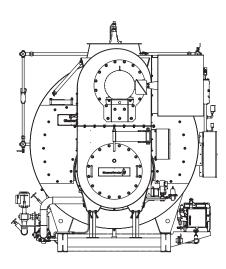


# **CBEX Premium**

Packaged Boiler 900-1200 HP

**Operation and Maintenance** 



Manual Part No. 750-367

10/2013



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 alleviate certain repetitive chores, allowing more time for proper upkeep of the 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 the 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.

It is essential to obtain the services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices.

The operation of this equipment must comply with all requirements or regulations of the owner's 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	Basics
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### 1.1 — Overview

CBEX Premium boilers are available for steam applications ranging from 100 to 1200 horsepower. Basic construction consists of a cylindrical vessel with horizontal tubes passing through and connected to the front and rear tube sheets. The vessel contains the water and absorbs the energy generated from the flame.

The CBEX Premium is a 2-pass water-back design with a rear access port for inspection and maintenance.

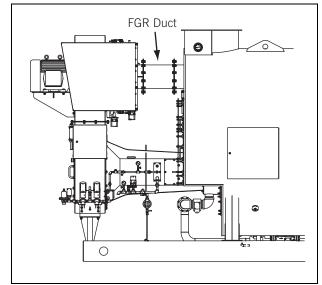
The front door provides the seal to contain the hot combustion gases. The flame originates in the furnace. As the combustion gases travel down the furnace and through the various firetube channels, heat from the flame and combustion gases is transferred to the water.

Transferred energy develops into the required steam. The primary purpose of the boiler is to supply energy to the facility's operations — for heat, manufacturing processes, laundry, kitchen, etc. The nature of the facility's operation will dictate whether a steam or hot water boiler should be used.

This manual applies to CBEX Premium boilers ranging from 900 through 1200 boiler horsepower for the following fuels:

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





For lower emissions the CBEX Premium Firetube Boiler line is designed to incorporate Induced Flue Gas Recirculation (IFGR). IFGR may be used when firing either natural gas and/ or light oil, and is compatible with both hot water and steam systems.

The low emission option for the CBEX Premium line of Firetube Boilers reduces Nitrogen Oxide (NOx) emissions, a major contributor to ozone pollution (smog). Carbon Monoxide (CO) emissions also tend to be lower due to increased turbulence caused by the addition of the flue gases into the combustion air stream.

FIGURE 1-1. Induced Flue Gas Recirculation (IFGR)

The IFGR system mixes a portion of the relatively cool flue gas from the exit of the second-pass tubes with the incoming combustion air to reduce the furnace flame temperature, thereby reducing NOx emissions. In this approach, the combustion air fan handles both the combustion air and the recirculated flue gases.

The low emission design, with its various levels of IFGR systems, can affect the selection of the combustion air fan, motor, burner, and other components. Several different system configurations are available, depending on the requirements for NOx emissions and the fuels used. All systems use similar primary components, but may have a different IFGR damper fan and different motor sizes.

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 CBEX Premium boilers in the series comply, when equipped with optional equipment, to Industrial Risk Insurers (IRI), Factory Mutual (FM), or other insuring underwriters requirements.

#### 1.2 — The Boiler

The CBEX Premium boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, air pump, refractory, and appropriate boiler trim.

The horsepower rating of the boiler is indicated by the numbers following the fuel series. For example, CBEX700-900 indicates a gas-fired 900 hp boiler.

The firetube construction provides some characteristics that differentiate it from other boiler types. Because of its vessel size, the firetube contains a large amount of water, allowing it to respond to load changes with minimum variation in steam pressure.



Firetube boilers are rated in boiler horsepower (BHP), which should not be confused with other horsepower measurements.

Steam 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 it 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 frequent valve 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.

Feedwater equipment should be ready for use upon installation of the boiler. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

The proper observance of water requirements is essential to boiler life and length of service. Constant attention to water requirements will pay dividends in the form of longer life, less downtime, 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.

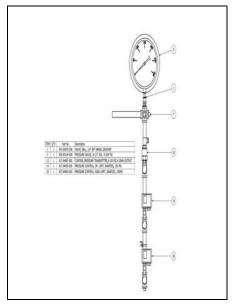
#### 1.3 — Construction

Steam boilers designed for 15 psig are constructed in accordance with Section IV, Heating Boilers, of ASME Code.

Steam boilers designed for operating pressures exceeding 15 psig are constructed in accordance with Section I, Power Boilers, of the ASME Code.



### 1.4 — Steam Controls (all fuels)

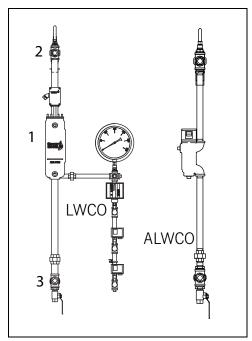


#### 1.4.1 — Pressure Controls

- 1. Pressure Gauge: Indicates boiler internal pressure.
- **2.Operating Limit Pressure Control:** Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
- **3.High Limit Pressure Control:** Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. The high limit pressure control is normally equipped with a manual reset.
- **4.Pressure Transmitter:** Senses changing boiler pressure and transmits a signal to change the boiler firing rate (overridden when boiler is operating in 'manual' mode).

FIGURE 1-2. Steam Controls

#### 1.4.2 — Low Water Cutoff



The Low Water Cutoff (LWCO) shuts down the burner if water level goes below the safe operating point. The LWCO is also responsible for starting and stopping the feedwater pump to maintain the proper boiler water level. The style of LWCO is determined by the design pressure of the vessel or by customer preference.

- **1.Low Water Cutoff and Pump Control**: Float-operated control responds to the water level in the boiler. It performs two distinct functions:
- Stops firing of the burner if water level lowers below the safe operating point. Energizes the low-water light in the control panel; also causes low-water alarm bell (optional equipment) to ring. Code requirements of some models require a manual reset type of low water cutoff.
- Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.
- **2.Vent Valve**: Allows the boiler to be vented during filling and facilitates routine boiler inspection as required by ASME Code.
- **3.Water Column Drain Valve**: Provided so that the LWCO and its piping can be flushed regularly to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with the auxiliary low water cutoff.

FIGURE 1-3. Low Water Cutoff, Aux. Low Water Cutoff

The Auxiliary Low Water Cutoff (ALWCO) stops burner operation in the event boiler water drops below the primary low water cutoff point. May require manual reset in order to restart the boiler after a low water condition.



#### 1.4.3 — Safety Valve(s)

**Safety Valves**: Prevent pressure in excess of the design pressure of the 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. 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.

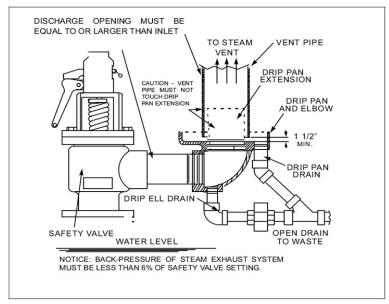




FIGURE 1-4. Safety Valve Piping and Safety Valves



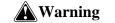
Only properly certified personnel such as the safety valve manufacturer's certified representative can adjust or repair the boiler safety valves. Failure to follow these instructions could result in serious injury or death.





# CHAPTER 2 Preparations for Startup

# 2.1 — General Preparation for Startup: All Fuels



It is recommended that the starting instructions be read completely until they are thoroughly understood before attempting to operate the boiler, rather than performing each operation as it is read for the first time. Failure to follow these instructions could result in serious injury or death.

Instructions in this chapter are based upon installation being complete and all electrical, fuel, water, and vent stack connections are made.

The operator should be familiar with the burner, boiler, and all controls and components. The wiring diagram should also have been studied, along with the firing sequence.

Verify supply of fuel and proper voltage. Check for blown fuses, open circuit breakers, dropped out overloads, etc. Check reset of all starters and controls having manual reset features. Check the lockout switch on the flame safeguard and reset if necessary.



Prior to firing a boiler, be sure that discharge piping from safety valves or relief valves, and discharge piping from all blowdown and drain valves, is piped to a safe point of discharge, so that emission of hot water or steam cannot possibly cause injury. Failure to follow these instructions could result in serious injury or death.

The boiler should be filled to the proper operating level with water at ambient temperature. Be sure that treated feedwater is available. In heating applications, the entire system should be filled and vented. On a steam boiler, open the test valve to vent air displaced during filling. Leave the test valve open until steam is noted after the burner is operating.

Check for rotation of all motors by momentarily closing the motor starter or relay. The blower motor rotation is counterclockwise when viewed from the motor side. The air pump rotation is clockwise when viewed from the drive end.



Before operating the boiler feed pump or oil supply pump, be sure all valves in the line are properly positioned.

For safety reasons a final pre-startup inspection is recommended, including checking for any loose or incomplete piping or wiring or any other situations that might present a hazard.



The pressure vessel support legs are welded to mounting skids in front and secured by bolts at the rear of the pressure vessel. The bolts are tightened for shipment. When the boiler is installed, and prior to initial firing, the bolts securing the rear legs to the skid must be loosened to allow for expansion and contraction caused by differences in temperature between pressure vessel and skids and to avoid damage to the equipment.

## 2.2 — Control Settings

#### **Operating control:**

1. The operating pressure control of a steam boiler should be set slightly above the highest desired steam pressure, but at least 10% lower than the setting of the safety valve.

#### High limit control:

1. On a high pressure steam boiler, the high limit control should be set approximately 10 psig above the operating limit pressure control setting, if feasible, or midway between the operating limit pressure and the safety valve setting.

#### **Modulating control:**

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

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

Inspect the low-water cutoff and pump control as well as the auxiliary low-water cutoff (if equipped with this optional equipment). Check for freedom of float movement. Float movement can be verified by observing the level of water in the gauge glass when the water supply has been cut off either by stopping the feed pump or by closing the feed valve. Restarting the pump or opening the valve should result in feed water entry. If not, secure the boiler immediately and determine the cause. The importance of proper functioning of low-water controls cannot be over-emphasized. Be sure that the control and the piping are level.

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



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

# 2.3 — Induced Flue Gas Recirculation (IFGR) Setup

**NOTE:** Initial IFGR linkage settings and adjustments must be established by a Cleaver-Brooks authorized representative. Setup of the low emission (LE) option requires simultaneous consideration of air-to-fuel ratios and  $NO_x$  levels. This can only be accomplished with proper combustion emissions monitoring equipment with  $NO_x$ ,  $O_2$ , CO, and smoke spot measuring capability.

It is recommended that the final "installed" settings be recorded for future reference. The settings should be marked on the linkage as well.

Normally, once the system has been set and adjusted, the settings should not be changed unless conditions (including boiler settings) change. In that case, it will be necessary to contact your local Cleaver-Brooks authorized representative for assistance.

After the IFGR system is initially set up, it will start up with the boiler as an integrated boiler system. After shutdown periods in which maintenance and/or adjustments have been performed on the fuel cams, fuel and air linkages, or IFGR control linkages, the recommended approach to startup is:

- 1. Set all boiler components to their initial settings as discussed in the appropriate chapters of this manual.
- 2. Check fan impeller and motor rotation. Correct rotation is counterclockwise when viewed from the front of the boiler.
- 3. Verify that all the IFGR components are set to the settings recorded on the Start Up report (as noted by the Cleaver-Brooks authorized representative during original setup). Be sure that all linkages are secure.
- 4. Start and warm the boiler as described in this manual.
- 5. Adjust the boiler components as described in this manual to achieve proper boiler operation.

# 2.4 — Startup, Operating, and Shutdown: All Fuels

See the burner chapter for starting, operating, and shutdown instructions.

# 2.5 — Control Operational Test and Checks

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

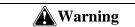
The operating limit control may be checked by allowing steam pressure or water temperature to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner shutoff point. If the load is light, the header valve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



the burner down. Slowly open the header valve to release steam pressure and check the cut-in setting as the burner restarts.

Check the proper operation and setting of the low-water cutoff (and pump operating control, if used).

Proper operation of the flame failure device should be checked at startup and at least once a week thereafter. Check the program relay's annunciation for any system failure. Observe the promptness of ignition of the pilot flame and the main flame.



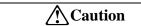
It is advisable to check for tight shutoff of fuel valves. Despite precautions and strainers, foreign material in either new or renovated fuel lines may lodge under a valve seat and prevent tight closure. The situation is especially true in new installations. Promptly correct any conditions causing leakage. Failure to follow these instructions could result in serious injury or death.



# CHAPTER 3 Profire XL Burner

Vertical Mount

Profire XL series burners are assembled, wired, and tested at the factory. All burners in the Profire series comply, when equipped with optional equipment, to CSD-1, NFPA-85, F.M., including the national Electrical Code (NEC), and associated insurance underwriters. Where applicable, the Canadian Gas Association (CGA) B149 and the Canadian Standards Association (CSA) B140 codes shall prevail. Other regulatory agency control options are available.



