CBEX Elite

Packaged Boiler

100-800 HP

Operation and Maintenance

Manual Part No. 750-324 09/2011

⚠ WARNING

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 his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

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

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.

CBEX ELITE 100-800 HP

Table of Contents

CHAPTER 1 Basics

1.1 — Overview

CBEX Elite boilers are available for steam or hot water applications. 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 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 or hot water. 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 covers CBEX Elite boilers ranging from 100 through 800 boiler horsepower for the following fuels:

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

The low emission option for the CBEX Elite 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 as increased turbulence caused by the addition of the flue gases into the combustion air stream results in improved combustion.

The CBEX Elite Firetube Boiler line is designed to incorporate Induced Flue Gas Recirculation (IFGR) when firing either natural gas and/or light oil, and is compatible with both hot water and steam systems.

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.

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

The low emission design 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 different IFGR damper fan and motor sizes.

The boiler and related equipment installation should 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 Elite 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 Elite 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, CBEX 700-600 indicates a gas-fired 600 hp boiler.

The firetube construction provides some characteristics that differentiate it from other boiler types. Because of its vessel size, the firetube boiler 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.

Hot water is commonly used in heating applications with boiler supplied water to the system at 180º F to 220º F. The operating pressure for hot water heating systems usually is 30 psig to 125 psig.

Steam and hot water boilers are defined according to design pressure and operating pressure.

Design pressure is the maximum pressure used in the design of the boiler for the purpose of calculating the minimum permissible thickness or physical characteristics of the pressure vessel parts of the boiler. Typically, the safety valves are set at or below design pressure.

Operating pressure is the pressure at which the boiler 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 thoroughly checked before use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

The close observance of water requirements for both steam and hot water boilers 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 and hot water boilers designed for 250º F at 125 psi or less 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. Hot water boilers designed for operating temperatures above 250º F or 125 psi are likewise built to Section I of the ASME Code.

*CBEX Elite steam boilers are high pressure steam only.

1.4 — Steam Controls (all fuels)

1.4.1 — 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.

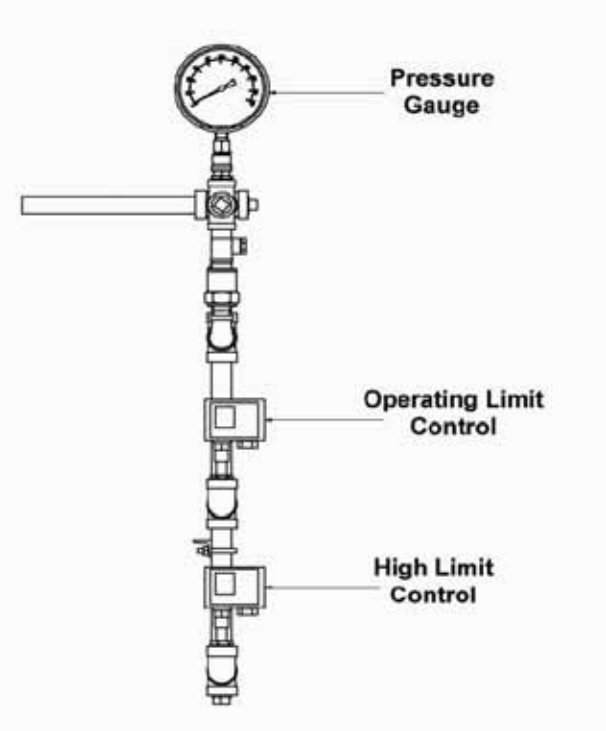
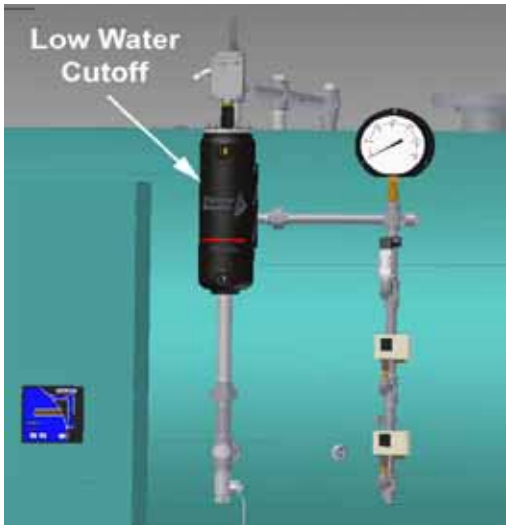


FIGURE 1-2. **Steam Controls**

1.4.2 — Low Water Cutoff



The style of Low Water Cutoff is determined by the design pressure of the vessel or by customer preference. The CB Level Master (for operation and maintenance information, consult the Level Master manual that accompanied the boiler) is used on all steam boilers 150 psig to 250 psig.

FIGURE 1-3. **Low Water Cutoff**

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. **Water Gauge Glass Drain Valve**: Provided to flush the gauge glass.
3. **Vent Valve**: Allows the boiler to be vented during filling and facilitates routine boiler inspection as required by ASME Code.
4. **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 auxiliary low water cutoff for the same purpose.

1.4.3 — Safety Valve(s)

Safety Valves: Prevent buildup over the design pressure of the pressure vessel. The size, rating, and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME Code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply 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.

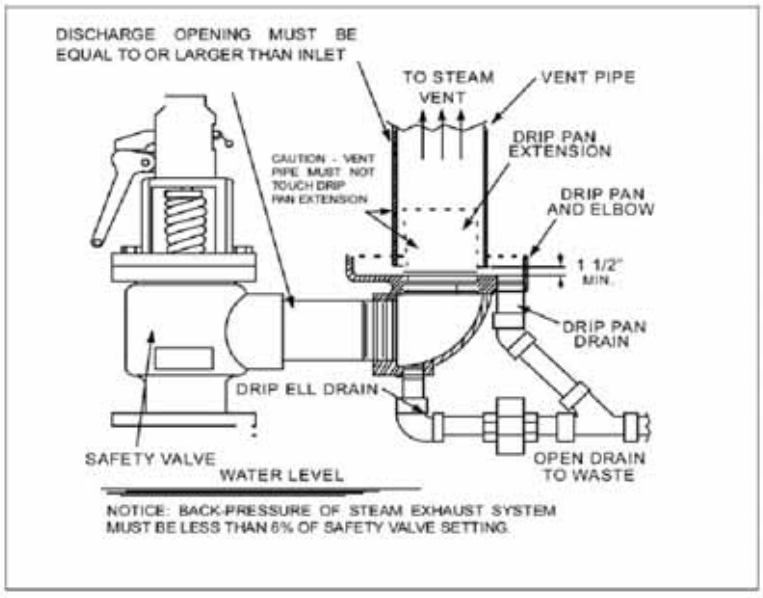


FIGURE 1-4. Safety Valve Piping and Safety Valves

⚠ Warning

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.

1.5 — Hot Water Controls (all fuels)

1.5.1 — Pressure and Temperature Gauges

1. **Water Pressure Gauge**: Indicates the boiler internal water pressure.
2. **Water Temperature Gauge**: Indicates the boiler water temperature.

1.5.2 — Controls

1. **Modulating Temperature Control**: Senses changing boiler water temperature and transmits the information to change the burner firing rate when the manual-automatic switch is set on "automatic."
2. **High Limit Temperature Control**: Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop the burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
3. **Operating Limit Temperature Control**: Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.

FIGURE 1-5. **Temperature Gauge and Hot Water Controls**

1.5.3 — Low Water Cutoff and ALWCO

1. **Low Water Cutoff**: Breaks the circuit to stop burner operation if the water level in the boiler drops below a safe operating point, activating the low-water light and the optional alarm bell.
2. **Auxiliary Low Water Cutoff (optional)**: Breaks the circuit to stop burner operation if the water level in the boiler drops below the master low-water cutoff point.

1.5.4 — Safety Valve(s)

Relieves the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME Code requirements.

1.6 — IFGR Components

1. **Flue Gas Transfer Port, IFGR Damper, Flange Collar**: The flue gas transfer port is a tube that allows the flue gases to travel from the exit of the second-pass tubes to the entrance of the combustion air fan.

   The IFGR damper controls the volume of flue gas induced into the combustion air stream. The damper is located in the flue gas transfer port and is positioned by the control linkage.
2. **Burner Drawer**: The gas spudding pattern for the IFGR system may be different than that of a non-IFGR, High-Turndown CB burner of the same horsepower (HP) model designation.
3. **Combustion Air Inlet**: The combustion air inlets are located at the top of the front door. Air enters from the rear of the air inlet shrouds, which reduces the sound level and captures heat from the boiler and stack flue outlet.
4. **Front Door Insulation**: If NOx emissions are below 60 ppm, the front door is insulated inside to control temperature buildup. The insulation is held in place with wire mesh.

1.7 — Fan/Motor Cassette

The fan and motor assemblies are designed as a cassette so that they can be removed from the front of the boiler without opening the front door. The front door davit arm can be used to remove the assembly (100-200 HP have a hinged front door and a davit specifically for blower use). When removing the cassette use the lifting lugs provided (3-point rigging recommended for 350-800 HP).

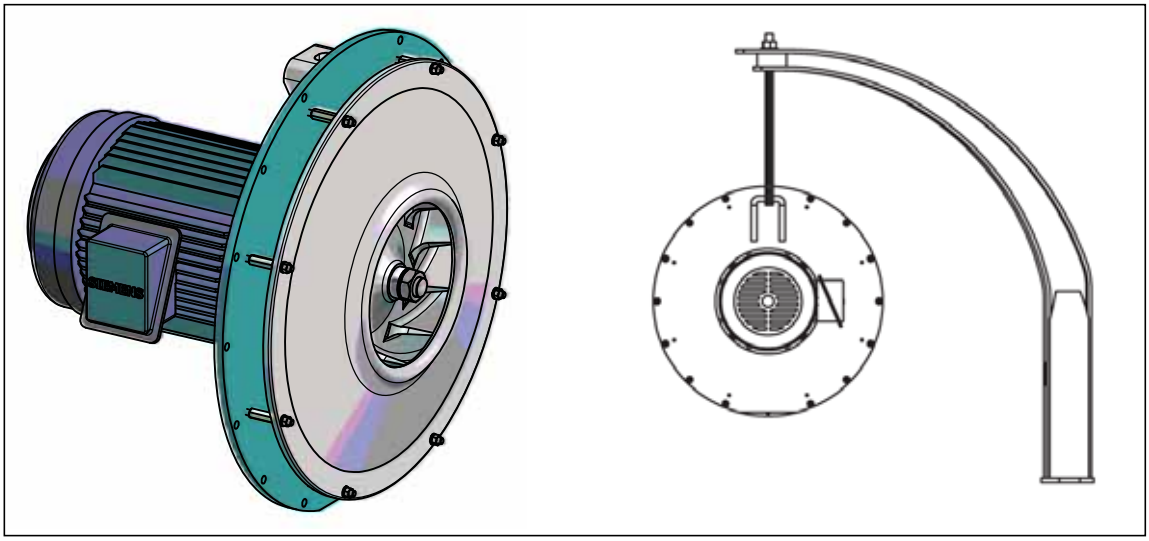


FIGURE 1-6. Fan/Motor Cassette

CHAPTER 2 Burner and Fuel System

2.1 — The Burner

The oil burner is of the low pressure, air atomizing (nozzle) type. The gas burner is of the non-premix orifice type. The burners are ignited by a spark ignited interrupted type gas pilot. The pilot is extinguished after the main flame is established.

Burners equipped to burn oil and gas (combination burners) include equipment for each fuel. Since the burner uses only one type of fuel at a time, a gas/oil selector switch is incorporated.

Regardless of which fuel is used, the burner operates with full modulation (within its rated operating range). The burner returns to minimum firing position for ignition.

A flame detector is present to supervise both oil and gas flames, and to shut the burner down in the event of loss of flame.

The control sequence provides a pre-purging period, proving of the pilot and main flame, and a period of continued blower operation to post-purge the boiler of all unburned fuel vapor. Other safety controls shut down the burner under low-water conditions or excess steam pressure (water temperature).

Safety interlock controls include combustion and atomizing air proving switches and, depending upon the fuel and insurance carrier requirements, controls that prove the presence of adequate fuel pressure.

The sequence of burner operation from startup through shutdown is governed by the Hawk controls in conjunction with the operating, limit, and interlock devices. The devices are wired into the circuitry to provide safe operation and protect against incorrect operating techniques.

All CBEX boilers have the burner assembly integral with the front head. The entire head may be swung open for inspection and maintenance.

Combustion air is provided by a centrifugal blower located in the front head. Combustion air delivery to the burner is under the control of the damper actuator.

Filtered primary air for atomizing fuel oil is furnished independently of combustion air by an air pump.

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

2.2 — Front Head and Panel

Front head, control/entrance panel, and additional components associated with the combustion process are described below. Boilers with optional features may have components not listed here.

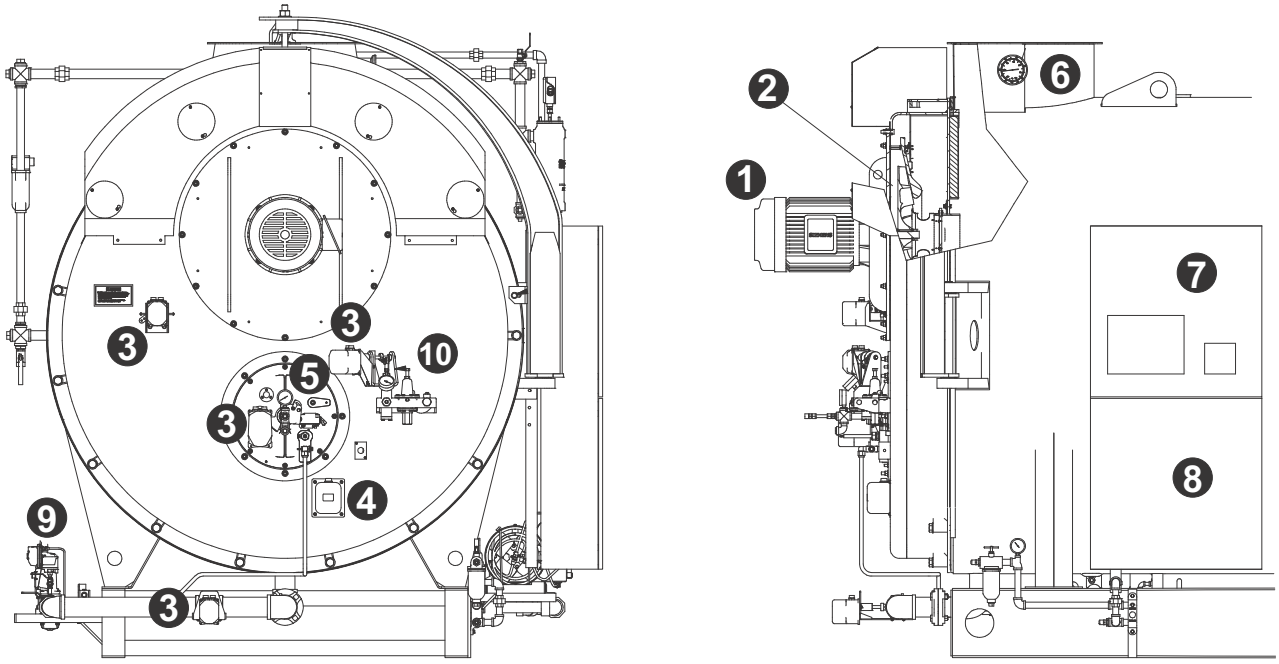


FIGURE 2-1. CBEX Steam Boiler

Component	Description
1. Forced Draft Fan Motor	Drives forced draft fan directly to provide combustion air. Also referred to as a blower motor.
2. Forced Draft Impeller	Provides all air, under pressure, for combustion of pilot fuel and main fuel, and for purging.
3. Actuators	Independent actuators for fuel, air, and FGR operate to provide proper air/fuel ratios under all boiler load conditions.
4. Ignition Transformer	Provides high voltage spark for ignition of gas pilot or light oil pilot.
5. Flame Detector	Monitors gas or oil pilot and energizes the programmer flame relay in response to a flame signal. It continues to monitor main flame (oil or gas) after expiration of pilot providing period. A standard equipped boiler has a lead sulfide (infrared sensitive) detector.
6. Stack Thermometer	Indicates temperature of vented flue gases.

Component	Description
7. Control panel	Houses the touchscreen HMI and boiler control system. Controller automatically programs each starting, operating, and shutdown period in conjunction with operating limit and interlock devices. Includes, in a timed and proper sequence, the operation of the blower motor, ignition system, fuel valve(s), damper, and FGR. The sequence includes air purge periods prior to ignition and upon burner shutdown.
8. Entrance box	Houses high voltage equipment including motor starters and fuses.
9. Gas train	See 2.4
10. Oil system	See 2.5

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

The control recycles automatically during normal operation, or following a power interruption. It must be manually reset following a safety shutdown caused by a loss of flame. An internal checking circuit, effective on every start, prevents burner operation in the event anything causes the flame relay to hold in during this period.

2.3 — Gas System

Depending upon the requirements of the insurance carrier or other governing agencies, the gas flow control system, or gas train, may consist of some, or all, of the following items. Refer to the Dimension Diagram (DD) prepared by Cleaver-Brooks for the installation.

Item numbers refer to the table following the illustrations.

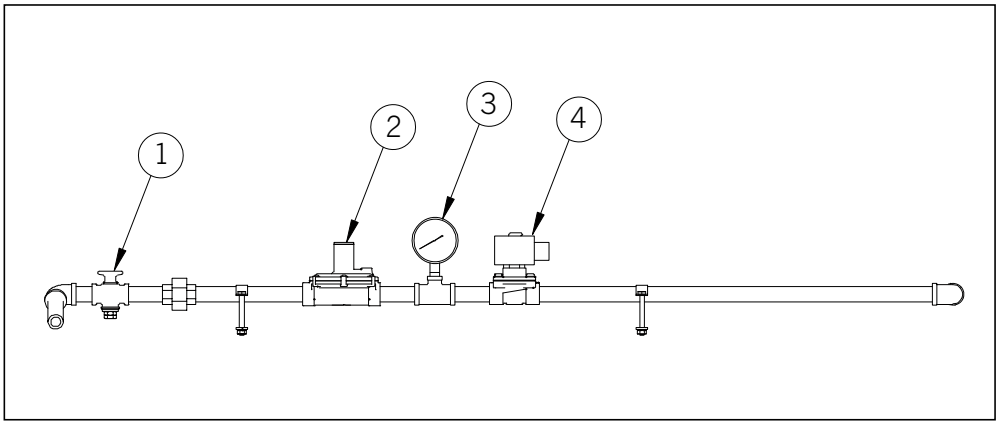


FIGURE 2-2. Pilot Gas Train

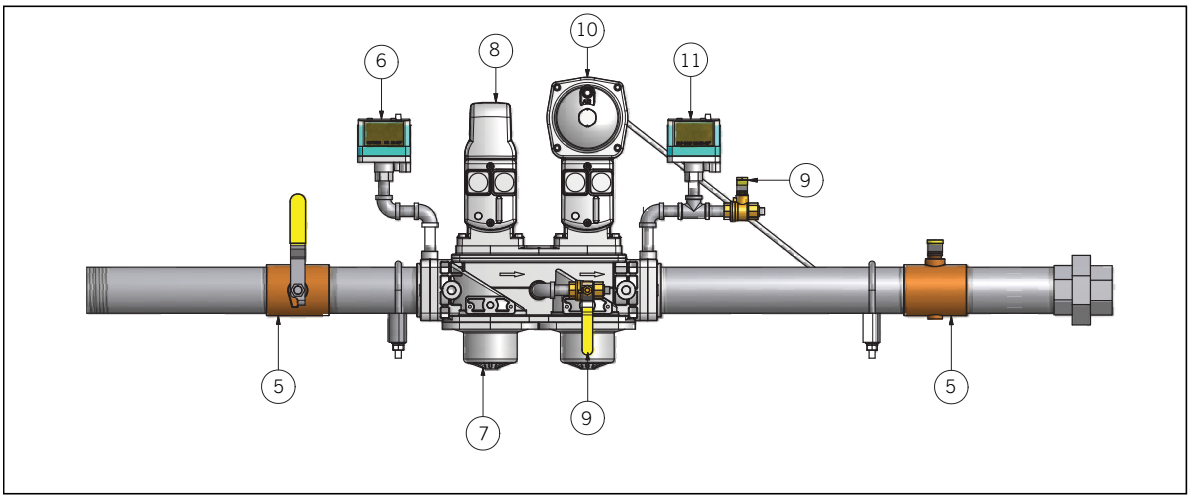


FIGURE 2-3. Main Gas Train

Component	Description
1. Pilot Gas Shutoff Cock	For manually opening or closing the pilot gas supply.
2. Pilot Gas Pressure Regulator	Reduces incoming gas pressure to suit the pilot.
3. Pilot Gas Pressure Gauge	Indicates gas pressure to pilot.
4. Pilot Gas Valve	A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established. The sequence of energizing and de-energizing is controlled by the programming relay. A second gas pilot valve may be required by insurance regulations.
5. Gas Shutoff Cock	The upstream gas cock manually opens and closes the main fuel gas supply. A second shutoff cock, downstream of the main gas valve(s), is installed to provide a means of shutting off the gas line whenever a test is made for leakage across the main gas valve.
6. Low Gas Pressure Switch	A pressure actuated switch that is closed whenever main gas line pressure is above a preselected pressure. Should the pressure drop below the setting, the switch contacts open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. The switch is usually equipped with a device that must be manually reset after being tripped.
7. Main Gas Valves	Electrically actuated shutoff valves that open simultaneously to admit gas to the burner. The downstream valve is equipped with a “proof of closure” switch that is connected into the pre-ignition interlock circuit.
8. Gas Valve Actuator w/o POC	Dual-body gas valve includes regulating valve with POC (see below) and second motorized safety shutoff valve.
9. Leakage Connection	The body of the gas valve has a plugged opening that is used whenever it is necessary to conduct a test for possible leakage across the closed valve.
10. Gas Regulating Actuator w/ POC	Regulates gas pressure to the pressure range required by the burner. Includes proof-of-closure switch.

Component	Description
11. High Gas Pressure Switch	A pressure actuated switch that is closed whenever main gas line pressure is below a preselected pressure. Should the pressure rise above the setting, the switch contacts will open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. The switch is usually equipped with a device that must be manually reset after being tripped.
12. Butterfly Gas Valve (not shown)	The pivoted disc in the valve is actuated by connecting linkage from the gas modulating cam to regulate the rate of gas flow to the burner.

2.4 — Oil System

The following items are applicable to all oil fired or combination fired boilers.

Component	Description
Oil Drawer Switch	Opens the limit circuit if the oil drawer burner gun is not latched in the forward position required for burning oil.
Atomizing Air Proving Switch	Pressure actuated switch whose contacts are closed when sufficient atomizing air pressure from the air pump is present for oil firing. Oil valve(s) will not open, or will not remain open, unless switch contacts are closed.
Atomizing Air Pressure Gauge	Indicates the atomizing air pressure at the burner gun.
Oil Solenoid Valves	Opens when energized through contacts in the programmer and allows fuel oil to flow from the oil metering valve to the burner nozzle. A light oil fired burner uses two valves operating simultaneously.
Fuel Oil Controller	An assembly combining into a single unit the gauges, regulators, and valves required for regulating the flow of fuel oil. All controllers have the following integral parts. A. Oil Metering Valve: Valve metering stem moves to increase or decrease the orifice area to regulate the supply of fuel oil to the burner nozzle in accordance with boiler load variances. Stem movement is controlled by the oil fuel actuator. B. Oil Burner Pressure Gauge: Indicates pressure of the fuel oil at the metering valve. C. Oil Pressure Regulator: For adjustment of the pressure of oil at the metering valve.
Oil Relief Valve	Maintains a constant oil supply pressure to the fuel oil controller by bypassing excess fuel oil.
Terminal Block	Provides connections for fuel oil supply piping.
Fuel Oil Strainer	Prevents foreign matter from entering the burner system.
Back Pressure Orifice	A restriction located in the oil return line immediately downstream of the fuel oil controller to create back pressure (100 and 200 series only).

Component	Description
Low Oil Pressure Switch (optional)	Switch contacts open when the fuel oil pressure drops below selected pressure. Switch will interrupt the limit circuit upon loss of sufficient fuel oil pressure for correct combustion.
Fuel Oil Pump	Transfers fuel oil from the storage tank and delivers it under pressure to the burner system.

Air Pump Module Assembly	Provides the compressed air required to atomize the fuel oil for proper combustion. It is started automatically by the programmer's sequence. Includes the following components (see Figure 2-4): A. Air Pump Motor: Drives the air pump and an air cooling fan. The motor is started and stopped simultaneously with the forced draft fan motor. B. Air PUmp: Provides air for atomization of the fuel oil. C. Air Filter: The filter cleans the air supply prior to entering the air pump. D. Check Valve: Prevents lubricating oil and compressed air from surging back through the pump and air filter when the pump stops. E. Air-Oil Receiver Tank: Holds a supply of oil for lubricating the air pump. The receiver tank also separates lube oil from the atomizing air before delivery to the nozzle. F. Lube Oil Level Sight Glass: Indicates the level of lubricating oil in the air-oil receiver tank. G. Lube Oil Cooling Coil: Cools the lubricating oil before it enters the air pump. A fan driven by the air pump motor circulates cooling air over the coil. H. Lube OIl Fill Pipe and Strainer: Used when adding oil to the air-oil receiver tank.

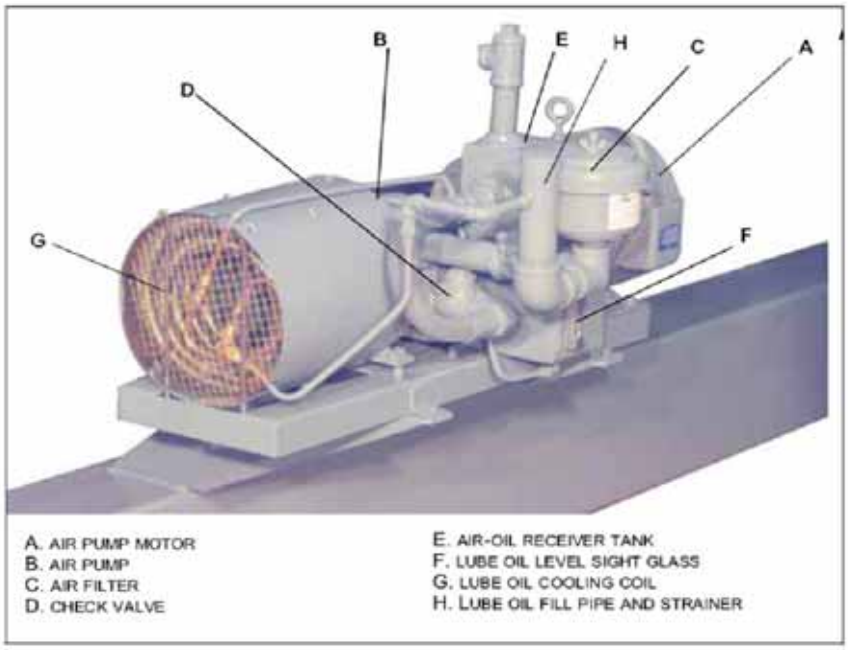


FIGURE 2-4. Air Pump (Primary Air)

2.5 — Controls for Combination Burners Only

Gas-Oil Switch: Burners equipped to burn either oil or gas include equipment for each fuel. The selector switch engages the appropriate interlocks and controls for gas or oil operation. Chapter 4 details the required functions of each fuel system.

2.6 — Combustion Air

Air for combustion of fuel (referred to as “secondary” air) is furnished by the forced draft fan mounted in the boiler head. In operation, air pressure is built up in the entire head and is forced through a diffuser plate for a thorough mixture with the fuel for proper combustion. The supply of secondary air to the burner is governed by automatically throttling the output of the fan by regulating the rotary air damper. The damper provides the proper amount of air for correct ratio of air to fuel for efficient combustion at all firing rates.

The use of a Variable Speed Drive (VSD), optional, works in conjunction with the air damper actuator. When high fire is not required the VSD reduces amperage to the fan motor, reducing energy consumption and the corresponding air flow simultaneously.

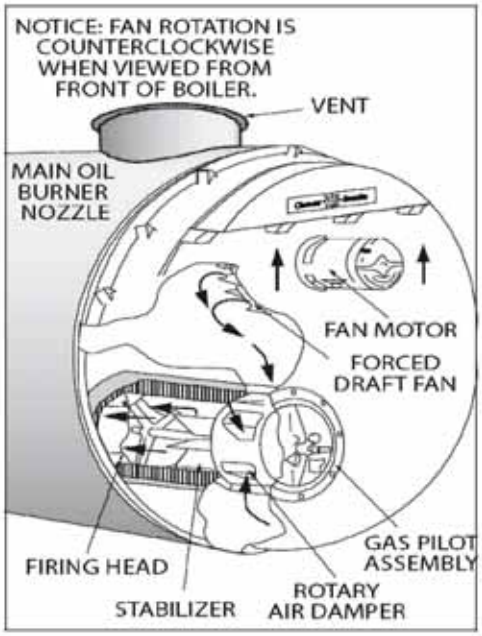


FIGURE 2-5. Secondary Air Flow Diagram

2.7 — Automatic Ignition

Oil or gas burners are ignited by an interrupted type pilot. The pilot flame is ignited automatically by an electric spark.

