the inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the

B. PERIODIC INSPECTION

operator with an excellent opportunity to perform a detailed check of all components of the boiler, including piping, valves, pumps, gaskets, refractory, etc. Complete cleaning, spot painting or repainting, and the replacement of expendable items, should be planned for and taken care of during this time. If possible, any major repairs or replacements that may be required should be taken care of during the boiler shutdown.

Replacement spare parts, if not on hand, should be ordered well in advance of a shutdown.

Note: Cleaver-Brooks genuine parts should be used to ensure proper operation and to avoid damage to the equipment.

Cleaver-Brooks boilers are designed, engineered and built to give long life and excellent service. Good operating practices and consistent maintenance and care will promote efficiency and economy of operation and contribute to many years of reliable performance from the equipment.

Cleaver-Brooks offers a Planned Maintenance Program that covers many of the items included on this chapter. For more information on the Planned Maintenance Program, contact your local Cleaver-Brooks authorized representative.

C. FIRESIDE CLEANING

Soot and other noncombustible deposits are effective insulators and, if allowed to accumulate on boiler heat exchanger surfaces, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can absorb moisture and may attract moisture in the form of corrosive acids that will deteriorate fireside metal.

Inspection and cleanout should be performed at frequent intervals, depending upon the boiler's load, type and quality of fuel, internal boiler temperature, and combustion efficiency. Stack temperature can be used as a guide to determine cleanout intervals, since an accumulation of soot deposits will raise the stack temperature.

Access to the furnace for tube and refractory cleaning is provided through an access port at the rear of the boiler. When opening the burner door, first shut off the electrical and fuel supplies and then disconnect all fuel lines at the burner watching to see that there is no interference with field installed piping, wiring, or other obstructions. A temporary platform must be placed inside the furnace in order to protect the bottom drum insulating refractory when working inside the furnace.



To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight is recommended when working inside the boiler furnace area.

Tubes should be brushed with a wire brush to remove any soot or other accumulations. Refractory surfaces should be cleaned, if necessary, with a soft bristle brush. Loose material should be vacuumed from the bottom of the furnace.

D. UPPER PASS CLEANING

Upper pass access is gained through removal of the inner and outer side casing. To remove the outer casing panels, first disconnect and remove any electrical conduit, boxes and brackets attached to the side outer casing. Match mark the outer panels for repositioning. Remove screw (if installed) from frame above each outer panel. Starting with center panel, slide panel up, swing bottom of panel away from boiler and then slide down from the upper frame and set panel aside. After the center panel(s) are removed, the end panels can be slid (approximately 1") towards the center until they free from the corner frame and then removed in the same manner as the center panel(s). If obstructions are present, such as the gas train, there may not be enough room to slide the panel out from under the upper frame. In this case, unscrew the upper frame from the roof and side frames and remove it also.

Match mark all inner casing panels for repositioning later. To remove inner casing panels, remove nuts, bolts, and washers securing panels.

After removing the inner side casing, remove the insulation blanket covering the 2nd and 4th pass openings. Remove the insulation by starting at one end and carefully rolling it up. The insulation blocks can now be removed from the pass opening. Keep the insulation blocks in order once they have been removed so they can be re-installed in the same position.

Now that the 2nd (left side) and 4th (right side) pass openings are exposed, cleaning can be done in the same way as the furnace area. Since the 3rd pass is only open on the ends, cleaning is done by pushing a wire brush mounted on a long handle, through from each end. Since the arc of movement is restricted, cleaning the 3rd pass must be done from both sides of the boiler. The fifth pass is cleaned from above the tubes. As in the furnace, loose material should be removed by vacuuming after brushing. The pressure vessel should be inspected for any signs of deterioration after cleaning.

The flue outlet and stack should also be inspected annually and cleaned as necessary. Commercial firms are available to perform this work. The stack should also be inspected for damage and repaired as required.

Once everything has been cleaned and inspected the boiler can be put back together. Install insulation blocks in the 2nd and 4th pass openings in their previous positions. Spray adhesive on tubes above and below pass opening and install blanket insulation over opening. If any insulation was removed from under the tubes at bottom of boiler it should be replaced at this time.

To prepare the inner casing panels for installation, first pack the panels with insulation. The insulation should be pushed

from the top and bottom of the panel while tapping the insulation into the panel.

Place a gasket on the side of the panel. It should go the full height of the panel from the top to the bottom. Ensure that the gasket protrudes out the inside wall slightly (approximately 1/16") at the top and the bottom of the panel. It should be just above the holes in the middle of the panel.

NOTE: DO NOT touch the insulation when you are moving the panels. This can cause the insulation to move and undo previous work. Try not to let the insulation touch the boiler until it is in its resting position.

The inner casing panels are to be oriented with the lift eyes at the top.

Panels should be installed starting in the middle. Place the 1st (middle) panel on the base. Install a washer and place the nuts (several turns) on the 2nd and 4th stud. Repeat this at the top of the panel.

Using the silicone, seal the seam of the gaskets at the top and bottom of the center panel.

Install the next two panels by positioning them so that the bottom of the panel is at the same level as the middle panel. Angling it into position first rather than setting the panel on the studs and sliding it into position may be easier. Install the two nuts on the top and bottom, and place the remaining nuts. Repeat as necessary until panels are installed.

Place bolts in the two vertical seams between the panels. Starting at the top of the rear panel and working down, tighten the bolts. Repeat this on the front panel. After finishing this, return to the rear panel and tighten to the bottom; repeat this on the front panel.

Install the nuts and washers around the outside of the wall and evenly pull the panels to the boiler. Start in the middle of the bottom bolts, tighten them working out and stop at the last 4 bolts. Repeat this at the top, front and rear. When you are tightening the remaining bolts, work out to the corners, starting at the inside 8 bolts, then with the next 8 and so on, until you tighten the corners. The bolts should be tightened to a torque of 228 in-lb.