Only factory authorized burner service personnel should start up, adjust, or service this equipment.

The operator must be familiar with the individual functioning of all controls to understand the operations and procedures described in this manual.

# 3.1 — Description

The Profire XL series oil burners are of the low pressure, air atomizing (nozzle) type. Gas burners are of the peripheral mix type. 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.

Profire XL 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.



## 3.2 — Operating Controls

The Cleaver-Brooks Hawk control system is standard on CBEX boilers. The Hawk is a PLC-based system combining the functions of flame supervision and firing rate control. See manual 750-342 Hawk 4000 for details on how to set up and operate the controls.

# 3.3 — Combustion Air Handling System

The combustion air handling system consists of two major components:

Component	Details
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 and up to 4" W.C. furnace pressures. Alternate impeller wheels are available. For higher altitudes and higher furnace pressures, motor and impeller combinations are determined at the factory.

# 3.4 — Firing Head

Access to the firing head is provided by a hinged rear access door and removable side access covers on the housing.

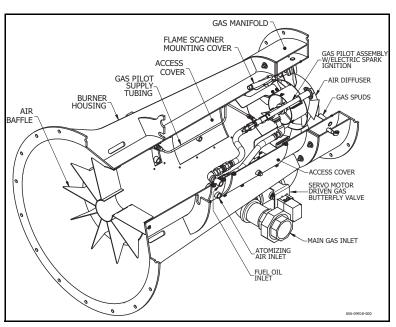


FIGURE 3-1. Burner Housing



## 3.5 — Oil System

XL 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.

#### 3.5.1 — 3-Way Regulating Valve

From supply, oil enters the common port of the 3-way regulating valve. During shutdown and purge the SSOV's are closed and upstream fuel returns to the storage tank. When firing oil, the valves are energized/ open and metered oil flows to the oil gun/nozzle.

#### 3.5.2 — 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 after-drip or baked-on residue.

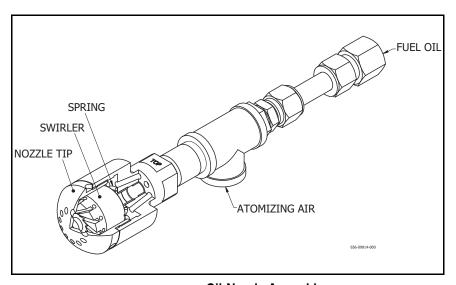


FIGURE 3-2. Oil Nozzle Assembly

#### 3.5.3 — Oil Strainer

Prevents foreign matter from entering the burner oil system.



#### 3.5.4 — 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.

#### 3.5.5 — Separate Compressor Module

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

**Atomizing Air** - Shop air is required for the atomizing air. Shop air should be regulated to 30-40 psig and 500 ACFM. Air pressure should be initially set to 10 psig over the oil pressure. As oil pressure increases the air pressure should maintain a 2-5 psig differential.

**Operation** - Oil is delivered to the metering system at 30-40 psi. From the supply pump, oil is delivered to the common port of a 3-way regulating 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, oil is returned to the tank. During normal firing, all metered oil is delivered to the oil gun/nozzle. For compressed air atomizing applications, 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 valve located on the compressor air breather. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering is controlled by the modulating motor through adjustable linkage.

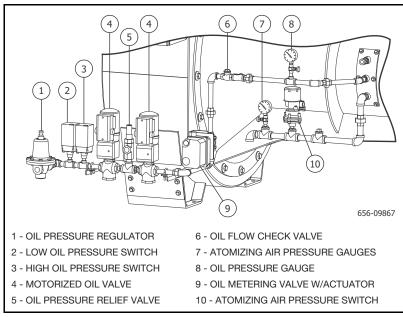


FIGURE 3-3. Oil System

**3-4** 750-367



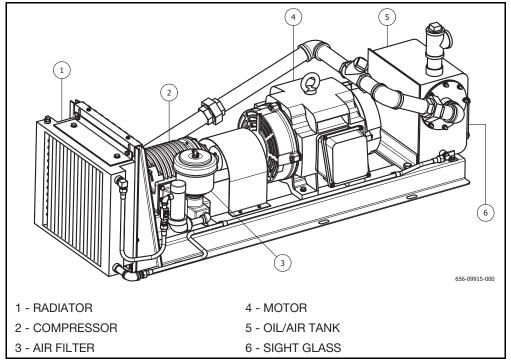


FIGURE 3-4. Compressor for atomizing air

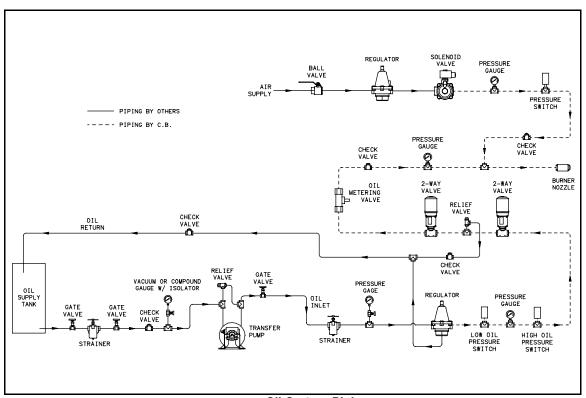


FIGURE 3-5. Oil System Piping



## 3.6 — Gas System

Gas is introduced into the combustion zone from the gas manifold. The firing rate is regulated by a rotary, butterfly type throttling valve at the manifold inlet. 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 valves. Safety shutoff gas valves are wired into the programming control to automatically open and close at the proper time in the operating sequence.

#### 3.6.1 — 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:

Main Gas Train Component	Description	
Gas Volume Valve	The butterfly-type valve is positioned by electric actuators and control the rate of flow of gas.	
Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner. Standard burners include two motorized gas valves w/ closure interlock.	
Main Gas Regulator	Regulates gas train pressure to specified pressure required at inlet to the gas train. Input is set my the main gas pressure regulator adjustment.	
Main Gas Cocks	For manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).	
High Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is below a pre-selected setting. Should the pressure rise above the setting, the switch contacts will open causing main gas valve(s) to close. This switch requires manual reset after being tripped.	
Low Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is above a pre-selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.	



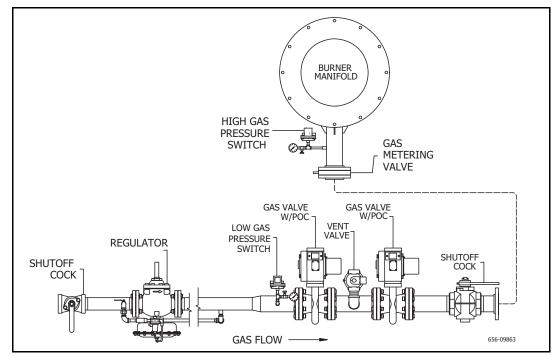


FIGURE 3-6. Main Gas Train

#### 3.6.2 — Pilot Gas Train Components

Pilot Gas Train Component	Description
Gas Pilot Valve	Solenoid valve(s) that open during the ignition period to admit fuel to the pilot. They close after main flame is established.
Gas Pressure Regulator	Reduces gas pressure to that required by the pilot.
Gas Pilot Shutoff Cock	For manually closing the pilot gas supply.



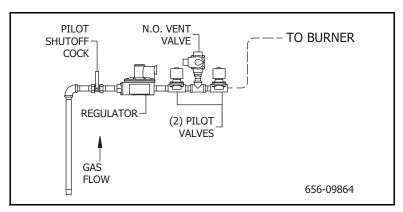


FIGURE 3-7. Pilot Gas Train

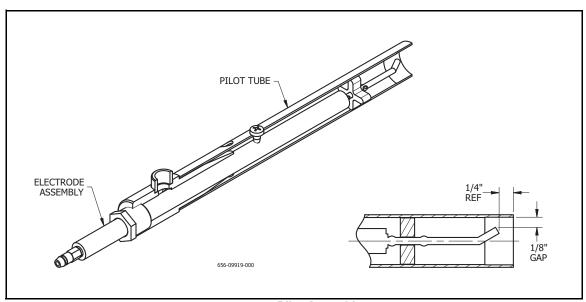


FIGURE 3-8. Pilot Assembly

#### 3.6.3 — **Operation**

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

The butterfly gas valve(s) modulate flow to burner input demand. The butterfly valve(s) are positioned by actuators and controlled by the parallel control system. The air control damper is also positioned simultaneously by actuators. The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high 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.



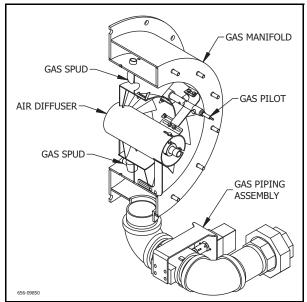


FIGURE 3-9. Gas Manifold

**NOTE:** The piping layouts shown in this section are for reference only and are subject to change without notice. Optional equipment may change a layout.

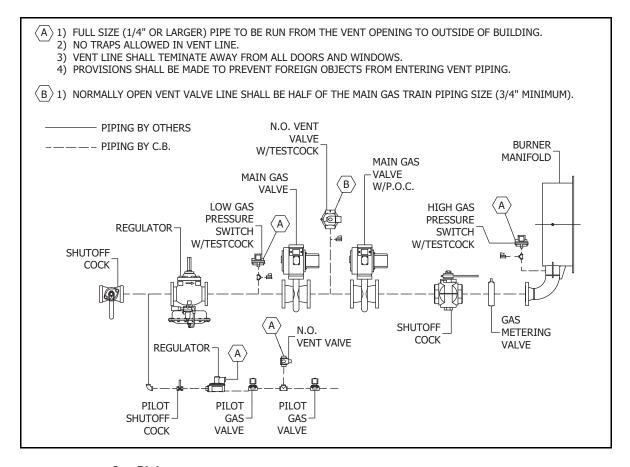


FIGURE 3-10. Gas Piping



# 3.7 — Preparing for Startup

Before placing the boiler into service, make certain all electrical, fuel, water, and vent stack connections are properly made. Operators should be thoroughly familiar with all controls, components, and operating sequences. Before starting, conduct the following pre-start checks.

Item	Check	
Boiler	Check the boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the desired temperature. Set modulating controls at the desired temperature or pressure.	
Burner	For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching the flame safeguard chassis to the base. The screw must be secure to assure low resistance connections. The relay chassis is mounted on the subbase with a screw which, when tightened, completes the connection between the sub-base and chassis contacts. Press the manual reset button to be sure safety switch contacts are closed.  Check the control actuators for proper movement of the air volume damper and fuel metering components.	
Oil-Air Tank (Lube Oil)	For a normal environment use SAE10 oil. Change oil every 2000 hours of operations.	

#### 3.7.1 — Oil Flow

Refer to piping diagrams. Open all valves in the oil suction and return line. The burner oil metering units are not capable of creating suction. Fuel oil must be supplied to the metering unit at a nominal 10 to 15 psi pressure by a circulating supply pump.

#### 3.7.2 — Oil Pressure

The system pressure is regulated by the back pressure valve. This should be set between 10 to 15 psi at the burner inlet after the temperature stabilizes.

#### 3.7.3 — Firing preparations for oil burners

Prior to initial firing, oil flow pressure and temperature should be verified.

Inspect the compressor lube oil sump level. Add oil to bring the oil level to the midpoint or slightly higher in the reservoir sight glass.

Make certain that the drive belts or couplings are aligned and properly adjusted.

To verify air flow and pressure, momentarily flip the switch "ON" and immediately turn "OFF." The programmer will continue through its cycle, however, without ignition or energizing the fuel valves. Observe the air pressure gauge. With the compressor running and no oil flow, the pressure should be approximately



10 psi. The schematic flow diagrams in Chapter 1 indicate the flow of fuel and atomizing air.

If the burner is a dual fuel model, make certain that the main gas shutoff cock is closed and the fuel selector switch is set to "OIL."

#### 3.7.4 — Firing preparations for gas burners

A representative of the gas utility should turn on the gas. Determine by a test gauge upstream of the burner regulator that sufficient pressure exists at the entrance to the gas train. The gas pressure regulator must be adjusted to the pressure required and the pressure setting recorded.

On combination fuel models, set the selector switch to "GAS." On initial startup, it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequences to determine that the main gas valve opens. Turn the burner switch "OFF" and let the programmer finish its cycle. Check to see that the gas valve closes tightly. Set the high and low gas pressure switches.

Check for leaks and determine there is adequate gas pressure available at the burner for operating at full capacity. Check with the local utility if necessary. Check gas pressure at the pilot and the main burner. Close the manual gas valve.

