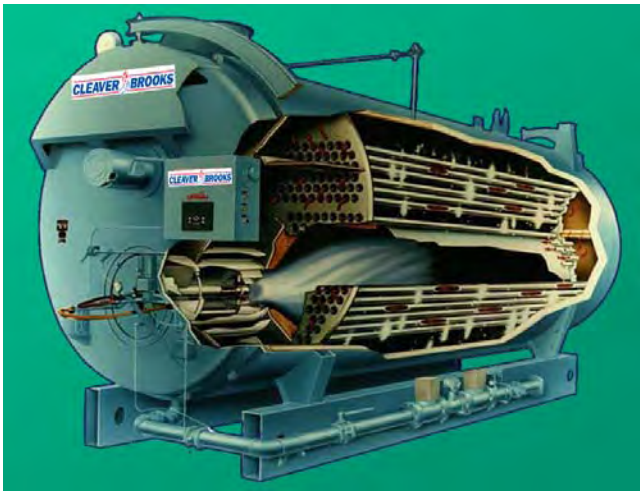
CleaverBrooks

Model 4WI

Promethean Boilers

100 to 800 HP Steam and Hot Water
Fuel: Light Oil, Gas or Combination

Operation, Service, and Parts Manual



750-211
12/09

⚠WARNING

If the information in this manual is not followed exactly, a fire or explosion may result causing property damage, personal injury or loss of life.

— Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance.

— WHAT TO DO IF YOU SMELL GAS

- Do not try to light any appliance.
- Do not touch any electrical switch; do not use any phone in your building.
- Immediately call your gas supplier from a neighbor's phone. Follow the gas supplier's instructions.
- If you cannot reach your gas supplier, call the fire department.

— Installation and service must be performed by a qualified Cleaver-Brooks, service agency or the gas supplier.

⚠WARNING

To minimize the possibility of serious personal injury, fire or damage to the equipment, never violate the following safety rules.

— Always keep the area around the boiler free of combustible materials, gasoline, and other flammable liquids and vapors

— Never cover the boiler, lean anything against it, stand on it, or in any way block the flow of fresh air to the boiler.

Notice

Where required by the authority having jurisdiction, the installation must conform to the Standard for Controls and Safety Devices for Automatically Fired Boilers, ANSI/ASME CSD-1.

⚠WARNING

Improper installation, adjustment, service, or maintenance can cause equipment damage, personal injury, or death. Refer to the Operation and Maintenance manual provided with the boiler. Installation and service must be performed by a qualified Cleaver-Brooks service provid-

⚠WARNING

Be sure the fuel supply which the boiler was designed to operate on is the same type as specified on the boiler name plate.

⚠WARNING

Should overheating occur or the gas supply valve fail to shut off, **do not** turn off or disconnect the electrical supply to the boiler. Instead turn off the gas supply at a location external to the boiler.

⚠WARNING

Do not use this boiler if any part has been under water. Immediately call your Cleaver-Brooks service representative to inspect the boiler and to replace any part of the control system and any gas control which has been under water.

Notice

This manual must be maintained in legible condition and kept adjacent to the boiler or in a safe place for future reference. Contact your local Cleaver-Brooks representative if additional manuals are required.

⚠WARNING

The boiler and its individual shutoff valve must be disconnected from the gas supply piping system during any pressure testing of that system at test pressures in excess of 1/2 psi (3.5 kPa).

⚠WARNING

The installation must conform to the requirements of the authority having jurisdiction or, in the absence of such requirements, to UL 795 Commercial-Industrial Gas Heating Equipment and/or the National Fuel Gas Code, ANSI Z223.1

TO: Owners, Operators and/or Maintenance Personnel

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

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

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

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

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

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

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

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation. Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