Repeat these steps on the other side of the boiler. The outer casing panels can now be installed starting with the end panels. Slide each end panel under the upper frame and push the bottom section into the boiler and allowing it to slide down to catch the bottom clamp angle. Then slide the end panels under the corner frames and install any remaining center panels.

The fireside should be thoroughly cleaned prior to any extended layup of the boiler. Depending upon circumstances, a protective coating may be required. See Chapter 3, Section H "Preparation for Extended Layup".

E. CONTROLS

Relief Valves

The relief valve is a very important safety device and deserves attention accordingly. Proper removal, installation or handling of a relief valve is of primary importance. Exercise care when removing, installing or handling a relief valve to ensure proper operation, long service life, and to ensure that the valve functions as designed.

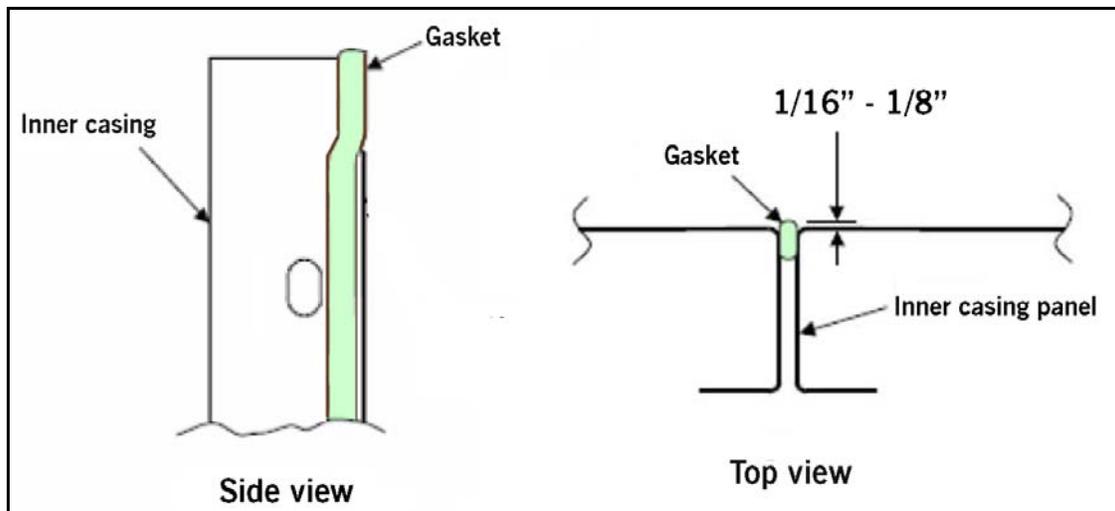


Figure 7-1 Gasket application to inner casing



Improper removal, handling or installation of a relief valve may adversely affect the valve's operation, resulting in serious personal injury or death.

Observe the following precautions when removing, handling or installing relief valves.

- Use only flat jawed wrenches on the flats of the valve
- Do not use a pipe threaded into the outlet to turn a valve
- Apply only a moderate amount of pipe compound to male threads
- Avoid over tightening, which can distort valve seating surfaces
- Do not paint, oil or otherwise cover any interior or working parts of the valve. A relief valve does not require any lubrication or protective coating to work properly.
- Discharge piping must be properly arranged and supported so that its weight does not bear on the relief valve.
- Handle with care a valve that has been removed from the boiler. A dropped valve should be considered as damaged until it has been inspected and passed by the valve manufacturer's authorized representative.



Only properly certified personnel such as the relief valve manufacturer's representative should adjust or repair the boiler relief valves. Failure to heed this warning could result in serious personal injury or death.

Relief valves should be operated only often enough to assure that they are in good working order. Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency and method of testing should be based on the recommendation of your boiler inspector and/or the valve manufacturer, and should be in accordance with Section IV of the ASME Boiler and Pressure Vessel Code.

Low Water Controls (Hot Water)

Most instances of major boiler damage result from operating with low water. Since low water cutoff devices are set by the original manufacturer, no attempt should be made to adjust these controls in order to alter the point of low water cutoff. If a low water cutoff should become erratic in operation, immediately replace it or contact your local Cleaver-Brooks authorized representative for assistance.

It is essential to verify proper operation of low water cutoff devices as frequently as possible. However, it is impractical to perform daily and monthly maintenance on some models of the low water cutoff devices on a hot water boiler. Hot water systems are fully closed. Daily or monthly maintenance on some models of the low water cutoff devices would involve draining the entire water content of the system and would require makeup and additional feedwater treatment that might not otherwise be necessary.

To verify the proper operation of float style low water cutoff devices, the system must be drained. Remove the operating mechanism from the bowl and check and clean the float ball, internal moving parts, and the bowl housing. Also, check the cross-connecting piping to make certain that it is clean and free of obstruction.

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



Safe operation of your boiler demands periodic inspection and maintenance of all low water cutoff devices. If controls do not shut off the burner when the water level drops below the safe operating level, or if controls appear in poor physical condition, or become erratic in operation, they must be repaired or replaced at once. Failure to heed this warning could result in serious personal injury or death.

If test-n-check valves are installed on the float style low water cutoff devices, these controls can be tested by opening the blow down valve. The test-n-check valves restrict water flow when the blow down valve is open allowing water to drain from the control. The test-n-check valves permit testing of the control without draining the entire system therefore allowing regularly scheduled verification of float style low water cutoff.

Water Gauge Glass

A broken or discolored glass must be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use "loose packing."

which could be forced below the glass and possibly plug the valve opening.

Close the valves when replacing the glass. Slip a packing nut, a packing washer, and packing ring onto each end of the glass. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.

If the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by cracking the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.

Check trycocks and gauge cocks for freedom of operation and clean as required.

It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

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

Electrical Controls

The operating controls should be inspected monthly. Examine the tightness of electrical connections and keep the controls clean. Remove any dust that accumulates on the interior of the controls using low pressure air that is free of moisture and oil. Take care not to damage the mechanism.