Burners are equipped with a gas burning pilot. In the case of a combination burner, the gas pilot is used to ignite either the main gas flame or the oil flame.

At the beginning of the ignition cycle, and governed by the program relay and the Hawk 2000 system, the pilot solenoid valve and ignition transformer are simultaneously energized.

The ignition transformer supplies high voltage current for the igniting spark. A gas pilot has a single electrode and a spark arcs between the tip of the electrode and the wall of the tube surrounding it. A light oil pilot has two electrodes and the arc is between their tips. The pilot solenoid valve and the transformer are de-energized after main flame is ignited and established.

Fuel for the gas pilot is supplied from the utility's main, or from a tank (bottle) supply. Secondary air flows into and mixes with the pilot gas stream to provide an adequate fuel and air mixture for combustion.

Insurance regulations may require two gas pilot solenoid valves with a normally open vent valve between them. The vent valve closes when the gas pilot valves open, and opens when the gas pilot valves shut to vent gas, should any be present in the pilot line during the de-energized period of the gas pilot valves.

2.8 — Atomizing Air

Air for atomizing the fuel oil (referred to as "primary" air) is pumped by the air pump into the air-oil receiver tank and delivered under pressure through a manifold block to the oil burner nozzle.

The atomizing air mixes with the fuel oil just prior to the oil leaving the nozzle.

Atomizing air pressure is indicated by the air pressure gauge on the burner gun.

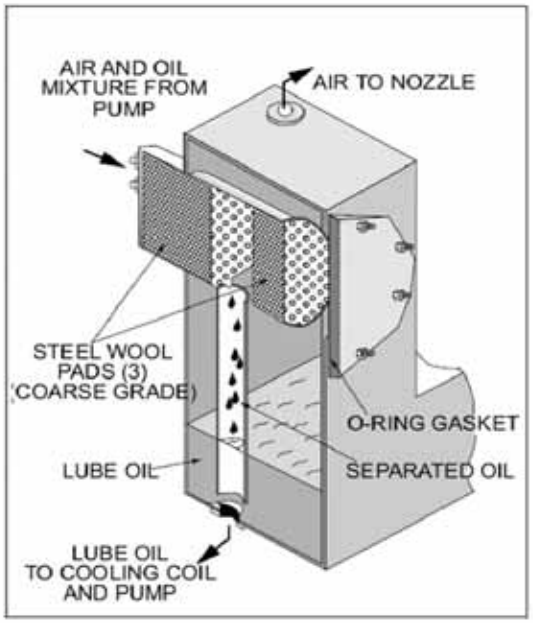


FIGURE 2-6. Air-Oil Receiver Tank

Air pressure from the pump also forces sufficient oil from the tank to the pump bearings to lubricate them and also to provide a seal and lubrication for the pump vanes. As a result, the air delivered to the tank contains some lube oil; however, most of it is recovered through baffles and filters in the tank before the air passes to the burner.

Some of the primary air is also used to assist the oil pressure regulators of the fuel oil controller. Further explanation is given in Chapter 5.

2.9 — Oil Fuel Flow

In Figure 2-9 the oil flow is indicated by arrows and the pertinent controls are identified.

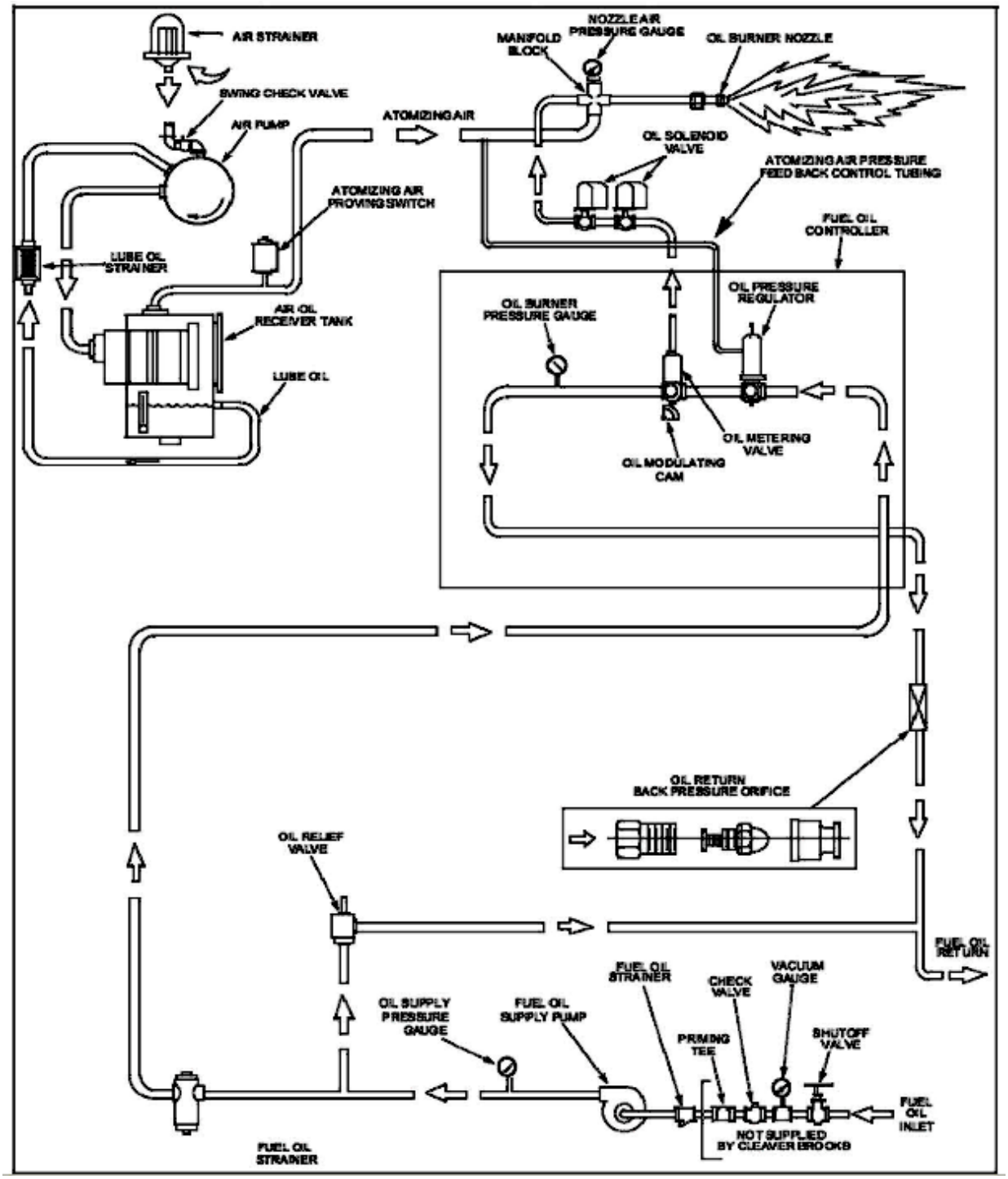


FIGURE 2-7. Diagram for Light Oil Flow

Fuel oil is delivered into the system by a supply pump which delivers part of its discharge to the oil burner. Excess oil is returned to the oil storage tank through the fuel oil relief valve and oil return line. Normally, the pump operates only while the burner is in operation, although a positioning switch is often provided so that either continuous or automatic pump operation can be obtained.

The oil flows through a fuel oil strainer to prevent any foreign material from flowing through the control valves and nozzle. The fuel oil controller contains in a single unit a metering valve, a regulator, and a gauge required to regulate the pressure and flow of oil to the burner. The adjustable regulator controls the pressure. To assist in the regulations, back pressure is created by an orifice nozzle located in the oil return line immediately downstream of the fuel oil controller.

The programming relay energizes or de-energizes the solenoid oil valves to permit or cut off oil flow to the burner. Two valves, operating simultaneously, are used. The valves are closed when de-energized. They cannot be opened (energized) unless the combustion air proving switch and the atomizing air proving switch are closed. The two switches are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan and pressurized air from the air pump.

The oil flow to the burner is controlled by the movement of the metering stem in the oil metering valve, which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by independent actuators to proportion combustion air and fuel for changes in load demand.

2.10 — Gas Fuel Flow

Metered gas from the utility flows through the pressure regulator at a reduced pressure suitable to burner requirements, through the main gas shutoff cock, main gas valve(s), and modulating butterfly gas valve to the nonpremix orifice-type burner.

The main gas valve is of the normally closed type, and is opened (energized) in proper sequence by the programming relay.

The butterfly gas valve modulates the flow of gas from low through high fire settings. The position of the butterfly valve disc is governed by the gas valve actuator. The butterfly gas valve and the air control damper are controlled simultaneously by independent actuators to proportion combustion air and fuel for changes in load demand.

The gas flow rate required for rated burner input depends upon the heating valve (Btu/cubic foot) of the gas supplied. The gas pressure regulator adjusts the gas pressure (flow rate) to the entrance of the gas train. The regulator is not always supplied with the burner, but may be provided by others.

The main gas valves cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air. The low gas pressure and high gas pressure switches must be closed to prove sufficient, but not excessive, gas fuel pressure.

2.11 — Modulating Firing

A combustion curve for each fuel is programmed into the Hawk controls during boiler commissioning. The combustion curve settings will determine how the butterfly gas valve (or the oil metering valve), air damper, and FGR

damper are positioned throughout the boiler's firing range. When properly adjusted, the combustion settings will maintain the correct air/fuel ratio while responding to changing load conditions.

During burner operation, the process variable (steam pressure or water temperature) is compared to the setpoint to determine the control signal sent to the actuators.

Manual burner operation is possible through the Hawk control system. Manual mode is used primarily for initial setting or subsequent checking of fuel input. Normal operation should be with the manual-automatic selector in the "automatic" position.

A feature designed into the control program maintains the boiler in the low-fire position during ignition and keeps it there until the main flame is established.

2.12 — Ultra Low NOx Systems

For Ultra low NOx (<15 PPM) operation refer to the NTI burner manual 750-220.

CHAPTER 3

Waterside Care

3.1 — 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 checked and ready for use. Be sure that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital care be taken in placing the pressure vessel into initial service. 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 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.

NOTE: This manual covers boilers using water. Glycol solutions have different operating requirements, circulation rates, temperatures, etc.

3.2 — Water Requirements

3.2.1 — Hot Water Boilers

Air Removal

The hot water outlet includes a dip tube which extends 2 to 3 inches into the boiler. Oxygen or air released in the boiler will collect or be trapped at the top of the boiler shell. The dip tube reduces the possibility of air, which may be trapped at the top of the shell, from entering into the system.

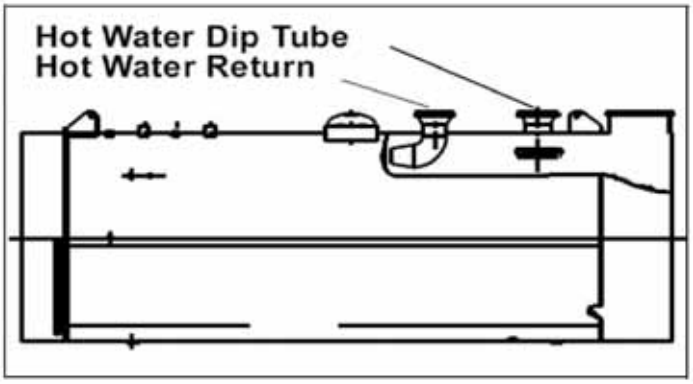


FIGURE 3-1. Dip Tube

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Air trapped at the top of the boiler will find its way out of the boiler through the tapping.

Minimum Water Temperature

The minimum recommended boiler water temperature is 170º F. When water temperatures lower than 170º F are used, the combustion gases are reduced in temperature to a point where water vapor condenses, which can cause corrosion in the boiler and stack.

Condensation is more severe on a unit that operates intermittently and which is greatly oversized for the actual load. Condensation can be minimized by maintaining boiler water temperatures above 170º F.

Rapid Replacement of Boiler Water

The system layout and controls should be arranged to prevent the possibility of pumping large quantities of cold water into a hot boiler, which will cause shock or thermal stresses. Water temperature in a boiler of 200° F or 240° F cannot be completely replaced with 80° F water in a few minutes time without causing thermal stress. The same fact applies to periods of normal operation, as well as during initial startup.

When individual zone circulating pumps are used, it is recommended that they be kept running-even though the heat users do not require hot water. The relief device or bypass valve will thus allow continuous circulation through the boiler and can help prevent rapid replacement of boiler water with cold zone water.

Continuous Flow Through the Boiler

The system should be piped and the controls arranged to allow water circulation through the boiler under all operating conditions. The operation of three-way valves and system controls should be checked to be sure that the boiler will not be by-passed. Constant circulation through the boiler mitigates the possibility of stratification within the boiler and results in more even water temperatures to the system.

A rule of thumb of 3/4 to 1 gpm per boiler horsepower can be used to determine the minimum continuous flow rate through the boiler under all operating conditions. The operator should determine that water flow exists through the boiler before initial firing or refiring after boiler has been drained.

NOTE: If the operating water temperature going to the system must be lower than 170º F, the operating boiler water temperature should be a minimum of 170º F and mixing valves should be used to avoid damage to the equipment.

NOTE: The circulating pumps should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running in order to avoid damage to the equipment.

Water Circulation

The Maximum Circulating Rate Chart, Figure 3-2, shows the maximum gpm circulation rate of boiler water in relation to full boiler output and system temperature drop.

BOILER SIZE (BHP)	BOILER OUTPUT (1000) BTU/HR	SYSTEM TEMPERATURE DROP - DEGREES °F									
		10	20	30	40	50	60	70	80	90	100
		MAXIMUM CIRCULATING RATE - GPM									
15	500	100	50	33	25	20	17	14	12	11	10
20	670	134	67	45	33	27	22	19	17	15	13
30	1,005	200	100	67	50	40	33	29	25	22	20
40	1,340	268	134	89	67	54	45	38	33	30	27
50	1,675	335	168	112	84	67	56	48	42	37	33
60	2,010	402	201	134	101	80	67	58	50	45	40
70	2,345	470	235	157	118	94	78	67	59	52	47
80	2,680	536	268	179	134	107	90	77	67	60	54
100	3,350	670	335	223	168	134	112	96	84	75	67
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

FIGURE 3-2. Maximum Circulating Rate Chart

Multiple Boiler Installations

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

If care is not taken to ensure adequate or proportional flow through the boilers, wide variations in firing rates between the boilers can result.

In extreme cases, one boiler may be in the high-fire position while the other boiler or boilers may be at low fire. The net result would be that the common header water temperature to the system would not be up to the desired point.

Pump Location

It is recommended that the system circulating pumps take suction from the outlet connection on the boiler, and that they discharge to the system load. The suction side is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

Pump Operation

Pumps are normally started and stopped by manual switches. It is also desirable to interlock the pump with the burner so that the burner cannot operate unless the circulating pump is running.

Pressure

The design of the system and usage requirements often dictate the pressure exerted upon the boiler. Some systems are pressurized with air, or with an inert gas such as nitrogen. Caution must be exercised to ensure that the proper relationship of pressure-to-temperature exists within the boiler so that all of the boiler's internal surfaces are fully wetted at all times. For this reason, the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in the Internal Boiler Pressure graph below.

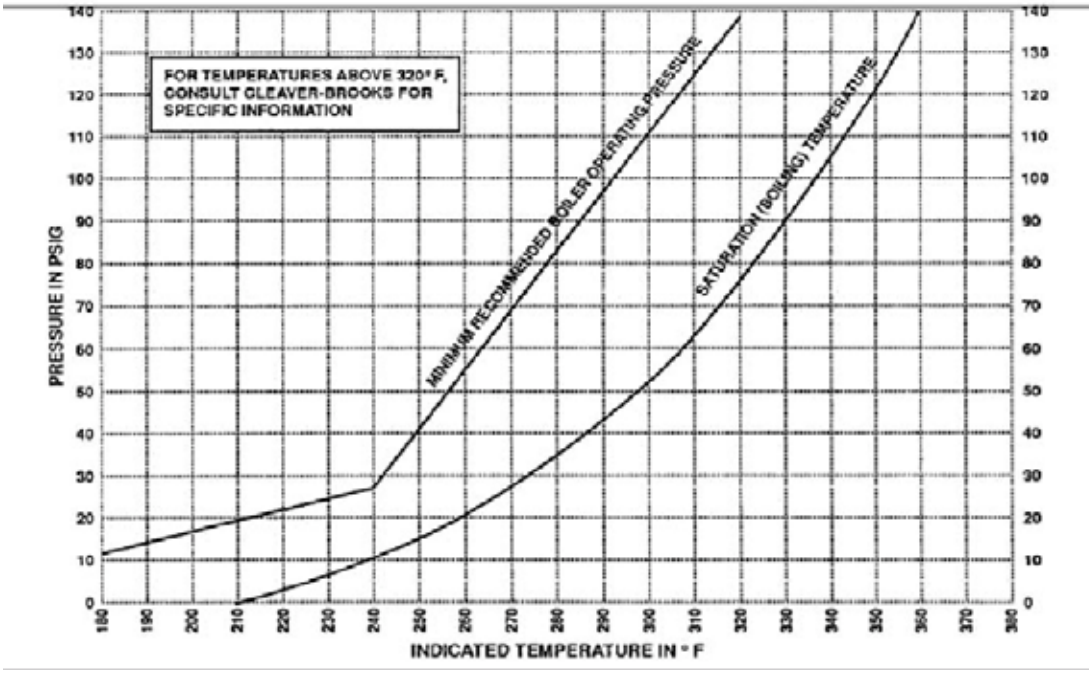


FIGURE 3-3. Internal Boiler Pressure

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

It is advisable to have a thermometer installed in the return line to indicate return water temperature. Knowing the supply water temperature, the boiler system differential can be established. With knowledge of the pumping rate, the operator can easily detect any excessive load condition and take appropriate corrective action.

Special caution must be taken to guard against any condition, or combination of conditions, that might lead to the transfer of cold water to a hot boiler or hot water to a cold boiler. It cannot be over-emphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

3.2.2 — Steam Boilers

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.

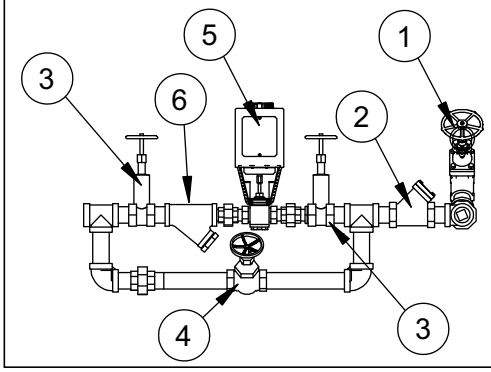
Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check the feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

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 sealed or locked in the open position. If the valves are installed, it is illegal to operate the boiler with closed or unsealed open valves.

⚠ Warning

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.



ITEM	DESCRIPTION
1	Globe Valve
2	Check Valve
3	Gate Valve
4	Globe Valve
5	Feedwater Valve
6	Strainer

FIGURE 3-4. Feed piping, typical

3.3 — 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.

3.4 — Cleaning

3.4.1 — Hot Water and Steam Piping

Steam and water 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.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult your local Cleaver-Brooks authorized representative for recommendations, cleaning compounds, and application procedures.

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

1. Cleaning has been inadequate.
2. Partial or total 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.

3.5 — 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.

⚠ Warning

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				
	Steam		Hot Water	
	Lbs.	Gal.	Lbs.	Gal.
100	6549	786	7185	863
125	6882	826	7549	906
150	8006	961	9102	1093
200	9062	1088	10314	1238
250	11618	1395	13755	1651
300	12188	1463	14419	1731
350	19340	2322	22499	2701
400	19647	2359	22942	2755
500	20059	2408	24975	2998
600	21619	2595	26884	3227
700	25051	3007	31731	3809
800	25868	3105	32741	3931

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 (refer to sections 1.4.3 and 8.15 for more on valve installation).

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.

⚠ Warning

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.

3.6 — Washing Out

3.6.1 — Hot Water Boiler

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

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient. However, if there is any doubt, the pressure vessel waterside should be inspected no later than three months after initially placing the boiler into operation, and periodically thereafter as indicated by conditions observed during inspections.

NOTE: It is advised a water meter be installed in the piping to detect leakage in a “closed” system.

3.6.2 — Steam Boiler

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.

3.7 — Blowdown: Steam Boiler

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that 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.

3.7.1 — 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 generally consists of two 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 fee 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.

3.7.2 — 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.

3.7.3 — 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 blow-off piping and tank, if used, are in proper operating condition. Discharge vents should be clear of obstruction, and the waste should be piped to a point of safe discharge.

If a quick opening valve and globe type slow opening valve are in combination, the former is normally opened first and closed last with blow down accomplished with the globe or slow opening valve.

Larger vessels may have two bottom blowdown lines, each with a quick opening valve. Lines may be blown down simultaneously by opening both quick opening valves before opening the downstream valve.

When opening the second 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) next 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.

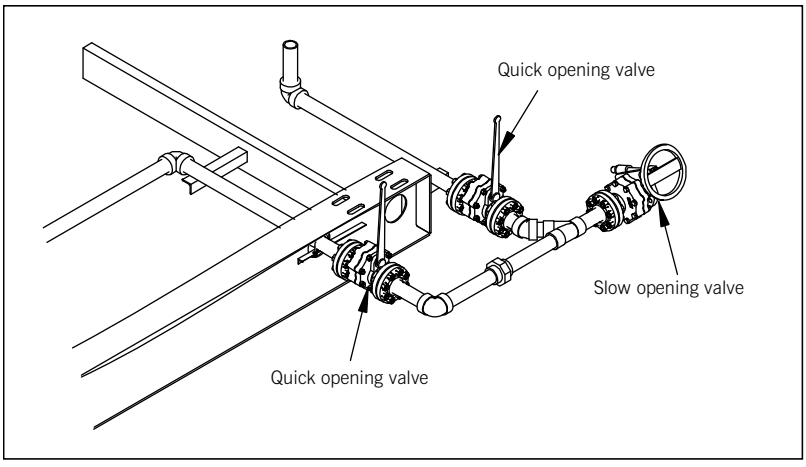


FIGURE 3-5. Bottom Blowdown Piping

3.8 — 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.

⚠ Warning

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.

3.9 — 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 manhole 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 4 Sequence of Operation

4.1 — Overview

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

NOTE: The intent of this section is to provide a general overview of a typical boiler operating sequence. Specific control circuit components/interlocks, and control system hardware and programming may vary depending on installation. Please refer to the wiring diagram prepared by Cleaver-Brooks for your specific installation.

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

- Boiler water is up to the correct level, closing the low-water cutoff switch, and the auxiliary low water cutoff, if applied.
- The low-water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control switches are closed.
- All other limit circuit switches are closed.
- All entrance panel switches are closed and power is present at the line terminals corresponding to:
  a. Blower motor starter.
  b. Air compressor motor starter (if provided).
  c. Oil pump motor starter (if provided).
- The load demand light is on.

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

4.2 — Circuits and Interlocks

The burner control circuit is a two-wire system designed for 115 VAC, 60 Hz, single-phase power.

The electrical portion of the boiler is made up of individual circuits with controls that are wired in a manner designed to provide a safe system. The program relay (standardly the CB780E) provides connection points for the interconnection of the various circuits.

The controls used vary depending upon the fuel burned and the requirements of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the actual controls provided. The circuits and controls normally used are listed below and are referred to in the following sequence of operation. Components may vary.

Circuit	Components/Controls
Limit Circuit	• Burner Switch (BS) • Operating limit control (OLC) - pressure or temperature • High limit control (HLC) - pressure or temperature • Low-water cutoff (LWCO - Level Master) • Gas-oil selector switch (GOS) - combination burner only • Oil drawer switch (ODS) - oil burner • Low gas pressure switch (LGPS) • High gas pressure switch (HGPS) • Fuel valve interlock circuit • Main gas valve auxiliary switch (MGVAS) • Oil valve auxiliary switch (OVAS)
Blower Motor Starter Circuit	• Blower motor starter (BMS) • Combustion air proving switch (CAPS) • Atomizing air proving switch (AAPS) - if provided
Running Interlock Circuit	• Blower motor starter interlock (BMSI) • Combustion air proving switch (CAPS) • Atomizing air proving switch (AAPS) - if provided
Running Interlock and Limit Circuit	• Low oil pressure switch (LOPS) • High oil pressure switch (HOPS) • High oil temperature switch (HOTS) • Auxiliary low-water cutoff (ALWCO)
Pilot Ignition Circuit	• Gas pilot valve (GPV) • Ignition transformer (IT) • Gas pilot vent valve (GPVV) - if provided
Flame Detector Circuit	• Flame detector (FD) • Main fuel valve circuit • Man gas valve (MGV) • Man gas vent valve (MGVV) - if provided • Oil valve (OV) • Main fuel valve light FVL)

To comply with requirements of insurance underwriters such as Factory Mutual (FM), XL GAP, or others, additional interlock devices may be used in addition to the circuits identified in section 4.2.

For additional information see the CB780E manual, 750-234.

4.3 — Firing Rate Controls

The Cleaver-Brooks Hawk boiler control system comprises two primary subsystems: flame supervision/burner sequencing, and modulation or firing rate control. Upon establishment of main flame, the program relay (CB780E) relinquishes control to the Hawk modulation controls. Modulated firing is accomplished by sending Modbus signals from the Hawk controls to the separately driven air, fuel, and FGR actuators.

Components/Controls
• Low Fire Relay (LFR)
• High Fire Relay (HFR)
• Release to Modulate Relay (RMR)
• Air Actuator • Fuel 1 Actuator • Fuel 2 Actuator (combination burners) • FGR Actuator

4.4 — Sequence of Operation: Gas or Oil

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

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

4.4.1 — Pre-Purge Cycle

When the **Burner Switch** (BS) is turned ON, and controls in the **Limit** and **Fuel Valve Interlock** circuits are closed and no flame signal is present, the **Blower Motor Start** circuit is powered, energizing the blower motor starter (BMS). The load demand light (LDL) turns on. When firing oil, the air compressor motor starter (ACMS) (if provided) is also powered.

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

The **High Fire Relay** (HFR) will prove that the damper actuator has driven the damper to the open position during the pre-purge cycle.

The controls wired into the Running Interlock circuit must be closed within 10 seconds after the start sequence. In the event any of the controls are not closed at this time, or if they subsequently open, the boiler will go into a safety shutdown.

At the completion of the high fire purge period, the damper actuator will drive the air damper to its low fire position.

To assure that the system is in low fire position prior to ignition, the **Low Fire Relay** (LFR) must be closed to complete the low fire proving circuit. Once the low fire switch is closed, the sequence is allowed to continue.

4.4.2 — Ignition Cycle

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

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

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

NOTE: If the main flame does not light, or stay lit, the fuel valve will close. The safety switch will trip to lock out the control. Refer to flame loss sequence (Section 4.5) for description of action.

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

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

⚠ Warning

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

4.4.3 — Run Cycle

With main flame established, the **Release to Modulate Relay** (RMR) switches operation to the Hawk firing rate controls. Depending on the selection AUTO or MANUAL, control is accomplished through the Hawk HMI (manual mode) or automatically based on the modulation signal and the current Hawk combustion settings.

The actuators for fuel, air, and FGR are positioned independently via Modbus signal.

The burner starting cycle is now complete. the LDL and FVL lights on the panel remain lit. Demand firing continues as required by load conditions.

4.4.4 — Burner Shutdown: Post-Purge

NOTE: Normal operation of the burner should be with the controls in the automatic mode and under the direction of the modulating signal. The manual mode is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in the manual mode at other than low fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. Excess air flow subjects the pressure vessel metal and refractory to undesirable conditions.

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

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

The blower motor start circuit is de-energized at the end of the post-purge cycle and the shutdown cycle is complete.

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

4.5 — Flame Loss Sequence

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

The control will prevent startup or ignition if limit circuit controls or fuel valve interlocks are open. The control will lock out upon any abnormal condition affecting air supervisory controls wired in the running interlock circuit.

⚠ Caution

The lockout switch must be manually reset following a safety shutdown. The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart. Failure to follow these instructions could cause damage to the equipment.

1. **No pilot flame:** The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately de-energized and the pilot valve closes, the reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

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

   The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed.
2. **Pilot but no main flame:** When the pilot flame is proven, the main fuel valve circuit is energized. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 or 15 seconds later. The

flame detecting circuit will respond to de-energize the main fuel valve circuit within 2 to 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

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

The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed.

3. **Loss of flame:** If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay will trip within 2 to 4 seconds to de-energize the fuel valve circuit and shut off the fuel flow. The reset switch lights and lockout occurs immediately. The blower motor continues operation. The flame failure light and alarm bell (optional) are energized 10 seconds later.

   The blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control manual for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the appropriate manuals.