#### 3.8 — Electrical Interference Test

Prior to putting the burner into service, conduct the following test to ascertain that the ignition spark will not cause the flame relay to pull in.

#### 3.8.1 — Gas Fired

- 1. Close the pilot and the main line manual gas valves.
- 2. Start the burner and at the time of the pilot trial, with just the electrical ignition system energized, the flame relay should not pull in (be energized).
- 3. Upon completion of successful test, proceed with startup procedures.

#### 3.8.2 — Oil Fired

- 1. Disconnect the electrical power to the burner.
- 2. Disconnect the electric oil safety shutoff valve.
- 3. Reconnect electric power to the burner.
- 4. Close the pilot line manual gas valve, if used.
- 5. Start the burner and at the time of the pilot trial, with just the electrical system energized, the flame relay should not pull in.
- 6. Upon completion of successful test, disconnect the power supply,
- 7. Reconnect oil safety shutoff valve and turn on manual pilot gas valve.
- 8. Reconnect power supply and proceed with startup procedures.



### 3.9 — Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 8" to 20" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

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

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout.

# 3.10 — Startup Sequence

The programming control sequences the operation of all controls and components through the starting, ignition, firing, and shutdown cycle. The burner and control system are in starting condition when:

- The operating and high limit control (temperature or pressure) are below their cutoff setting.
- All power supply switches are closed.
- Power is present at the control panel.

Refer to the controls manual and burner wiring diagrams for detailed information. When ready for startup:

- 1. Begin starting sequence, with burner switch off, and with all manual valves closed. Switch main power on.
- 2. When firing oil, open the manual oil valves.
- 3. When firing on gas, open the main manual gas valve.
- 4. When firing on gas, manually reset the high and low gas pressure switches.
- 5. Place the gas/oil selector switch in position for the desired fuel. With all limit and operating controls calling for heat, the burner will follow the Flame Safeguard Sequence.
- **6.** When the blower motor starts, open the gas cock.
- 7. If firing on gas, when the main fuel lamp lights indicating pilot flame proven, slowly open the second shutoff cock downstream of the main gas valve(s).

#### 3.11 — Automatic Shutdown

- 1. Limit or operating controls open:
- 2. Fuel valves close. Main fuel lamp goes off. Flame safeguard timer starts.
- 3. Flame safeguard timer and burner motor stop. Burner is ready for startup on the next call for heat.

#### 3.12 — Manual Shutdown

- 1. Turn gas/oil selector switch off. The burner shuts down in Automatic Shutdown as above.
- 2. When the burner motor stops, close all manual valves.



### 3.13 — Safety Shutdown

If at any time during the operating cycle a flame failure occurs, the burner shuts down as in automatic shutdown, with an additional post-purge, and the flame failure lamp is energized.

### Warning $\triangle$

Read the Flame Safeguard manual and fully understand its contents before attempting to operate this equipment. If the manual is not read and understood, serious personal injury or death may result.

### Warning $\triangle$

Should a starting failure occur for any reason, combustible fumes may fill the combustion chamber. Never attempt to re-light the burner under these conditions. The combustion chamber must first be purged before relighting.

## Warning $\triangle$

Keep fingers away from the combustion air intake below the damper. The damper is actuated with sufficient force to cause severe injury. Always make high and intermediate rate adjustments when the burner has reached low fire position. Do not disturb the low fire setting.

After a safety shutdown, the lockout switch on the flame safeguard control must be manually reset before the burner will fire again.

If a low water condition occurs, the burner shuts down as in automatic shutdown.

If a high or low gas pressure condition occurs while firing on gas, the burner shuts down as in automatic shut-down. Condition must be corrected and the respective gas pressure switch manually reset before the burner will fire again on gas.

# 3.14 — Startup and Operating

#### 3.14.1 — Gas Burners

- 1. Close the main and pilot gas cocks.
- 2. Make sure the ON-OFF switch is in the "OFF" position and the fuel selector switch is turned to "GAS."
- 3. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
- 4. Set the MANUAL-AUTO switch in the "MANUAL" position.
- 5. Set the manual potentiometer in the low fire position.
- 6. Open the gas pilot cock.



- 7. Set the ON-OFF switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized. Before proceeding, conduct electrical interference and pilot turndown tests if not previously done (see Section 3.2).
- 8. On initial startup it is recommended that the main gas shutoff cock remains closed until the programmer has cycled through pre-purge and pilot sequence. Then determine that the main gas valve opens. When this is confirmed, turn the burner switch "OFF" and let the programmer finish its cycle.
- 9. Check to see that the gas valve has closed tightly. If ignition does not occur, turn the burner switch "OFF" and allow the programmer to recycle for a new ignition trial.
- 10. Turn the burner "ON" and after pilot ignition when the flame relay pulls in, the slow opening, motorized, main gas valve is energized. The main flame should ignite at this time. The gas valve and air damper continue advancing until high fire is reached.
- 11. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt.
- 12. Set the gas low fire rate by adjusting the butterfly gas valve and air valve.
- 13. When low fire is adjusted, shut down the burner.
- 14. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of an emergency, open the main power switches and close all fuel valves.
- 15. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.
- 16. Turn the potentiometer switch to the high fire position. Check high fire at this point using combustion instruments.
- 17. Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

High fire CO2 concentrations are typically 9% to 10.5% CO2. When conditions covered above are assured, refer to Sections 3.15 and 3.16.

#### 3.14.2 — Oil Burners

- 1. Set the fuel selector switch to "OIL." On initial startup of a combination burner, it is recommended that oil firing be adjusted before gas firing. The gas low firing rate is set to match the oil low fire rate.
- 2. Be sure the ON-OFF switch is in the "OFF" position and the fuel selector switch is on "OIL."
- 3. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
- 4. Be sure the MANUAL-AUTO switch is set to "MANUAL".
- 5. Set the manual modulating control potentiometer in the "LOW FIRE" position.
- 6. Open the pilot gas valve (if used).
- 7. Set the ON-OFF switch to "ON." The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot are energized. Before proceeding, conduct electrical interference and pilot turndown tests if not previously done.
- 8. Observe the primary atomizing air pressure gauge on the air/oil tank. The gauge reading should be approximately 10 psi during pre-purge.
- 9. When the pilot flame is proven, the programmer will proceed to the main flame position. Allow the burner to operate in low fire, to warm the boiler before moving to high fire. Typically, for No. 2 oil, CO2 is 8% to 11% at low fire.

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- **10.** Turn the manual potentiometer switch to the "HIGH FIRE" position. Check the high fire combustion at this point. Do not disturb previously established low fire adjustment.
- 11. Allow the burner to return to the low fire position before adjusting high or intermediate settings. The primary atomizing air pressure will increase automatically with the oil flow rate. Typically, for No. 2 oil, CO2 is 10% to 13% at high fire.

When conditions covered above are assured, refer to Sections 3.15 and 3.16.

# 3.15 — Normal Operation

Normal operation must be with the MANUAL-AUTO switch set on "AUTO".

In automatic operation, the operating cycle always proceeds sequentially through pre-purge, pilot ignition, main flame ignition, run, and post-purge. The length of the purge and ignition trial vary according to the type of programmer used.

During the run cycle, burner input is regulated to the load demand by the modulating pressure or temperature control on the boiler. The burner will continue to modulate until the operating pressure or temperature is reached.

Programmer control operation should be tested when the burner is initially placed into service, when a control is replaced, and at scheduled intervals in the maintenance program.

Refer to adjustment procedures and maintenance instructions in this manual.

### 3.16 — Shutdown

When the operating limit control setting is reached or the burner switch is in the "OFF" position, the following sequence occurs:

- 1. The fuel valve(s) de-energize and the flame extinguishes. The blower motor continues running during post-purge.
- **2.** At the end of post-purge, the blower motor is de-energized.
- 3. The programmer returns to its starting position and stops. The unit is ready to restart.

Abnormal shutdown might result from motor overload, flame outage, low water, current or fuel supply interruption, combustion or atomizing air pressure below minimum level, tripped circuit breakers, blown fuses, or other interlock devices. Check for the cause and make the necessary corrections before restarting the burner.

Safety shutdown caused by ignition or flame failure will actuate a red indicator light and energize an audible alarm (if so equipped). If the programmer has a non-recycling interlock circuit, any interruption in this circuit during the pre-purge or firing cycle will cause a safety shutdown. This type of shutdown requires manual reset of the programming control and must be corrected before operation can be resumed.

# Warning $\triangle$

An ultraviolet flame sensor electrical spark interference test must be performed after final adjustment. See Section 3.8 in this chapter for additional information.





# CHAPTER 4 Waterside Care

### 4.1 — Overview

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

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 Cleaver-Brooks service and parts representative.

Feedwater equipment should be ready for use upon installation of the boiler. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

The strict observance of water requirements is essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. The waterside of new boilers and new or remodeled steam systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove the accumulations is described later in this chapter.

Boilers require proper water circulation. The system must be operated as intended by its designer in order to avoid thermal shock or severe, possibly damaging, stresses from occurring to the pressure vessel.

# 4.2 — Feed Pump Operation

Before turning on the pump motor be certain that all valves in the water feed line are open to prevent possible damage to the feed pump mechanism. After opening the valves, momentarily energize the feed pump motor to establish correct pump rotation. With the correct rotation established, close the boiler feed pump entrance switch. The pump should shut down when the water level reaches the proper level.

Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check the feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

**NOTE:** Prior to operating the pump, carefully check the alignment of the flexible coupling, if one is used. A properly aligned coupling will last a long time and provide trouble-free mechanical operation.



**NOTE:** In the event that water column isolation valves are provided, it must be established that the valves are open and seated or locked in the open position. It is illegal to operate the boiler with closed or unseated open valves.



The isolation valves and the water column piping must be locked open during operation. Failure to do so may result in a low water condition. Failure to follow these instructions could result in serious injury or death.

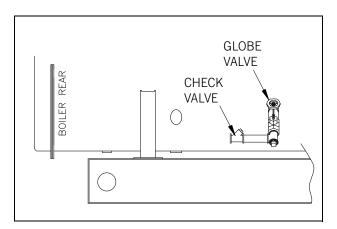


FIGURE 4-1. Feedwater Piping

#### 4.3 — Water Treatment

Properly treated boiler feed water, coupled with good engineering and operating practices, lead to maximum effectiveness and long trouble-free life of pressure vessels. Contact your local Cleaver-Brooks authorized representative for information on how to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment are:

- 1. Prevent hard scale deposits or soft sludge deposits, which reduce heat transfer and can lead to overheated metal and costly downtime and repairs.
- 2. Eliminate corrosive gases in the supply or boiler water.
- 3. Prevent inter-crystalline cracking or caustic embrittlement of boiler metal.
- 4. Prevent carryover and foaming.

Accomplishment of the above objectives generally requires proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, amount of makeup water needed, plant operating practices, etc. Treating methods



include filtering, softening, de-mineralizing, deaerating, and preheating. After-treatment involves chemical treatment of the boiler water.

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

The internal or waterside surfaces of the pressure vessel should be inspected with enough frequency to determine the presence of any contamination, accumulations of foreign matter, or corrosion, and/or pitting. If any of the conditions are detected, contact your local Cleaver-Brooks authorized representative for advice on corrective action.

A properly sized water meter should be installed in the raw water make-up line in order to accurately determine the amount of raw water admitted to the boiler (steam or hot water) and to aid in maintaining proper waterside conditions.

### 4.4 — Cleaning

#### 4.4.1 — Steam Piping

Steam piping systems connected to the boiler may contain oil, grease, or foreign matter. The impurities must be removed in order to prevent damage to pressure vessel heating surfaces. On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make-up so that an accumulation of unwanted materials or corrosion does not occur. For more information, contact your local Cleaver- Brooks authorized representative.

#### 4.4.2 — Pressure Vessel

The waterside of the pressure vessel must be kept clean from grease, sludge, and foreign material. Such deposits, if present, will shorten the life of the pressure vessel, will interfere with efficient operation and functioning of control and safety devices, and quite possibly cause unnecessary and expensive rework, repairs, and downtime. The installation and operating conditions that the boiler will be subjected to should be considered and cleaning of the waterside of the pressure vessel should be provided during the course of initial start-up.

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

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

The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6-, 9-, or 12-month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed, contact your local Cleaver-Brooks authorized representative for recommendations.



Any sludge, mud, or sediment found will need to be flushed out. If excessive mud or sludge is noticed during blowdown, the scheduling or frequency of blowdown may need to be revised. The need for periodic draining or washout will also be indicated.

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

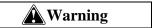
#### 4.5 — Boil-Out of a New Unit

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed because they lower the heat transfer rate and could cause overheating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

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

Your local Cleaver-Brooks authorized representative will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unscheduled, the following information may be of assistance.