Make certain that controls are correctly leveled. Covers should remain on controls and panels at all times. Dust and dirt can cause excessive wear or overheating of the motor stator and the relay contacts, and affect operation of other controls. The power supply to the boiler must be protected with dual element fuses (fusetrans) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended.

Flame Safeguard Control

This control requires minimal maintenance because the safety and logic sections are integral and inaccessible, with no accessible contacts. Regularly check to see that the retaining screws holding the chassis to the mounting base are secure, and that the amplifier and the program module are securely inserted.

It is recommended that a spare control be kept on hand and service be rotated between the active and the spare control (programmer).

Note: NOTE: Be sure that the connecting contacts on the control and the base are not bent out of position.



When replacing a control, be sure to lock out the main power supply, since the control is “hot” even though the burner switch is off. Failure to heed this warning could result in serious personal injury or death.

Your spare control should be wrapped in plastic and stored in a dry atmosphere. During an extended shutdown (for example, a seasonal shutdown), the active control should be removed and stored in a dry atmosphere. Moisture can cause problems with control operation.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth moistened with detergent to clean the lens.

A safety check procedure should be established to test the complete flame safeguard system at least once a month. Tests should verify safety shutdown and a safety lockout upon failure to ignite the main flame and upon loss of flame. Each of these conditions should be checked on a scheduled basis. Refer to the burner manual for information regarding tests of the flame safeguard system. Contact your local Cleaver-Brooks authorized representative for assistance, if required.

Checking Loss of Flame

With the burner in normal operation at the low fire rate, shut off the main burner fuel valve to interrupt the fuel supply and extinguish the main flame.

The relay must signal the loss of flame, resulting in the fuel valve(s) being deenergized. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will stop.

Turn the burner switch off. Reset the safety switch. Reestablish the main fuel supply.

F. OIL BURNER MAINTENANCE

Refer to the burner sections for specific information regarding operation and maintenance of the burner.

Oil strainers should be serviced frequently in order to maintain a free and full flow of fuel to the burner. Installation of a vacuum gauge in the burner supply line between the burner oil pump and the strainer is strongly recommended. Regular observation and recording of the gauge indication will assist in determining when the strainer needs servicing.

Strainer Servicing

The fuel oil strainer element must be removed and cleaned or replaced at regular intervals, or when a rising trend in the burner supply pump suction indicates blockage. When

servicing the strainer, fuel supply and return line valves should be shut off. The strainer should be drained of oil and any sediment collected at the bottom of the canister. Remove the cover and withdraw the strainer element. Replaceable elements should be disposed of properly. Reusable elements may be cleaned by immersing them in solvent until attached deposits have been loosened, and then shaking them dry.



Use only safety type solvents for cleaning strainers or other components. Work only in a well ventilated area. Do not use gasoline or other flammable liquids as a solvent. Do not dry the strainer elements with compressed air. Failure to heed this warning could result in serious personal injury or death.

Reassemble the strainer, taking care to seal the canister properly to avoid air infiltration and resulting loss of suction. Open the fuel supply and the return line valves.

G. GAS BURNER MAINTENANCE

Refer to the burner sections for specific information regarding operation and maintenance of the burner. The motorized gas valve requires little maintenance, as the operating mechanism is immersed in oil and completely sealed. However, proper operation should be checked on a routine basis.

Keep the outer parts of the valve(s) clean, especially the stem between the operator and the valve. A nicked, scored, or otherwise damaged valve stem can cause leakage. Do not remove dust covers if installed.

The stem packing gland is the O-ring type. If oil is noticed around the operator base, or if leakage occurs, the valve must be repaired. If the actuator is sluggish or fails to operate, and the oil level is known to be correct, the operator portion should be replaced.

Solenoid Valves

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

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

Solenoid coils can be replaced without removing the valve from the line.



Be sure to disconnect the main power supply to the boiler in order to prevent the possibility of electrical shock, which could result in serious personal injury or death.

Check the coil position and make sure that any insulating washers or retaining springs are reinstalled in the proper order.

H. REFRACTORY

The boiler is shipped with completely installed refractory. High temperature refractory lines the burner door and floor of the boiler. Front and rear walls, side casing panels, the roof section, the bottom drum and the drum vent are protected with high temperature insulation. Preventive maintenance through periodic inspection will keep the operator aware of the condition of the refractory and insulation and will guard against unexpected downtime for repairs.

I. CASING SEALS

The most obvious indication of a problem is the appearance of discolored paint on the casing or soot and hot gases escaping at seal joints. It is important that at start-up any problems are noted and corrected before the boiler is put back into operation. The following are areas requiring inspection.

Burner Dry Oven

Inspect the area around the dry oven and look for discolored paint or evidence of combustion gas leakage. If a problem is noted look for warped sealing surfaces and make sure that the insulation on the front wall around the dry oven has not pushed away from the wall. Cracks may appear in the burner dry oven refractory as a result of expansion and contraction from operation. If cracks are larger than 1/8" when the refractory is cooled, the cracks should be filled with a high temperature bonding air-dry mortar such as Cleaver- Brooks "Corline."

Access to the boiler furnace area is gained through an access port at the rear of the boiler

Drum Seals

Inspect the areas around the drum seals and look for soot or hot gas leaks. If a problem is noted look for the source of the leak. Remove the old insulation and sealant from around the drum. Using a pumpable insulation material (p.n. 872-680), fill the void flush with the outside of the wall. Allow the area to set up and apply a thick bead of high temperature silicone around the drum and install the cover plates.

Sight Port

Inspect the area around the sight port for paint discoloration. A hot spot around the rear sight port is caused by either a poor seal between the sight port insulator and the wall, a cracked insulator or a flue gas leak at the sight port cap.

Check the threads of the cap and sight tube. If necessary, clean the threads and/or replace the cap. If the screws that hold the sight glass retainer in place are leaking tighten the screws or replace the cap.