Knowledge of the system and its controls will make troubleshooting much easier. Costly downtime or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

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

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

CHAPTER 5

Starting and Operating Instructions

5.1 — General Preparation for Startup: All Fuels

Warning

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. To quickly locate and identify the various controls and components mentioned in this chapter, refer to the illustrations and the contents of Chapters 1, 2, and 3. Instructions for adjusting major components are given in Chapter 6, and these instructions should be reviewed prior to firing. The wiring diagram should also have been studied, along with the firing sequence outlined in Chapter 4.

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 programmer and reset if necessary.

Warning

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 with water to the proper operating level using water of ambient temperature. Be sure that treated feedwater is available and used. In heating applications, the entire system should be filled and vented. Refer to Chapter 3 for water requirements. 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 impeller rotation is counterclockwise when viewed from the front of the boiler. The air pump rotation is clockwise when viewed from the drive end.

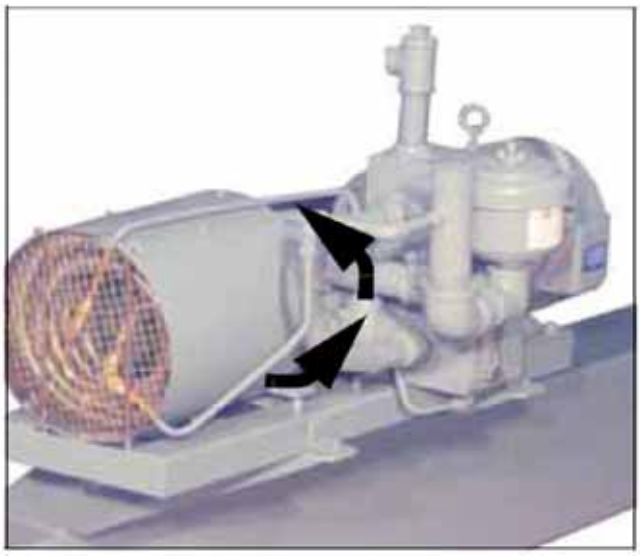


FIGURE 5-1. Air Compressor Motor Rotation

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

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

⚠ Caution

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.

5.2 — Control Settings: Steam and Hot Water

See Chapter 6 for adjustment instructions for the following controls. Inspect the operating limit control for proper setting as follows:

1. The operating pressure control of a steam boiler should be set slightly above the highest desired steam pressure, but at least 15% lower than the setting of the safety valve.
2. The temperature operating control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the high limit control for proper setting as follows:

3. 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. The setting on a low pressure steam boiler may be 2 or 3 psig above the operating limit setting, but must not exceed the safety valve setting.
4. On a hot water boiler, the high limit temperature control should be 5° F to 10° F above the operating limit temperature control setting but within the limits of the design pressure of the pressure vessel.

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 so equipped). See manual 750-281 for complete information on the CB Level Master.

In the event the boiler is equipped with optional control devices not listed here, be certain to ascertain that their settings are correct. If additional information is required, see your local Cleaver-Brooks 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 should be set at “manual”. 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 automatically in accordance with load demands.

5.3 — Gas Pilot

The gas pilot should be checked for satisfactory performance prior to initial firing. Follow the pilot flame adjustment instructions provided in Chapter 6.

On initial starting attempts, several efforts might be required to fully bleed the pilot line. While checking pilot adjustment, observe whether the pilot flame is extinguished promptly when the burner switch is opened. A lingering flame indicates a leaking gas pilot valve, which is a condition requiring correction before proceeding.

5.4 — Atomizing Air

The supply and pressure of the atomizing air on an oil-fired burner should be checked. Before starting, inspect the oil pump lube oil level. Add oil if necessary to bring the level to the mid-point or slightly higher in the sight glass. Use SAE 20 detergent oil of a grade mentioned in Chapter 8 and fill in accordance with instructions given there.

Check the oil level of the air intake strainer.

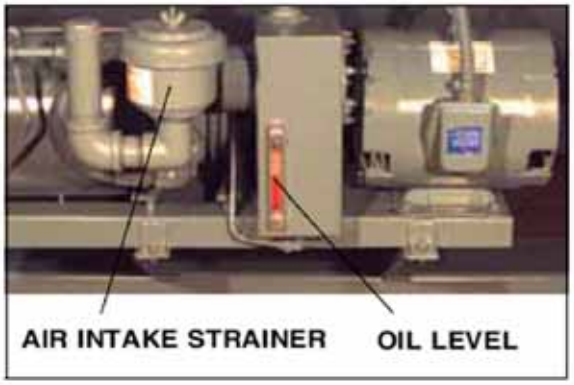


FIGURE 5-2. Atomizing Air Pump

To verify air flow and pressure, place the burner run/test switch on the flame safeguard to the “test” position. If the burner is a combination fuel burner, be sure that the gas/oil selector switch is set to “oil.” Turn the burner switch on. The burner will cycle to the low-fire pre-purge position and stop there.

Observe the reading on the air pressure gauge. With no oil flow, the pressure should be a minimum of 7 psi.

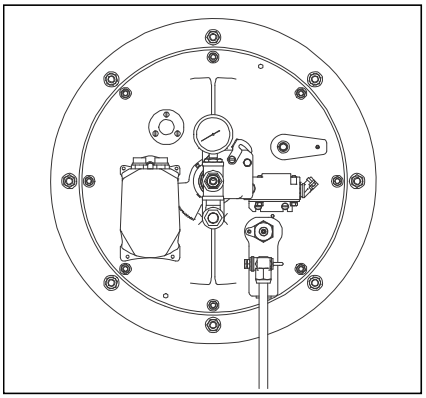


FIGURE 5-3. Burner Drawer with Damper Actuator

If there is no pressure, determine the cause and correct it before proceeding. Check for obstructions in the air inlet line, incorrect rotation (remember, air pump rotation is clockwise), or a loose oil nozzle or other leaks. If the pressure is much higher without any oil flow, check for obstruction in the discharge line or at the oil nozzle.

NOTE: Abnormally high pressure indicated on the nozzle air pressure gauge is an indication that the burner nozzle has become clogged. In the event of clogging, check the nozzle and clean as necessary.

The air pressure will increase when an oil flow exists. At low firing rate, the air pressure may rise to 12 psi or more.

> **⚠ Caution**
>
> The air pressure should not exceed 35 psi at high-fire. Greater air pressure causes excessive wear of the air pump, increases lube oil usage, and can overload the motor, thus causing damage to the equipment.

After air flow has been verified, turn the burner switch off and return the run/test switch to the “run” position.

5.5 — Firing Preparations for No. 2 Oil (Series 100-200)

Prior to initial firing, oil flow and pressure should be established and verified. Atomizing air pressure should also be established as outlined in Section 5.4. The schematic flow diagram in Chapter 2 indicates the flow of fuel and atomizing air.

If the burner is a combination fuel model, be certain that the main gas shutoff cock is closed and set the gas/oil selector switch to “oil.” Insert the burner drawer gun into its most forward position and latch it in place, closing the oil drawer switch.

FIGURE 5-4. Oil Gun Locked in Firing Position

If the oil supply tank is located above the level of the pump and flow to the pump is by gravity, then it will usually be necessary to vent the suction line to allow oil to fill the line. Venting the suction line can generally be accomplished by cracking a union fitting, or by opening the cap of the oil strainer using care to prevent spillage of oil. Tighten the fitting or the cap as soon as oil flow appears.

If the oil supply tank is below the level of the oil pump, it is mandatory that the suction line to the pump be completely filled with oil prior to starting the pump to avoid the possibility of damage to the pump gears. Non-lubricating fluids such as kerosene should not be used for priming.

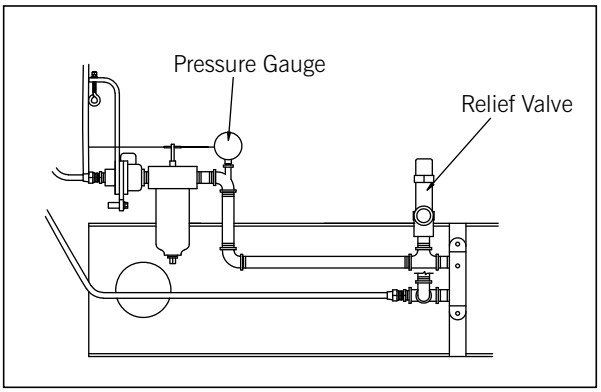
Prior to priming the suction line and the initial start, check to make certain that all plugs, connections, etc., have been securely tightened to prevent leaks.

If the fuel oil supply originates from a pressurized loop, it is assumed that the pressure of the loop will be at a minimum of 75 psi. Under these conditions, the relief valve at the terminal block should be adjusted to the point where it becomes inoperative (or removed and openings plugged). To render inoperative, turn the adjusting screw in as far as possible.

A standardly equipped boiler has a selector switch incorporated in the oil pump motor starter. Momentarily energize the starter to check for proper pump rotation. With the rotation verified, operate the pump to determine that oil circulation exists. Observe the oil burner pressure gauge for indication that flow is established. If no pressure shows on the gauge after a few moments, stop the oil pump and re-prime. If the supply tank is lower than the pump, it is possible that the initial priming of the suction line, followed by operation of the pump, will not establish oil flow. This might be caused by obstruction in the suction line, excessive lift, inadequate priming, suction

line leaks, etc. If oil flow is not readily established, avoid prolonged operation of the pump to minimize risk of damage to internal parts of the pump. If oil flow is not established after a second or third priming attempt, a full investigation is required to determine the cause.

A vacuum (or a compound pressure-vacuum) gauge should be installed at the suction port of the pump and its reading observed and recorded for future guidance. If a vacuum condition exists, the reading will reveal the tightness of the system. It is advisable to maintain the vacuum reading at less than 10" Hg. A vacuum in excess off 10" Hg may allow oil to vaporize, causing cavitation, loss of prime, and an unstable firing condition.



Oil supply pressure is regulated by adjusting the pressure relief valve at the oil terminal block. A pressure gauge should be installed in the terminal block and the relief valve adjusted to obtain a minimum reading of 75 psi when the burner is firing at maximum rate.

FIGURE 5-5. Oil Terminal Block

Adjustment may also be required to the regulator on the fuel oil controller. The pressure regulating valve is equipped with tubing that directs and adds atomizing air pressure to the adjustable spring pressure. Since the air pump is not running at this time, only tentative adjustment can be made. Without the air supply, adjust the fuel oil pressure regulator so that the oil burner gauge registers approximately 35 psi.

The pressure gauge will indicate a higher reading when air is present and the flame exists and will increase as the firing rate increases. After the burner is firing and when the air pump is running, final adjustment can be made at the fuel oil controller.

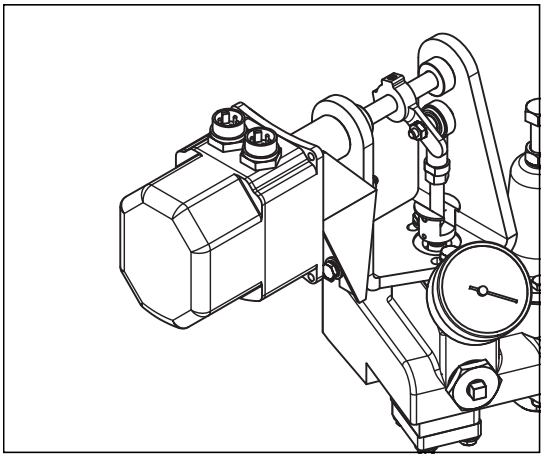


FIGURE 5-6. Fuel Oil Actuator

When all the conditions covered above and in Sections 5.1, 5.2, 5.3, 5.4, and 5.5 are assured, the burner is ready for firing. Refer to Section 5.8 for further starting and operating information.

5.6 — Firing Preparations for Gas (Series 200-700)

- Prior to initial starting, check the linkage attached to the gas butterfly valve to assure that movement is free from binding.
- Verify the presence and availability of gas. On a new installation, representatives of the gas utility should be present when gas first flows into the system to supervise purging of the new gas line, unless they have already done so.
- Determine that the pilot is operating properly, as outlined in Section 5.3.
- Determine that sufficient pressure exists at the entrance to the gas train by installing a test gauge downstream of the regulator.
- The gas pressure regulator must be adjusted to the proper pressure level. Since the regulator is generally supplied by others, adjustment should proceed according to instructions supplied by its manufacturer.

It is necessary for the operator to know the burner requirements in gas quantity and pressure.

The information can generally be found on the Dimension Diagram (DD) supplied by Cleaver-Brooks for the specific installation. Should the information not be readily available, consult the Cleaver-Brooks Service Department and be ready to provide the boiler serial number.

Chapter 6 contains additional information along with standard gas flow and pressure requirements.

•If the burner is a combination fuel model, set the gas/oil switch to “gas.” Withdraw the oil burner gun and latch it in its rearward (lockout) position.

•On initial startup, it is recommended that the main gas shutoff cock remains closed until the programmer has cycled through pre-purge and pilot sequences. When the fuel light on the control panel comes on, observe the action of the motorized gas valve stem to determine that it opens when energized.

FIGURE 5-7. Oil Gun in the Lock-Out Position

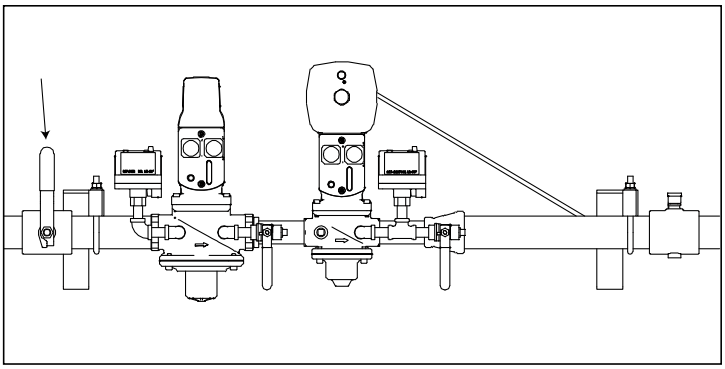
As soon as it is confirmed, turn the burner switch “off” and let the programmer finish its cycle. Check that the gas valve has closed. Again, turn the burner “on.” When the fuel valve light glows, slowly open the main gas cock. Main flame should ignite unless there is air present in the line. If the flame is not established within about

5 seconds, turn the burner switch “off” and allow the programmer to recycle normally for a new lighting trial. Several efforts may be necessary to “bleed” air from the line.

⚠ Warning

Do not repeat unsuccessful lighting attempts without re-checking the burner and pilot adjustments. Failure to follow these instructions could result in serious injury or death.

NOTE: The burner and control system are designed to provide a pre-purge period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to circumvent this feature.



Once the main flame is established, turn the burner switch to the “off” position and observe that the flame is extinguished promptly. The flame may continue to burn for a second or two after normal shutdown due to the gas remaining downstream from the fuel valve. If the flame continues to burn for a longer period or during blower motor spindown, it could indicate a main gas valve leak. Immediately turn the burner switch “off” and close the main gas cock. Investigate and correct the cause of the valve leakage before relighting the burner.

FIGURE 5-8. Gas Train and Shutoff Cock

The main gas valve should provide a tight seal, if nothing prevents tight closure. Foreign material may be present in either the new or renovated gas lines unless adequate care is taken in cleaning and purging.

When the conditions covered above in Section 5.1 - 5.6 are assured, the burner is ready for firing.

5.7 — Startup, Operating, and Shutdown: All Fuels

Depending upon the fuel being burned, the applicable pervious sections in this chapter should be reviewed for preliminary instructions.

When firing with oil, be certain that the burner gun is in its most forward position and latched in place. When firing with gas, the burner gun should be properly withdrawn and latched in place. The fuel selector switch should be, accordingly, set to either oil or gas.

Set the AUTO/MANUAL control to MANUAL.

Turn the burner switch ON. The load demand light should glow. The low-water level light should remain out, indicating a safe water level in the boiler. The programmer is now sequencing.

⚠ Warning

Do not relight 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. Failure to follow these instructions could result in serious injury or death.

NOTE: On an initial starting attempt, several efforts might be required to accomplish "bleeding" of fuel lines, main or pilot. If ignition does not then occur, do not repeat unsuccessful attempts without rechecking the burner and pilot adjustment.

On ignition failure, the flame failure light will glow and the blower will purge the boiler of unburned fuel vapors before stopping. After ignition failure, wait a few moments before resetting the lockout switch.

⚠ Warning

The burner and control system is designed to provide a "pre-purge" period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system or take any action that might circumvent the "pre-purge" feature. Failure to follow these instructions could result in serious injury or death.

After main flame ignition, the burner should be set on manual control at its low-fire setting (with manual flame control at "close") until the boiler is properly warmed. Close the steam header.

In the case of a steam boiler, close the vent valve when the steam begins to appear.

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

If the flame at low-fire provides insufficient heat to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the manual flame control in one point increments to no higher than the third cam screw. Operate at the increased fuel input rate for a period of time until an increase is noted in pressure or temperature.

After the boiler is thoroughly warmed, turn the manual flame control to high fire. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. Refer to the adjustment procedures in Chapter 6. After making the high-fire adjustment, manually decrease the firing rate, stopping at each cam screw to analyze combustion gases, and adjust as required.

To properly perform the testing and adjusting, it is necessary that the burner be allowed to fire at a maximum rate long enough to achieve desired results.

5.7.1 — Operating

Normal operation of the burner should be with the controls in automatic mode. Manual mode is provided for initial adjustment of the burner over the entire firing range. When a shutdown occurs while operating in manual at other than low-fire, the damper will not be in a closed position, thus allowing more air than desired to flow through the boiler. The hot flame to cool air cycling subjects the pressure vessel metal and refractory to undesirable stresses.

With the controls in AUTO, the burner will operate on a modulating basis according to the load demand.

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

1. The burner is manually turned “off.”
2. The low-water condition is detected by low-water level control.
3. The electrical or fuel supply is interrupted.
4. The combustion air pressure or atomizing air pressure drops below minimum level.

NOTE: There can be other reasons for shutdown such as motor overload, flame outage, tripped circuit breakers, blown fuses, or through other interlock devices in the circuitry.

When the burner is shut down normally, by either the operating limit control or by manually switching the burner off, the load demand light will turn off.

Shutdown through flame failure will actuate the flame failure light (and alarm, if so equipped) and the load demand light will remain lit. The cause of this type of shutdown will have to be located, investigated, and corrected before operation can be resumed.

5.7.2 — Shutdown

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

1. The fuel valve is de-energized and the flame is extinguished.
2. The timer begins operation and the blower motor continues running to force air through the furnace in the post-purge period.
3. At the end of the programmed post-purge period, the blower motor is turned off. The air pump motor of an oil fired burner is also turned off.
4. The timer has returned to its original starting position and stops. The unit is ready to restart.

5.8 — Control Operational 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 modulating control for the desired operating pressure range. See chapter 6 for instructions on the adjustment of controls.

The water temperature on a hot water boiler that may be operating at less than full load may be raised by manually increasing the firing rate until the burner shuts down through the action of the operating limit control. Observe the thermometer to verify the desired settings at the point of cutout and again when the burner restarts. Return the manual-automatic switch to “automatic” and check the modulating control for the desired temperature range. See Chapter 6 for instructions on the adjustment of the controls.

Check the proper operation and setting of the low-water cutoff (and pump operating control, if used). For CB Level Master, see manual 750-281

Proper operation of the flame failure device should be checked at startup and at least once a week thereafter. Refer to Chapter 8 for information on flame safety checks. Check the program relay’s annunciation for any system failure. Observe the promptness of ignition of the pilot flame and the main flame.

⚠ Warning

It is advisable to check for tight shutoff of fuel valves. Despite the presence of strainers and other precautions, 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 6 Adjustment Procedures

6.1 — 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.

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 Chapter 6 apply to standard components furnished on steam or hot water boilers fired with gas and/or light oil.

In order to reduce stress on boiler components and to improve boiler operating efficiency, burners have been designed for enhanced fuel turndown capabilities.

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.

6.2 — Burner Operating Controls: General

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

- The **Operating Limit** and **High Limit** controls, hardware devices which turn the boiler on and off according to their respective switch settings.
- The **Modulating** and **Flame Safeguard** controls, which provide for modulated firing and burner sequencing/flame supervision. On a standard CBEX Elite these functions are managed by the **Hawk 2000,** an integrated control system comprising both hardware (PLC, Input/Output devices, and touchscreen HMI) and software (programming for the PLC and HMI).

The limit controls are described below; for a complete description of the Hawk 2000 including adjustment procedures, see manuals 750-338 and 750-217.

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

1. **Operating Limit Control**: Senses pressure or temperature and automatically turns the burner on to initiate the startup sequence when required and turns the burner off to initiate the shutdown sequence when the demand is satisfied. The control must be set to initiate startup only at the low-fire position.
2. **High Limit Control**: Senses the steam pressure or hot water temperature. It is used as a safety limit to turn the burner off in the event the operating limit control fails. The high limit control should be set sufficiently above the operating limit control to avoid nuisance shutdowns, because it has a manual reset feature

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

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

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

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

The Hawk 2000 modulates the boiler firing rate according to stored combustion curves. The Firing Graph (Figure 6-1) depicts a typical setting relationship of the operating limit control, modulating control, and the high limit control.

The burner will be “on” whenever the pressure or temperature is less than point **B** and “off” whenever pressure or temperature is greater than point **A**. The distance between points **A** and **B** represents the “on-off” differential of the operating limit control.

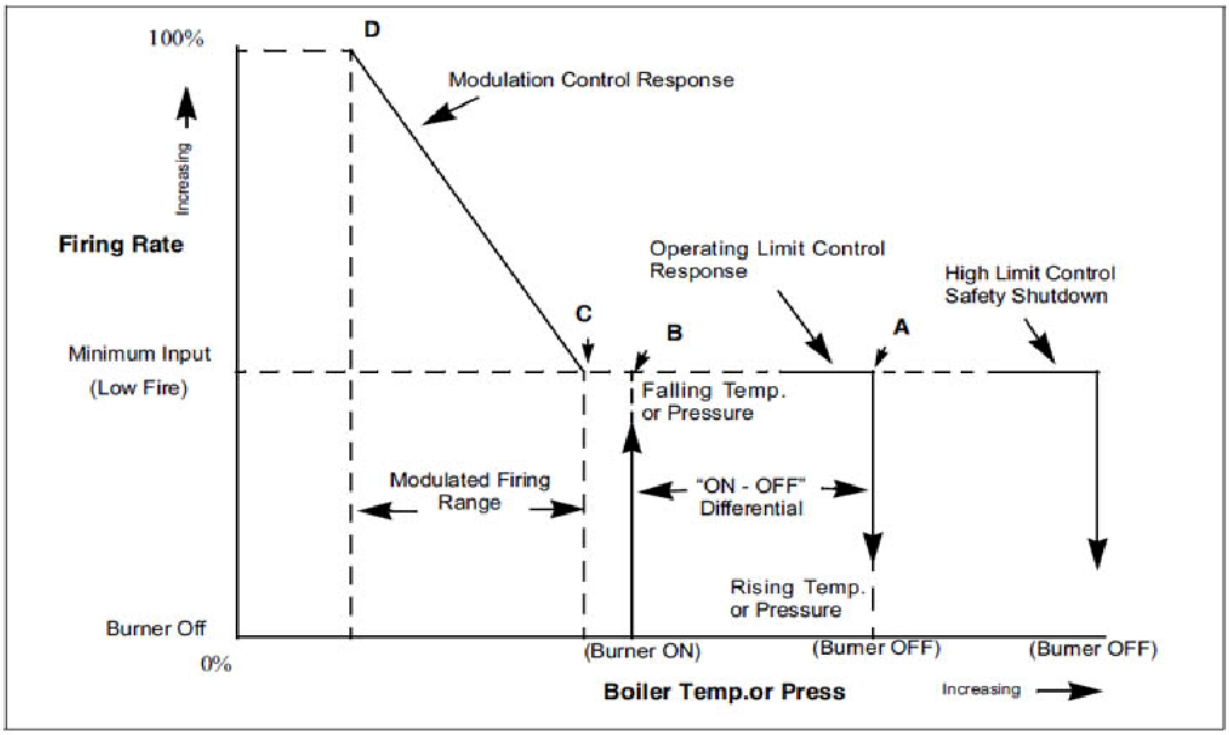


FIGURE 6-1. Firing Graph

In normal operation, the burner will shut down whenever the pressure or temperature rises above setting **A**. At that point the switch in the operating limit control will open. As the pressure or temperature drops back to **B**, the operating limit control closes and the burner will restart. The boiler control system will signal the actuators to be in a low-fire position. If the load demands exceed the low-fire input potential, the controls will increase the firing rate proportionately as pressure or temperature falls toward point **D**. The controls will stop at any intermediate point between **C** and **D** whenever the fuel input balances the load requirement.

As the load requirement changes, the firing rate will change accordingly. This it is referred to as modulated firing.

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

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

When set as shown, with a time lag between **B** and **C**, the burner will be in a low-fire position upon a restart and will fire at that rate for a short period of time before falling pressure or temperature requires an increase in the firing rate.

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

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

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

Ideally, the boiler operating controls should be set under actual load conditions. Especially under new construction conditions, the boiler is initially started and set to operate under less than full load requirements. As soon as possible thereafter, the controls should be reset to provide maximum utilization of the modulating firing system. To accomplish maximum utilization, and assuming that air/fuel combustion ratios have been set, make the required adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

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

Modulation settings should be adjusted under load conditions, until the load is maintained with the burner firing at a steady rate. The firing rate at that point may be full high-fire or slightly less, depending upon the relationship of the boiler size to the load.

NOTE: Rapid heat input can subject the pressure vessel metal and refractory to premature failure.

6.3 — Operating Limit Pressure Control

Set the “cutout” (burner off) pressure on the range scale using the large adjusting screw. The “cut-in” (burner on) pressure is the cutout pressure minus the (fixed) differential. The cutout pressure should not exceed 90% of the safety valve setting.

6.4 — High Limit Pressure Control

The high limit control provides a safety factor to shut the burner off in the event the operating limit control should fail.

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

The control requires manual resetting after tripping on a pressure increase. To reset, allow pressure to return to normal and then press the reset button. Failure to do this will disallow restarting.

In the setting of the controls, consideration must be given to the time required for a burner restart. Each start requires a pre-purge period, plus the fixed time required for proving the pilot and main flame. In addition, approximately one-half minute is required for the damper actuator to travel from low- to high-fire. The time lag may allow pressure or temperature to drop below desirable limits.

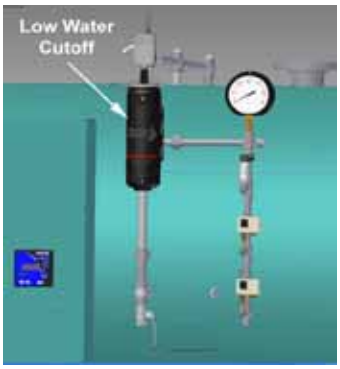
6.5 — Operating Limit Temperature Control: Hot Water

Set the “cutout” (burner off) temperature on the scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw. The “cut-in” (burner on) temperature is the cutout temperature minus the differential.

6.6 — High Limit Temperature Control: Hot Water

Set the “cutout” (burner off) temperature on scale using the adjusting screw. The control will break the circuit and lockout on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. On a 30 psig hot water boiler, the setting is not to exceed 240° F. The control requires manual resetting after tripping on a temperature increase. To reset, allow the water temperature to drop below the cutout setting less the differential, and then press the manual reset button. Failure to do this will disallow restarting.

6.7 — Low Water Cutoff Devices: Steam and Hot Water



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

FIGURE 6-2. Low Water Cutoff

6.8 — Combustion Air Proving Switch

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

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

FIGURE 6-3. Combustion Air Proving Switch

To have the modulating damper motor drive to high-fire (damper open), remove the cover from the motor and remove the wire from terminal W.

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

Recycle the program relay to be sure that normal operation is obtained. Replace the wire on terminal W and reinstall the cover. Return the test switch to the “Run” position.

6.9 — Atomizing Air Proving Switch

The air pressure against the diaphragm actuates the switch which, when closed, completes a circuit to prove the presence of atomizing air. Since the pressure of the atomizing air is at its minimum value when there is no fuel present at the nozzle, adjustment of the switch should be done while the unit is running but not firing. The control should be set slightly below the minimum pressure, but not too close to that point to cause nuisance shutdowns.

The control adjustment may be made during the pre-purge period of operation by stopping the programmer during the pre-purge period through the use of the Test switch. Refer to the control instruction bulletin for details.

FIGURE 6-4. Atomizing Air Proving Switch

NOTE: On an oil fired boiler, the atomizing air proving switch (AAPS) must also be closed. This is an automatic operation.

The adjustment screw of the atomizing air proving switch can then be adjusted until it breaks the circuit. Here, the programmer will lockout and must be manually reset before it can be restarted. Turn the adjusting screw up a half turn or so to remake the circuit.

After making the adjustment, recycle the control to be sure that normal operation is obtained. The Test switch must be set to the “Run” position.

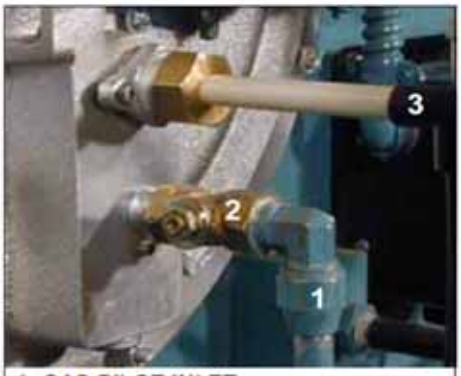
NOTE: On a combination fuel fired burner, firing gas, the fuel selector switch could be set to “gas” to eliminate the atomizing air proving switch from the circuitry.