There are several chemicals suitable for boil-out. 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 serving as a wetting agent.



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

The suggested general procedure for cleaning a boiler is:

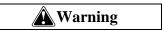
1. Refer to the table below to determine water capacity. Have sufficient cleaning material on hand to complete the job.



#### Water Capacity and Weights

CBEX Premium Water Capacity			
	Lbs.	Gal.	
900	34,430	4133	
1000	34,430	4133	
1100	32,670	3922	
1200	32,670	3922	

- 2. All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.
- 3. When dissolving chemicals:
  - A. Put warm water into a suitable container.
  - B. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved.
  - C. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.
- 4. Water relief valves and steam safety valves must be removed before adding the boilout solution so that neither the boilout solution nor the grease the solution may carry will contaminate the valves. Use care in removing and reinstalling the valves.
- 5. An overflow pipe should be attached ton one of the top boiler openings and routed to a safe point of discharge. The safety valve tapping is usually used.
- **6.** Fill the pressure vessel with clean water at ambient temperature until the top of the tubes are covered. Add the cleaning solution, slowly and in small amounts, and then fill to the top with water.
- 7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. Do not produce steam pressure.
- **8.** Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
- 9. Continue the boil and overflow process until the water clears. Shut the burner down.
- 10. Let the boiler cool to 120° F or less.
- 11. Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
- 12. Inspect the surfaces. If they are not clean, repeat the boilout.
- 13. After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180° F to drive off any dissolved gases, which might otherwise corrode the metal.



Be sure to drain the hot water to a safe point of discharge to avoid scalding. Failure to follow these instructions could result in serious injury or death.

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



### 4.6 — Washing Out

No later than three months after initially placing the boiler into operation, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature. Handhole covers should be removed and waterside surfaces should be inspected for corrosion, pitting, or formation of deposits.

Upon completion of the inspection, the pressure vessel interior should be flushed out, as required, with a high pressure hose. If deposits are not fully removed by flushing, a consultation may be required with your local Cleaver-Brooks authorized representative. In extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

The inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washouts. Contact your local Cleaver-Brooks authorized representative for more information.

#### 4.7 — Blowdown

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

Dissolved solids are brought in by the feedwater even though the water may be treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of the processes can remove all substances. Regardless of their efficiency, some dissolved solids will be present in the boiler feedwater.

Dissolved solids become less soluble in the high temperature of the boiler water and tend to accumulate on heating surfaces. Therefore blowdown and internal chemical treatment are required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer value and acts as an insulation barrier. Scale retards heat transfer, which not only results in lower operating efficiency, and consequently higher fuel consumption, but equally important, can cause overheating of boiler metal. Overheating of boiler metal can result in tube failures or other pressure vessel metal damage and lead to boiler downtime and costly repairs.

Scale is caused primarily by calcium and magnesium salts, silica and oil. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate, along with organic materials, to maintain the precipitates or "sludge" in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale. But as the boiler water boils off as relatively pure steam, the remaining water is thickened with the solids. If the concentration is permitted to accumulate, the sludge will build possibly causing overheating of the metal.

Therefore, we must control the amounts of totally dissolved solids (TDS) and sludge and so so in the following ways.

#### 4.7.1 — Types of Blowdown

The two principal types of blowdown are intermittent manual blowdown and continuous blowdown.



#### Intermittent Manual Bottom Blowdown

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

The blowdown tappings are located at the bottom or lowest part of the boiler in order to rid the sludge in the lower part of the vessel.

Equipment consists of three quick opening valves and one slow opening valve. All piping must be routed to a safe point of discharge. Piping must be properly supported and free to expand.

## Continuous Blowdown (Controlling TDS)

Continuous blowdown is used in conjunction with a surface blowoff tapping (furnished on units 60" in diameter and larger) and is the continuous removal of totally dissolved solids in the water.

The surface blowoff opening, when furnished, is on the top center line of the pressure vessel. It is provided with an internal collecting pipe terminating slightly below the working water level for the purpose of skimming TDS, oil, or other impurities from the surface of the pressure vessel water.

A controlled orifice valve or an auto-sensing/metering valve is used to allow a continual, yet controlled flow of concentrated water to drain or a place of recovery.

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

## 4.7.2 — Frequency of Manual Blowdown

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

When surface or continuous blowdown is not utilized manual blowdown is used to control the dissolved or suspended solids in addition to the sludge. This will involve chemical treatment to sequester the TDS.

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

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

It is generally recommended that a steam boiler be blown down at least once in every eight-hour period, but frequency may vary depending upon water and operating conditions. The blowdown amounts and schedule should be recommended by your local Cleaver-Brooks authorized representative.



A hot water boiler does not normally include openings for surface and bottom blowdown since blowdowns are not practiced. The need remains to be alert to system water losses and corresponding amount of raw water make-up. A water meter is recommended for water make-up lines.

#### 4.7.3 — Manual Blowdown Procedure

Blowdown is most effective at a point when the generation of steam is at the lowest rate and feedwater input is also low.

Be sure the blowoff piping and separator tank are in proper operating condition. Discharge vents should be clear of obstruction, and the waste should be piped to a point of safe discharge.

The quick opening valve(s) are normally opened first and closed last with blow down accomplished using the globe or slow opening valve.

When opening the slow opening valve, crack it slightly to allow the lines to warm, then continue opening slowly.

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

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

## **Caution**

Do not pump the lever action valve open and closed, as water hammer is apt to break the valve bodies or pipe fittings. Failure to follow these instructions could cause damage to the equipment.

Under no circumstances should a blowdown valve be left open. The operator should never leave until the blowdown operation is completed and the valves are closed.

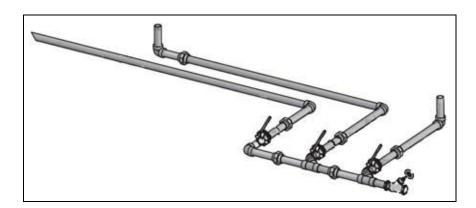


FIGURE 4-2. Bottom Blowdown Piping



## 4.8 — Periodic Inspection

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

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



To avoid the hazard of electrical shock, we recommend the use of a low voltage flashlight during an internal inspection. Preferably, inspectors should work in pairs. Failure to follow these instructions could result in serious injury or death.

If the internal inspection is being made at the request of an authorized inspector, it is advisable to ask the inspector to observe the conditions prior to cleaning or flushing of waterside surfaces.

Be certain that a supply of manhole and handhole gaskets is available, along with any other gaskets or items needed to place the unit back into operation after inspection.

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

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

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

The fireside surface should also be thoroughly cleaned so that metal surfaces, welds, joints, tube ends, fittings and any previous repairs can be readily checked.

Be sure that steam valves, and valves to expansion tank (hot water), feedwater valves, blowoff valves, all fuel valves, and electrical switches are shut off prior to opening handholes, manhole, and front or rear doors. Adequately vent the pressure vessel prior to entry.

Clean out the low-water cutoff piping, the water level controls and cross-connecting pipes. Replace the water gauge glass and clean out the water cocks. Also check and clean the drain and the blowdown valves and piping.

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



## 4.9 — Preparation for Extended Layup

Many boilers used for seasonal loads or for standby service may have extended periods of non-use. Special attention must be given to idle boilers so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

There are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better method depending upon circumstances in the particular installation.

Although pollution control regulations may continue to limit the permissible sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shut down. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during its off cycle. Moisture and any sulphur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid will be serious enough to eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

The condition does not generally occur during normal firing operation, because the high temperature of operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gases from falling below the dew point.

At the start of layup, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, tube sheets, and other fireside surfaces. Brushing will generally suffice. Sweep away or vacuum any accumulation. The fireside surfaces may be flushed with water. However, all moisture must be eliminated after flushing and the surface dried by blowing air or applying some form of heat. It is good practice to protect the cleaned surfaces by coating them with an anti-corrosive material to prevent rust.

Swing open the boiler head at the stack end of the unit to prevent flow of warm, moist air through the boiler tubes.

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 control should be removed and stored in a dry atmosphere.

**Dry storage** is generally employed when the boiler will be out of service for a significant period of time, or where freezing temperatures may exist. In the dry storage method the boiler must be thoroughly dried because any moisture would cause corrosion. Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture-absorbing materials such as quick lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume) on trays inside the vessel. Fireside surfaces may be coated with an anti-corrosive material, grease or tar paint. Refractories should be brushed clean and wash-coated. All openings to the pressure vessel, such as manholes and handholes, should be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air form reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in standby condition or in cases where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must again be taken to protect metal surfaces. Variables preclude definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and re-filled to overflowing with treated water. If deaerated water is not available, the unit should be fired to boil the water for a short period. Additional chemicals may be suggested by your local Cleaver-Brooks authorized representative to minimize corrosion. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used to pressurize the vessel.



# CHAPTER 5 Adjustment Procedures

## 5.1 — Overview

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.

For boilers equipped with a Cleaver-Brooks Hawk control system, refer also to the controls manual:

> Hawk 1000 — 750-366 Hawk 4000 — 750-342

A combustion efficiency analysis made during the initial startup 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 this chapter apply to standard components furnished on steam or hot water boilers fired with gas and/or the various grades of oil.

In order to reduce stress on boiler components and to improve boiler operating efficiency, burners have been designed for enhanced fuel turndown capabilities. A burner is equipped to fire light oil (Series 100), or gas (Series 700), or both, Series 200 (for light oil and gas). Air and fuel inlets, the diffuser, and the air damper control linkage have been modified for these burners.

Contact the local Cleaver-Brooks authorized representative or the Cleaver-Brooks Service Department for recommendations covering special controls that are not included in this chapter.

## 5.2 — ProFire XL Burner Adjustments

While each burner is tested at the factory for correct operation before shipment, variable conditions such as burning characteristics of the fuel used and operating load conditions may require further adjustment after installation to assure maximum operating efficiency.



Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts, and setscrews to be sure that no damage or misadjustments occurred during shipment and installation.

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

## 5.2.1 — Combustion Adjustment on Gas and Oil

Efficient combustion cannot be properly judged by flame appearance, although it may help in making preliminary settings.

The proper settings of air-fuel ratios must be determined by flue gas analysis. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. Instruments are available to measure carbon dioxide  $(CO_2)$ , oxygen  $(O_2)$ , and carbon monoxide (CO). At no time should  $CO_2$  measurements alone be used to indicate proper excess air levels. Only  $O_2$  measurement can definitively show whether sufficient air has been provided for combustion.

## Stack Temperature

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high net stack temperature indicates wasted heat. Decreasing either the temperature of the volume of the flue gas, or both, can reduce stack heat loss. Flue gas temperature is reduced by improving heat transfer or by reducing excess combustion air. A certain amount of excess air is necessary to complete combustion. More efficient burners require minimum excess air.

#### Smoke Measurement

Smoke measurements can be made using a variety of different methods. The standards will vary somewhat according to the equipment used, and instructions accompanying the instrument should be followed.

Smoky combustion can result from improper air delivery, insufficient draft, improper fuel viscosity, improper fuelair ratio, excessive air leaks in the combustion chamber, or improper fuel oil temperature.

### Gas Adjustments

Low fire combustion analysis typically is 7% to 9% CO2 and less than .04% CO (400 ppm). A high fire reading typically is 9% to 10.5% CO2 and less than .04% CO.

#### Fuel Oil Adjustments

Adjust for a "clean fire." Typically for No. 2 oil CO2 is 8% to 11% at low fire and 10% to 13% at high fire.

#### 5.2.2 — Electrical Interference Test

Prior to putting the burner into service, conduct the following test to ascertain that ignition spark will not cause the flame relay to pull in.

#### Gas Fired

- 1. Close the pilot and main line manual gas valves.
- 2. Start the burner and at time of pilot trial with just the electrical ignition system energized, the flame relay should not pull in (be energized).
- 3. Upon completion of successful test, proceed with startup procedures.



#### Oil Fired

- 1. Disconnect the electrical power to the burner.
- 2. Disconnect the electric oil safety shutoff valve.
- 3. Reconnect electric power.
- 4. Close the pilot line manual gas valve, if used.
- 5. Start the burner and at the time of pilot trial, with just the electrical ignition system energized, the flame relay should not pull in.
- 6. Upon completion of successful test, disconnect the power supply.
- 7. Reconnect the oil safety shutoff valve and turn on the manual pilot gas valve.
- 8. Reconnect the power supply and proceed with startup procedures.

## 5.2.3 — Gas System

## Gas Pressure

Gas must be supplied at a pressure high enough to overcome the pressure loss in the burner gas train and furnace pressure while running at full input. Refer to nameplate for gas pressure requirements at train inlet and manifold. The pressures listed are based on nominal 1000 Btu/cu ft. natural gas at elevations up to 2000 feet above sea level.