CHAPTER 8

Parts

FLX 1250-2500 Hot Water

Recommended Spare Parts List	8-2
Outer Casing	8-3
Inner Casing,	8-4
Temperature Controls	8-7
Level Controls.	8-8
EV Burner	8-9

RECOMMENDED SPARE PARTS LIST

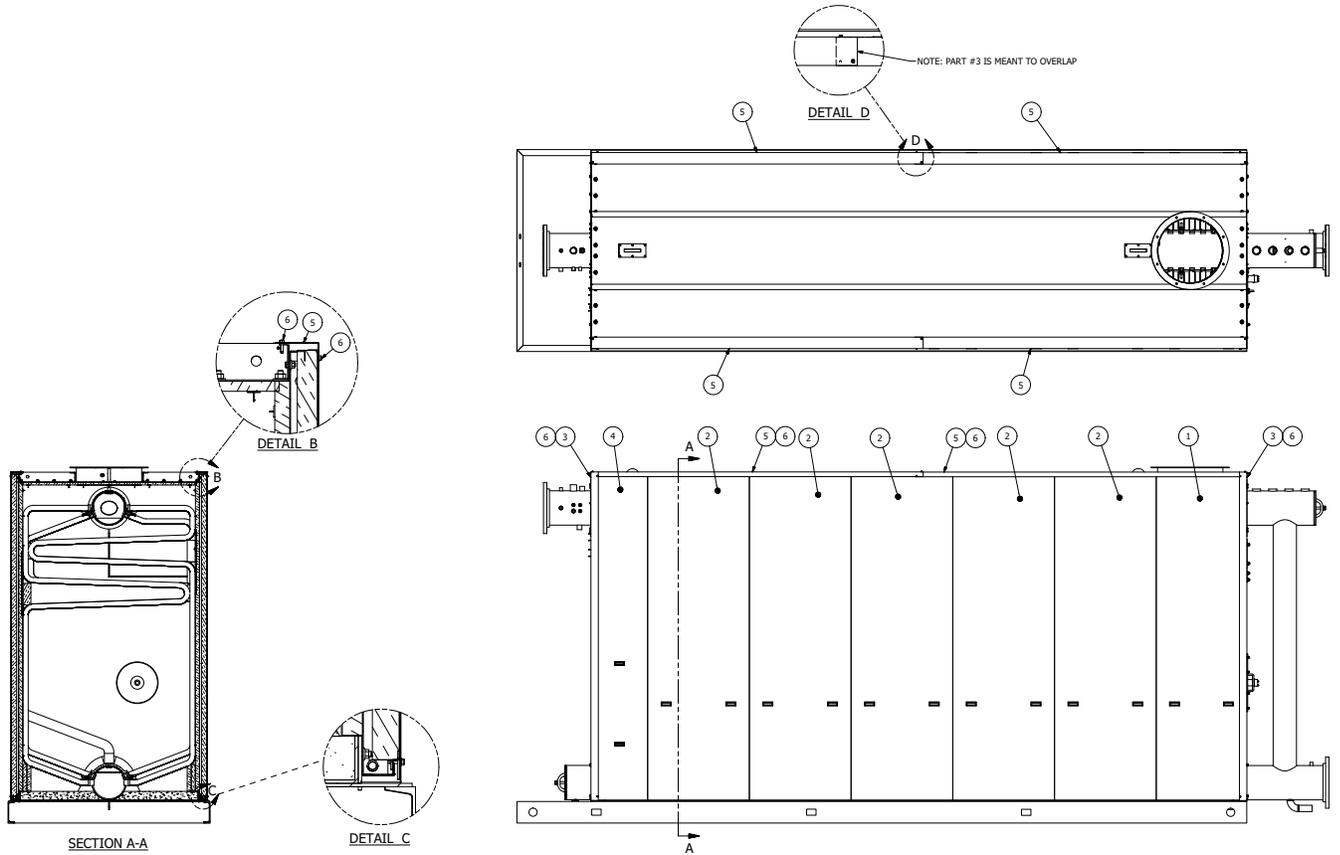
Item	1250	1450	1650	1850	2100	2500
HANDHOLE GASKETS	853-00973	853-00973	853-00973	853-00973	853-00973	853-00973
REAR ACCESS PLUG GASKET	853-00996	853-00996	853-00996	853-00996	853-00996	853-00996
BURNER GASKET	see table					
GASKET, INNER CASING	see table					
FUSE, BLOWER MOTOR	see table					
IR SCANNER	817-04133	817-04133	817-04133	817-04133	817-04133	817-04133
SIGHT GLASS	550-00042	550-00042	550-00042	550-00042	550-00042	550-00042

Burner Gasket P/N 853-00996	1250	1450	1650	1850	2100	2500
Qty inches	186	186	202	202	228	228

Inner Casing Gasket P/N 032-02560	1250	1450	1650	1850	2100	2500
Qty feet	175	180	220	225	260	290

Blower Motor Fuse		1250	1450	1650	1850	2100	2500
230V/3 phase/60Hz	Uncontrolled NOx	832-1847	832-1848	832-1847	832-1848	832-1848	832-1850
	30 PPM	832-1848	832-1848	832-1848	832-1850	832-1848	832-1852
460V/3 phase/60Hz	Uncontrolled NOx	832-1842	832-1844	832-1842	832-1844	832-1844	832-1847
	30 PPM	832-1844	832-1844	832-1844	832-1847	832-1844	832-1848
575V/3 phase/60Hz	Uncontrolled NOx	832-1841	832-1843	832-1841	832-1843	832-1843	832-1845
	30 PPM	832-1843	832-1843	832-1843	832-1845	832-1843	832-1845