6.10 — Gas Pilot Flame Adjustment

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

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

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



1. GAS PILOT INLET
2. GAS PILOT ADJUSTING COCK
3. IGNITION ELECTRODE

FIGURE 6-5. Gas Pilot Adjusting Cock and Electrode

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

To measure and adjust the pilot:

1. When making a pilot adjustment, turn the manual-automatic switch to "manual". Open both the pilot cutoff cock and the pilot adjusting cock. The main gas cock should remain closed.

   The regulator in the pilot line, if provided, is to reduce the gas pressure to suit the pilot's requirement of between 5" to 10" WC. Regulator adjustment is not critical, however, with a lower pressure the final adjustment of the pilot flame with the adjusting cock is less sensitive.

2. Connect the micro-ammeter.
3. Turn the burner switch "on." Let the burner go through the normal pre-purge cycle. When the ignition trial period is signaled, set the Run/Test switch on the flame safeguard to the "Test" position to stop the sequence.
4. If the pilot flame is not established within 10 seconds, turn off the burner switch. Repeat the lighting attempt.
5. When the pilot flame is established, and with the pilot adjusting cock wide open, remove the flame detector from the burner plate. The pilot flame can then be observed through this opening.

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

⚠ Warning

Wear a protective shield or suitable glasses and keep eyes sufficiently away from the sight tube opening. Never remove the flame detector while the main burner is firing. Failure to follow these instructions could result in serious injury or death.

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

The adjustment must be accomplished within the time limit of the safety switch or approximately 30 seconds after the detector is removed. If the control shuts down, manually reset it. Replace the detector and repeat the process from step 5.

⚠ Warning

When checking the pilot flame, be aware the electrode is energized. Failure to follow these instructions could result in serious injury or death.

7. When a suitable flame as indicated in step 6 is obtained, replace the detector. Observe the reading on the micro-ammeter. The reading should be between 2-1/4 and 5 micro amps when using a lead sulfide detector and a standard amplifier. See the flame signal table in the manufacturer's bulletin for values of other combinations.

   The flame signal indicated on the annunciator type relay should not be less than 5 Vdc, and may be as high as 20 Vdc or greater.

   The reading must be steady. If the reading fluctuates, recheck the adjustment. Be sure that the flame detector is properly seated and that the lens is clean.
8. Return the Run/Test switch to the "Run" position.
9. If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.
10. The reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in step 7. If there are any deviations, refer to the troubleshooting section in the technical bulletin.

6.11 — Gas Pressure and Flow Information

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields the highest combustion efficiency at rated performance yet prevents over-firing. Once the optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency. Since the gas pressure regulator itself is usually furnished by others, detailed adjustment instructions and adjusting procedures recommended by the manufacturer should be followed.

6.11.1 — Pressure

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

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

The pressure requirement varies with boiler size, altitude, and type of gas train. Refer to Table 6.1 for pressure requirements.

TABLE 6-1. Minimum gas pressure required at entrance to regulator/gas valve

BOILER HP	Combination Regulator and Gas Valve Size (in)	PRESSURE REQUIRED ("WC)
100	1.5	12.5
125	1.5	20
150	1.5	27.5
200	1.5	38.5
250	2	41
300	2	55
350	2	75.5
400	2	92
500	2.5	55
600	2.5	79
700	3	80.5
800	3	105

The pressures listed are based on 1000 Btu/cu ft natural gas at elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from Table 6.2.

TABLE 6-2. Pressure/Altitude Correction Factors

Altitude Feet Above Sea Level	Correction Factor
1000	1.04
2000	1.07
2500	1.09
3000	1.11
4000	1.16
5000	1.21
6000	1.25
7000	1.30
8000	1.35
9000	1.40

NOTE: For undersized or oversized gas trains or altitudes above 9000 feet, contact your local Cleaver-Brooks representative.

6.11.2 — Gas Flow

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

$$\text{INPUT} = \frac{\text{OUTPUT} \times 100\%}{\text{EFFICIENCY}}$$

$$\text{GAS FLOW} = \frac{\text{INPUT}}{\text{GAS BTUs/FT}^3}$$

$$= \frac{\text{OUTPUT} \times 100}{\text{EFFICIENCY} \times \text{GAS BTUs/FT}^3}$$

6.11.3 — Pressure Correction

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

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

To express the volume obtained from an actual meter reading into cubic feet at base pressure, it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 6.3.

TABLE 6-3. Pressure Correction Factors

1	1.05
2	1.11
3	1.18
4	1.25
5	1.32
6	1.39
7	1.45
8	1.53
9	1.59
10	1.66
11	1.72
12	1.81
13	1.86
14	1.93
15	2.0

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

As an example, assume that a 600 horsepower boiler is installed at 2,000 feet above sea level, is equipped with a standard gas train and burner, and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

Pressure

Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 37.5" WC gas pressure at sea level, Table 6.1. Table 6.2 indicates a correction factor of 1.07 for 2,000 feet. Multiplying the results in a calculated net regulated gas requirement of approximately 40.1" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input, Table 6.3, and "correct" this answer by applying the correction factor for 3 psig, Table 6.4.

$$\frac{\text{Btu/hr input}}{\text{Btu/cu. ft.}} = \text{CFH (Cubic feet/hour)}$$

or

$$\frac{25{,}100{,}000}{} = 25{,}100 \text{ CFH (at 14.7 lb, atmospheric base 1,000 pressure)}$$

then

$$\frac{25{,}100}{1.18} = 21{,}271 \text{ CFH}$$

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 25,100 CFH (at base pressure) will be delivered.

6.11.4 — Checking Gas Flow

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

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

6.12 — Adjusting Combustion

Combustion settings are made using the Hawk 2000 control system. Refer to manuals 750-338 (Hawk 2000) and 750-217 (parallel positioning).

6.13 — Low Gas Pressure Switch

Adjust the scale setting to slightly below the normal burning pressure. The control circuit will be broken when pressure falls below this point. Since gas line distribution pressure may decrease under some conditions, shut-downs may result if the setting is too close to normal. However, regulations require that the setting may not be less than 50% of the rated pressure downstream of the regulator. Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored.

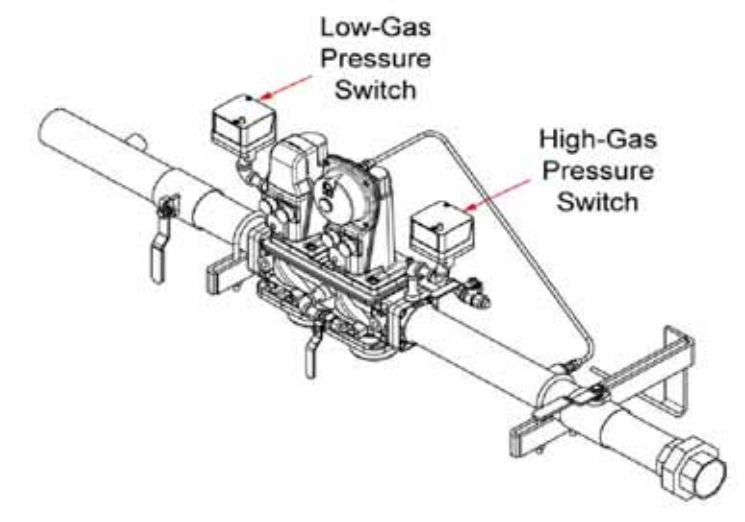


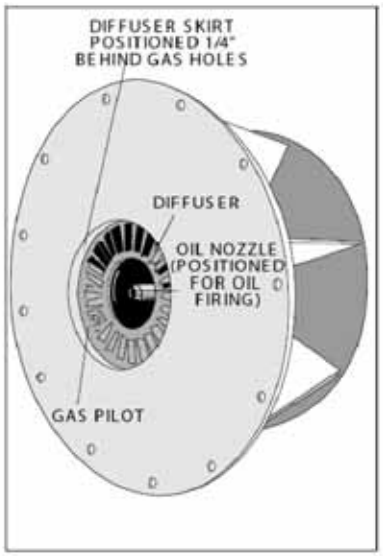
FIGURE 6-6. Gas Train Pressure Switches

6.14 — High Gas Pressure Switch

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

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure falls.

6.15 — Burner Drawer Adjustment



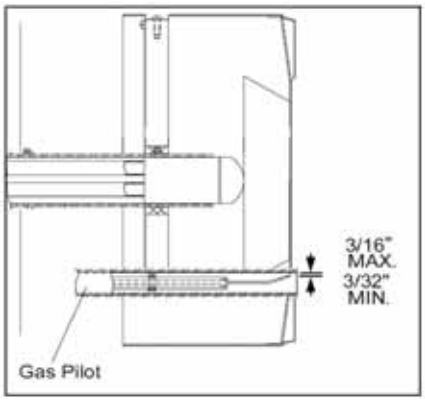
There are relatively few adjustments that can be made to the burner, however, a check should be made to assure that all components are properly located, and that all holding screws are properly tightened.

The diffuser location on gas fired boilers is important. There should be 1/4” distance between the edges of the diffuser fins and gas outlet tubes (spuds) coming from the burner housing. The setting of an oil fired burner is less exacting and the diffuser should be located with the diffuser skirt approximately 1-1/8” in front of the oil nozzle.

When the proper diffuser location is ascertained, the setting of the nozzle in relation to the diffuser should be checked. This generally is set at time of manufacture and seldom needs altering. It is most important that oil spray does not impinge upon the diffuser. The distance that the nozzle is behind the diffuser has some latitude, and individual installation may require a slight deviation.

FIGURE 6-7. Burner Drawer in Burner Housing

Check the setting of the ignition electrode(s) for proper gap and position. Be sure that the porcelain insulator is not cracked and that ignition cable connections are tight.



The oil nozzle tip should be seated tightly in the body with the swirler and the seating spring in place.

Check to see that the flame detector sight tube and the gas pilot tube extend through their respective openings in the diffuser face.

FIGURE 6-8. Gas Pilot Electrode

6.16 — Oil Drawer Switch

The integral contacts of the control are closed by proper positioning and latching of the oil nozzle lance in its forward position. Adjustment of the switch must be such that its contacts open if the oil nozzle lance is not properly positioned for oil firing. The switch is electrically removed from the circuit when a combination fuel burner is fired on gas (fuel selector switch is in GAS position).

CHAPTER 7 Troubleshooting

Chapter 7 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.

⚠ Warning

Troubleshooting should be performed only by personnel familiar with the equipment and who have read and understood 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.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies.

Knowledge of the system and its controls will make troubleshooting much easier and can be obtained by studying the contents of this manual and others provided with the boiler. 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 cause for a problem 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.

⚠ Warning

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

7.1 — Problem-Cause Suggestions

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

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

CHAPTER 8

Inspection and Maintenance

8.1 — 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.

TABLE 8-1. **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 pressure/temperature	Check indicating lights and alarms	Remove and clean oil preheater	
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			

8.1.1 — 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.

8.2 — 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 8-1. Stack Thermometer

Tube cleaning is accomplished by opening the front and rear doors. Tubes may be brushed from either end. All loose soot and accumulations should be removed. Any soot, or other deposits, should be removed from the furnace and tube sheets.

Refer to Section 8.17 for instructions on properly closing rear heads.

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. See Section 3.9 in Chapter 3.

8.3 — 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.

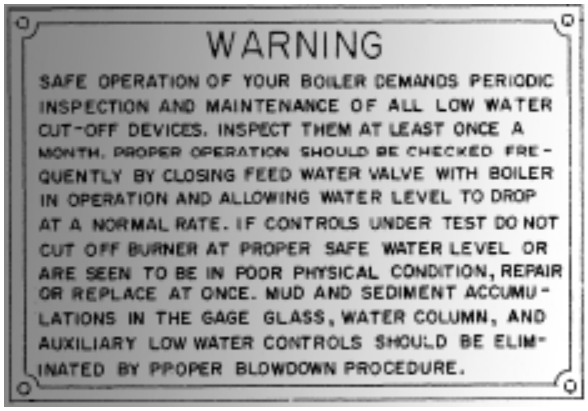
8.3.1 — Steam Boiler

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. Refer to Chapter 3 for blowdown instructions.

No attempt should be made 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.

FIGURE 8-2. Low Water Cutoff

The instructions on the low water cutoff plate 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.


WARNING

SAFE OPERATION OF YOUR BOILER DEMANDS PERIODIC INSPECTION AND MAINTENANCE OF ALL LOW WATER CUT-OFF DEVICES. INSPECT THEM AT LEAST ONCE A MONTH. PROPER OPERATION SHOULD BE CHECKED FREQUENTLY BY CLOSING FEED WATER VALVE WITH BOILER IN OPERATION AND ALLOWING WATER LEVEL TO DROP AT A NORMAL RATE. IF CONTROLS UNDER TEST DO NOT CUT OFF BURNER AT PROPER SAFE WATER LEVEL OR ARE SEEN TO BE IN POOR PHYSICAL CONDITION, REPAIR OR REPLACE AT ONCE. MUD AND SEDIMENT ACCUMULATIONS IN THE GAGE GLASS, WATER COLUMN, AND AUXILIARY LOW WATER CONTROLS SHOULD BE ELIMINATED BY PPOPER BLOWDOWN PROCEDURE.

FIGURE 8-3. Low Water Cutoff Plate

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.

8.3.2 — 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.

8.4 — 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.

⚠ Warning

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 8-4. Water Column Gauge Glass Replacement

8.5 — 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. Information given below is included for guidance to fuse requirements.

MOTOR & CCT FUSE SIZING
RECOMMENDED MAXIMUM "FUSETRON" FUSE SIZES

ELECTRICAL LOAD	SINGLE PHASE 50/60 HERTZ		THREE PHASE 50/60 HERTZ				
	110-120 V	220-240 V	200-208 V	220-240 V	346-416 V	440-480 V	550-660 V
1/4 HP MOTOR	FRN-8	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10		FRS-1	FRS-8/10
1/3 HP MOTOR	FRN-9	FRN-4-1/2	FRN-1-8/10	FRN-1-8/10		FRS-1	FRS-8/10
1/2 HP MOTOR	FRN-12	FRN-6-1/4	FRN-2-8/10	FRN-2-8/10	FRS-1-8/10	FRS-1-4/10	FRS-1
3/4 HP MOTOR	FRN-17-1/2	FRN-9	FRN-4-1/2	FRN-4-1/2	FRS-2-1/4	FRS-1-8/10	FRS-1-4/10
1 HP MOTOR	FRN-20	FRN-10	FRN-5	FRN-5	FRS-3-2/10	FRS-2-1/4	FRS-1-8/10
1-1/2 HP MOTOR	FRN-25	FRN-12	FRN-7	FRN-7	FRS-4	FRS-3-2/10	FRS-2-1/2
2 HP MOTOR	FRN-30	FRN-15	FRN-9	FRN-9	FRS-5-6/10	FRS-4-1/2	FRS-3-1/2
3 HP MOTOR	FRN-40	FRN-20	FRN-12	FRN-12	FRS-8	FRS-6-1/4	FRS-5
5 HP MOTOR		FRN-35	FRN-20	FRN-20	FRS-12	FRS-10	FRS-8
7-1/2 HP MOTOR		FRN-50	FRN-30	FRN-30	FRS-17-1/2	FRS-15	FRS-12
10 HP MOTOR		FRN-60	FRN-40	FRN-35	FRS-20	FRS-17-1/2	FRS-15
15 HP MOTOR			FRN-60	FRN-50	FRS-30	FRS-25	FRS-20
20 HP MOTOR			FRN-70	FRN-70	FRS-40	FRS-35	FRS-25
25 HP MOTOR			FRN-90	FRN-80	FRS-50	FRS-40	FRS-35
30 HP MOTOR			FRN-100	FRN-100	FRS-60	FRS-50	FRS-40
40 HP MOTOR			FRN-150	FRN-150	FRS-80	FRS-70	FRS-50
50 HP MOTOR			FRN-175	FRN-175	FRS-100	FRS-80	FRS-70
60 HP MOTOR			FRN-200	FRN-200	FRS-125	FRS-100	FRS-80
75 HP MOTOR			FRN-250	FRN-250	FRS-150	FRS-125	FRS-100
100 HP MOTOR			FRN-350	FRN-300		FRS-150	FRS-125
125 HP MOTOR			FRN-450	FRN-400		FRS-200	FRS-150
150 HP MOTOR			FRN-500	FRN-450		FRS-225	FRS-200
200 HP MOTOR				FRN-600		FRS-300	FRS-250

CONTROL CIRCUIT XFMR VOLTAGE	1/2 KVA.	1 KVA.	1-1/2 KVA.	2 KVA.
110-120	FRN-7	FRN-15	FRN-17-1/2	FRN-25
200-208	FRN-4	FRN-8	FRN-12	FRN-15
220-240	FRN-3-1/2	FRN-7	FRN-10	FRN-12
346-416	FRS-2-8/10	FRS-4	FRS-6-1/4	FRS-8
440-480	FRS-2-1/2	FRS-3-1/2	FRS-5-6/10	FRS-7
550-600	FRS-2	FRS-3-1/2	FRS-4-1/2	FRS-5-6/10
SECONDARY FUSE	FRN-5-6/10	FRN-12	FRN-15	FRN-20

CONSULT CLEAVER-BROOKS ELECTRICAL ENGINEERING DEPT. FOR "FUSETRON" FUSE SIZE
FOR POWER SYSTEMS WITH VOLTAGE, FREQUENCY OR PHASE NOT MENTIONED ABOVE.

FIGURE 8-5. Recommended Maximum Fusetron® Fuse Sizes

8.6 — 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 shut-down (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.

⚠ Warning

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.

8.6.1 — 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.

8.6.2 — 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.

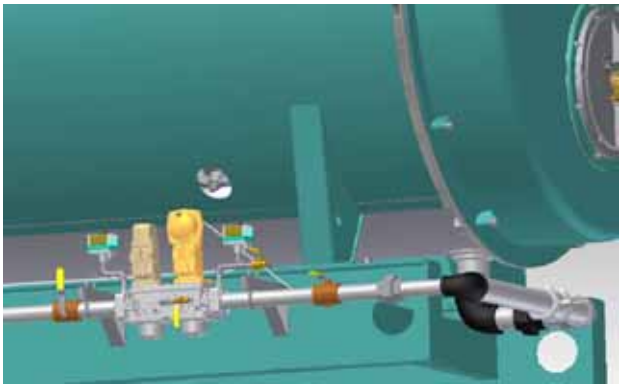
Turn the burner switch off. Reset the safety switch. Re-establish main fuel supply.

8.6.3 — 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 moistened with detergent if necessary.

FIGURE 8-6. **Main Gas Train**

8.7 — Oil Burner Maintenance

The burner should be inspected for evidence of damage due to improperly adjusted combustion. Any soot buildup on the diffuser or the oil nozzle should be removed. The positioning of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked. See Section 6.19 in Chapter 6.

8.7.1 — Light Oil Strainers

NOTE: All oil strainers should be cleaned frequently to maintain a free and full flow of fuel.

The fuel oil strainer screen must be removed and cleaned at regular intervals. It is advisable to remove the screen each month and clean thoroughly by immersing it in solvent and blowing it dry with compressed air. To remove, loosen the cover cap screw, being careful not to lose the copper gasket. If necessary, tap the strainer cover gently to loosen. Check the cover gasket for damage and replace if necessary. Slip pliers into the cross on the top of the strainer and twist counter-clockwise to remove the basket. Reassemble in reverse order.

8.7.2 — Cleaning the Oil Nozzle

The design of the burner should be kept operationally clean when firing on oil. A routine check and any necessary cleaning should be made during off periods or when the burner is firing on gas.

If at any time the burner flame appears “stringy” or “lazy,” it is possible that the nozzle tip or swirler has become partially clogged or worn. Any blockage within the tip will cause the air pressure gauge to increase above its normal value.

FIGURE 8-7. Standard and High Turndown Burner Nozzle Components

Disassemble with the power off by unlatching and withdrawing the burner gun. Insert the nozzle body into the hanger vice and use the spanner wrench to remove the tip. Remove the swirler and seating spring being careful not to drop or damage any parts.

Perform any necessary cleaning with a suitable solvent. Use a soft fiber brush or pointed piece of soft wood for cleaning. Do not use wire or a sharp metallic object, which could scratch or deform the orifices as well as the precision ground surfaces of the swirler and tip. Inspect for scratches or signs of wear or erosion, which may make the nozzle unfit for further use. Take the necessary precautions in working with solvents.

The tip and swirler are a matched set, which are precision lapped at the time of assembly. The close fit of the lapped surfaces must be maintained in order to provide optimum performance. Additional lapping may be required to provide better atomization for more efficient combustion. Do not interchange parts if a spare is kept. In reassembling, be certain that the seating spring is in place and that it is holding the swirler tightly against the tip. The swirler is stationary and does not rotate, but rather imparts a swirling motion to the oil.

See that the plugged hole is at the bottom of the nozzle body when the gun is installed.

8.7.3 — Cleaning the Back Pressure Orifice Nozzle

Clean the strainer screen carefully to remove any foreign matter. Use suitable solvents in cleaning. Hot water at high velocity is also helpful in cleaning. Replace strainer by screwing it into the nozzle body only finger tight. Do not use an orifice of a size other than originally installed.

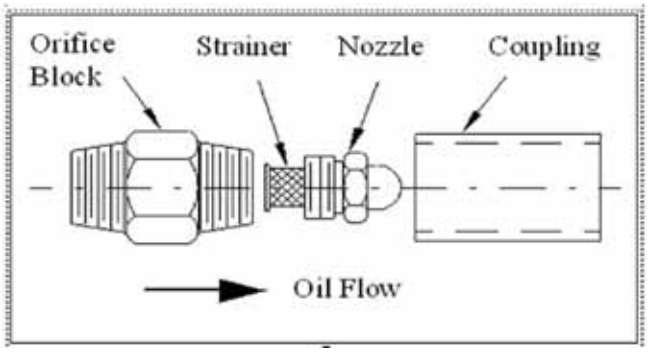
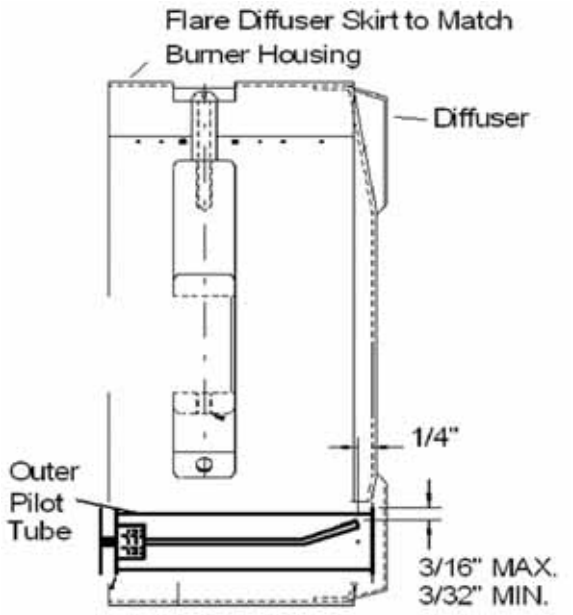


FIGURE 8-8. Back Pressure Orifice

8.7.4 — Ignition System

For best results, maintain the proper gap and dimensions for the ignition electrode(s).

Inspect the electrode tip for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the porcelain insulator (s) for any cracks that might be present. If there are cracks, replace the electrode since they can cause grounding of the ignition voltage. Since carbon is an electrical conductor, it is necessary to keep the insulating portion of electrode(s) wiped clean if any carbon is present. Ammonia will aid in removing carbon or soot.



Check ignition cables for cracks in the insulation. Also see that all connections between the transformer and the electrodes are tight. Periodically remove the access plug from the gas pilot aspirator and clean out any accumulated lint or other foreign material.

FIGURE 8-9. Gas Pilot Electrode and Diffuser Spacing

8.8 — Gas Burner Maintenance

The gas burner components should be inspected for evidence of damage due to improperly adjusted combustion. Combustion adjustments should be checked monthly.

Check periodically for a proper seal between the end of the burner housing and boiler refractory. Any deterioration of the seal should be corrected, as an improper or poor seal allows air leaks, which can cause overheating or burning of the burner housing.

Whenever the burner is removed, the diffuser, gas housing and gas spuds (HTB model only) should be checked for any deterioration. Verify that the diffuser skirt conforms to the bore of the burner housing so as to minimize the amount of combustion air which bypasses the diffuser. If the burner is a high turndown burner (HTB) model, check to see that the diffuser is properly located in reference to the gas spuds. There should be 1/4” between the edge of the diffuser fins and the gas spuds when the burner is installed. Check to see that the diffuser fins do not interfere with the gas ports or gas spuds in the burner housing.

Check the electrode setting for any cracks that might be present on the porcelain insulator. Replace the electrode if cracking is evident since cracking can cause grounding of the ignition voltage. Inspect the tip of the electrode for signs of pitting, combustion deposits and wear, dressing as required with a fine file.

Periodically remove the access plug from the gas pilot aspirator and clean out any accumulated lint or other foreign material.

Check the ignition cables for cracks in the insulation. Verify that all connections between the transformer and the electrode are tight.

8.9 — Motorized Gas Valve

The motorized gas valve operating mechanism contains no user serviceable parts. An inoperative actuator must be replaced.

8.10 — Solenoid Valves

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

⚠ Warning

Be sure to turn off power to the valve in order to avoid electrical shock. Failure to follow these instructions could result in serious injury or death.

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

Coils may be replaced without removing the valve from the line.

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

8.11 — Air Control Damper

The burner air control damper should be checked for free movement as a part of the monthly inspection. With the burner off and the actuator removed, the air control damper should rotate freely through its entire range of movement. Any resistance to movement or excessive play in the support bearing should be investigated and corrected before the burner is put back in operation.

Ensure the gears are fully engaged throughout the entire damper rotational range.

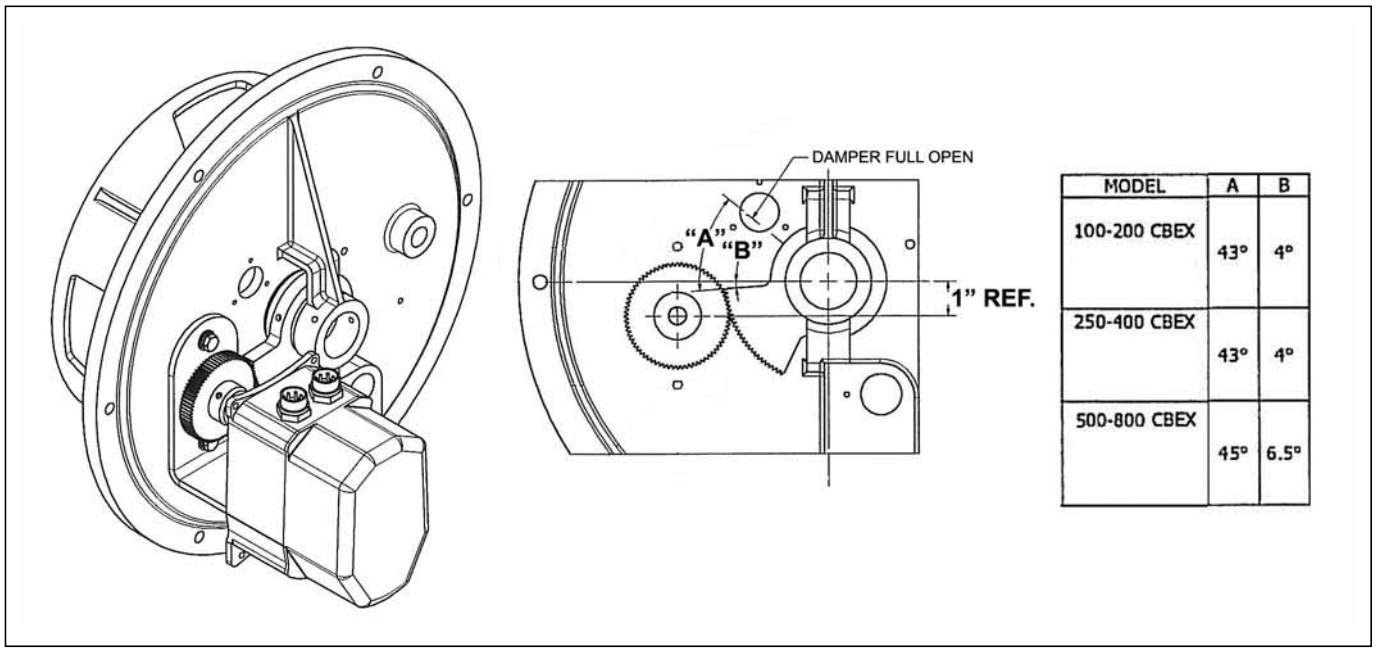


FIGURE 8-10. Rotary Air Damper

⚠ Caution

Combustion should be checked and readjusted as required whenever the burner is removed or any control linkage is disturbed. Failure to follow these instructions could result in equipment damage.