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

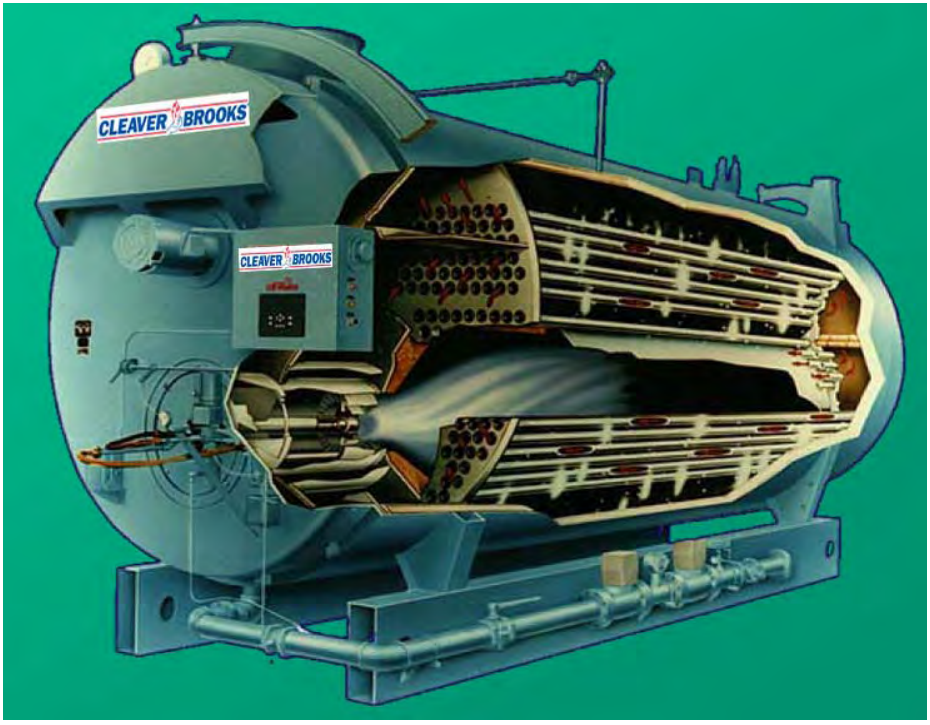
It is essential to obtain the services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices.

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

CLEAVER-BROOKS

Model 4WI, Promethean Boilers

Operation and Maintenance Manual



Manual Number: 750-211

Release Date: December 2009

Cleaver-Brooks

11950 West Lake Park Drive

Milwaukee, WI 53224

414-359-0600

www.cleaver-brooks.com

Promethean Boilers, Model 4WI

750-211

Table of Contents

CHAPTER 1

Firetube Operation Basics

1.1 — Overview

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging for 15 to 1800 horsepower. A firetube boiler is 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 front door and rear door provide the seal to contain the hot combustion gases. Baffles designed into the doors serve to redirect the combustion gases through the various firetube passages. 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.

FIGURE 1-1. Open Front and Rear Doors

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.

The general information in this manual applies directly to Cleaver-Brooks Promethean 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 400	Heavy Oil (No. 6) or Gas
Series 600	Heavy Oil (No. 6)
Series 700	Gas

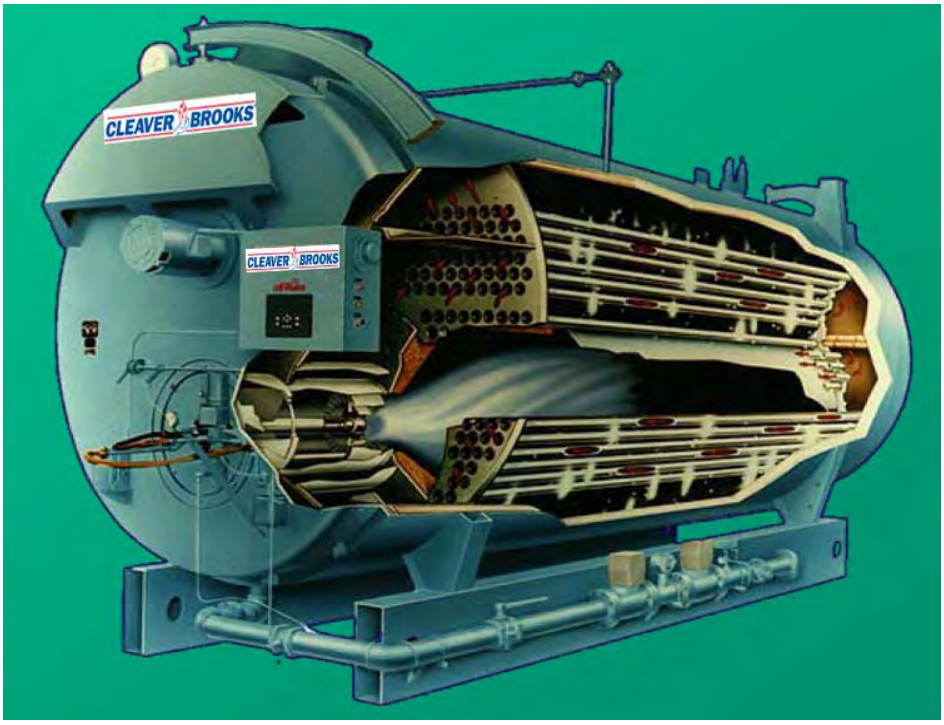
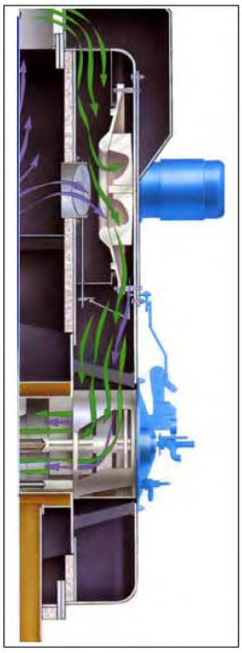


FIGURE 1-2. Firetube Boiler Cutaway View



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

The Promethean 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 fourth-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 1-3. Induced Flue Gas Recirculation (IFGR)

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

The boiler and related equipment installation are to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained, etc.