#### Gas Flow

The volume of gas is measured in cubic feet as determined by a meter reading. The gas flow rate required depends on the heating value (Btu/cu ft.). The supplying utility can provide this information as well as pressure correction factors. To determine the required number of cubic feet per hour of gas, divide burner input (Btu/hr) by the heating value (Btu/cu ft.).

**NOTE:** When checking the input rate, Make sure no other equipment is operating on the same meter.

#### Gas pilot flame adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 8" to 20" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

To adjust pilot gas pressure, unscrew regulator cap and turn the adjusting screw in or out.

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

The flame safeguard amplifier has a meter jack for this purpose. At initial startup and during planned maintenance, test the pilot flame signal, pilot turndown, and safety switch lockout.

#### Warning

An ultra-violet flame sensor electrical spark interference test must be performed after final adjustment.

See Section 5.2.2 of this chapter for additional information.



## Main Gas Pressure Regulator

The gas pressure required at the burner manifold is the pressure that is required to fire the burner at its rated capacity. The gas pressure regulator must be adjusted to achieve this pressure to assure full input. Refer to manufacturer's literature for regulator adjustment.

#### Low Gas Pressure Switch

Turn adjusting screw until indicator moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this set point. The control should be finally adjusted to prevent operation with low gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. The switch must be manually reset after tripping. To reset, allow gas pressure to rise and press the manual reset button.

## High Gas Pressure Switch

Turn the adjusting screw until the indicator moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure, but not at a pressure so close to normal operating pressure that unnecessary shutdowns occur. This switch must be manually reset after tripping. To reset, allow gas pressure to drop and press the manual reset button.

## Gas Combustion Adjustment

After operating for a sufficient period of time to assure a warm boiler, make adjustments for most efficient combustion. The butterfly gas valve directly controls the rate of flow. The low fire light-off setting should be regarded as preliminary until proper gas pressure for high fire operation is established.

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

When proper gas flow is obtained, take a flue gas analysis reading.

With the high fire air-fuel ratio established, the gas pressure regulator needs no further adjusting. Recheck low fire and adjust if necessary.

Proper setting of the air-fuel ratios at all rates must be determined by combustion analysis.

**NOTE:** Check for CO through the entire firing range.

## 5.2.4 — Oil System

#### Oil Metering System

Fuel oil supply to the separate metering unit must be 10 psi to 20 psi. The oil spray should ignite as soon as the oil solenoid valve opens. If the oil spray fails to ignite, move the metering unit adjustment lever a few degrees counterclockwise. This increases the amount of oil at low fire and makes ignition easier, it will also increase the oil on high fire, and this must be checked later. Once adjusted, the pump should operate with a minimum amount of adjustment. If a burner failure is caused by the oil metering pump, check the following:

- 1. Oil tanks are not empty.
- 2. All oil valves between the burner and the tank are open.
- 3. The suction line is not airbound.
- 4. The low fire setting has not been disturbed.
- 5. There is pressure at the separate metering unit, but not exceeding 20 psi.



- **6.** The pump turns freely.
- 7. The strainer at the suction side of the circulating pump is not clogged.
- 8. The burner strainer is not dirty.
- 9. The nozzle is not plugged or carboned. This will show up as excessive primary air pressure.
- 10. The oil bypass valve is not bypassing the metered fuel oil.

Internal wear of the pump may take place due to the presence of dirt in the oil and in time this will result in excessive clearances which reduce the pump capacity.

If the oil metering pump fails to deliver capacity or meters erratically, replace the oil and air pump as a unit and return the old pump for repair or exchange (where allowed).

## Atomizing Air Pressure

Atomizing air pressure is regulated by adjusting the regulator for compressed air. The air pressure is indicated by the pressure gauge at the oil gun. A minimum of 10 to 12 psi air pressure at low fire is suggested. As the firing rate increases, the air pressure also increases. Air pressure will be less with light oils. If any change in atomizing air pressure is made, check ignition several times for reliable light off. Adjustments should be set to obtain reliable ignition with best low and high fire combustion results.

If the required atomizing air pressure cannot be maintained, a lack of lubricating oil may be the cause or the intake filter may be dirty.

## Atomizing Air Proving Switch

The knurled nut between the switch and bellows is turned in to raise pressure setting. The minimum amount of atomizing air is during pre- and post-purge. During pre-purge, adjust switch until it breaks the circuit. Readjust the switch above this circuit breakpoint to actuate under a condition of minimum pressure, but not so close as to cause nuisance shutdowns. Since the pressure of the atomizing air is at minimum when no fuel is present at the nozzle, adjustment of the switch should be made while the unit is purging, but not firing.

## High & Low Oil Pressure Switch

The high oil pressure switch is set 1-2 psig over the maximum system pressure. The low oil pressure switch is set 102 psig below the minimum system pressure.

## 5.2.5 — Parallel Positioning Adjustment

For parallel positioning systems refer to the control documentation and to the accompanying wiring diagram for information on adjusting the system. In a properly tuned parallel positioning system the independent actuators for fuel, air, and FGR (if so equipped) will be coordinated to provide optimum combustion throughout the firing range.

## 5.2.6 — Actuator Setup

Actuator travel will normally be factory pre-set, but should be verified before commissioning the controls. Refer to the control manuals and any additional manufacturer's documentation.

#### 5.2.7 — Air and Fuel Controls

The combustion system fuel and air controls have been factory adjusted. Regardless of preliminary adjustment and operation, it may be necessary to readjust the controls for local conditions:

• The fuel flow controls may require adjustment to establish the rated fuel input over the full range of firing- rate modulation.



- The air controls may need to be adjusted, relative to the established fuel flow rates, to provide the correct amount of air for complete, efficient combustion.
- Gas pressure to the regulator must be a minimum of 10 psig.
- The inner and outer manifold pressures must be balanced to provide a stable flame. The balancing of the inner and outer manifold gas pressures will vary somewhat, depending on altitude, weather and barometric conditions.

Fuel and air adjustments are similar on all CB Profire burners, whether gas-fired, oil-fired, or combination gas/oil fired. The following topics describe air and fuel flow rate adjustments, and the combustion set-point objectives for optimum combustion performance.

#### Air Flow Control

CB Profire burners incorporate a multi-blade air shutter combustion air control system. The multi-blade system consists of independent blades that can be adjusted to provide more or less combustion air throughout the firing range. The air damper is linked to the damper actuator and the damper linkage can be adjusted to increase or decrease the air opening rate. The air damper is almost closed in the low fire position and fully open in the high fire position.

#### Fuel and Air Flow Settings

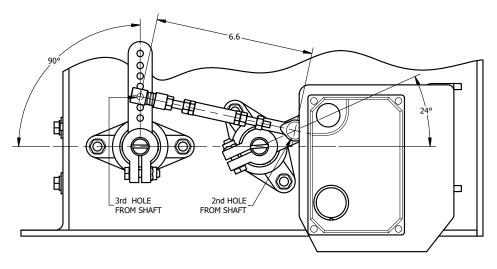
Fuel and air flow rates can be individually adjusted at low fire and high fire to achieve rated heat input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (air temperature, humidity, barometric pressure), and fuel property changes. Adjustments may be required to meet certain environmental emissions criteria, such as NOx or CO. Combustion adjustments also vary with specific system applications.

Turndown capability for oil is less than that of natural gas. On combination fueled burners, gas turndown performance may be restricted by the excess air and fuel turndown levels set for oil combustion.

Excess air (O2) and unburned fuel (CO) levels in boiler flue gases are used to determine combustion efficiency and fuel and air input adjustments. The system should be adjusted to a minimum excess air quantity that provides low levels of unburned fuel with sufficient remaining O2 to cope with normal atmospheric and fuel related changes. Unburned fuel is measured as CO when burning natural gas, and smoke spots when burning oil.

The burner should be set up and maintained to yield smoke spot levels less than #1 spot (ASTM D2156 Shell Bacharach Scale) to minimize soot and buildup in the boiler.





ACTUATOR END VIEW

## AIR DAMPER BLADE LINKAGES

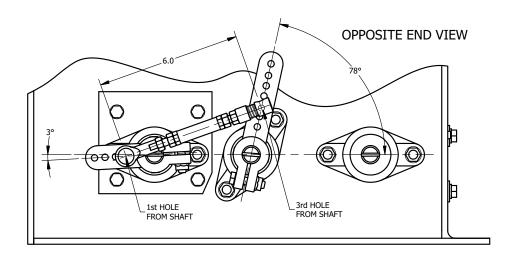


FIGURE 5-1. Firing Rate Control Positions

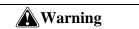




# CHAPTER 6 Troubleshooting

## 6.1 — Introduction

This chapter 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.

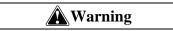


Troubleshooting should be performed only by personnel familiar with the equipment and who have read and understood the contents of this manual. Failure to follow these instructions could result in serious injury or death.

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

Knowledge of the system and its controls will make troubleshooting much easier. Costly downtime 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 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.

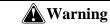


Disconnect and lockout the main power supply in order to avoid the hazard of electrical shock. Failure to follow these instructions could result in serious injury or death.

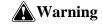


**A**Caution

Never attempt to circumvent any of the safety features.



The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart. Failure to do so may result in serious personal injury or death.



Do not repeat unsuccessful lighting attempts without rechecking the burner and pilot adjustments. Failure to do so may result in serious personal injury or death.



Do not re-light the pilot or attempt to start the main burner, either oil or gas, if the combustion chamber is hot and/or if gas or oil vapor combustion gases are present in the furnace or flue passages or when excess oil has accumulated. Promptly correct any conditions causing leakage. Failure to do so may result in serious personal injury or death.

The control system and program relay have 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.

## 6.2 — Emergency Shutdown

In case of emergency, shut down the burner by turning the "ON-OFF" switch to the "OFF" position. Turn the fuel selector switch to the "OFF" position. Shut off the main manual fuel shutoff valves on the fuel supply line. The unit can also be shut down with the main electrical power disconnect. Inspect the burner carefully and trouble-shoot before restarting the unit.



## 6.3 - Troubleshooting Chart

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



Problem	Possible Cause(s)
PILOT FLAME, BUT NO MAIN	Insufficient pilot flame.
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	Manual-automatic switch in wrong position.
SHUTDOWN OCCURS DURING	Loss or stoppage of fuel supply.
FIRING	2. Defective fuel valve, loose electrical connection.
	3. Flame detector weak or defective.
	4. Lens dirty or sight tube obstructed.
	<b>5.</b> 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.
	7. Improper air/fuel ratio (lean fire):
	A. Damper stuck open.
	B. Fluctuating fuel supply:
	1) Temporary obstruction in fuel line.
	2) Temporary drop in gas pressure.
	8. Interlock device inoperative or defective.



# **CHAPTER 7** Inspection and Maintenance

## 7.1 — Overview

A well-planned maintenance program will help avoid unnecessary down-time or costly repairs, promote safety, and aid boiler inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly, semi-annually, and yearly maintenance activities provides a valuable guide and aids in obtaining economical and reliable service from Cleaver-Brooks equipment. A boiler inspection schedule is shown in Table 8-1. It is important to realize that the frequency of inspection will depend on variable conditions: such as load, fuel, system requirements, boiler environment, etc.

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

Even though the boiler has electrical and mechanical devices that make it automatic or semi-automatic in operation, the devices require systematic and periodic maintenance. Any automatic feature does not relieve the operator from responsibility, but rather frees the operator from certain repetitive chores providing time to devote to upkeep and maintenance.

## **⚠** Caution

Inspection and maintenance should be performed only by trained personnel who are familiar with this equipment. Failure to follow these instruction could result in equipment damage.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction and permit prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks — fuel, water, steam, exhaust gas — should be repaired promptly and under conditions that observe 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.



## **Recommended Boiler Inspection Schedule**

Daily	Monthly	Semi-Annually	Annually
Check water level	Inspect burner	Clean low water cutoff	Clean fireside surfaces
Check combustion visually	Inspect for flue gas leak	Clean oil pump strainer, filter	Clean breeching
Blow down boiler	Inspect for hot spots	Clean air cleaner and air/ oil separator	Inspect waterside surfaces
Blow down water column	Check for tight closing of fuel valves	Inspect refractory	Check operation of safety valves
Record feedwater pres- sure/temperature	Check indicating lights and alarms	Remove and clean oil pre- heater	
Record flue gas temperature	Check operating and limit controls	Check air pump coupling alignment	
Record oil pressure and temperatures	Check safety and interlock controls	Inspect/repair burner housing to refractory seal	
Record gas pressure	Check for leaks, noise, vibration, unusual conditions, etc.		
Treat water according to the established program	Check low water cutoff operation		
Record atomizing air pressure			

## 7.1.1 — Periodic Inspection

Insurance regulations and local laws require periodic inspection of the pressure vessel by an authorized inspector. Inspections are usually, though not necessarily, scheduled for periods of normal boiler down time, such as an off season. This major inspection can often be used to accomplish maintenance, replacement or repairs that cannot easily be done at other times. Inspection 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 operator an excellent opportunity for detailed inspection and check of all components of the boiler including piping, valves, pumps, gaskets, refractory, etc. Comprehensive cleaning, spot painting or repainting, and the replacement of expendable items should be planned for and taken care of during this time. Any major repairs or replacements that may be required should also, if possible, be coordinated with the period of boiler shutdown.