Inspection of the air damper should be performed on a more frequent basis if the boiler is operating in a dirty environment.

Lubricate occasionally with a non-gumming, dripless, high-temperature lubricant such as graphite or a silicone derivative.

8.12 — Fan/Motor Cassette Removal

⚠ Warning

BEFORE removing the fan/motor cassette, disconnect and lockout electrical power to the boiler and ensure the front door is securely bolted to the boiler. Failure to follow these instructions could result in serious injury or death.

Before the boiler is commissioned at the job site, the Integral Flue Gas Recirculating (IFGR) system should be visually inspected. The fan/motor cassette should be removed to expose the internal IFGR linkage and damper. Remove the fan/motor cassette as follows:

1. Disconnect and lockout electric power to the boiler.
2. Be sure that the front door is securely bolted to the boiler.
3. Release the davit arm by removing the retaining bolt at the top center of the boiler.
4. Connect the davit arm to the fan/motor cassette using the suspension system shown in Figure 8-11.
5. Arrange the attaching chains so the lifting point is over the motor shaft centerline and the center of balance for the fan/motor cassette. This point is approximately 4 inches from the motor backplate for 600-800 HP units, and 3 inches for 250-500 units.
6. Remove the fan/motor cassette fastening nuts.
7. Swing the fan/motor cassette to the side and secure it to the boiler using high strength cord. Do not over-extend the motor wires.

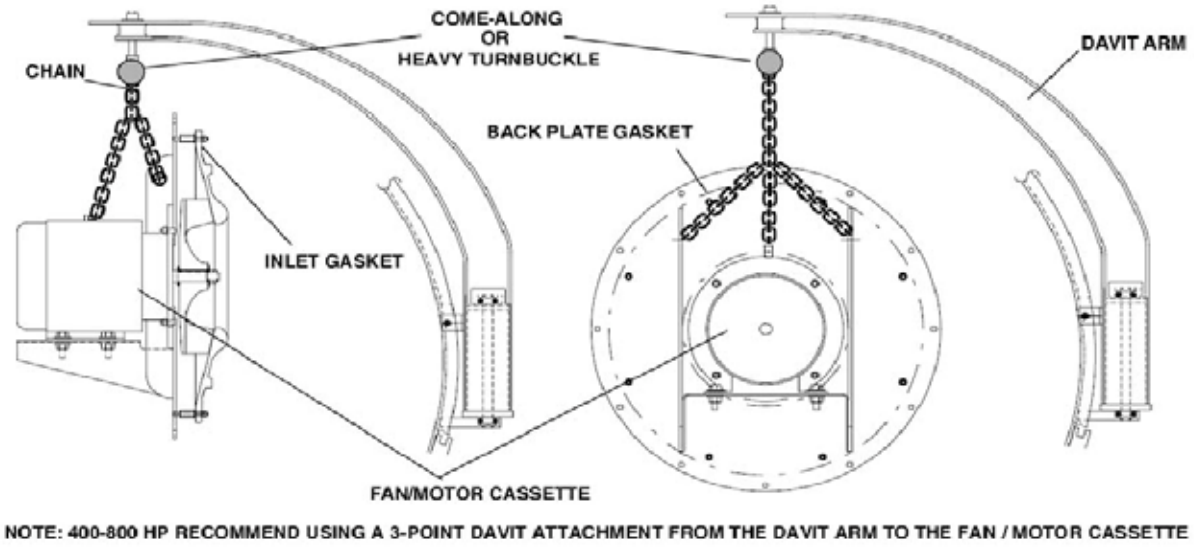


FIGURE 8-11. Fan/Motor Cassette

⚠ Warning

When suspending the fan/motor cassette from the davit arm, all equipment used must be of adequate strength to safely support the complete cassette. Failure to follow these instructions could result in serious injury or death.

8.13 — 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.

To ensure proper operation of the IFGR system and burner, inspection and cleaning should be performed at regular intervals, depending on the load, type of fuel, and combustion temperatures.

1. With the IFGR damper exposed, inspect the internal linkages for secure connections, and check for free movement of the linkage arms and the IFGR damper assembly.
2. The clearance between the impeller and backplate should be checked and adjusted if required. Impeller clearances must correspond to the measurements in the table below:

Standard 60 PPM	**30 PPM 9 PPM**
.040 ± .010	.050 + .010 - .005

3. The impeller clearance is checked by inserting a long feeler gauge of the proper thickness between the impeller and the impeller housing. Impeller clearances should be checked at the highest fin on the impeller (that fin which is closest to the impeller housing), and must be checked at each point where the housing is attached to the motor backplate.
4. If the impeller clearance is not correct at all points, adjust:
   A. Loosen the retaining nuts on both sides of the impeller housing.
   B. Adjust the retainers for the correct impeller clearance at two housing attachment points 180º apart.
   C. Adjust the retainers for correct clearance at the housing attachment points 90º from those initially adjusted.
   D. Adjust for correct impeller clearance at the remaining attachment points.
5. Check and replace any gaskets that have been damaged. Gaskets that have been in use for one year or more should be replaced. In particular, inspect the airbox gasket for damage.

⚠ Caution

When replacing the airbox gasket, use only Cleaver-Brooks components. Failure to use components designed for this application can result in improper combustion. Failure to follow these instructions could result in equipment damage.

8.14 — Fan/Motor Cassette Installation

To close the fan/motor cassette:

1. Check that all adjustment screws are tight, and check the linkage and IFGR damper for free movement before closing the unit.

> **⚠ Warning**
>
> Do not remove the davit arm assembly from the motor/fan cassette without first verifying that the cassette is securely bolted to the boiler. Failure to follow these instructions could result in serious injury or death.

2. Position the cassette into the front door.
3. Slide the cassette into position until it begins to contact the airbox gasket then measure the clearance between the cassette flange and the front door mounting face. There must be clearance of at least 1/4" to provide adequate gasket compression when the cassette is mounted tightly to the door.
4. Secure the cassette with the fastening nuts.
5. After the cassette has been secured to the front head, reconnect the davit to the front door by screwing in the retaining bolt at the top centerline.

Check occasionally that the fan is securely tightened to the motor shaft. Check the clearance between the fan vanes and housing.

8.15 — Safety Valves

FIGURE 8-12. 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 Sections VI and VII of 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 8-13. 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.

8.16 — Fuel Oil Metering Valve

In the event that a leak occurs in the packing of the metering valve, the packing nut should be snugged gradually to stop the leak.

⚠ Caution

Do not over-tighten the metering valve packing nut. Excessive tightening of the packing nut prevents free movement of the metering stem. Failure to follow these instructions could result in equipment damage.

If replacement of the metering valve packing is necessary, procure **Kit P/N 880-370** (Figure 8-14) and install in accordance with the following procedure.

1. Shut off the oil flow. Be sure no pressure shows on the gauge.
2. Match-mark the cam hub and drive shaft. Match-marking will enable replacement of the cam in its original position and result in a minimum of cam adjustment when the burner is refired.

FIGURE 8-14. Fuel Stem Packing Kit

3. Clamp or hold the metering stem in the down position.
4. Loosen the setscrews in the cam hub and rotate, or move the cam to a position where it does not interfere with stem removal.

5. Withdraw the metering vale stem and spring. Do not drop or mishandle. Check for nicks or scratches. Check that the pin holding the metering portion is not protruding.
6. Back off the packing gland.
7. Remove the capscrews holding the jackshaft support bracket so that the bracket can be moved. It may also be necessary to loosen the supporting bracket on the far end of the shaft.
8. Remove the existing packing and guides. Do not re-use the packing and guides.
9. Lightly coat the stem with the lubricant provided with the packing kit. Place the new packing, o-rings, and guides onto the stem in the sequence shown. The beveled face of the guides and the teflon rings must face upward, with the exception of the upper brass guide which is faced down. Be sure that the o-rings are properly located.
10. Using the stem as a guide, insert the assembled packing into the cavity, then withdraw the stem.
11. In the event the packing is too high, remove one teflon packing from each side of the middle brass guide as needed.
12. Under no circumstances eliminate the two teflon packings on only one side of the brass guide.
13. Replace the gasket, put the support in place, and secure all fastenings.
14. Replace the metering stem and spring. Lightly lubricate the stem to facilitate insertion and easy movement. Use care when inserting so that the orifice and the stem are not damaged.

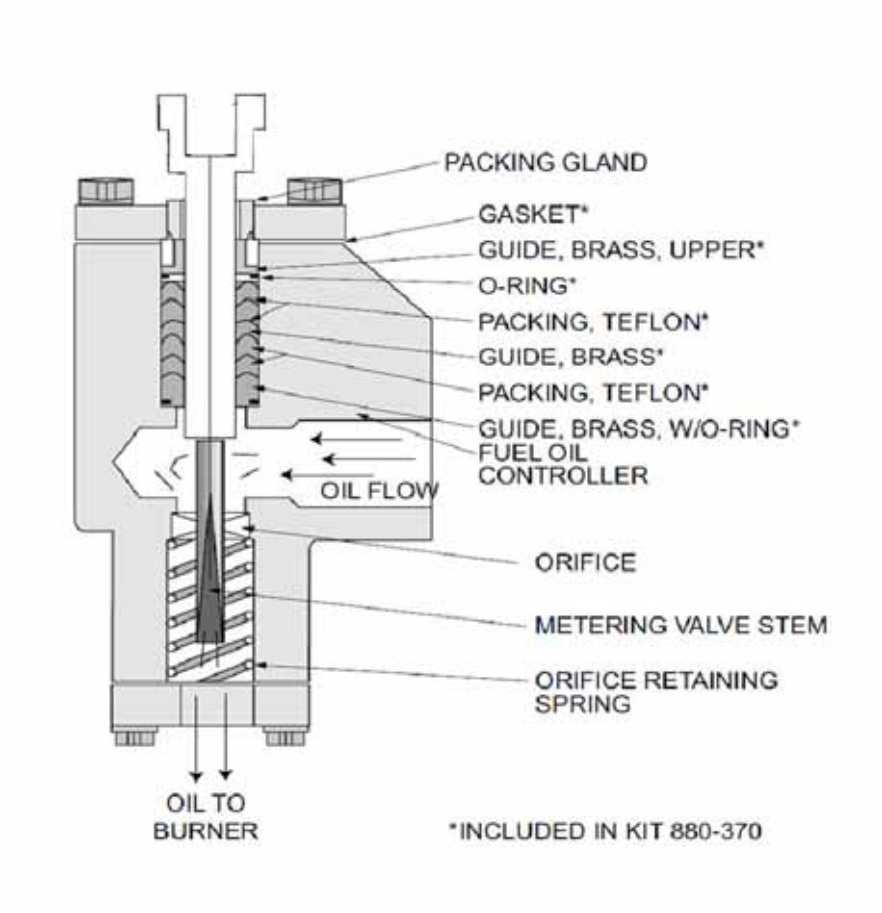


FIGURE 8-15. **Fuel Stem Packing, Cross-Section**

15. Snug the packing gland, but only sufficiently to place slight tension on the packing. The stem must move freely from the force of the spring.
16. Work the stem up and down several times to ensure that it moves freely.
17. Depress the valve stem and replace the cam. Mate the match-marks and secure the setscrews. Be sure the cam spring is centered in the roller.
18. Restore oil flow. Test fire the burner at various firing rates being certain that the metering stem freely follows the cam.
19. Tighten the packing gland after a period of operation, if necessary, to maintain proper pressure on the packing. Do not over-tighten.

If there are indications that the oil metering valve has become clogged at its orifice, it will be necessary to disassemble the control to remove the obstruction. Clean the slotted stem of the oil metering valve with suitable solvent and blow-dry with dry shop air. Follow the procedure outlined above when removing or re-installing the metering valve stem. Also check all fuel line strainers.

Should a pressure adjusting or relief valve become clogged, disassemble by releasing the locknut and backing off the screw to relieve tension on the diaphragm. Remove the valve cover and the diaphragm to expose any dirt or foreign material which may have entered the valves. Clean out carefully and reassemble. It is recommended that the diaphragms be replaced annually.

8.17 — Air Pump and Lubricating System

8.17.1 — 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.

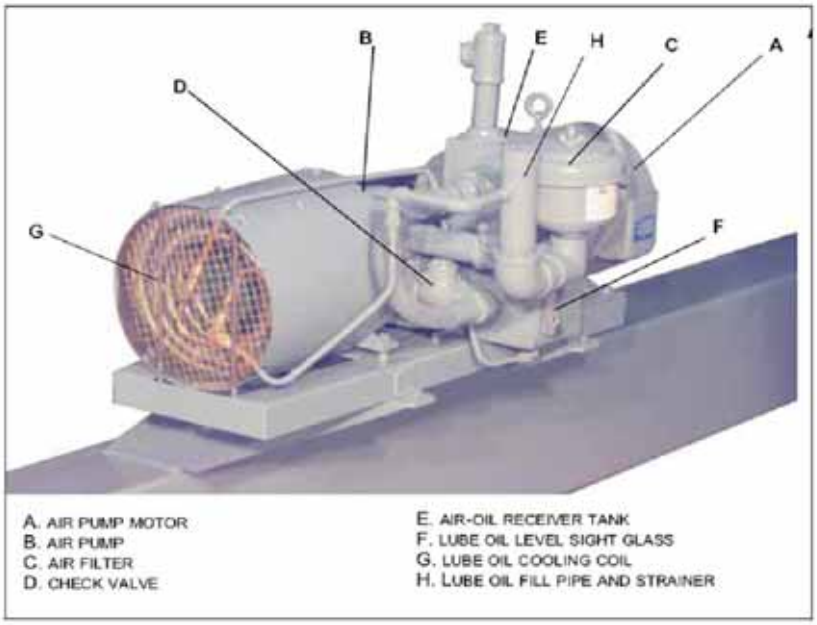


FIGURE 8-16. Air Pump

8.17.2 — 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.

⚠ Caution

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

8.17.3 — 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.

8.17.4 — 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 o-ring gasket under the cover so that a tight seal is obtained.

Follow previous instructions for oil replacement.

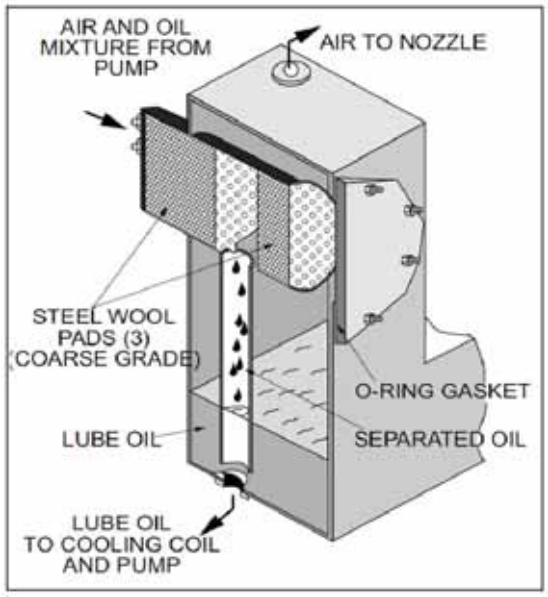
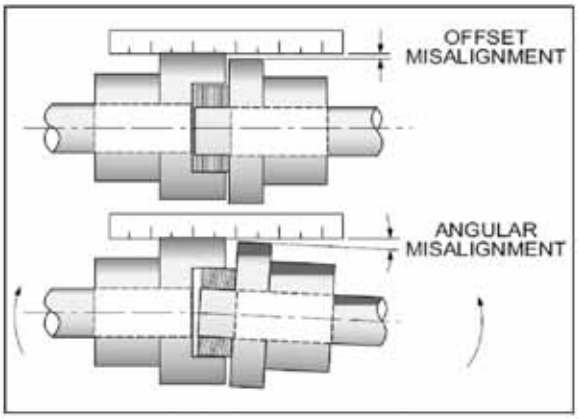


FIGURE 8-17. Air-Oil Receiver Tank

8.17.5 — 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.

8.17.6 — Flexible Coupling Alignment



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

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

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

FIGURE 8-18. 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.

8.17.8 — Air Compressor Replacement

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

Dismantling

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

Reassembly

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

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

Refer to the previous section on coupling alignment instructions.

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

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

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

Be sure that all piping connections are tight.

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

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

8.18 — Refractory

The boiler is shipped with completely installed refractory. This consists of furnace throat tile, furnace liner, and the crawl-way plug. Normal maintenance requires little time and expense, and prolongs the operating life of the refractory.

Preventive maintenance through periodic inspection will keep the operator informed of the condition of the refractory, and will guard against unexpected and unwanted downtime and major repairs.

Frequent wash coating of the refractory surfaces is recommended. High-temperature bonding, air-dry type mortar, diluted with water to the consistency of light cream, is used for wash coating. Re-coating intervals will vary with operating loads and are best determined by the operator when the boiler is opened for inspection.

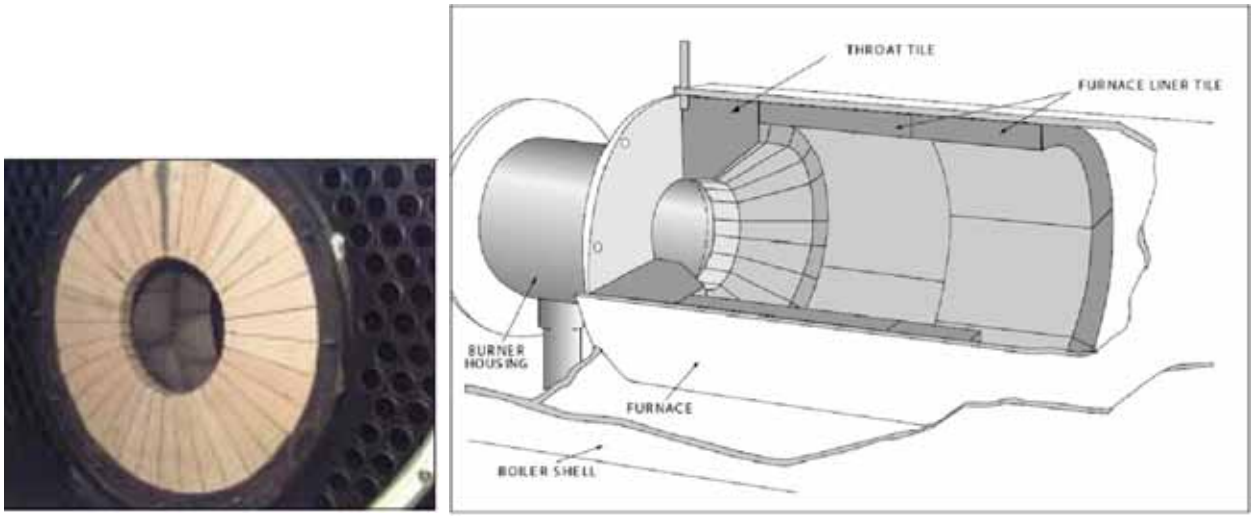


FIGURE 8-19. Throat Tile and Furnace Liner

8.18.1 — Furnace Liner

Maintenance consists of occasional wash coating of the entire liner. Face all joints or cracks by applying high temperature bonding mortar with a trowel or fingertips. Wash coating should be done as soon as cracks are detected.

⚠ Caution

The area between the burner housing and the throat tile requires a good seal. An improper or poor seal allows air leaks that can cause overheating and burning of the burner housing metal. The area should be inspected semi-annually. Contact your local Cleaver-Brooks representative.

Should segments of the liner burn away or fall out, replace the entire refractory piece. Any refractory that may break out should be removed as soon as detected so that it will not fuse to the bottom of the furnace and obstruct the flame.

If replacement is necessary, refer to Chapter 9 to order proper replacement items. Remove existing refractory. Thoroughly clean the furnace to remove all old refractory cement or other foreign material to ensure the new liner seats firmly against the steel. Inspect the furnace metal.

The furnace may be plain or corrugated. If the furnace is corrugated it is necessary to fill in the corrugation valleys under the furnace liner tile from the 4 o'clock position to the 8 o'clock position with insulating cement. The liner tile should be fitted tightly against the crown of the corrugation.

8.18.2 — Throat Tile and Liner

The throat tile must be installed to maintain an approximate inside diameter to match the burner housing, and be centered in the furnace. Since the thickness of the furnace metal varies with the boiler design pressure, a shim of appropriate thickness must be used to compensate for the variance. A layer or two of insulating board or equal, or a bed of refractory material, may be used to center the ring. The liner tile can be fitted tightly against the furnace, since the finished diameter is not critical.

⚠ Caution

The area between the burner housing and throat tile requires a good seal. An improper or poor seal allows air leaks that can cause overheating and burning of the burner housing metal. This area should be inspected semi-annually in order to avoid damage to the equipment.

It is recommended that the tile be dry-fitted, match-marked, removed, and then re-installed with the proper amount of refractory cement. Thin joints (less than 1/16") are desirable. Generally, it will be necessary to shave a portion from one or more tiles to obtain a fit. If a fill piece is required, cut it to fit and install the piece at the bottom of the furnace. When installing the housing, or the tile against the housing, liberally coat the surface with refractory cement. Remove any cement that is squeezed out.

Allow refractory to air dry as long as possible. If immediate use is required, fire intermittently at a low rate for several hours to thoroughly dry the refractory. For detailed information, request Bulletin C10-5921 from your local Cleaver-Brooks representative.

8.18.3 — Installation

NOTE: The arch bricks may need to be trimmed to match the burner housing I.D. on higher pressure boilers.

The following procedure is typical for all boilers with corrugated furnaces. When working with plain furnaces, disregard any steps referring to insulation of corrugated areas.

1. Install studs, bricking tool, cerafelt, bottom and top arch bricks as shown on DETAIL "A" (Figure 8-20) to check for correct fit up. If interference is present at the arch brick, measure this distance and trim inside diameter (I.D.) of all bricks.
2. Install the bottom half of arch bricks as shown on DETAIL "B".

Mix the vee block to a mortar-like consistency (per manufacturer's instructions) and pack the front (3) valleys of the furnace corrugations with the mixture, flush with the furnace I.D. up to 3 o'clock and 9 o'clock from the centerline of the furnace. Install both pieces of cerafelt to insulate the tile from the corrugation, and begin bottom half of first row of tiles as shown on DETAIL "C".

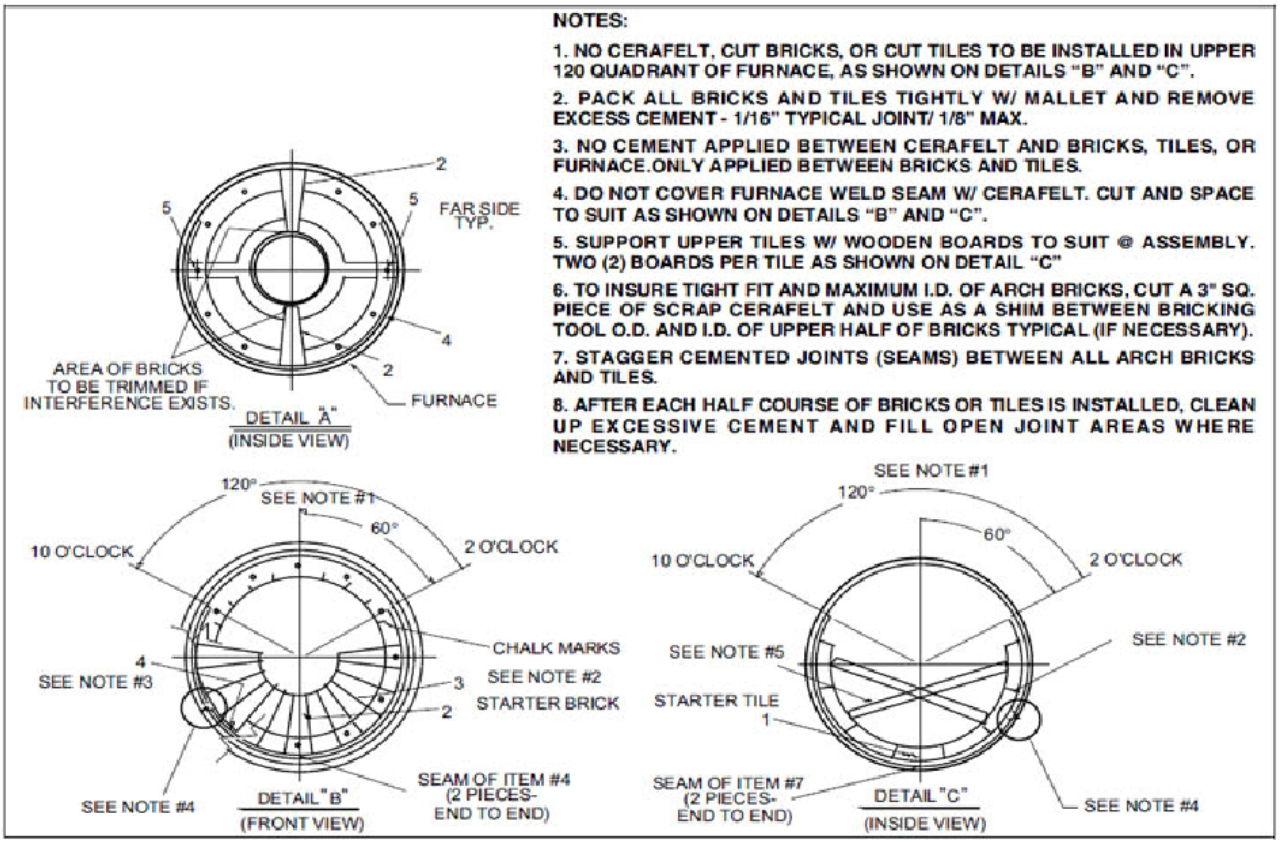


FIGURE 8-20. Throat Tile and Furnace Liner Installation

3. To begin the top half of arch bricks and tiles, measure off the upper half of furnace arch bricks and tiles with templates, mark with chalk, and determine if a cut brick or cut tile is needed (see DETAIL "B"). If cut brick is required, locate below the 2 o'clock and 10 o'clock positions (see note #4 on Figure 8-20). If brick is cut, angle of the cut surface should be the same as original brick. If cut brick or tile measures less than 1/2" full width, cut two pieces (see note #1 on Figure 8-20).
4. Install bricking tool as shown on DETAIL "A" and continue installing upper half by alternating one arch brick and one corresponding tile behind brick typical (see notes #5 and #6 on Figure 8-20).
5. For the last two rows of tiles, pack all remaining valleys of furnace corrugations (measure 36" from inside surface of arch bricks) with vee block mixture flush with furnace I.D. up to the 3 o'clock and 9 o'clock centerlines of the furnace.
6. Install both pieces of cerafelt and continue laying furnace tiles to complete the last two rows (see note #7 on Figure 8-20).
7. After joint cement hardens (approximately 2 hours), remove bricking tool, wooden tile supports, and discard cerafelt shims.

8.19 — Front Door and Rear Access Plug

8.19.1 — Opening Front Door

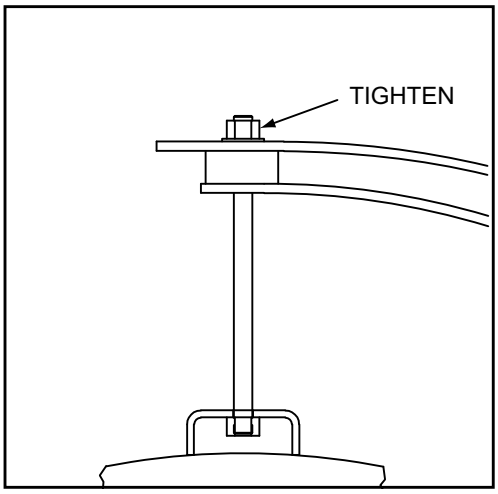


FIGURE 8-21. **Tighten the Davit Nut**

Before opening the door, tighten the nut on the davit arm to create a slight tension. This will minimize sagging and facilitate opening of the door. After opening, 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.

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

8.19.2 — Rear Access Plug

FIGURE 8-22. **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 new rope gasket.

8.20 — Lubrication

8.20.1 — 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 8-23. 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.

8.20.2 — Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

8.21 — 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.

CHAPTER 9 Parts

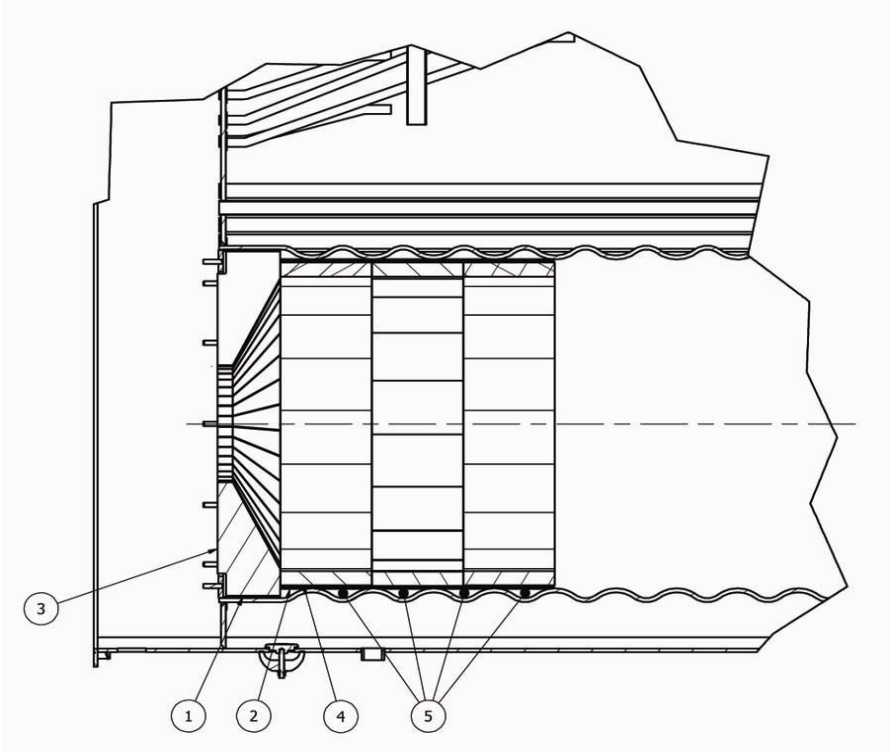
Ordering Parts

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.