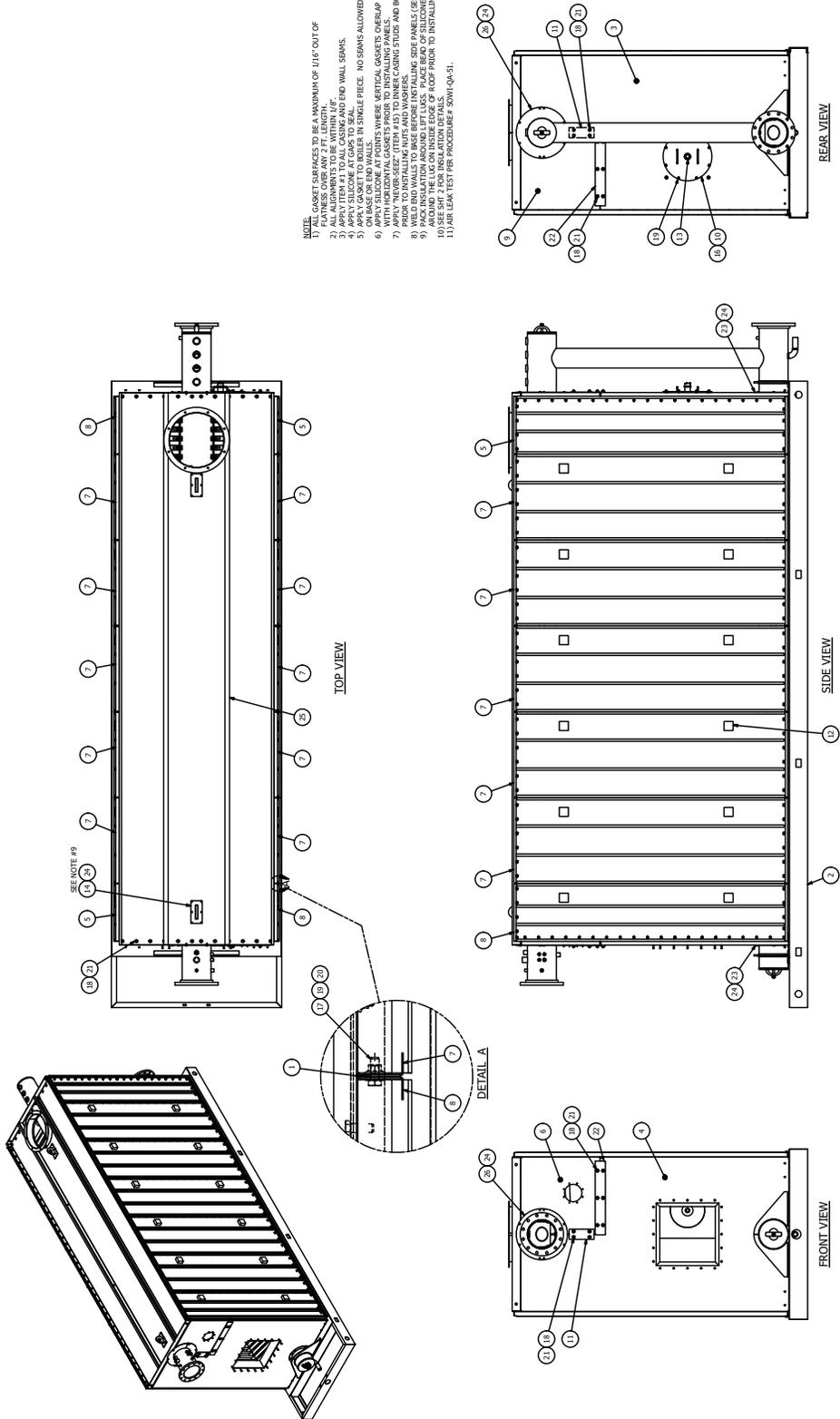
Outer Casing



ITEM	DESCRIPTION	1250		1450		1650		1850		2100		2500	
		PART #	QTY										
1	CASING PANEL, OUTER SIDE, REAR	-	-	105-12326	1	-	-	-	-	-	-	105-12341	1
2	CASING PANEL, OUTER SIDE, MIDDLE	105-12217	8	105-12217	6	105-12360	10	105-12360	10	105-12252	10	105-12252	10
3	OUTER CASING, SIDE CORNER	315-01187	4	315-01187	4	105-12362	4	105-12362	4	105-12254	4	105-12254	4
4	CASING PANEL, OUTER SIDE, FRONT	105-12216	2	105-12229	2	105-12359	2	105-12373	2	105-12251	2	105-12260	2
5	OUTER CASING, TOP CORNER	105-12219	4	105-12230	4	105-12361	4	105-12374	4	105-12253	4	105-12261	4
6	SCREW, SELF TAPPING	841-00423	24	841-00423	24	841-00423	24	841-00423	24	841-00423	24	841-00423	24

Inner Casing

- NOTE:**
- 1) ALL GASKET SURFACES TO BE A MAXIMUM OF 1/16" OUT OF SQUARE.
 - 2) ALL ALIGNMENTS TO BE WITHIN 1/16".
 - 3) APPLY ITEM #1 TO ALL CASING AND END WALL SEAMS.
 - 4) APPLY ITEM #2 TO ALL CASING AND END WALL SEAMS.
 - 5) APPLY GASKET TO BOLTER IN SINGLE PIECE. NO SEAMS ALLOWED ON BASE OR END WALLS.
 - 6) APPLY GASKET TO BOLTER IN SINGLE PIECE. NO SEAMS ALLOWED WITH HORIZONTAL GASKETS PRIOR TO INSTALLING PANELS.
 - 7) APPLY GASKET TO BOLTER IN SINGLE PIECE. NO SEAMS ALLOWED PRIOR TO INSTALLING NUTS AND WASHERS.
 - 8) WELD END WALLS TO BASE BEFORE INSTALLING SIDE PANELS (SEE SHIT 2).
 - 9) WELD END WALLS TO BASE BEFORE INSTALLING SIDE PANELS (SEE SHIT 2).
 - 10) SEE SHIT 2 FOR INSULATION DETAILS.
 - 11) FOR LIGHT TEST PER PROCEDURE P-2004 (Q8-51).