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

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

**NOTE:** To ensure proper operation, use only Cleaver-Brooks genuine parts. Contact your local Cleaver-Brooks representative for parts information and ordering.



## 7.2 — Fireside Cleaning



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

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

FIGURE 7-1. Stack Thermometer

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

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

## 7.3 — Water Level Controls

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

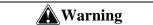
Always be sure of the boiler water level. On steam boilers, the water column should be blown down daily. Check samples of boiler water and condensate in accordance with procedures recommended by your local Cleaver-Brooks authorized representative.

Since low-water cutoff devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low-water cutoff or point of pump cut-in or cut-out. If a low-water device should become erratic in operation, or if its setting changes from previously established levels, contact your local Cleaver-Brooks authorized representative.



#### 7.3.1 — Steam Boiler

The instructions on the low water cutoff plate (see below) on a steam boiler should be followed in accordance with a definite schedule. The controls normally function for long periods of time, which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.



Safe operation of your boiler demands periodic inspection and maintenance of all low water cut-off devices. Open and inspect them at least once a month. Check operation frequently by stopping water flow to the boiler, allowing water level to lower. If controls do not cut off burner at proper safe water level or the internal wiring/switches appear in poor physical condition, repair or replace at once.

On a steam boiler, the head mechanism of the low-water cutoff device(s) should be removed from the bowl at least semi-annually to check and clean the float ball, the internal moving parts, and the bowl or water column.

Remove the pipe plugs from the tees or crosses and make certain the cross-connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance. Determine that piping is vertically aligned after shipment and installation and throughout life of equipment.

A blowdown of the water controls on a steam boiler should be performed daily. Open the drain valve slowly to prevent float damage.

## 7.3.2 — Hot Water Boiler

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

## 7.4 — Water Gauge Glass

A broken or discolored glass should 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.

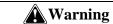
Close the gauge glass valves when replacing the glass and open the drain valve to release any pressure. Slip a packing nut, a packing washer, and packing ring onto each end of the glass. Insert one end of the glass into the upper gauge valve body far enough to allow the lower end to be dropped into the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





It is recommended that the boiler is off and cool when the glass is replaced.

Check try-cocks and gauge cocks for freedom of operation and clean as required. It is imperative that the gauge cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.



Do not attempt to change the gauge glass while the boiler is in service. Failure to follow these instructions could result in serious injury or death.

FIGURE 7-2. Water Column Gauge Glass Replacement

## 7.5 — Electrical Controls

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

Be certain that controls are correctly leveled. The internal piping leading to the pressure control actuators should be cleaned, if necessary. Covers should be left on controls at all times.

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts. Use a burnishing tool or a hard surface paper to clean and polish contacts. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Replacement of the contacts is necessary only if the silver has worn thin.

## **Caution**

Do not use files or abrasive materials such as sandpaper on the contact points. Failure to follow these instructions could result in equipment damage.

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

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



## 7.6 — Flame Safety Control

The microprocessor based control requires minimal maintenance because the safety and logic timings are inaccessible. There also are not any accessible contacts. Check to see that the retaining screw is securely holding the chassis to the mounting base. Also check to see that the amplifier and the program module are tightly inserted.

The relay's self-diagnostic ability includes advising when it or its plug-in modules are at fault and require replacement.

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

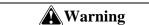
It is recommended that service be rotated between the active and a spare control to assure a working replacement is available.

Be sure the connecting contacts on the control and its base are not bent out of position.

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 safeguard system at least once a month, or more often. Tests should verify safety shutdown and a safety lockout upon failure to ignite the pilot, upon failure to ignite the main flame, and upon loss of flame. Each of the conditions should be checked on a scheduled basis.

The following tests should be used to test the complete safeguard system. If the sequence of events is not as described, then a problem may exist. Contact your local Cleaver-Brooks authorized representative for assistance.



When replacing a control, be sure to lock out the main power supply switch since the control is "hot" even though the burner switch is off. Failure to follow these instructions could result in serious injury or death.

## 7.6.1 — Checking Pilot Flame Failure

Close the gas pilot shutoff cock. Also shut off the main fuel supply. Turn the burner switch "on."

The pilot ignition circuit will be energized at the end of the pre-purge period. There should be an ignition spark, but no flame. The ignition spark can be viewed through the sight port in the rear door. Since there is no flame to be detected, the program relay will signal the condition. The ignition circuit will de-energize and the control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Reopen the gas pilot shutoff cock and re-establish main fuel supply.



## 7.6.2 — Checking Failure to Light Main Flame

Leave the gas pilot shutoff cock open. Shut off the main burner fuel supply. Turn the burner switch on. The pilot will light upon completion of the pre-purge period. The main fuel valve(s) will be energized, but there should be no main flame.

The fuel valve(s) de-energize within 4 seconds after the main burner ignition trial ends. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Re-establish main fuel supply.

## 7.6.3 — Checking Loss of Flame

With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame.

The fuel valve(s) will be de-energized and the relay will signal the condition within 4 seconds. The control will then lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will run through the post-purge and stop.

Turn the burner switch off. Reset the safety switch. Re-establish main fuel supply.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth moist-ened with detergent if necessary.

## 7.7 — IFGR Inspection and Adjustment

NOx levels should be checked periodically to ensure compliance with all local and federal regulations, as well as to ensure that the boiler is operating at maximum efficiency. Linkages should be inspected and free movement (no binding) of the IFGR damper confirmed.

Increasing or decreasing NOx levels could indicate incorrect damper positioning, an improper air-to-fuel ratio, or stack draft changes. If adjustment is required, or if problems persist, contact your local Cleaver-Brooks authorized representative for further assistance.

As ash and products of combustion pass through the IFGR damper, there will be some accumulation on the damper, windbox, and other parts of the IFGR system and burner.



## 7.8 — Safety Valves



FIGURE 7-3. Safety Valves

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

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



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

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

FIGURE 7-4. = Operating Safety Valves

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

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

## 7.9 — Air Pump and Lubricating System

## 7.9.1 — Air Pump

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.

## 7.9.2 — Lubricating 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.

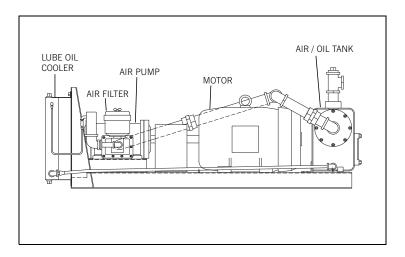


FIGURE 7-5. Air Pump



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.

## 7.9.3 — Lubricating 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.

#### 7.9.4 — Air-Oil Tank

Pads of steel wool are used in the air-to-oil tank as a filtering medium to separate the lube oil form 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 oring gasket under the cover so that a tight seal is obtained.

Follow previous instructions for oil replacement.

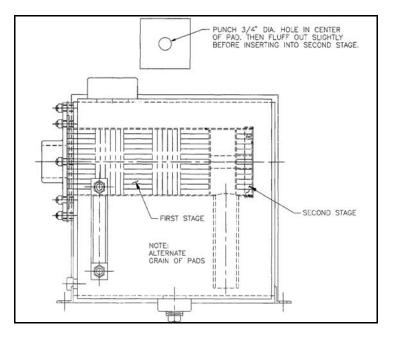


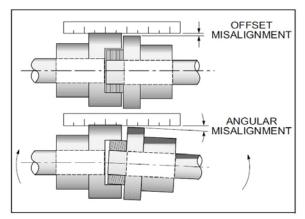
FIGURE 7-6. Air-Oil Receiver Tank

## 7.9.5 — 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.



## 7.9.6 — Flexible Coupling Alignment



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.

Alignment of the pump and motor through the flexible coupling

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.

FIGURE 7-7. Flexible Coupling Alignment

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.



## 7.10 — Front and Rear Access

#### 7.10.1 — Front Smoke Box

#### **Opening Doors**

Before opening the door, tighten the nut on the davit arm to create slight tension. This will prevent sagging and facilitate opening of the door. After opening either door, check the gaskets and seating surfaces. Replace the door gaskets if they are hard or brittle. Clean the sealing surfaces of the door and tube sheet. If the blanket insulation is torn away the insulation will require replacing.

## **Insulating the Smoke Box**

When replacing the insulation in the front smoke box area, be sure to clean the installation area. Be sure all fire-tubes are clean and free of old insulation material. If necessary replace the retainer pins. Cut the blanket insulation 1-1/2" to 2" back from the door mounting flange. The space is required for the doors to close and compress into the inner lining of insulation with out causing distortion to the blanket insulation. Use spray adhesive to hold the insulation in place prior to placing the wire mesh over the blanket insulation. Install the retainers and bend the pins parallel to the blanket insulation and retainers. WetPack insulation should be used on the base of the smoke box and around the furnace area.

### **Preparing to Close Doors**

The doors are insulated with 2" blanket insulation and held in place with wire mesh, retainer pins and clips.

Before closing the doors check all the mounting studs by running a mounting nut down the threads to check for burs or flat spots. Checking the mounting studs before trying to close the door will greatly facilitate the closing process. If a flat spot or bur is found, remove the nut and chase the thread with the appropriate sized Thread die.

When closing the doors, inspect the threads on all studs and where necessary use the correct sized die to clean the threads. Damaged stud threads can strip the brass nuts.

Use spray adhesive to secure the 1/2" rope (872-622) to the sealing area of the doors.

Cut 2" blanket insulation to fit in the door baffle seal area. Use a spray adhesive to hold the baffle seal in place.

## **Closing and Sealing Doors**

Swing the door to the closed position, adjusting the davit bolt to align the door. Be sure the gasket is positioned correctly prior to tightening the door. Tighten the bolts uniformly, starting at the top center and alternating between the top and bottom bolts until both are tight. Do not over-tighten. Tighten alternate bolts until all are secure and the door is gas tight.

After closing the door, loosen the nut on the davit arm stud to release tension on the davit arm. Failure to do so may result in damage to the boiler due to thermal stresses during boiler operation.

After the boiler is back in operation, re-tighten the door bolts to compensate for compression of the gasket or movement of the door.



## 7.10.2 — Rear Access Plug

The rear access plug houses the rear sight port and is removable for rear fireside access.

Resealing the rear access plug requires cleaning the seal area. After cleaning, spray adhesive into the sealing area and insert the 2" rope gasket.

## 7.11 — Lubrication

### 7.11.1 — Electric Motors



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

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

FIGURE 7-8. Electric Motors

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

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

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

NOTE: Siemens TEFC motors use a different grease incompatible with those listed above.

**NOTE:** For Siemens motors: Contains re-greasable bearings. The shaft end (impeller end) requires the use of CB's high temperature auto grease system (PN 884-133) for proper lubrication.

The opposite shaft end (opposite impeller) can be greased by the auto grease system or by hand pump, using two or three pumps every three months with a grease compatible with a high temperature aluminum complex grease.



#### 7.11.2 — Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

## 7.12 — Combustion Adjustments

The frequency of burner adjustments depends upon several factors, including:

- Type of burner.
- Type of fuel.
- Load conditions.
- Ambient temperature.
- Climatic variables.
- General maintenance practices.

The air-fuel ratio should be checked monthly in order to alert the operator to losses in efficiency, which do not produce visible flame change.

Readjustment of the burner may be required due to variations in fuel composition. A combustion analyzer should be used to adjust air-fuel ratio for maximum operating efficiency. If your burner requires adjustments, contact your local Cleaver-Brooks authorized representative for assistance.

## 7.13 — Burner Maintenance

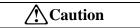
A maintenance program avoids unnecessary downtime, costly repairs, and promotes safety. It is recommended that a record be maintained of daily, weekly, monthly, and yearly maintenance activities.

Electrical and mechanical devices require systematic and periodic inspection and maintenance. Any "automatic" features do not relieve the operator from responsibility, but rather alleviate certain repetitive chores, providing time for upkeep and maintenance.

Unusual noise, improper gauge readings, leaks, signs of overheating, etc. can indicate a developing malfunction requiring corrective action.



Only factory authorized burner service personnel should start-up, adjust, or service this equipment.