9.1 — Arch Brick & Liner Tiles

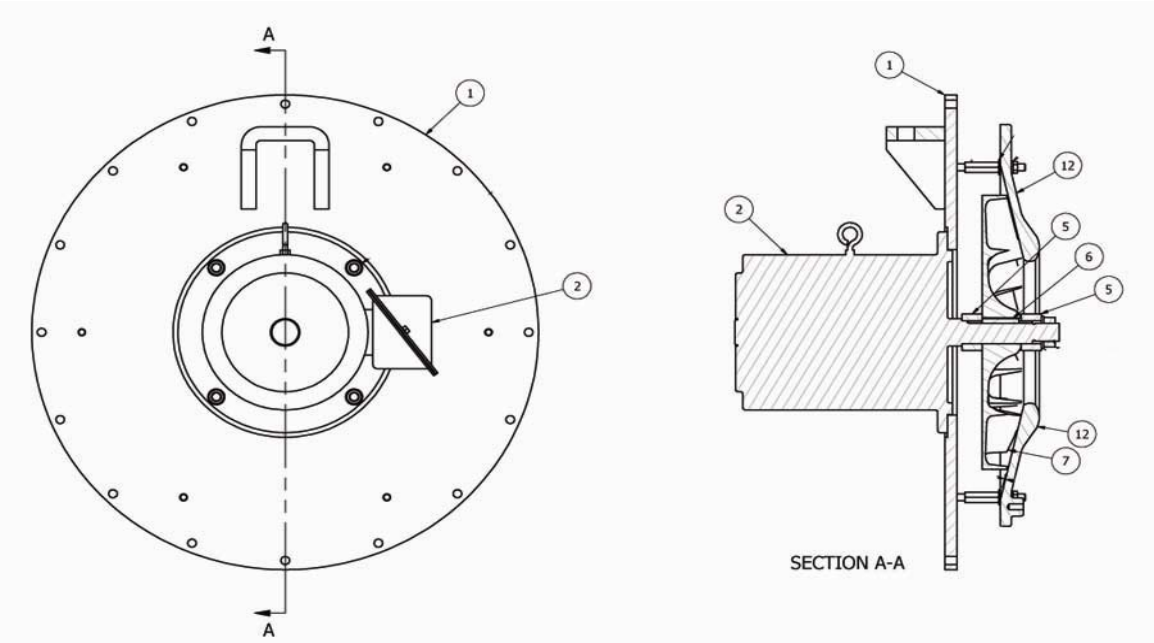
Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Ceramic Felt	872-00518	872-00655	872-00655	872-00655	872-00518	872-00518
2	1	Ceramic Felt	X	X	X	X	872-00518	872-00518
3	*	Archbrick	094-08463	094-01014	094-00449	094-00643	094-01010	094-00655
4	*	Liner Tile	X	094-01013	094-00204	094-00746	094-00205	094-00747
5	*	Refractory, Vee Block Mix	X	X	X	X	872-00162	872-00162
6	*	Cement, Joint Mortar	872-00390	872-00390	872-00390	872-00390	872-00390	872-00390



Item	*Description/Qty	55"	60"	67"	78"	85"	92"
3	*Archbrick/Qty	18	20	25	29	35	35
4	*Liner Tile/Qty	X	20	36	36	48	51
5	*Refractory, Vee Block Mix/ Qty	X	X	X	X	30 lbs	40 lbs
6	*Cement, Joint Mortar/Qty	5 lbs	5 lbs	10 lbs	10 lbs	25 lbs	30 lbs

9.2 — Blower Cassette

Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Base Assembly	407-00070	407-00067	407-00067	872-00655	*	*
2	1	Motor	894-03563	894-04044	894-04045	*	*	*
5	2	Spacer, Impeller	077-00489	077-00445	077-00491	*	*	*
6	1	Key	841-00646	841-01105	841-01105	841-01105	841-01105	841-01105
7	1	Impeller	192-00261	192-00314	192-00078	*	*	*
12	1	Impeller Housing	040-00420	040-00606	040-00606	40-C-618	40-C-502	40-C-502



NOTE: Impeller size is based on boiler hp, ppm emission level, boiler operating pressure and altitude. To ensure proper application sizing, contact Cleaver-Brooks Aftermarket.

9.2.1 — 78" CBEX/Blower Cartridge Components Part Numbers

FGR Rate	Boiler HP	HZ	Motor Size/ HP 0 - 150#	Impeller Part #	Group
50	350	60	15	192-D-303	A
50	350	50	15	192-D-303	A
50	400	60	15	192-C-78	A
50	400	50	15	192-C-78	A
30	350	60	20	192-D-86	A
30	350	50	20	192-D-86	A
30	400	60	20	192-C-79	A
30	400	50	20	192-C-79	A
9	350	60	20	192-D-79	A
9	350	50	20	192-D-79	A
9	400	60	25	192-C-330	B
9	400	50	25	192-C-330	B

	QTY	Spacer Part #
For Impeller Group "A"	2	077-00445
For Impeller Group "B"	1	077-00445

Impeller Grouping List for Altitude Applications The following list groups all available 78" impellers into what will be needed for altitude delete and adds	
Impeller Group "A" 1.375" DIA Bore/10-30 MTR HP	Impeller Group "B" 1.375" DIA Bore/10-30 MTR HP
192-C-77 (18")	192-C-87(25")
192-C-85 (20")	192-C-88 (28")
192-C-78 (21")	192-C-89 (30")
192-C-86 (23")	192-C-90 (31")
192-C-79 (24")	192-C-294 (24.5")
192-D-303 (19.25")	192-C-330 (23")
192-C-289 (22")	

N/A - 60 PPM Motor Part Number						
Steam and Hot Water						
	ODP (60 HZ)			ODP (50 HZ)	T.E.F.C./High Effic. (60 HZ)	
Motor HP	200V	230 & 460V	575V	230 & 380V	200V	230 & 460V
15	894-4455	894-4454	894-4537	894-4748	894-4463	894-4462
20	894-4469	894-4468	894-4739	894-4536	894-4490	894-4489
25	894-4488	894-4487	894-4740	894-4749	894-4758	894-4650

"Siemens" Motor Part Numbers for 30 PPM and Less				
	200V	208/230/380/ 450V	600V	220V
Motor HP	2 Pole w/1.15 SF 3 PH 60 HZ	2 Pole w/ 1.15 SF 3 PH 60 HZ	2 Pole w/ 1.15 SF 3 PH 60 HZ	2 Pole w/ 1.15 SF 3 PH 50 HZ
15	894-4036	894-4045	894-4054	894-4063
20	894-4037	894-4046	894-4055	894-4064
25	894-4038	894-4047	894-4056	894-4065

9.2.2 — 85” & 92” CBEX/Blower Cartridge Components Part Numbers

FGR Rate	Boiler HP	HZ	Motor Size/ HP 0 - 150#	Impeller Part #	Group
60	500	60	15	192-D-301	A
60	500	50	15	192-D-301	A
60	600	60	25	192-C-268	B
60	600	50	25	192-C-268	B
60	700	60	40	192-D-271	B
60	700	50	40	192-D-271	B
60	800	60	50	192-C-274	B
60	800	50	50	192-C-274	B
9	500	60	30	192-C-268	B
9	500	50	30	192-C-268	B
9	600	60	50	192-C-274	B
9	600	50	50	192-C-274	B
9	700	60	75	192-C-279	B
9	700	50	75	192-C-279	B

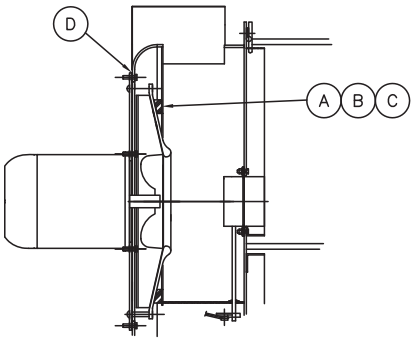
	QTY	Thickness	Spacer Part #
For Impeller Group “A”	1	1/2” thk	077-00445
For Impeller Group “B”	1	5/16” thk	077-00479
	1	1/4” thk	077-00495

60 PPM Motor Part Number						
Steam and Hot Water						
	ODP (60 HZ)			ODP (50 HZ)	T.E.F.C./High Effic. (60 HZ)	
Motor HP	200V	208-230 & 460V	575V	230 & 380V	200V	208-230 & 460V
15	894-04455	894-04454	894-04537	894-04748	894-04463	894-04462
20	894-04469	894-04468	894-04739	894-04536	894-04490	894-04489
25	894-04488	894-04487	894-04740	894-04749	894-04758	894-04650
30	894-04733	894-04735	894-04741	894-04750	894-04759	894-04763
40	894-04505	894-04669	894-04742	894-04753	894-04510	894-04509
50	894-04508	894-04507	894-04743	894-04754	894-04534	894-04533
60	894-04734	894-04663	894-04744	894-04755	894-04760	894-04764
75	All 75 HP Motors are to be SIEMENS TEFC					

Siemens/WEG TEFC Motor Part Numbers for 30 PPM and Less								
	200V		208/230/380/450V 380 Only For 50 HZ		600V		220V	
Motor HP	2 Pole w/1.15 SF 3 PH 60 HZ		2 Pole w/ 1.15 SF 3 PH 60 HZ		2 Pole w/ 1.15 SF 3 PH 60 HZ		2 Pole w/ 1.15 SF 3 PH 50 HZ	
	Siemens	WEG	Siemens	WEG	Siemens	WEG	Siemens	WEG
15	894-04036	894-04998	894-04045	894-04712	894-04054	894-04720	894-04063	894-05012
20	894-04037	894-04999	894-04046	894-04713	894-04055	894-05007	894-04064	894-05013
25	894-04038	894-05000	894-04047	894-04714	894-04056	894-04721	894-04065	894-04724
30	894-04039	894-05001	894-04048	894-04715	894-04057	894-04722	894-04066	894-05014
40	894-04040	894-05002	894-04049	894-04716	894-04058	894-04723	894-04067	894-05015
50	894-04041	894-05003	894-04050	894-04717	894-04059	894-05008	894-04068	894-05016
60	894-04042	894-05004	894-04051	894-04718	894-04060	894-05009	894-04069	894-05017
75	894-04043	894-05005	894-04052	894-04719	894-04061	894-05010	894-04070	894-05018

9.2.3 — Blower Gasket Components

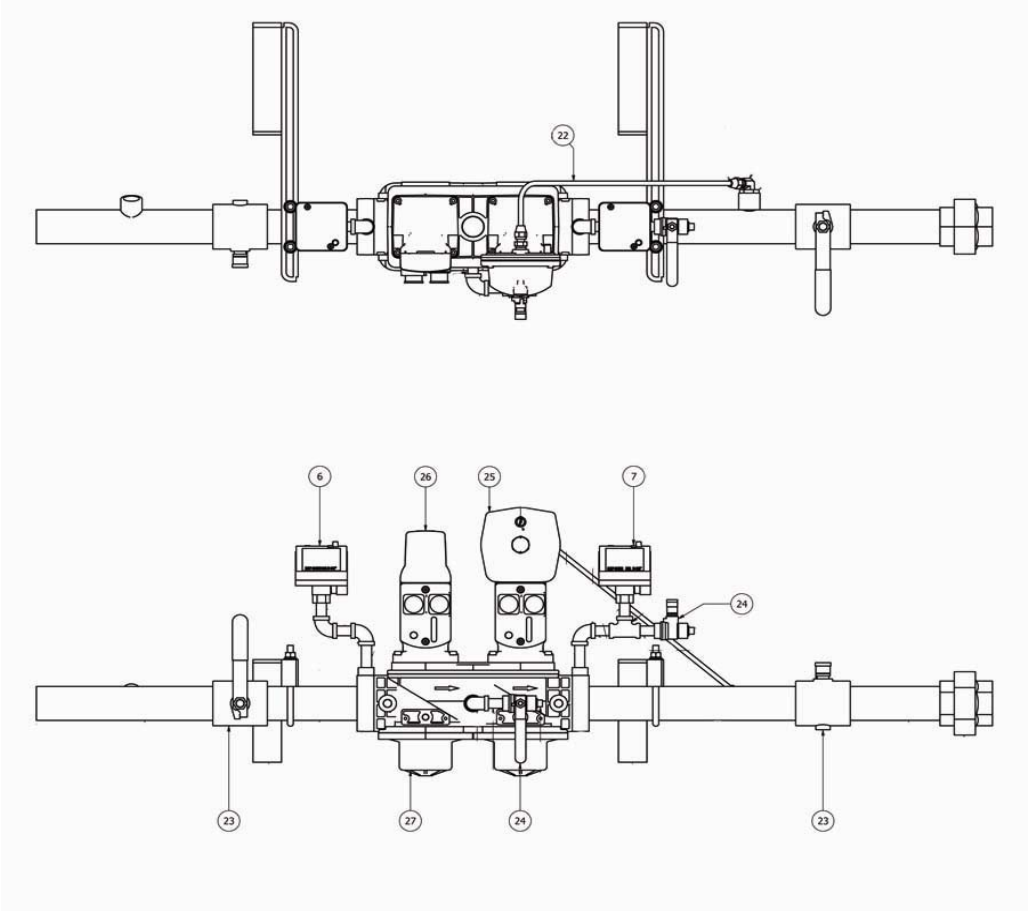
NOTE: THESE COMPONENTS NOT INCLUDED W/ 880–FIRESIDE GASKET KITS. IF REQUIRED, ORDER SEPARATELY.



FRONT HEAD
(UPPER SECTION VIEW)

	55" DIA.	60" DIA. 67" DIA.	78" DIA.	85" DIA. 92" DIA.		
ITEM	PART No.	PART No.	PART No.	PART No.	QTY	DESCRIPTION
A	032–03177–000	032–02542–000	032–02543–000	032–02543–000	1	GASKET, AIR DUCT
B	065–08410–000	065–00810–000	065–00811–000	065–00811–000	8	RETAINER, AIR DUCT GASKET
C	841–01545–000	841–01545–000	841–01545–000	841–01545–000	24	FASTENER, HEX. HEAD, SELF DRILLING
D	032–03176–000	032–02535–000	032–02532–000	032–02524–000	1	GASKET, BLOWER CASSETTE

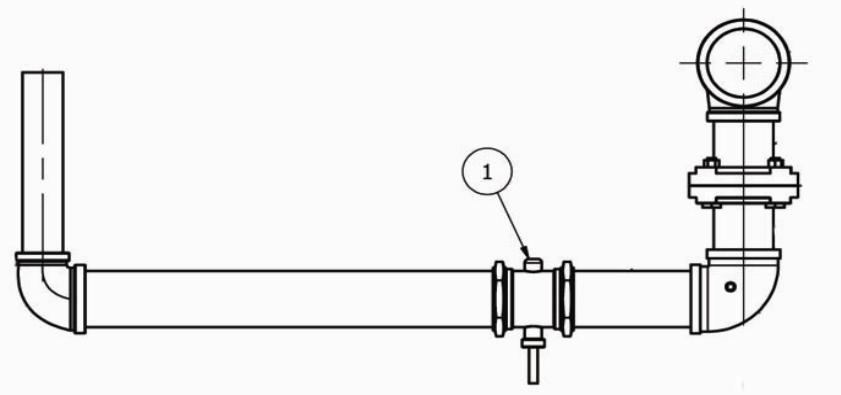
9.3 — Main Gas Train



Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
6	1	LGPS	817-02416	817-02416	817-02418	817-02418	*	817-03591
7	1	HGPS	817-02420	817-02420	817-02417	817-02417	817-02423	817-02423
22	1	Alum. Tubing	939-00642	939-00642	939-00642	939-00642	939-00642	939-00642
23	2	Butterball Valve	941-01946	941-01946	941-01947	941-01947	*	*
24	2	Ball Valve	*	941-02640	941-02640	*	*	*
25	1	Actuator w/POC	945-00234	945-00234	945-00234	945-00234	945-00234	945-00234
26	1	Actuator w/o POC	X	945-00238	945-00238	945-00238	945-00238	945-00238
27	1	Gas Valve Body	949-00461	949-00447	949-00448	949-00448	949-00445	949-00446

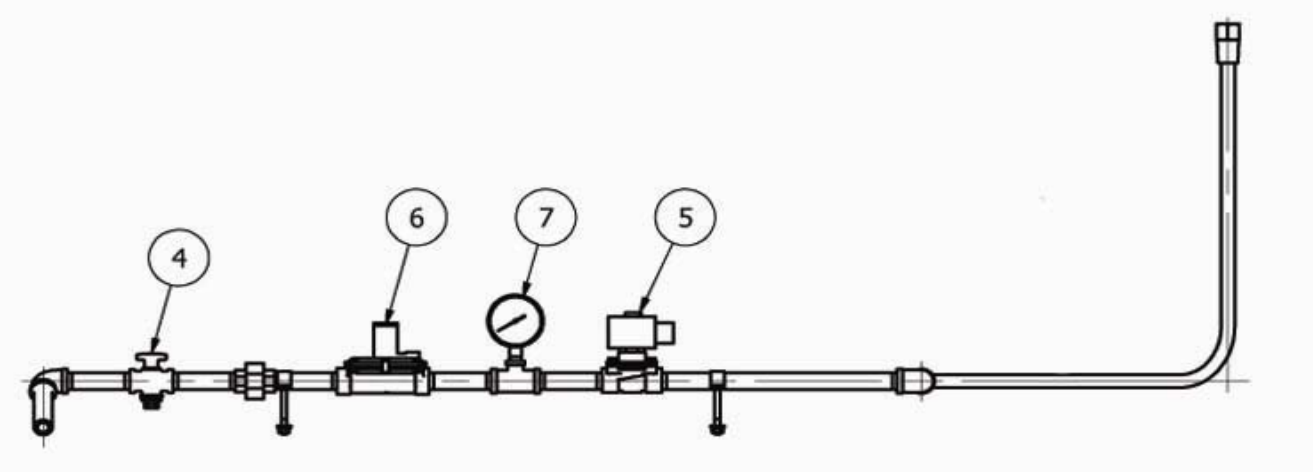
Item	Qty	Description	55" Part #	78" Part #	85"500HP Part #	85" 600HP Part #	92" Part #
6	1	LGPS			817-02418	817-03591	
23	2	LUB Plug Valve			941-00129	941-00130	941-00130
24	1	Ball Valve	941-02640	941-02640	941-02640	941-02640	941-02640

9.4 — Starter Gas Train



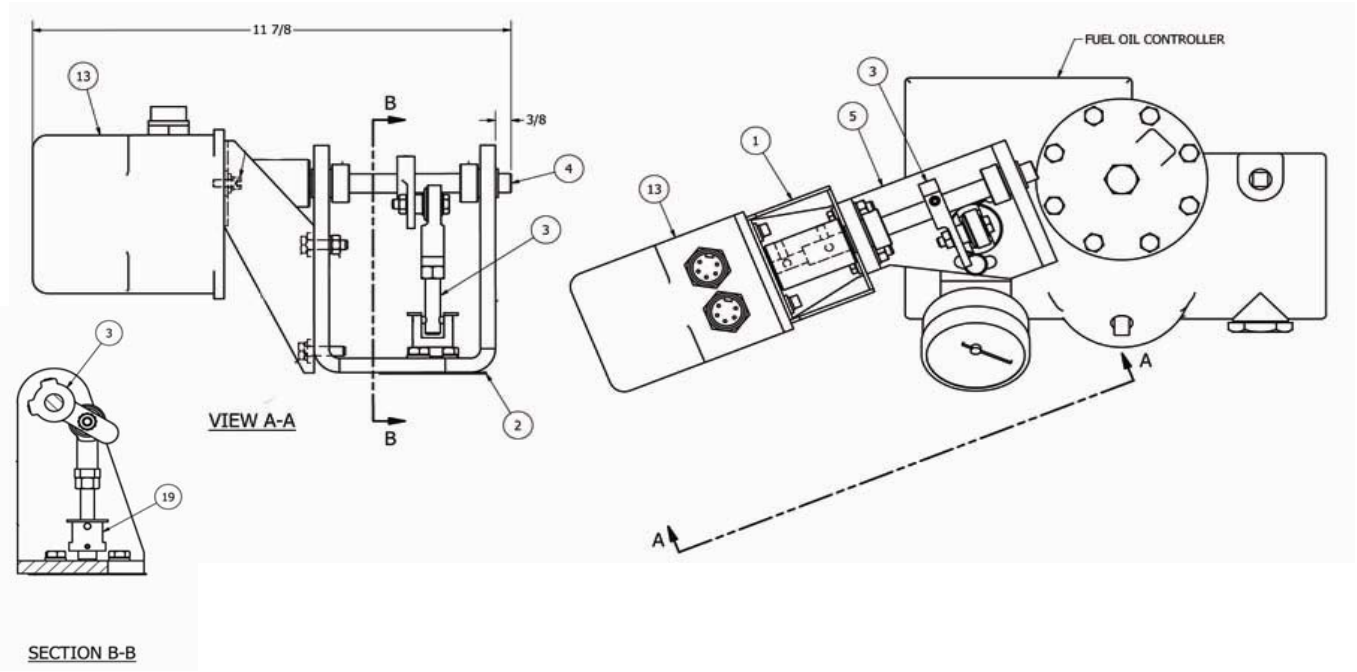
Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Butterfly Valve	940-00133	940-00133	940-00134	940-00134	940-00134	940-00134

9.5 — Pilot Gas Train



Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
4	1	Gas Cock	825-00030	825-00030	825-00030	825-00030	825-00030	825-00030
5	1	Solenoid Valve	948-00197	948-00197	948-00197	948-00197	948-00197	948-00197
6	1	Regulator	918-00356	918-00356	918-00356	918-00356	918-00356	918-00356
7	1	Pressure Gauge	850-00109	850-00109	850-00109	850-00109	850-00109	850-00109

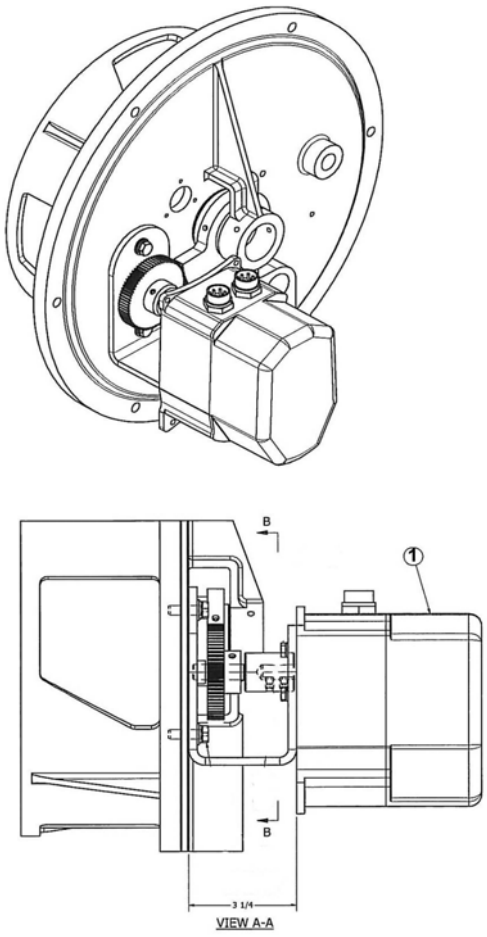
9.6 — Actuator Assembly, Fuel Oil



Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Actuator Bracket	008-03521	008-03521	008-03521	008-03521	008-03521	008-03521
2	1	Gasket	032-01295	032-01295	032-01295	032-01295	032-01295	032-01295
3	1	Linkage	067-00880	067-00880	067-00880	067-00880	067-00880	067-00880
4	1	Jackshaft	074-00529	074-00529	074-00529	074-00529	074-00529	074-00529
13	1	Actuator, Servo Motor	945-00259	945-00259	945-00259	945-00259	945-00259	945-00259
19	1	Oil Valve Stem	SEE CHART	SEE CHART	SEE CHART	SEE CHART	SEE CHART	SEE CHART

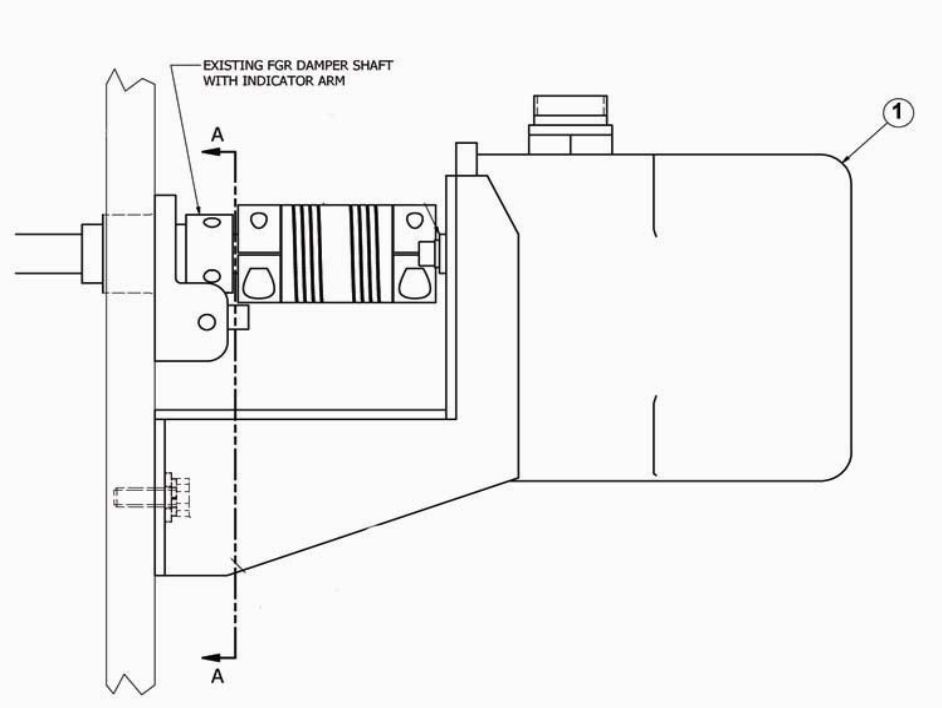
Oil Stem Chart			
Boiler Size	**Stem Number**	**Boiler Size**	**Stem Number**
100 HP	024-00095	500-700 HP	024-00100
125, 150 HP	024-00096	800 HP	024-00101
200 HP	024-00097		
250-350 HP	024-00098		
400 HP	024-00099		

9.7 — Actuator Assembly, Air Damper



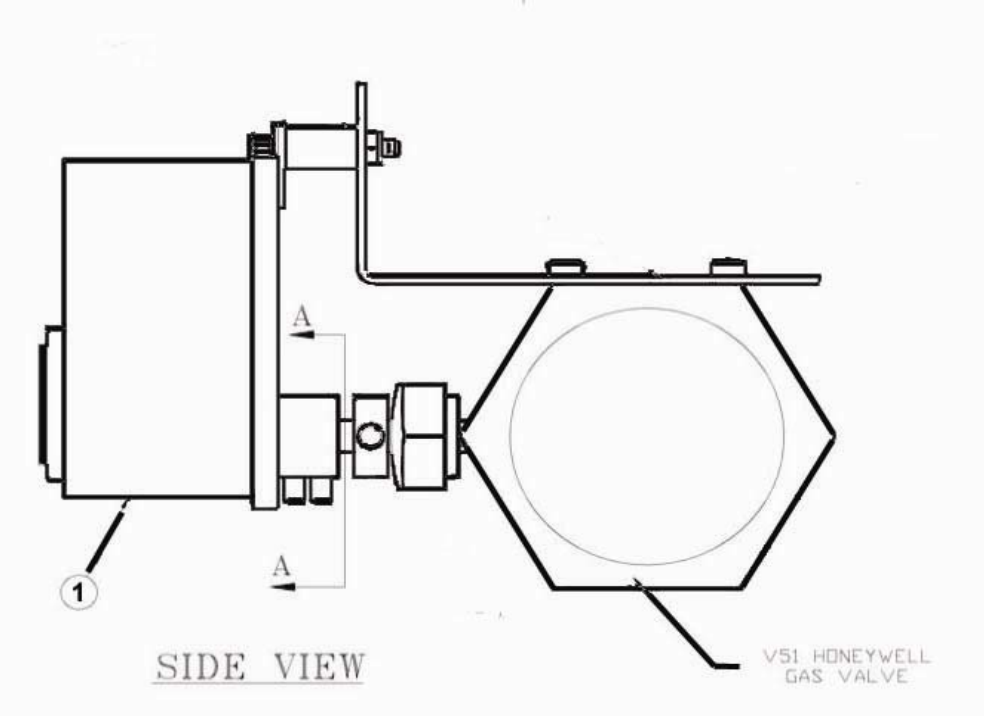
Item	Qty	Description	55” Part #	60” Part #	67” Part #	78” Part #	85” Part #	92” Part #
1	1	Actuator, Servo Motor	945-00260	945-00260	945-00260	945-00260	945-00260	945-00260