Inner Casing cont'd

Inner Casing cont'd

ITEM	DESCRIPTION	1250	1450	1650	1850	2100	2500	QTY
1	GASKET, EXPANDED PTFE	032-02560	032-02560	032-02560	032-02560	032-02560	032-02560	260 FT
2	BASE, ASSEMBLY	003-02522	003-025635	003-02526	032-02560	032-02560	032-02560	1
3	END WALL ASSEMBLY, REAR, LOWER	105-12204	105-12204	105-12365	105-12365	105-12223	105-12223	1
4	END WALL ASSEMBLY, FRONT, LOWER	105-12203	105-12203	105-12364	105-12364	105-12222	105-12222	1
5	CASING PANEL, INNER, SIDE, FRONT AND REAR	105-12206	105-12209	105-12367	105-12375	105-12225	105-12257	2
6	END WALL ASSEMBLY, FRONT, UPPER	105-12237	105-12237	105-12363	105-12363	105-12256	105-12256	1
7	END WALL ASSEMBLY, FRONT, UPPER, w/FGR	105-12442	105-12442	105-12444	105-12444	105-12255	105-12255	1
8	CASING PANEL, INNER, SIDE	105-12208	105-12208	105-12369	105-12369	105-12228	105-12228	10
9	END WALL ASSEMBLY, REAR, UPPER	105-12205	105-12205	105-12366	105-12366	105-12224	105-12224	1
10	REAR END WALL ACCESS PANEL	105-12165	105-12165	105-12165	105-12165	105-12165	105-12165	1
11	MOUNTING PLATE	105-12220	105-12220	105-12346	105-12346	105-12189	105-12189	2
12	INNER CASING SPACER BLOCK	315-01336	315-01336	16	315-01336	20	315-01336	24
13	SIGHT PORT ASSEMBLY	550-00042	550-00042	1	550-00042	1	550-00042	1
14	PLATE, COVER, LUG, LIFTING	315-01099	315-01099	2	315-01099	2	315-01099	2
15	NEVER-SEEZ, 16 OZ. CAN	797-01816	797-01816	1	797-01816	1	797-01816	1
16	ROPE, FIBERGLASS	853-00996	853-00996	5 FT	853-00996	5 FT	853-00996	5 FT
17	CAPSCREW, 3/8-16 UNC	868-00056	868-00056	112	868-00056	160	868-00056	228
18	NUT, HEX HD, 1/2"-13 UNC	869-00144	869-00144	32	869-00144	36	869-00144	44
19	LOCKNUT, 3/8"-16 UNC	869-00510	869-00510	288	869-00510	356	869-00510	410
20	WASHER, FLAT, 3/8	952-00106	952-00106	112	952-00106	160	952-00106	190
21	WASHER, FLAT, 1/2	952-00286	952-00286	32	952-00286	36	952-00286	44
22	MOUNTING PLATE	315-01143	315-01143	2	315-01143	2	315-01397	2
23	SEALING PLATE, LOWER, OUTER	105-12443	105-12443	2	105-12443	2	105-12447	2
24	SCREW, SELF TAPPING, 1/4	841-00423	841-00423	40	841-00423	40	841-00423	40
25	ROOF ASSEMBLY	105-12211	105-12231	1	105-12370	1	105-12377	1
26	PLATE, COLLAR, UPPER, OUTER	315-01210	315-01210	2	315-01210	2	315-01210	2
27	PYRO-LOG	872-00911	872-00911	14	872-00911	16	872-00911	17
28	INSULATION, WET PACK	872-00782	872-00782	5	872-00782	6	872-00782	7
29	INSULATION BLANKET 1-1/2" 2400 deg F	SEE TABLE						
30	INSULATION BLANKET 1-1/2" 2400 deg F	SEE TABLE						
31	PUMPABLE CERAWOOL	094-00474	094-00474	8 LB	094-00474	8 LB	094-00474	10 LB
32	PLATE, COLLAR, UPPER, INNER	315-01183	315-01183	2	315-01183	2	315-01183	2
33	RETAINING PLATE, LOWER, INNER	105-12332	105-12332	4	105-12332	4	105-12327	4

ITEM	QTY	PART #	1250	1450	1650	1850	2100	2500
29	4	872-00500	1-1/2" x 6" x 142" LG	1-1/2" x 6" x 157" LG	1-1/2" x 8" x 172" LG	1-1/2" x 8" x 186" LG	1-1/2" x 11" x 200" LG	1-1/2" x 11" x 230" LG
30	2	872-00500	1-1/2" x 24" x 142" LG	1-1/2" x 24" x 157" LG	1-1/2" x 24" x 172" LG	1-1/2" x 24" x 186" LG	1-1/2" x 24" x 200" LG	1-1/2" x 24" x 230" LG

Temperature Controls

200-250# H.W. ASSEMBLY # 507-09039		
REQ.	PART NO.	DESCRIPTION
1	817-4292	CONTROL, OPER. LIMIT, TEMPERATURE, AUTO RESET
1	817-4289	CONTROL, HIGH LIMIT, TEMPERATURE, MANUAL RESET
1	817-3354	CONTROL, MODULATING
2	817-699	WELL, SEPARABLE, 3/4" NPT, W/CLAMP & SEAL 3-1/4" LGTH.
1	937-772	WELL SEPARABLE, 3/4" NPT, W/CLAMP & SEAL 6" LGTH.
1	8-3269	MOUNTING BRAKET, TEMP. CONTROLS (13-7/8"L X 6"W X 1"H)

200-250# H.W. ASSEMBLY # 507-09040		
*OPTIONAL HIGH LIMIT CONTROL - MANUAL RESET		
1	817-4289	CONTROL, HIGH LIMIT, TEMPURATURE, MANUAL RESET
1	817-699	WELL SEPARABLE, 3/4" NPT, W/CLAMP & SEAL 3 1/4" LGTH.
1	008-3273	MOUNTING BRAKET, OPTIONAL TEMP. CONTROL (4"L X 4"W X 1"H)