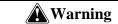


Any cover plates, enclosures, or guards anchored to the burner, or any burner related equipment, must remain in position at all times. Only during maintenance and service shutdown can these cover plates, enclosures, or guards be allowed to be removed. They must be replaced, and securely anchored before testing, adjusting, or running the burner or burner related equipment.



## 7.13.1 — Control System

Most operating controls require very little maintenance beyond regular inspection. Examine electrical connections. Keep the controls clean. Remove any dust from the interior of the control. Covers should be left on controls at all times. Keep the control cabinet doors closed. Dust and dirt can damage motor starters and relay contacts. Starter contacts are plated with silver and are not harmed by discoloration. Never use files or abrasive materials such as sandpaper on contact points.



When replacing a control or cleaning contacts, be sure to disconnect the main power supply since the control is energized even though the burner switch is "OFF." More than one disconnect switch may be required to disconnect all power.

## Programming Control

This control requires no adjustment, nor should any attempt be made to alter contact settings or timing logic. Those programmers with contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Never use abrasive materials. The manufacturer's bulletin also contains troubleshooting information. The flame detector lens should be cleaned as often as conditions demand.

A periodic safety check procedure should be established to test the complete safeguard system. Tests should verify safety shutdown with a safety lockout upon failure to ignite the pilot or he main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. The safety check procedures are contained in the manufacturer's bulletin.

#### Motors

Supply voltage to the motor must not vary more than 10% from nameplate ratings. At initial startup and regularly thereafter, check the motor current with an ammeter while the burner is in high fire position. If the reading exceeds the nameplate rating plus service factor, determine the cause and correct it. In dusty locations, clean the motor regularly to assure adequate cooling. Lubricate in accordance with the manufacturer's instructions.

#### 7.13.2 — Gas System

Check the gas train for leaks. Check the gas valves and verify the low and high gas pressure settings.

#### Solenoid Valves

A faint 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 the 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 the manufacturer's bulletin for the 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 valve body.



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

<u> </u>	-
All power must be disconnected before servicing valves.	

#### 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 operations.

## 7.13.3 — Oil System

Little maintenance is required on the oil systems other than cleaning the oil filter. This procedure should be done at regular intervals. Increased inlet vacuum reading may indicate a clogged filter. Follow the strainer manufacturer's maintenance schedule.

Maintenance checks on the flexible coupling between the fuel unit and motor for alignment, tightness and wear and oil piping connection tightness should also be made at regular intervals. You access the coupling by removing the airbox cover and loosening the two setscrews on the flex coupling.

The nozzle should be checked. Inside the nozzle lies a small screen that keeps out any particle not caught by the strainer. These particles will interfere with the normal oil flow pattern exiting the nozzle. A distorted flame can indicate a clogged nozzle. Inspect and clean the nozzle and screen. To clean the screen, swirler, and tip, unscrew the tip from the nozzle body. Clean the nozzle parts in solvent. Never use wire or sharp metal tools to clean the nozzle orifice. A metal tool will distort the orifice and ruin the nozzle. Reassemble the nozzle. The tailpiece must be screwed in with the swirler seating tight against the tip to ensure proper atomization. Reassemble the nozzle into the nozzle body. If a nozzle is replaced, it must be an identical nozzle (make, size, and spray angel).

## 7.13.4 — Drawer Assembly

The drawer assembly may be removed for inspection and service.

- 1. Shut off the burner, position the switch to "OFF."
- 2. Shut off all electric power to the burner.
- 3. Disconnect the fuel lines from the drawer assembly access cover.
- 4. After making note of where the bolts are located in relationship to the access cover slots, remove the drawer assembly access cover bolts. Pull the drawer partially out of the housing. Reach inside to disconnect the ignition cables from the electrodes for direct spark applications. Pull the drawer assembly completely out of the housing.
- 5. To reinstall the drawer assembly, insert it part way into the housing, connect the ignition cables, if applicable, and seat the assembly fully. Install the access cover bolts loosely. Slide the cover into the original location and tighten the bolts. Reconnect the fuel lines.

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## 7.13.5 — Ignition Electrode, Cable and Pilot

Failure to keep electrodes clean and set in the proper position accounts for much faulty burner operation. Not only must the gap be correct, but the electrode points must be carefully located with respect to the nozzle. Sometimes difficulty in securing the electrodes in their clamps can be corrected by using light metal shims around the porcelain. Defective or cracked porcelains require replacement to prevent short-circuiting of the spark. A gradual wearing away of the electrode tips may require re-spacing of the points or replacement of the electrode.

The pilot should be checked monthly for loosening of components and carbon buildup. Before removing the pilot, ensure that the fuel supply is shut off.

On direct spark oil units, once the drawer assembly has been removed, check the electrode to nozzle gap and adjust if necessary.

For burners equipped with a gas pilot, the pilot is located on the side opposite to the main gas entrance. Close the gas pilot cock. Disconnect the pilot gas supply line. Remove the screws on the pilot access plate. Disconnect the pilot gas supply line. Remove the screws on the pilot access plate. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly,. The pilot gun assembly will slide back away from the flame side of the burner. Once the pilot assembly is clear of the burner head bracket, turn the pilot assembly and retract it through the access hole. Inspect the electrode and adjust the gap if necessary. Thoroughly clean and adjust the porcelain insulated electrodes. Correct all variations from the clearance dimensions. If the insulation on the high voltage cables becomes cracked or charred, install new cables. Ignition cable should not be exposed to moisture, abrasion, or rough handling. See that the connectors are in perfect contact with the cable ends. Unscrewing the snap portion of the connector will show whether this is true.

## 7.13.6 — 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. Check pilot and flame signal strength.

## 7.13.7 — Burner Mounting Inspection

The seal between the burner flange and furnace front plate must not permit combustion gases to escape. Periodic inspection is important.

### 7.13.8 — 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 burner control and store in a dry area.



## 7.13.9 — Maintenance Flow Chart Recommended Test Schedule

DAILY	
Instrument and Equipment Settings  Low Water, Fuel Cutoff and Alarms  WEEKLY  Firing Rate Control Operator Oper	
Settings  Low Water, Fuel Cutoff and Alarms  WEEKLY  Firing Rate Control  Operator  Operator  Operator  Operator  Verify factory settings.  Igniter  Operator  Close manual fuel supply for (1) pilot and (2) main dand/or valve(s). check safety shutdown timing. Recommendation and one of the safety shutdown timing. Recommendation and the safety shutdown timing and the safety	
WEEKLY  Firing Rate Control Operator Verify factory settings.  Igniter Operator Make visual inspection. Check flame signal strength Operator Open limit switch. Make audible and visual check, valve position indicators, and check fuel meters.  Flame Failure Controls Operator Close manual fuel supply for (1) pilot and (2) main fand/or valve(s). check safety shutdown timing. Record and log the flame signal for both pilot and mandor valve(s). check safety shutdown timing. Record Read and log the flame signal for both pilot and mandor valve(s) in generator Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock Operator Manually adjust until switch opens.  High and Low Gas Pressure Interlock Operator Check, inspect and clean for soot buildup.  Scanner and Diffuser Operator Check, inspect and clean for soot buildup.  ANNUALLY	ions.
Firing Rate Control  Operator  Operator  Operator  Operator  Operator  Operator  Make visual inspection. Check flame signal strength Make visual inspection. Check flame signal strength Operator  Operator  Operator  Operator  Operator  Operator  Close manual fuel supply for (1) pilot and (2) main frand/or valve(s). check safety shutdown timing. Recompany for the flame signal for both pilot and mand Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock  Operator  Operator  Manually adjust until switch opens.  High and Low Gas Pressure Interlock  Operator  Operator  Operator  Operator  Check, inspect and clean for soot buildup.  Operator  Operator  Operator  Check for loosening of components, erosion or carbin buildup.  ANNUALLY	
Igniter Operator Make visual inspection. Check flame signal strength Pilot and Main Fuel Valves Operator Open limit switch. Make audible and visual check. Operator Valve position indicators, and check fuel meters.  Flame Failure Controls Operator Close manual fuel supply for (1) pilot and (2) main frank and/or valve(s). check safety shutdown timing. Record and log the flame signal for both pilot and mand Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock Operator Manually adjust until switch opens.  High and Low Gas Pressure Interlocks Operator Refer to instructions. Manually adjust until switch opens.  Scanner and Diffuser Operator Check, inspect and clean for soot buildup.  Pilot Assembly Operator Check for loosening of components, erosion or carbon buildup.  ANNUALLY	
Pilot and Main Fuel Valves Operator Open limit switch. Make audible and visual check. Valve position indicators, and check fuel meters.  Close manual fuel supply for (1) pilot and (2) main fund/or valve(s). check safety shutdown timing. Record and log the flame signal for both pilot and mand Notify service if readings are very high, very low, or ing.  MONTHLY Low Fan Pressure Interlock Operator Manually adjust until switch opens.  High and Low Gas Pressure Interlocks Scanner and Diffuser Operator Operator Operator Check, inspect and clean for soot buildup.  Operator Check for loosening of components, erosion or carbon buildup.  ANNUALLY	
valve position indicators, and check fuel meters.  Flame Failure Controls  Operator  Close manual fuel supply for (1) pilot and (2) main of and/or valve(s). check safety shutdown timing. Record and log the flame signal for both pilot and man Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock  Operator  Manually adjust until switch opens.  High and Low Gas Pressure Interlocks  Scanner and Diffuser  Operator  Operator  Check, inspect and clean for soot buildup.  Pilot Assembly  Operator  Check for loosening of components, erosion or carbon buildup.  ANNUALLY	1.
Flame Signal Strength Controls  Operator  Read and log the flame signal for both pilot and ma Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock  Operator  High and Low Gas Pressure Interlocks  Operator  Operator  Refer to instructions. Manually adjust until switch opens.  Refer to instructions. Manually adjust until switch opens.  Check, inspect and clean for soot buildup.  Pilot Assembly  Operator  Check for loosening of components, erosion or carbo buildup.  ANNUALLY	Check
Notify service if readings are very high, very low, or ing.  MONTHLY  Low Fan Pressure Interlock	
Low Fan Pressure Interlock  Operator  High and Low Gas Pressure Interlocks  Scanner and Diffuser  Operator  Operator  Operator  Check, inspect and clean for soot buildup.  Operator  Operator  Operator  Check for loosening of components, erosion or carbon buildup.  ANNUALLY	
High and Low Gas Pressure Interlocks  Scanner and Diffuser  Operator  Operator  Check, inspect and clean for soot buildup.  Pilot Assembly  Operator  Operator  Check for loosening of components, erosion or carbon buildup.  ANNUALLY	
Scanner and Diffuser Operator Check, inspect and clean for soot buildup.  Pilot Assembly Operator Check for loosening of components, erosion or carbo buildup.  ANNUALLY	
Pilot Assembly  Operator  Check for loosening of components, erosion or carbo buildup.  ANNUALLY	pens.
buildup.  ANNUALLY	
	on
Strainer (Oil Units) Operator Replace or clean the oil strainer element.	
Impeller Operator Inspect and clean the combustion impeller.	
Combustion Test Service Tech Perform a complete combustion test. Adjust burner sary. Read and log data.	if neces-
Pilot Turndown Test Service Tech Required after any adjustment to flame, scanner, or adjustment.	pilot
Operating Controls Service Tech Refer to instructions.	



CHAPTER 8	Part.	C
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## 8.1— Ordering Parts

Furnish complete information when ordering parts by giving the item number, description, and the quantity of parts desired, together with the complete boiler nameplate data, including all electrical requirements.

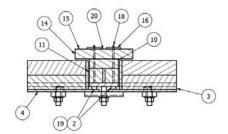
Repair and replacement parts should be ordered from your local Cleaver-Brooks authorized representative.