9.8 — Actuator Assembly, IFGR Valve



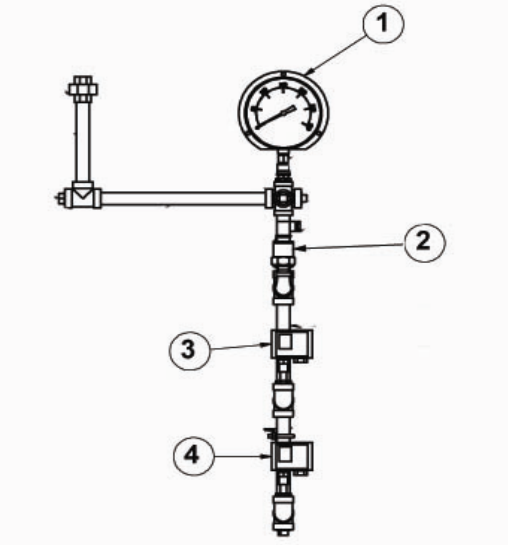
Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Actuator, Servo Motor	945-00259	945-00259	945-00259	945-00259	945-00259	945-00259

9.9 — Actuator Assembly, Gas Butterfly Valve



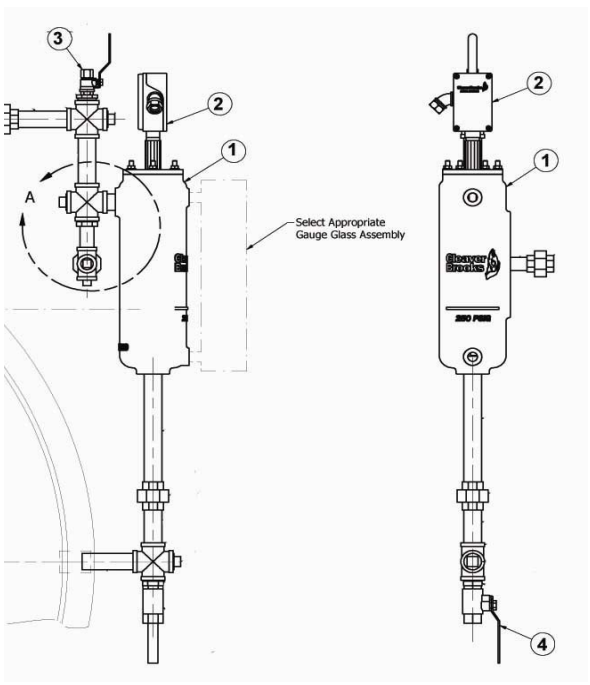
Item	Qty	Description	55" Part #	60" Part #	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Actuator, Universal Parallel Positioning	945-229	945-229	945-229	945-229	945-229	945-229

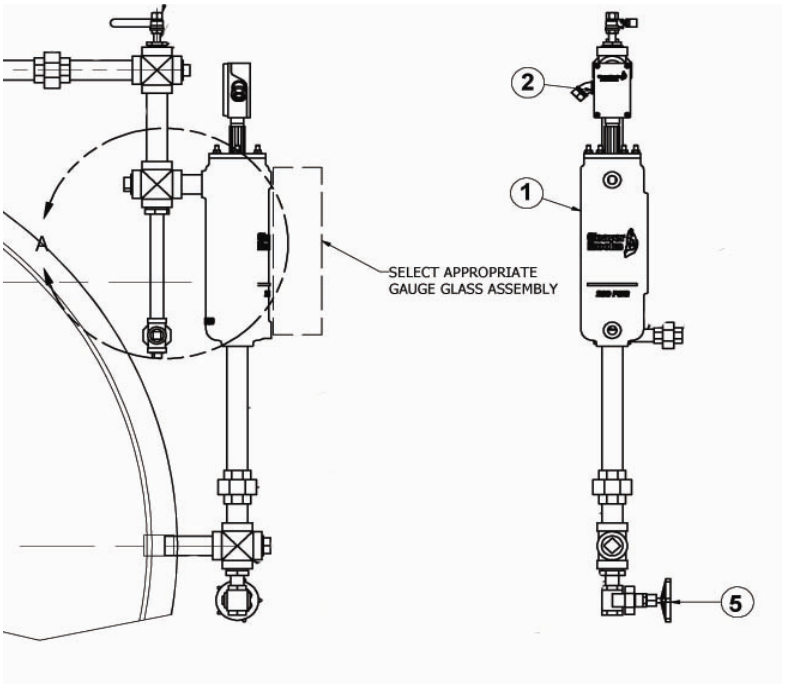
9.10 — Water Column Controls



Item	Qty	Description	Boiler Size	150 PSI Part #	200 PSI Part #	250 PSI Part #	300 PSI Part #
1	1	Pressure Gauge	55”	850-00222	850-00222	850-00320	850-00400
1	1	Pressure Gauge	60”	850-00222	850-00222	850-00320	850-00400
1	1	Pressure Gauge	67”	850-00222	850-00222	850-00320	850-00400
1	1	Pressure Gauge	78”	850-00222	850-00222	850-00320	850-00400
1	1	Pressure Gauge	85”	850-00222	850-00222	850-00320	850-00400
1	1	Pressure Gauge	92”	850-00222	850-00222	850-00320	850-00400
2	1	Transmitter Control	55”	817-04867	817-04868	817-04868	817-04868
2	1	Transmitter Control	60”	817-04867	817-04868	817-04868	817-04868
2	1	Transmitter Control	67”	817-04867	817-04868	817-04868	817-04868
2	1	Transmitter Control	78”	817-04867	817-04868	817-04868	817-04868
2	1	Transmitter Control	85”	817-04867	817-04868	817-04868	817-04868
2	1	Transmitter Control	92”	817-04867	817-04868	817-04868	817-04868
3	1	Pressure Control, OP, Limit	55”	817-04093	817-04883	817-04147	817-04091
3	1	Pressure Control, OP, Limit	60”	817-04093	817-04883	817-04147	817-04091
3	1	Pressure Control, OP, Limit	67”	817-04093	817-04883	817-04147	817-04091
3	1	Pressure Control, OP, Limit	78”	817-04093	817-04883	817-04147	817-04091
3	1	Pressure Control, OP, Limit	85”	817-04093	817-04883	817-04147	817-04091
3	1	Pressure Control, OP, Limit	92”	817-04093	817-04883	817-04147	817-04091
4	1	High Limit Pressure Control	55”	817-04092	817-04148	817-04149	817-04073
4	1	High Limit Pressure Control	60”	817-04092	817-04148	817-04149	817-04073
4	1	High Limit Pressure Control	67”	817-04092	817-04148	817-04149	817-04073
4	1	High Limit Pressure Control	78”	817-04092	817-04148	817-04149	817-04073
4	1	High Limit Pressure Control	85”	817-04092	817-04148	817-04149	817-04073
4	1	High Limit Pressure Control	92”	817-04092	817-04148	817-04149	817-04073

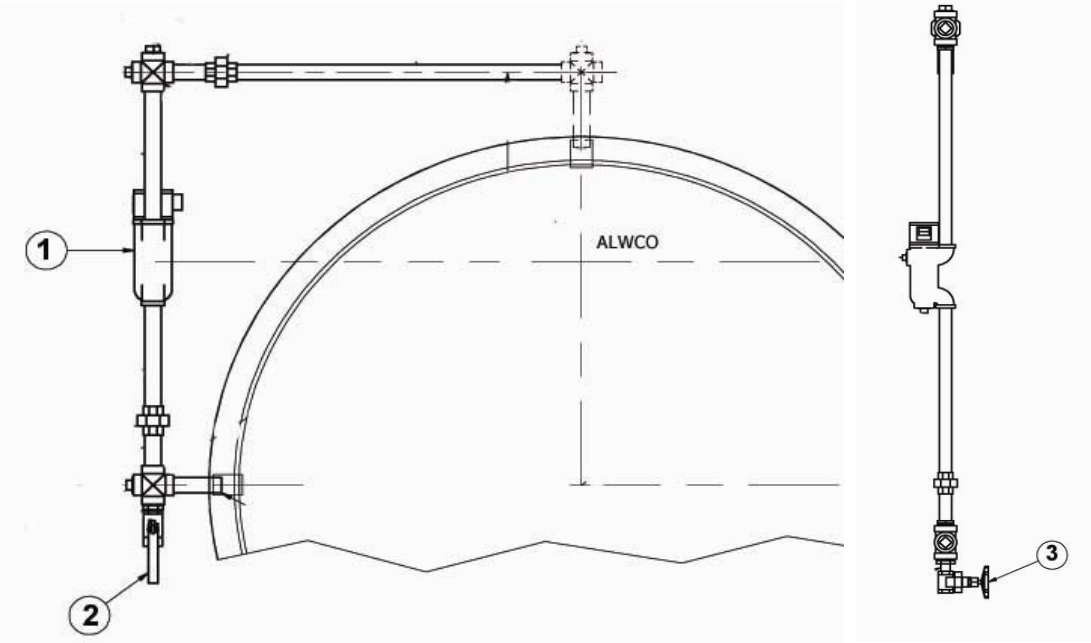
9.11 — Water Column, LWCO





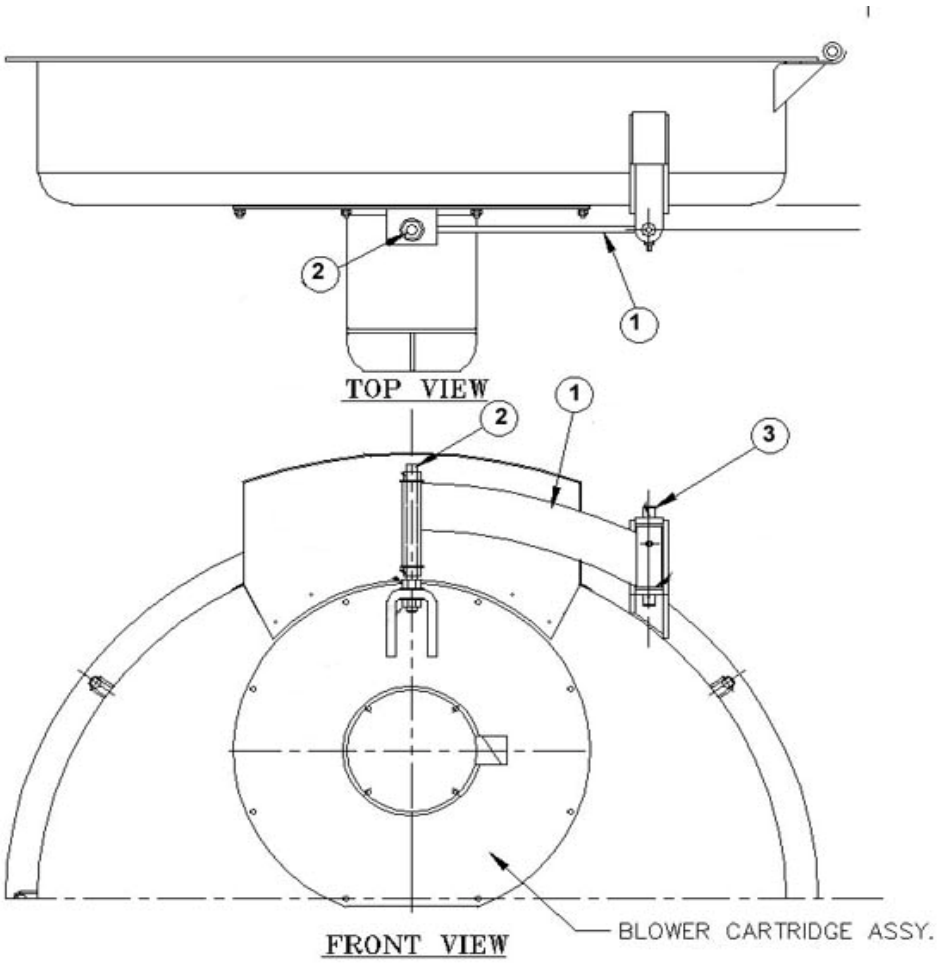
	Item	Qty	Description	Boiler HP	150 PSI Part #	200 PSI Part #	250 PSI Part #
Level Master II w/o Tri-Cocks	1	1	Water Column, Level Master	100-200	289-00991	289-00991	289-00991
	2	1	Sensor Assembly, Level Master	100-200	623-00230	623-00230	623-00230
	3	1	Ball Valve	100-200	941-00055	941-00055	941-00055
	4	1	Ball Valve	100-200	941-01790	941-01790	X
	5	1	Gate Valve	100-200	X	X	941-00170
	1	1	Water Column, Level Master	250-800	289-00830	289-00830	289-00830
	2	1	Sensor Assembly, Level Master	250-800	623-00230	623-00230	623-00230
	3	1	Ball Valve	250-800	941-00055	941-00055	941-00055
	4	1	Ball Valve	250-800	941-01790	X	X
	5	1	Gate Valve	250-800	X	941-00170	941-00170
Level Master II w/ Tri-Cocks	1	1	Water Column, Level Master	100-200	289-00993	289-00993	289-00993
	2	1	Sensor Assembly, Level Master	100-200	623-00230	623-00230	623-00230
	3	1	Ball Valve	100-200	941-00055	941-00055	941-02656
	4	1	Ball Valve	100-200	941-01790	941-01790	X
	5	1	Gate Valve	100-200	X	X	941-00170
	1	1	Water Column, Level Master	250-800	289-00831	289-00831	289-00831
	2	1	Sensor Assembly, Level Master	250-800	623-00230	623-00230	623-00230
	3	1	Ball Valve	250-800	941-00055	941-02656	941-02656
	4	1	Ball Valve	250-800	941-01790	X	X
	5	1	Gate Valve	250-800	X	941-00170	941-00170

9.12 — Auxiliary Low Water Cutoff



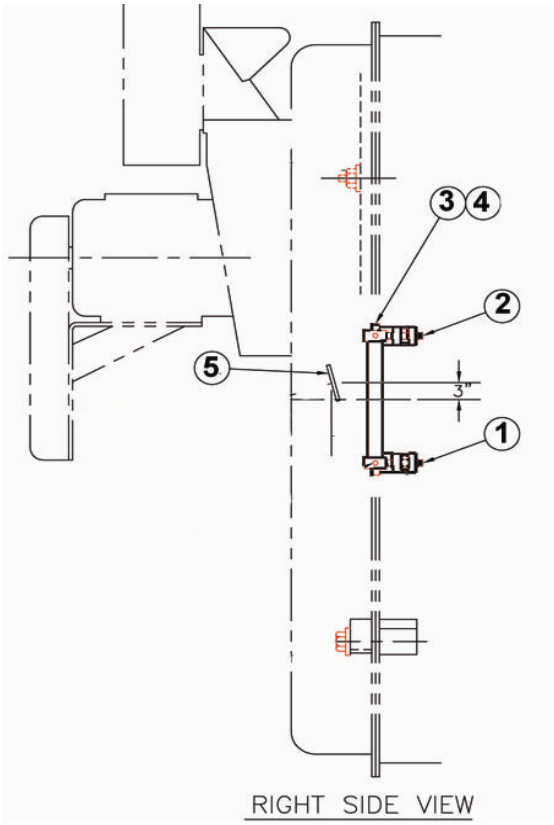
	Item	Qty	Description	Boiler HP	150 PSI Part #	200 PSI Part #	250 PSI Part #
Warrick C2	1	1	ALWCO Coontrol	100-800	817-02372	817-02372	817-02372
	2	1	Ball Valve	100-400	941-01790	941-01790	X
	2	1	Ball Valve	500-600	941-01657	941-01790	X
	2	1	Ball Valve	700-800	941-01657	941-01790	X
	3	1	Gate Valve	100-800	X	X	941-00170
Warrick 3K-3	1	1	ALWCO Control	100-800	817-02259	817-02259	817-02259
	2	1	Ball Valve	100-800	941-01790	941-01790	X
	3	1	Gate Valve	100-800	X	X	941-00170
McD-M 150S-B-M	1	1	ALWCO Control	100-800	817-2407	N/A	N/A
	3	1	Gate Valve	100-800	941-00170	N/A	N/A
McD-M 93-M	1	1	ALWCO Control	100-800	817-00435	N/A	N/A
	3	1	Gate Valve	100-800	941-00170	N/A	N/A
McD-M 94-M	1	1	ALWCO	100-800	N/A	817-00306	817-00306
	3	1	Gate Valve	100-800	N/A	941-00170	941-00170

9.13 — Blower Davit: 55” & 60”



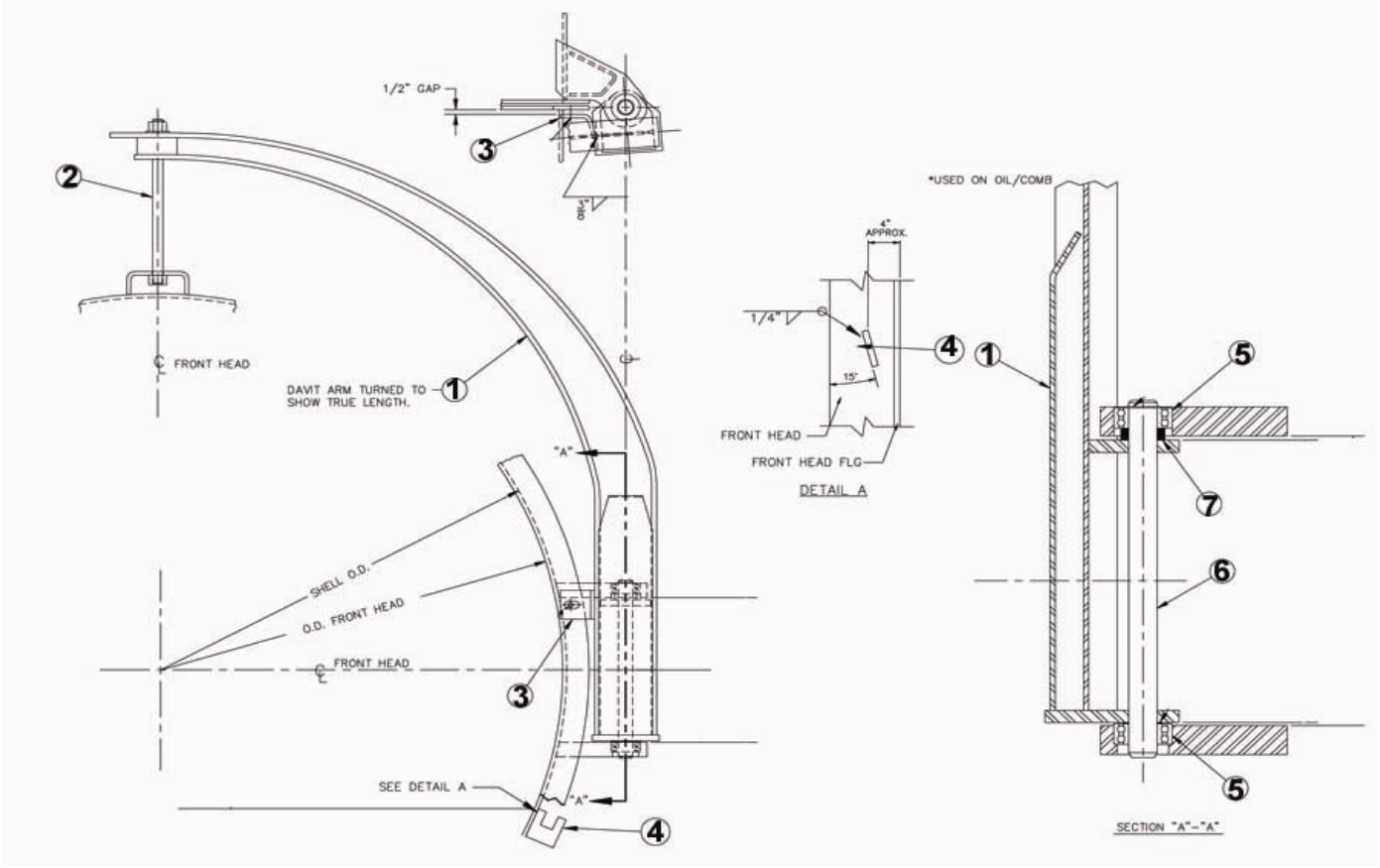
Item	Qty	Description	55” Part #	60” Part #
1	1	Davit Arm Assembly	287-00052	287-00052
2	1	Threaded Rod	841-01047	841-01047
3	1	Davit Pin	056-00043	056-00043

9.14 — Front Head Hinge: 55” & 60”



Item	Qty	Description	55” Part #	60” Part #
1	1	Eyebolt, Door Hinge (Lower)	007-00061	007-00061
2	1	Eyebolt, Door Hinge (Upper)	007-00058	007-00058
3	1	Retaining Ring	914-00147	914-00147
4	1	Hinge Pin	056-00002	056-00002
5	1	Oil Gun Bracket	008-03328	008-03328

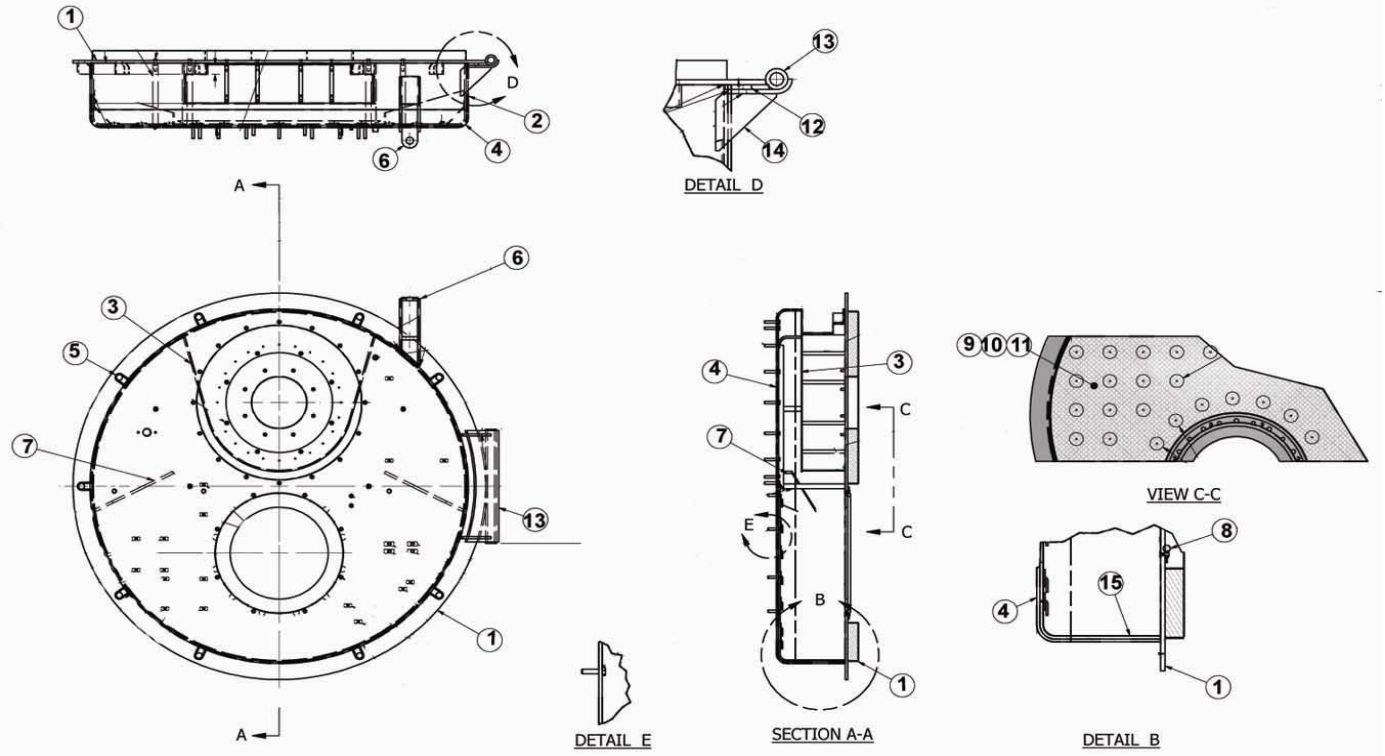
9.15 — Front Davit Assembly



Item	Qty	Description	67" Part #	78" Part #	85" Part #	92" Part #
1	1	Davit Arm (right hand)	287-00088	287-00048	287-00082	287-00110
2	1	Stud	841-01594	841-01594	841-01585	841-01585
3	1	Restraint Tab	011-00115	011-00115	011-00115	011-00115
4	1	Oil Gun Mounting Bracket	008-03326	008-03328	008-03328	008-03328
5	2	Double Row Ball Bearing	807-00031	807-00031	807-00324	807-00324
6	1	Front Hinge Pin	056-00026	056-00026	056-00027	056-00027

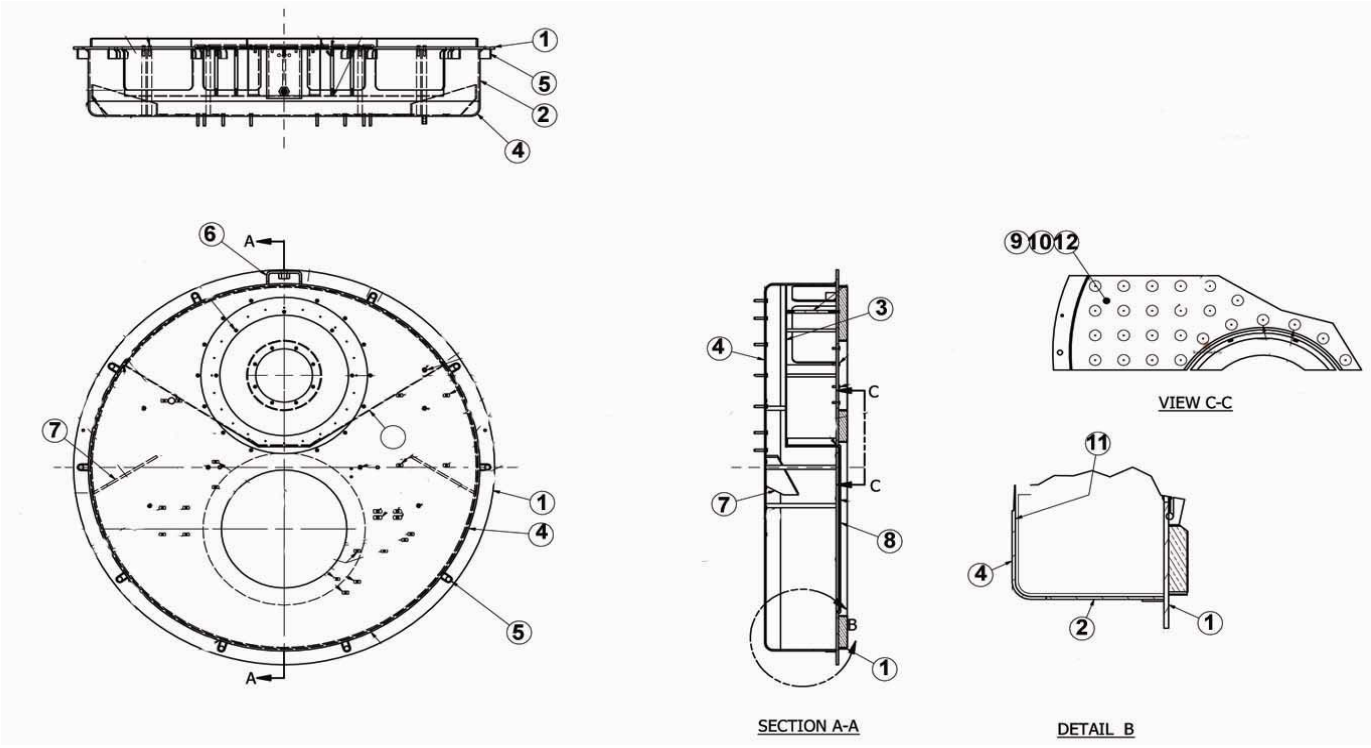
9.16 — Front Head Assembly

9.16.1 — 55” & 60”