160# H.W. ASSEMBLY # 507-08467		
REQ.	PART NO.	DESCRIPTION
1	817-400	CONTROL, OPER. LIMIT, TEMPERATURE, AUTO RESET
1	817-2402	CONTROL, HIGH LIMIT, TEMPERATURE, MANUAL RESET
1	817-3354	CONTROL, MODULATING
2	817-405	WELL, SEPERABLE, 1/2" NPT, W/CLAMP & SEAL 3-3/8" LGTH COPPER
1	817-378	WELL SEPERABLE, 3/4" NPT, W/CLAMP & SEAL 4-1/4" LGTH COPEPR
1	8-3269	MOUNTING BRAKET, TEMP. CONTROLS (13-7/8"L X 6"W X 1"H)

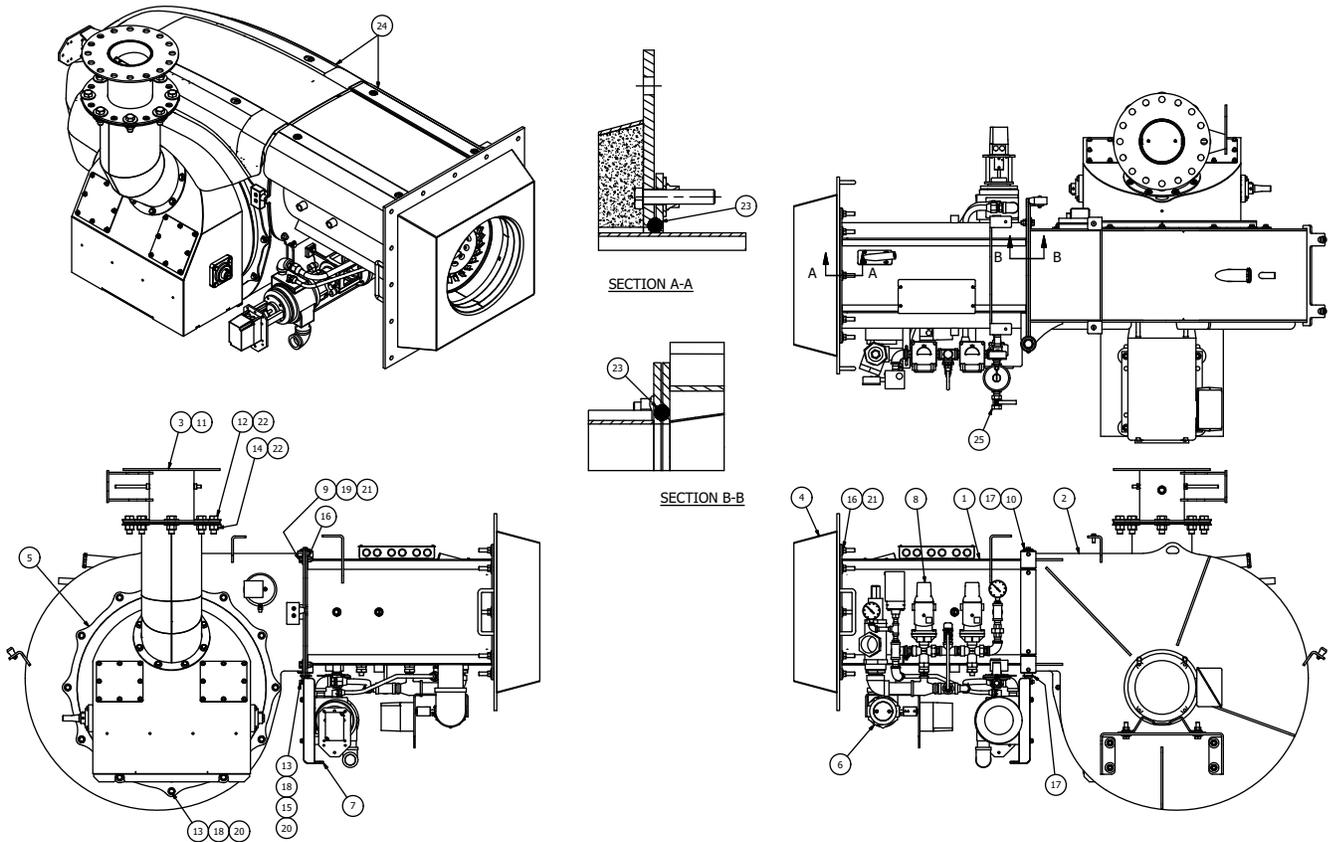
160# H.W. ASSEMBLY # 507-08620		
*OPTIONAL HIGH LIMIT CONTROL - MANUAL RESET		
1	817-2402	CONTROL, HIGH LIMIT, TEMPURATURE, MANUAL RESET
1	817-405	WELL SEPERABLE, 1/2" NPT, W/CLAMP & SEAL 3-3/8" LGTH COPEPR
1	008-3273	MOUNTING BRAKET, OPTIONAL TEMP. CONTROL (4"L X 4"W X 1"H)

160# H.W. ASSEMBLY # 507-08626		
*OPTIONAL HIGH LIMIT CONTROL - AUTO RESET		
1	817-400	CONTROL, HIGH LIMIT, TEMPURATURE, AUTO RESET
1	817-405	WELL SEPERABLE, 1/2" NPT, W/CLAMP & SEAL 3-3/8" LGTH COPEPR
1	008-3273	MOUNTING BRAKET, OPTIONAL TEMP. CONTROL (4"L X 4"W X 1"H)