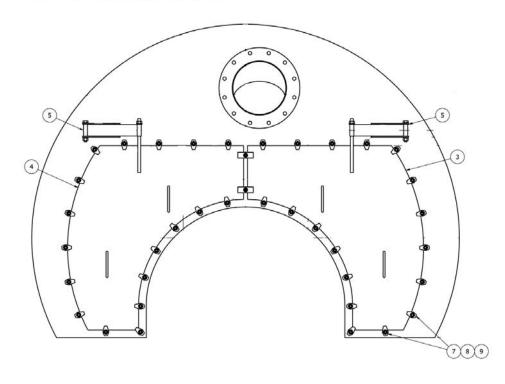
Item P	age
Front Smoke Box	3-2
Main Gas Train	3-3
Pressure Controls	3-4
Safety Valves 8	3-5
Handhole/Manway Parts	3-6
Burner Gasket & Dry Oven (30 PPM)	3-6
Low Water Cutoff - Level Master	3-7
Gauge Glass	8-8
Aux. Low Water Cutoff	3-9
Rear Access Plug	3-10

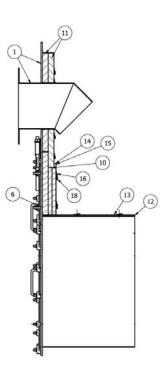


## 8.2—Front Smoke Box

ITEM	QTY	PART NO.	DESCRIPTION			
2	2	872-00622-000	ROPE, FIBERFAX, 2300 DEG. 1/2" DIA. X 160-1/2" LG. EA.			
3	1	132-02732-000	DOOR, FRONT SMOKE BOX, RIGHT HAND			
4	1	132-02733-000	DOOR, FRONT SMOKE BOX, LEFT HAND - DWG. 132-02732-000			
5	2	462-00099-000	DAVIT, FRONT & REAR DOOR			
6	2	149-00917-000	SIZED CHANNEL, 1-1/2" X 1/2" X 1/8" X 4" LG. A575 GR. M1020 STEEL			
7	36	103-00375-000	LOCKING LUG			
8	38	952-00108-000	WASHER, FLAT, 1/2" S.A.E. PLAIN STEEL			
9	38	869-00015-000	NUT, HEX HD. 1/2-13 UNC ASTM A563 GR. A			
10	1	872-01007-000	INSULATION BOARD, 1" 1900 DEG. GEMINITE 19 SERIES (.26 SQ. FT.)			
11	2	872-01008-000	INSULATING BOARD, 1-1/2" 1900 DEG. GEMINITE 19 SERIES (19.4 SQ. FT. EA.)			
12	1	872-01081-000	VET FELT, 1/4" X 24" X 138" LG. SUPERWOOL 607 (13.2 SQ. FT.)			
13	1	930-00135-000	WIRE MESH, 1/2" MESH X 18 GA. X 24" X 138" LG. 304 S.S. (3312 SQ. IN.)			
14	1	872-01082-000	INSULATING BLANKET, 1" THK. X 6" X 13-1/4" LG. SUPERWOOL 607 (.55 SQ. FT.)			
15	1	930-00135-000	WIRE MESH, 1/2" MESH X 18 GA. X 6" X 13-1/4" S.S. (80 SQ. IN.)			
16	54	828-00034-000	CLIP, INSULATION RETAINER, 1-1/2" SQ. X 10 GA. S.S.			
17	50	903-00299-000	PIN, WELDING, 10 GA. X 4" LG. S.S.			
18	4	903-00298-000	PIN, WELDING, 10 GA. X 5" LG. S.S.			
19	1	797-01813-000	SUPER TACK ADHESIVE			
20	6 oz.	872-00443-000	RIGIDIZER			
21	1	872-00757-000	INSULATION, FIBREFRAX CAULK - TUBE			



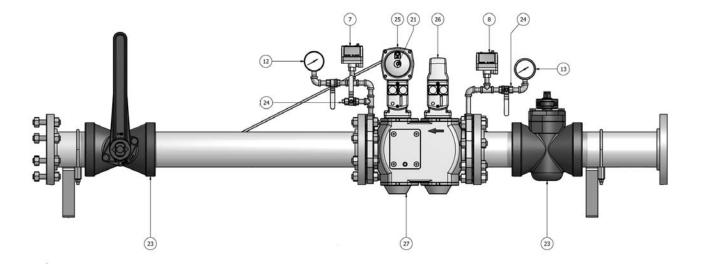






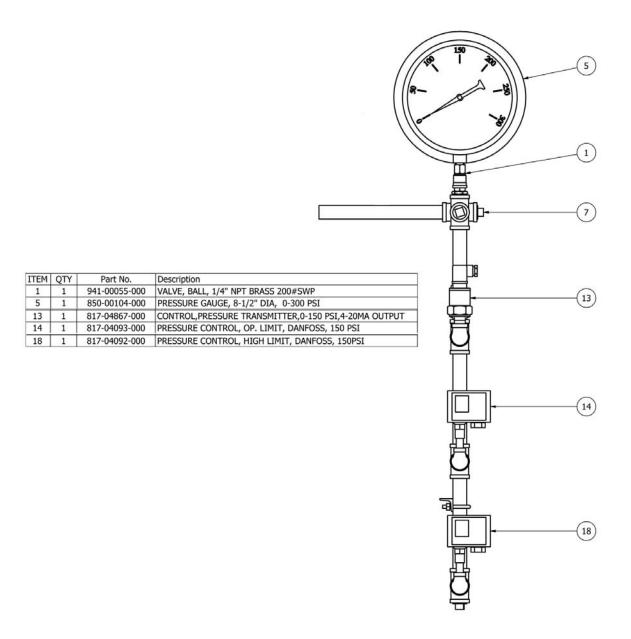
## 8.3—Main Gas Train

ITEM	QTY	PART NO.	DESCRIPTION
7	1	817-02423-000	HGPS, 1.5-7 PSI RANGE, MR, 1/4" NPT MOUNT
8	1	817-03591-000	LGPS, 1.5-7 PSI RANGE, MR, 1/4" NPT MOUNT
12	1	850-00613-000	GAUGE, PRESSURE, 2-1/2", 0-200" WC, 1/4" NPT BOTTOM MOUNT
13	1	850-02363-000	GAUGE, PRESSURE, 2-1/2", 0-15 PSI, 1/4" BTM CONN.
21	1	924-00174-000	SPRING, RED (FOR SIEMENS REG. ACTUATOR)
23	2	941-00131-000	VALVE, LUB PLUG, 4" NPT W/WRENCH
24	3	941-02640-000	VALVE, BALL, BRASS, 1/4", 150#
25	1	945-00234-000	ACTUATOR, REGULATING, W/POC, 0"-100" WC
26	1	945-00236-000	ACTUATOR, GAS VALVE, W/ POC
27	1	949-00452-000	VALVE BODY, 4", FLANGED





## 8.4—Pressure Controls





## 8.5—Safety Valves

## 8.5.1—150 psi

	First Valve(s)		First Valve(s) Second Valve(s)	
Boiler HP	Qty	Part Number	Qty	Part Number
900	3	940-2108		
1000	3	940-2108	1	940-2109
1100	3	940-2108	1	940-2109
1200	4	940-2108		

## 8.5.2—200 psi

	First Valve(s)		Second Valve(s)	
Boiler HP	Qty	Part Number	Qty	Part Number
900	2	940-2981	1	940-2979
1000	2	940-2981	1	940-2979
1100	2	940-2981	1	940-2980
1200	3	940-2981		

## 8.5.3—250 psi

	First Valve(s)		Second Valve(s)	
Boiler HP	Qty	Part Number	Qty	Part Number
900	2	940-2985		
1000	2	940-2985		
1100	2	940-2985	1	940-2052
1200	2	940-2985	1	940-2984



## 8.6—Handhole/Manway Parts

## 8.6.1—Handholes

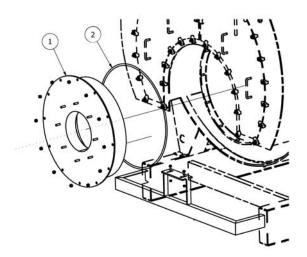
	150 PSI		200 PSI		
Handhole Cover Assembly	Yoke	Gasket	Handhole Cover Assembly	Yoke	Gasket
258-00010	104-00449	853-00935	258-00010	104-00449	853-01042

## 8.6.2—Manway

150 PSI					200	PSI	
Manway Ring	Gasket	Cover	Yoke	Manway Ring	Gasket	Cover	Yoke
914-00257	853-00939	821-00207	953-00050	914-00257	853-01044	821-00207	953-00050

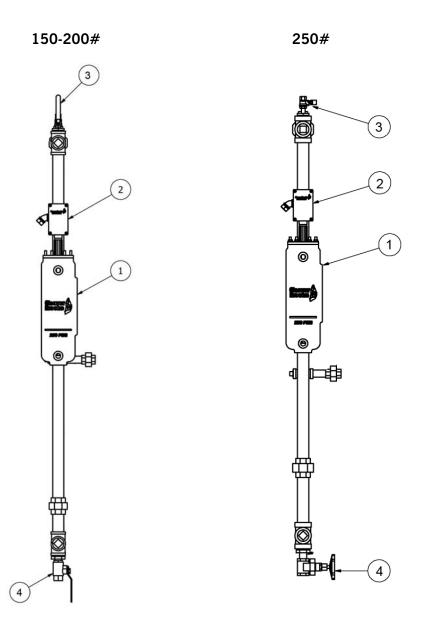
## 8.7—Burner Gasket & Dry Oven (30 PPM)

Boiler HP	Item 1 Dry Oven	Item 2 Burner Gasket
900		
1000	279-00619	853-01454
1100		
1200	279-00951	853-01454





## 8.8—Low Water Cutoff - Level Master



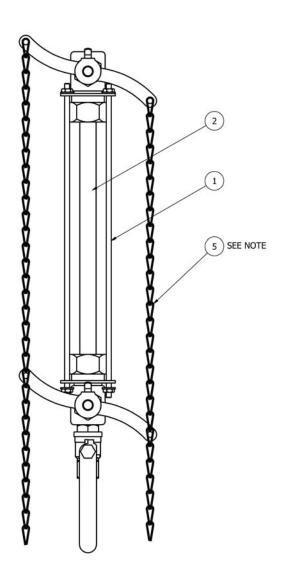
Item	Description	150-200#	250#	
1	Water Column, Level Master	289-00830	289-00830	
	W.C. with Tri-Cocks	289-00831	289-00831	
2	Sensor Assembly	623-00230	623-00230	
3	Ball Valve	941-00055	941-02656	
4	Ball Valve	941-01790	-	
	Gate Valve	-	941-00170	

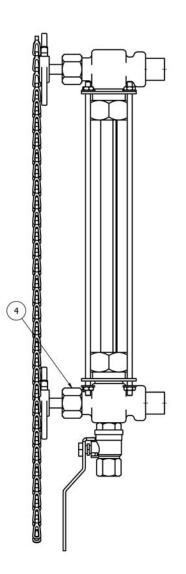


## 8.9—Gauge Glass

ITEM	QTY	Part No.	Description
1	4	912-00034-000	ROD, GAUGE GLASS
2	1	851-00034-000	GAUGE GLASS, 5/8' DIA. X 10-1/2" LG. PYREX
4	1	825-00394-000	GAUGE VALVE SET WITH BALL CHECK AND 1/4" DRAIN VALVE
5	12'	830-00028-000	BULK CHAIN, SASH, TRADE SIZE #40, ZINC PLATED, 0.042 METAL GAUGE

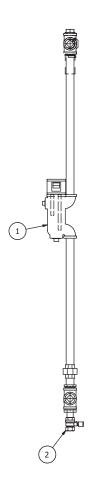
NOTE: USE12' OF CHAIN FOR 106" BOILERS







## 8.10—Aux. Low Water Cutoff

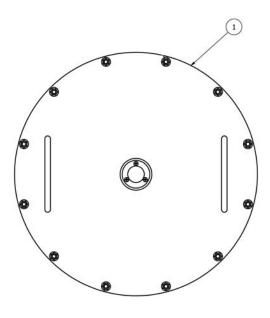


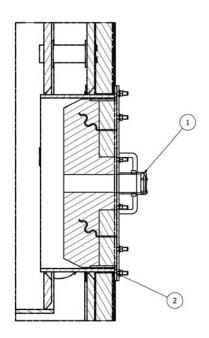
			150#	200#	250#
	ITEM 1	CONTROL, ALWCO		817-2372	
Warrick C2	ITEM 2	VALVE, BALL	941-01657	941-01790	-
		VALVE, GATE	-	-	941-00170
	ITEM 1	CONTROL, ALWCO		817-02259	
Warrick 3K-3	ITEM 2	VALVE, BALL	941-01790	941-01790	-
		VALVE, GATE	-	-	941-00170
McD-M 150S-B-M	ITEM 1	CONTROL, ALWCO	817-02407	-	-
	ITEM 2	VALVE, GATE	941-00170	-	-
McD-M 93-M	ITEM 1	CONTROL, ALWCO	817-00435	-	-
	ITEM 2	VALVE, GATE	941-00170	-	-
McD-M 94-M	ITEM 1	CONTROL, ALWCO	-	817-00306	
	ITEM 2	VALVE, GATE	-	941-00170	941-00170



## 8.11—Rear Access Plug

PARTS LIST				
ITEM	QTY	Part Number	Description	
1	1	465-02591-000	REAR ACCESS PLUG CBEX BOILERS	
2	1	872-00622-000	FIBERFRAX ROPE, 1/2" X 70"	







e-mail: info@cleaverbrooks.com Web Address: http://www.cleaverbrooks.com