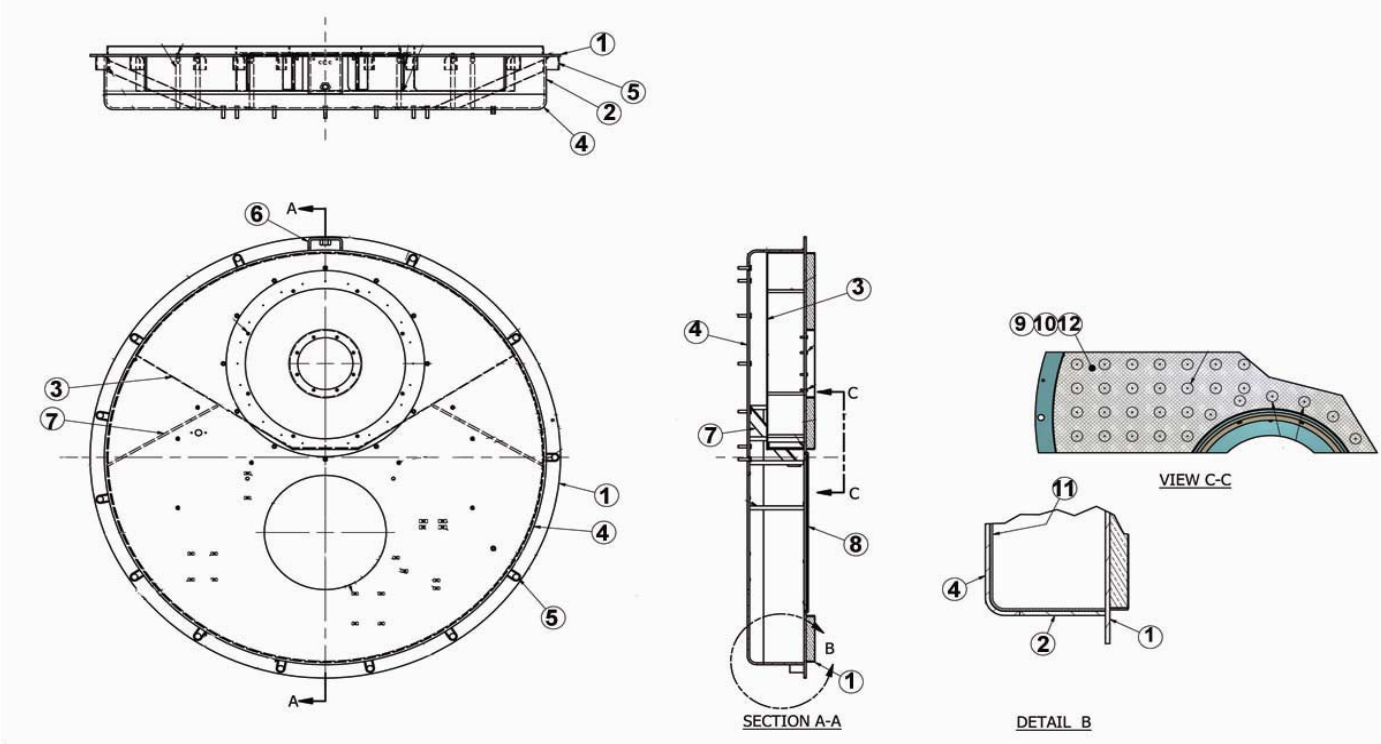
Item	Qty	Description	55” Part #	60” Part #
1	1	Inner Door Plate Assembly	132-02731	132-02702
2	1	Bulk Plate	972-00002	972-00002
3	1	Blower Inlet Windbox	039-01740	039-01736
4	1	Front Head	132-02730	132-02704
5	9	Lug	103-00097	103-00097
6	1	Blower Pedestal Assembly	085-04050	085-03140
7	2	Front Head Support	085-01542	085-01542
8	1	Housing to Head Gasket	032-03175	032-03171
9	1	Blanket Insulation	872-01084	872-01084
10	1	Screen	930-00135	930-00135
11	150oz	Coating Cement Rigidizer	872-00443	872-00443
12	1	Plate	077-02126	077-02126
13	1	Front Door Hinge	462-00183	462-00183
14	2	Gusset	059-09727	059-00805
15	1	Front Head Interior Insulation	465-02731	465-01675

9.16.2 — 67”



Item	Qty	Description	67” Part #
1	1	Inner Door Plate Assembly	132-02701
2	1	Front Head Ring	080-00951
3	1	Air Duct Assembly	039-01733
4	1	Front Head	132-02700
5	10	Lug	103-00097
6	1	Davit Support	085-03301
7	2	Front Head Support	085-01542
8	1	Head Plate Gasket	032-02619
9	1	Blanket Insulation	872-01084
10	1	Screen	930-00135
11	1	Interior Insulation	465-02484
12	180oz	Coating Cement Rigidizer	872-00443

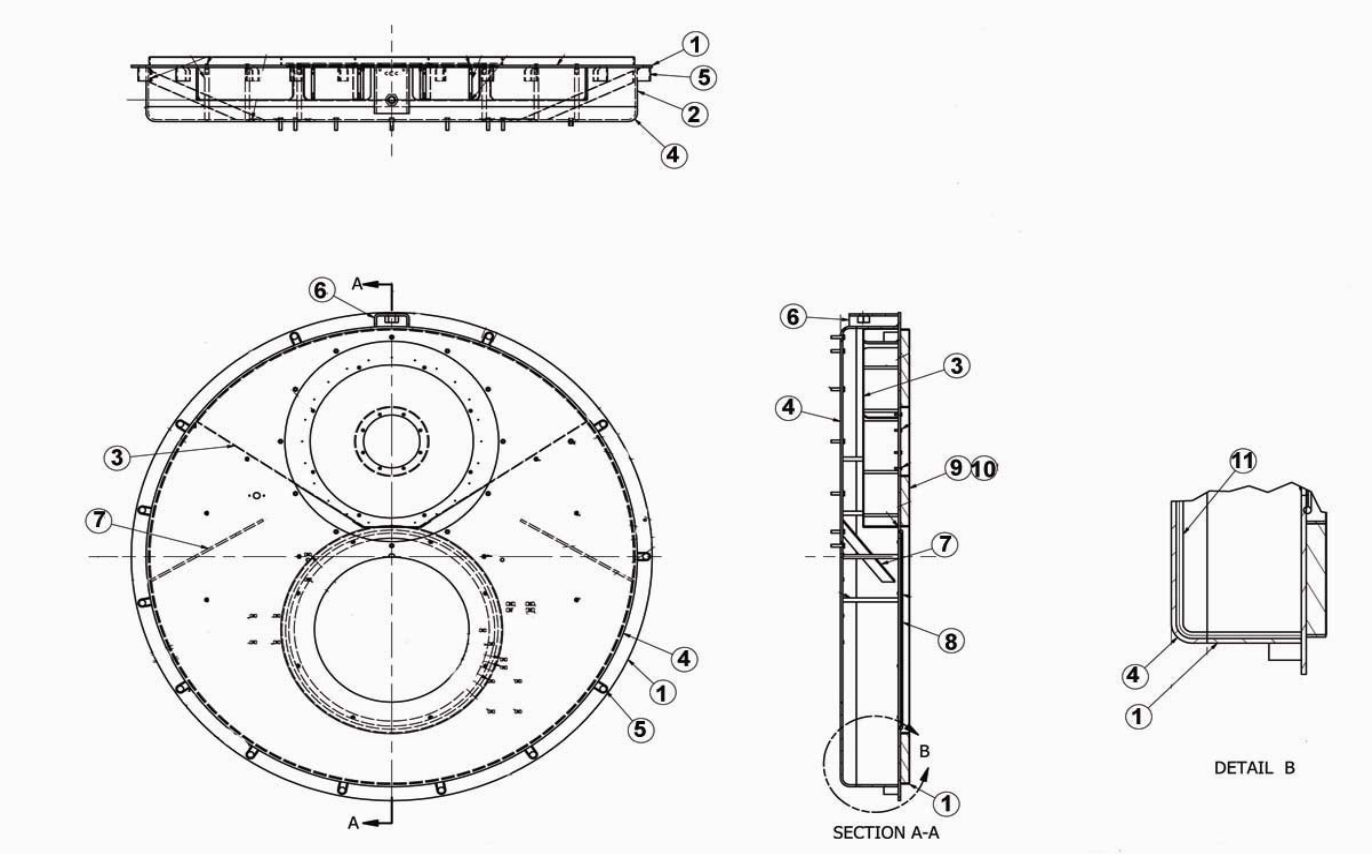
9.16.3 — 78”



Item	Qty	Description	78” Part #
1	1	Inner Door Plate Assembly	See Table
2	1	Front Head Ring	080-01460
3	1	Air Duct Assembly	039-01730
4	1	Front Head	132-02684
5	13	Lug	103-00107
6	1	Davit Support	085-03125
7	2	Flat Bar	971-00078
8	1	Head Plate Gasket	032-00898
9	1	Blanket Insulation	872-01084
10	1	Screen	930-00135
11	1	Interior Insulation	See Table
12	180oz	Coating Cement Rigidizer	872-00443

Assembly No.	IFGR Plate	Item #1	Item #11
132-02683 (RH)	30 ppm	132-02682	465-01680
132-02740 (RH)	60 ppm	132-02682	N/A

9.16.4 — 85” & 92”

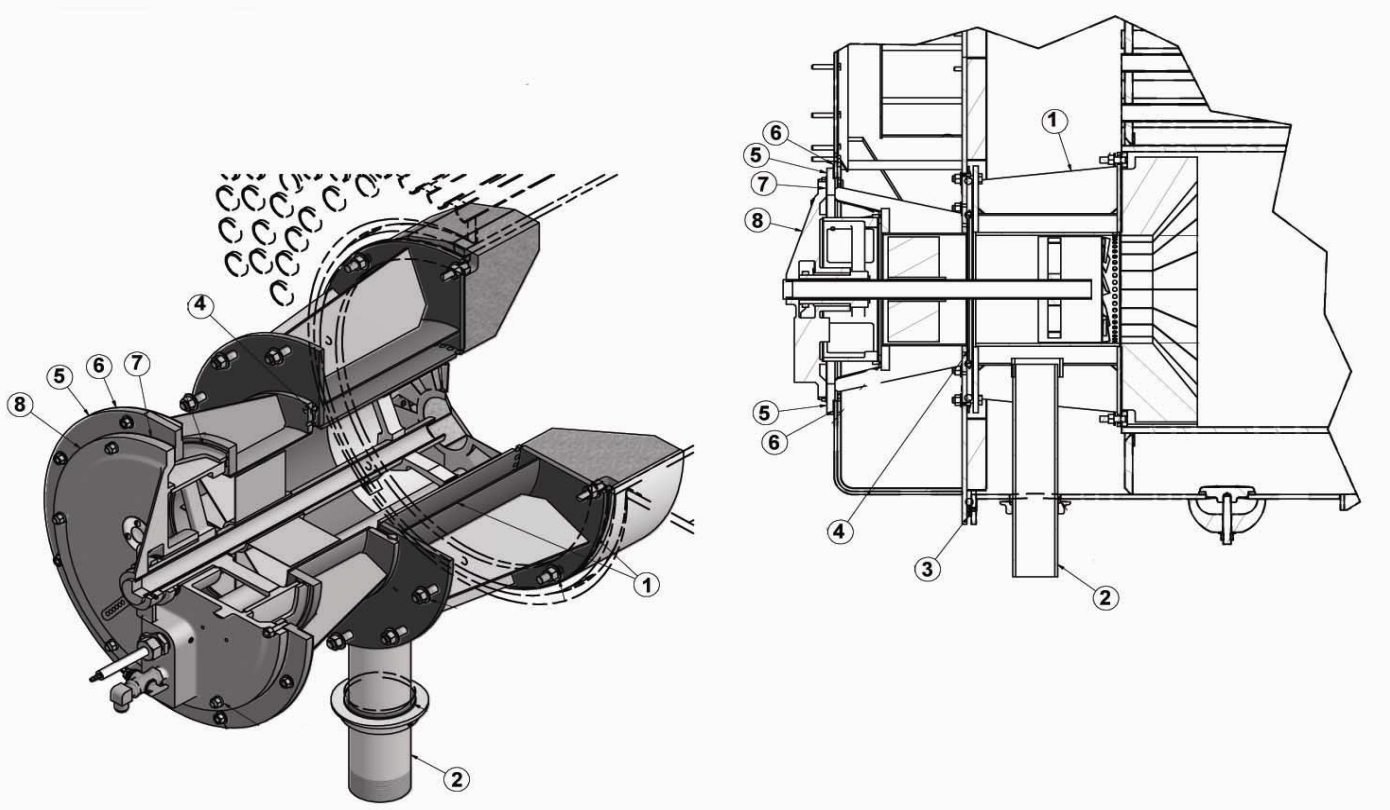


Item	Qty	Description	85” Part #	92” Part #
1	1	Inner Door Plate Assembly	See Table	See Table
2	1	Front Head Ring	080-00935	080-01330
3	1	Air Duct Assembly	039-01727	039-01732
4	1	Front Head	132-02677	132-02696
5	13	Lug	103-00107	103-00107
6	1	Davit Support	085-03119	085-03119
7	2	Flat Bar	971-00078	971-00078
8	1	Head Plate Gasket	032-00993	032-00993
9	1	Blanket Insulation	872-01084	872-01084
10	1	Screen	930-00135	930-00135
11	1	Interior Insulation	See Table	See Table

Assembly No.	IFGR Plate	Item #1	Item #11
85” 132-02675 (RH)	30 ppm	132-02674	465-02366
85” 132-02736 (RH)	60 ppm	132-02674	N/A
92” 132-02694 (RH)	30 ppm	132-02695	465-02655
92” 132-02744 (RH)	60 ppm	132-02695	N/A

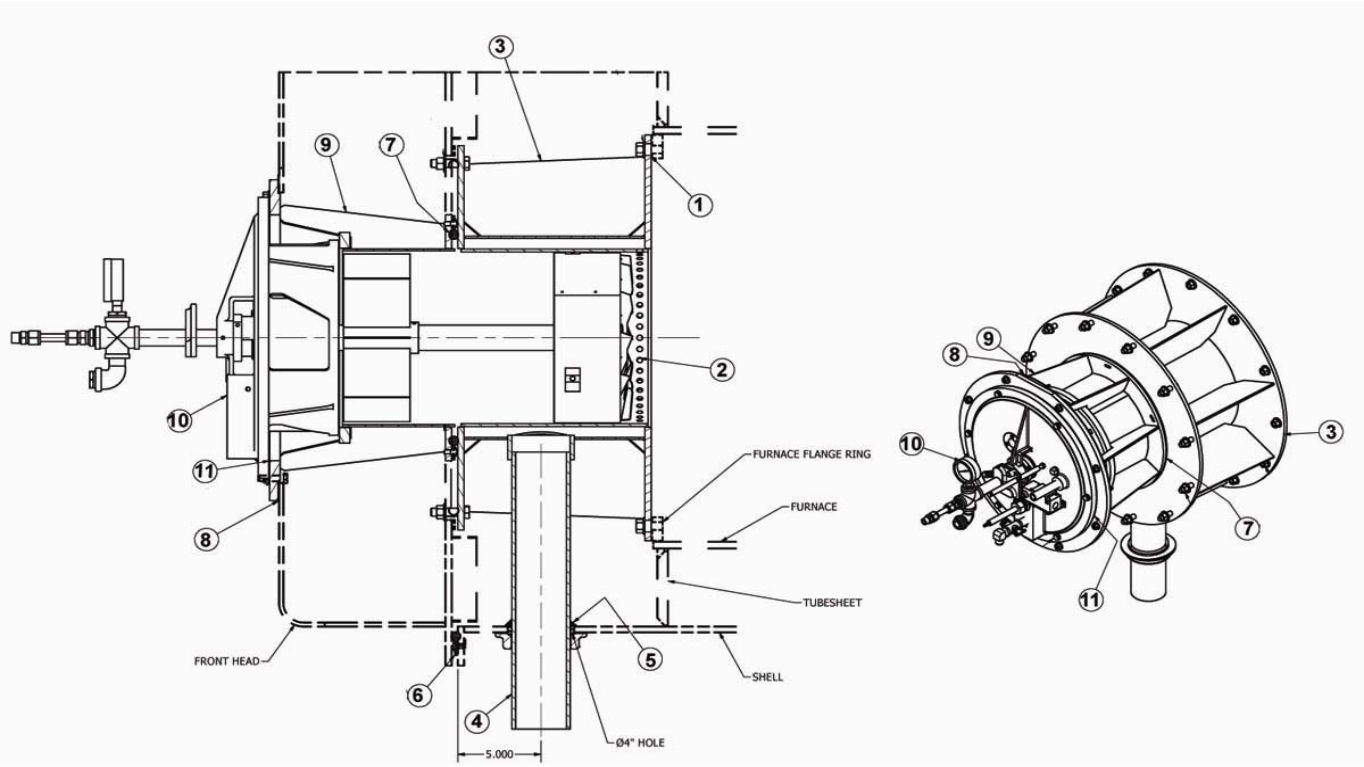
9.17 — Burner Installation

9.17.1 — 55”



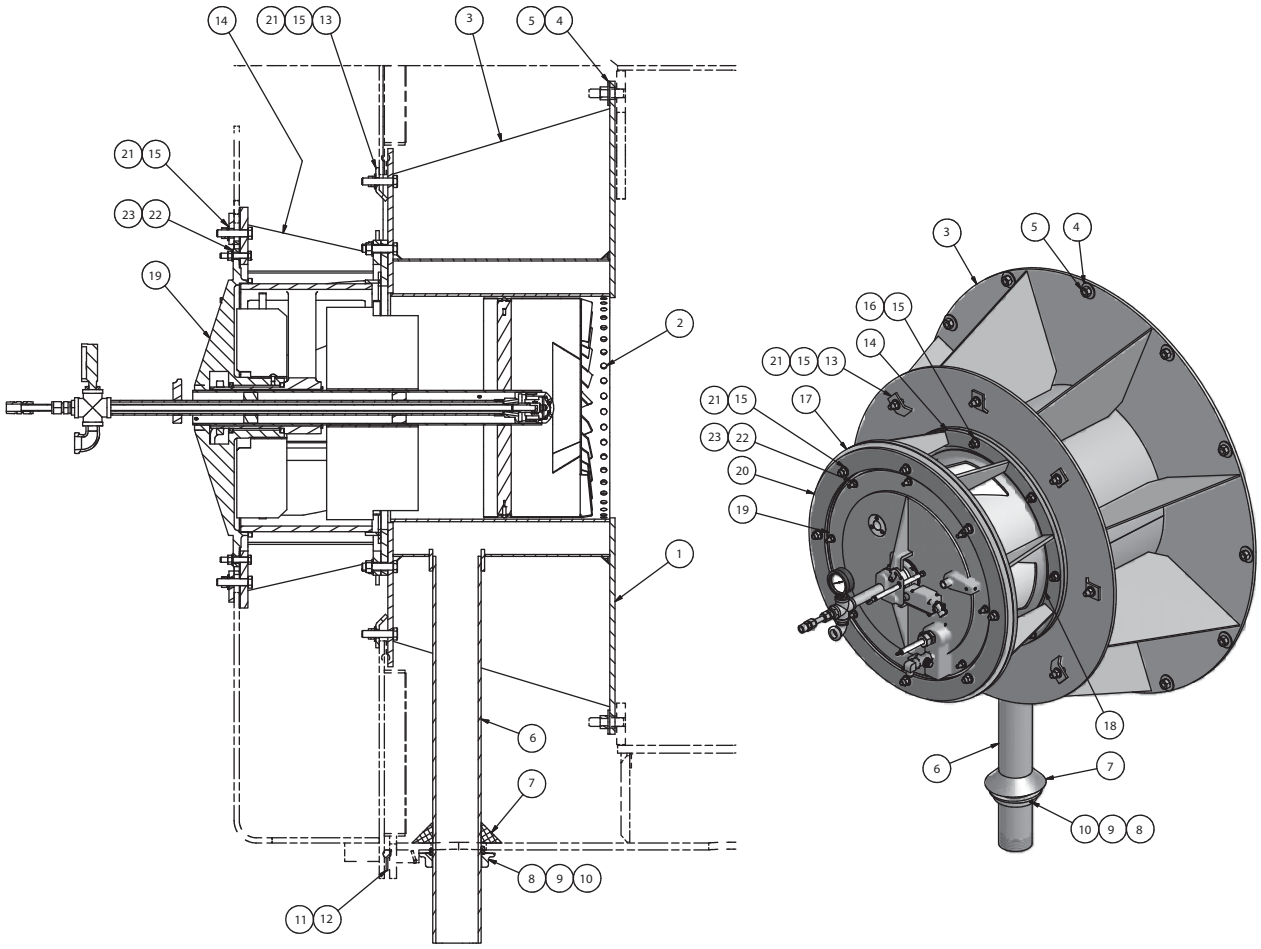
Item	Qty	Description	55” 101-200 Fuel Part #	55” 700 Fuel Part #
1	1	Burner Housing	040-00878	040-00878
2	1	Sized Pipe	057-05027	057-05027
3	1	Front Head Gasket	032-03173	032-03173
4	1	Support to Housing Gasket	032-03174	032-03174
5	1	Burner Support Housing	040-00879	040-00879
6	1	Housing to Front Head Gasket	032-00603	032-00603
7	1	Burner to Housing Gasket	032-00605	032-00605
8	1	Burner Drawer	429-01702	429-01703

9.17.2 — 60”, 67”, 78”



Item	Qty	Description	60” Part #	67” Part #	78” Part #
1	1	Burner Housing to Furnace	656-07965	656-07965	656-07965
2	1	Spud Kit and Pattern	146-00334	146-00334	146-00334
3	1	Burner Housing	040-00853	040-00719	040-00831
4	1	Sized Pipe	057-05027	057-05032	057-05261
5	8oz	High Temp Thermo Cement	872-00558	872-00558	872-00558
6	1	Front Head Gasket	032-00105	032-02602	032-00899
7	1	Burner Support to Housing Gasket	032-03170	032-00928	032-00928
8	1	Housing to Front Head Gasket	032-00603	032-02625	032-02625
9	1	Burner Support	085-03463	085-00444	085-00444
10	1	Burner Drawer	429-01668	429-01537	429-01477
11	1	Burner to Housing Gasket	032-00605	X	X

9.17.3 — 85”, 92”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9.17.3 continued

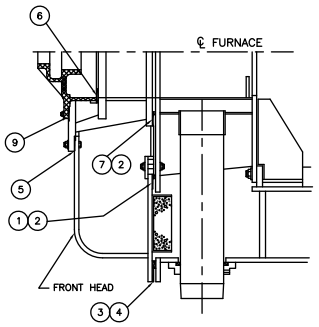
ITEM	QTY	PART NO.		DESCRIPTION
		500-600 HP	700-800 HP	
1	1	656-07965-000		INSTALLATION, BURNER HOUSING TO FURNACE
2	1	146-00334-000		SPUD KIT PATTERN
3	1	SEE TABLE		BURNER HOUSING, GAS/OIL
4	12	952-00287-000		WASHER
5	12	869-00002-000		NUT, HEX
6	1	057-04190-000	057-08618-000	SIZED PIPE
7	8 oz	872-00558-000		THERMO CEMENT
8	1	853-00348-000		BULK PACKING
9	1	065-00704-000		RETAINER
10	3	860-00015-000		SET SCREW
11	1	032-02598-000	032-03169-000	GASKET, FRONT HEAD
12	33	841-00507-000		FASTENER
13	8	296-00019-000		CLAMP
14	1	040-00594-000		HOUSING, BURNER SUPPORT
15	24	952-00108-000		WASHER
16	8	869-00029-000		NUT, HEX
17	1	032-02531-000		GASKET, BURNER SUPPORT/DRAWER TO FRONT HEAD
18	1	853-01017-000		SILICONE TAPE
19	1	SEE TABLE		BURNER DRAWER
20	1	015-00041-000		CLAMP RING
21	16	869-00015-000		NUT, HEX
22	8	952-00106-000		WASHER
23	8	869-00030-000		NUT, HEX

BURNER DRAWER TABLE		
USAGE	ITEM 19 P/N	ITEM 3 P/N
500 HP 30-60 PPM 100 FUEL		040-00884-000
500 HP 30-60 PPM 101 FUEL		040-00884-000
500 HP 30-60 PPM 200 FUEL	429-01715-000	040-00816-000
500 HP 30-60 PPM 700 FUEL		040-00816-000
600 HP 30-60 PPM 100 FUEL		040-00884-000
600 HP 30-60 PPM 101 FUEL		040-00884-000
600 HP 30-60 PPM 200 FUEL	429-01716-000	040-00816-000
600 HP 30-60 PPM 700 FUEL		040-00816-000
700 HP 30-60 PPM 100 FUEL		
700 HP 30-60 PPM 101 FUEL		
700 HP 30-60 PPM 200 FUEL	429-01723-000	040-00836-000
700 HP 30-60 PPM 700 FUEL		040-00836-000
800 HP 30-60 PPM 100 FUEL		
800 HP 30-60 PPM 101 FUEL		
800 HP 30-60 PPM 200 FUEL	429-01724-000	040-00836-000
800 HP 30-60 PPM 700 FUEL		040-00836-000

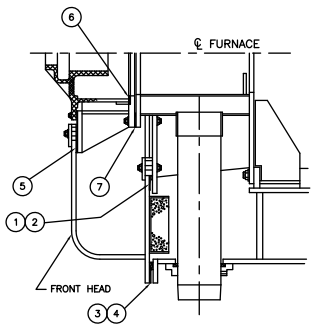
9.18 — Fireside Gaskets

55"–67" DIA. CBEX ELITE FIRESIDE GASKET KITS BILLS OF MATERIAL							
DIA.	55" (100–125 HP)		60" (150–200 HP)		67" (250–300 HP)		
KIT	880–06038–000		880–06039–000		880–06040–000		
ITEM	QTY	PART No.	QTY	PART No.	QTY	PART No.	DESCRIPTION
1	1	032–03175–000	1	032–03171–000	1	032–02619–000	GASKET, INNER HEAD TO BURNER HOUSING
2	18	841–00551–000	6	841–00551–000	8	841–00551–000	RIVET, SPLIT
3	1	032–03173–000	1	032–00105–000	1	032–02602–000	GASKET, FRONT HEAD FLANGE
4	22	841–00507–000	22	841–00507–000	34	841–00507–000	FASTENER, FRONT HEAD
5	1	032–00603–000	1	032–00603–000	1	032–02625–000	GASKET, BURNER SUPPORT TO FRONT HEAD
6	1	853–01017–000	1	853–01017–000	1	853–01017–000	SILICONE TAPE, 3/16" X 1" X 15 FT ROLL
7	1	032–03174–000	1	032–00443–000	1	032–00928–000	GASKET, BURNER SUPPORT TO BURNER HOUSING
8	1	032–03291–000	1	032–03291–000	1	032–03291–000	GASKET, REAR ACCESS PLUG
9	1	032–00605–000	1	032–00605–000	–	NOT USED	GASKET, BURNER DRAWER TO SUPPORT

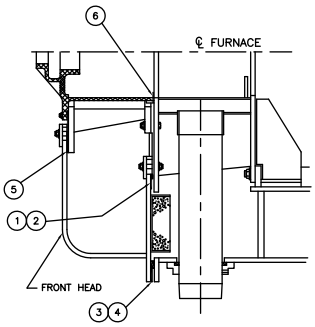
78"–92" DIA. CBEX ELITE FIRESIDE GASKET KITS BILLS OF MATERIAL							
DIA.	78" (350–400 HP)		85" (500–600 HP)		92" (700–800 HP)		
KIT	880–06041–000		880–06042–000		880–06043–000		
ITEM	QTY	PART No.	QTY	PART No.	QTY	PART No.	DESCRIPTION
1	1	032–00898–000	1	032–00993–000	1	032–00993–000	GASKET, INNER HEAD TO BURNER HOUSING
2	8	841–00551–000	8	841–00551–000	8	841–00551–000	RIVET, SPLIT
3	1	032–00899–000	1	032–02598–000	1	032–03169–000	GASKET, FRONT HEAD FLANGE
4	34	841–00507–000	33	841–00507–000	33	841–00507–000	FASTENER, FRONT HEAD
5	1	032–02625–000	1	032–02531–000	1	032–02531–000	GASKET, BURNER SUPPORT TO FRONT HEAD
6	1	853–01017–000	1	853–01017–000	1	853–01017–000	SILICONE TAPE, 3/16" X 1" X 15 FT ROLL
7	1	032–00928–000	–	NOT USED	–	NOT USED	GASKET, BURNER SUPPORT TO BURNER HOUSING
8	1	032–03291–000	1	032–03291–000	1	032–03291–000	GASKET, REAR ACCESS PLUG



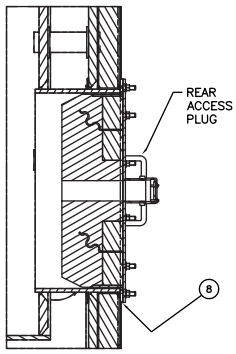
FRONT HEAD DETAIL #1
(LOWER SECTION VIEW)
USED FOR 55" & 60" DIA.



FRONT HEAD DETAIL #2
(LOWER SECTION VIEW)
USED FOR 67 & 78" DIA.



FRONT HEAD DETAIL #3
(LOWER SECTION VIEW)
USED FOR 85" & 92" DIA.



REAR ACCESS PLUG AREA
(LOWER SECTION VIEW)

FIRESIDE GASKET KIT DETAILS

NOTES: 1. INSTALL ALL GASKETS WITH SPRAY ADHESIVE, NOT PROVIDED WITH 880–KITS.

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