EV Burner

ITEM	QTY	PART NO.	DESCRIPTION
1	1	SEE TABLE	BURNER HOUSING / FIRING HEAD
2	1	SEE TABLE	HOUSING-ASSEMBLY, FAN
3	SEE TABLE	SEE TABLE	VALVE-WELDMENT,FGR
4	1	SEE TABLE	DRY OVEN
5	1	SEE TABLE	DAMPER-ASSEMBLY, INLET, AIR
6	1	SEE TABLE	PIPING-GAS, 2-1/2" METERING VALVE
7	1	085-04088-000	BRACKET, SUPPORT
8	1	700-00704-000	PIPING-ASSEMBLY, OIL TRAIN AND PUMP
9	2	868-00102	CAPSCREW, 1/2-13 x 1-1/2" LG. HEX HEAD
10	1	056-00272	PIN, HINGE
11	"A"	853-00610-000	GASKET, RING, 8"-150#, 1/16" THK. X 8-5/8" ID X 11" OD
12	8	868-00197-000	SCREW, CAP, 3/4-10 X 2" LG
13	"B"	868-00232	CAP SCREW, 3/8-16 x 1-1/4 LG., HEX HEAD

ITEM	QTY	PART NO.	DESCRIPTION
14	8	869-00018	NUT, 3/4-10
15	4	869-00207	NUT, SPINLOCK, 3/8-16, HEX
16	10	869-00209	NUT, SPINLOCK, 1/2-13, HEX
17	2	914-00205	RING, SNAP
18	"C"	952-00093	WASHER, LOCK, 3/8"
19	2	952-00094	WASHER, LOCK, 1/2" ZINC
20	"D"	952-00106	WASHER, FLAT, 3/8"
21	10	952-00108	WASHER, FLAT, 1/2"
22	16	952-00272A	WASHER, FLAT, 3/4"
23	2	853-00996-000	ROPE, FIBERGLASS, 1/2" DIA. X "E" LG.
24	1	656-10024-000	INSTALL, BURNER ENCLOSURE
25	1	185-01807-000	PIPING, GAS, PILOT



EV Burner cont'd

BOILER MODEL	BURNER MODEL	Nox RATING	BURNER ASSY
FLX 1250	EV-125	STANDARD	829-03044-000
	LNEV-125	30 PPM	829-03045-000
	NTEV-125	9 PPM	829-03064-000
FLX 1450	EV-145	STANDARD	829-03046-000
	LNEV-145	30 PPM	829-03047-000
	NTEV-145	9 PPM	829-03065-000
FLX 1650	EV-165	STANDARD	829-03052-000
	LNEV-165	30 PPM	829-03053-000
	NTEV-165	9 PPM	829-03066-000
FLX 1850	EV-185	STANDARD	829-03054-000
	LNEV-185	30 PPM	829-03055-000
	NTEV-185	9 PPM	829-03067-000
FLX 2100	EV-210	STANDARD	829-03048-000
	LNEV-210	30 PPM	829-03049-000
	NTEV-210	9 PPM	829-03068-000
FLX 2500	EV-250	STANDARD	829-03050-000
	LNEV-250	30 PPM	829-03051-000
	NTEV-250	9 PPM	829-03069-000

BURNER MODEL	ITEM #1	ITEM #2	ITEM #3	ITEM #4	ITEM #5	ITEM #6
EV-125	040-01001-000	040-01013-000	-	279-00628-000	656-10044-000	185-01178-000
LNEV-125	040-01010-000	040-01037-000	194-00241-000	279-00628-000	656-09949-000	185-01178-000
NTEV-125	040-01049-000	040-01022-000	194-00107	279-00628-000	656-09949-000	185-01178-000
EV-145	040-01001-000	040-01021-000	-	279-00628-000	656-10044-000	185-01178-000
LNEV-145	040-01010-000	040-01022-000	194-00241-000	279-00628-000	656-09949-000	185-01178-000
NTEV-145	040-01049-000	040-01057-000	194-00107	279-00628-000	656-09949-000	185-01178-000
EV-165	040-01005-000	040-01028-000	-	279-00658-000	656-10042-000	185-01178-000
LNEV-165	040-01027-000	040-01030-000	194-00107	279-00658-000	656-09916-000	185-01178-000
NTEV-165	*	*	*	*	*	*
EV-185	040-01005-000	040-01032-000	-	279-00658-000	656-10042-000	185-01178-000
LNEV-185	040-01027-000	040-01034-000	194-00107	279-00658-000	656-09916-000	185-01178-000
NTEV-185	*	*	*	*	*	*
EV-210	040-01003-000	040-01014-000	-	279-00635-000	656-10042-000	185-01193-000
LNEV-210	040-01008-000	040-01015-000	194-00107	279-00635-000	656-09916-000	185-01193-000
NTEV-210	040-01044-000	040-01045-000	194-00107	279-00635-000	656-09916-000	185-01193-000
EV-250	040-01003-000	040-01016-000	-	279-00635-000	656-10042-000	185-01193-000
LNEV-250	040-01008-000	040-01017-000	194-00107	279-00635-000	656-09916-000	185-01193-000
NTEV-250	040-01044-000	040-01047-000	194-00107	279-00635-000	656-10036-000	185-01193-000

* Not available at present release

BURNER MODEL	ITEM #11 "A"	ITEM #13 "B"	ITEM #18 "C"	ITEM #20 "D"	ITEM #23 "E"
EV-125	-	16	16	16	48"
LNEV-125	1	16	16	16	48"
NTEV-125	1	16	16	16	48"
EV-145	-	16	16	16	48"
LNEV-145	1	16	16	16	48"
NTEV-145	1	16	16	16	48"
EV-165	-	9	9	9	52-3/4"
LNEV-165	1	9	9	9	52-3/4"
NTEV-165					
EV-185	-	9	9	9	52-3/4"
LNEV-185	1	9	9	9	52-3/4"
NTEV-185					
EV-210	-	9	9	9	59-3/4"
LNEV-210	1	9	9	9	59-3/4"
NTEV-210	1	9	9	9	59-3/4"
EV-250	-	9	9	9	59-3/4"
LNEV-250	1	9	9	9	59-3/4"
NTEV-250	1	9	9	9	59-3/4"



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