All Promethean 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 Promethean 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.

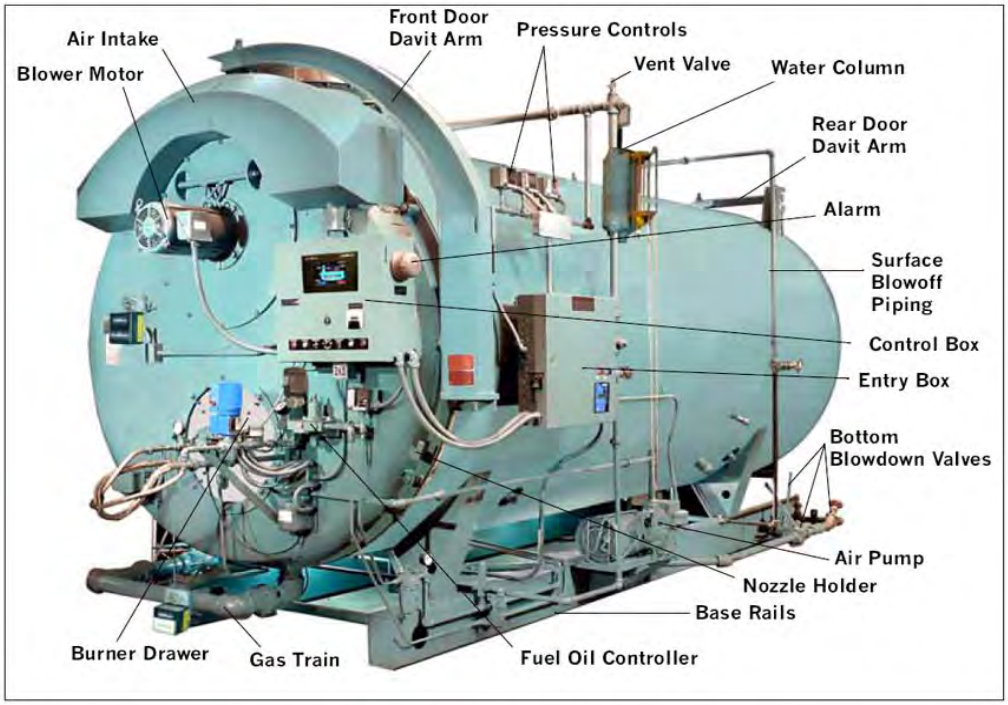


FIGURE 1-4. Typical Steam Boiler

The horsepower rating of the boiler is indicated by the numbers following the fuel series. For example, CB700-600 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 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 boilers are designed for low or high pressure applications. Low pressure boilers are limited to 15 psig design, and are typically used for heating applications. High pressure boilers are typically used for process loads and can have a design pressure of 75 psig to 350 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 it the pressure of the boiler at which it normally operates. The operating pressure usually is maintained at a suitable level below the setting of the pressure relieving valve(s) to prevent frequent valve opening during normal operation.

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

Feedwater equipment should be 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. Constant attention to water requirements will pay dividends in the form of longer life, less downtime, and prevention of costly repairs.

Care takin 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.

1.4 — Steam Controls (All Fuels)

1.4.1 — Controls

1.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.

2.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 1-5. Steam Controls

3. **Modulating Pressure Control**: Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."

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 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. The McDonnell-Millar (MM) LWCO is available on low pressure steam boilers to 15 psig and hot water boilers to 250º F and to 125 psi. For additional information on the Level Master, refer to the Level Master Operation and Maintenance manual, manual number 750-192.

FIGURE 1-6. Level Master Low Water Cutoff (LWCO)

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 — Water Column

1. **Water Column Assembly**: Houses the low water cutoff and pump control and includes the water gauge glass and shutoff cocks.

FIGURE 1-7. **Water Column Assembly**

1.4.4 — Steam Pressure Gauge and ALWCO

1. **Steam Pressure Gauge**: Indicates boiler internal pressure.
2. **Auxiliary Low Water Cutoff**: Breaks the circuit to stop burner operation in the event boiler water drops below the master low water cutoff point. Manual reset type requires manual resetting in order to start the burner after a low water condition.

FIGURE 1-8. **Steam Pressure Gauge and ALWCO (Hot Water)**

1.4.5 — 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 only a moderate amount of pipe compound to male threads and avoid over-tightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

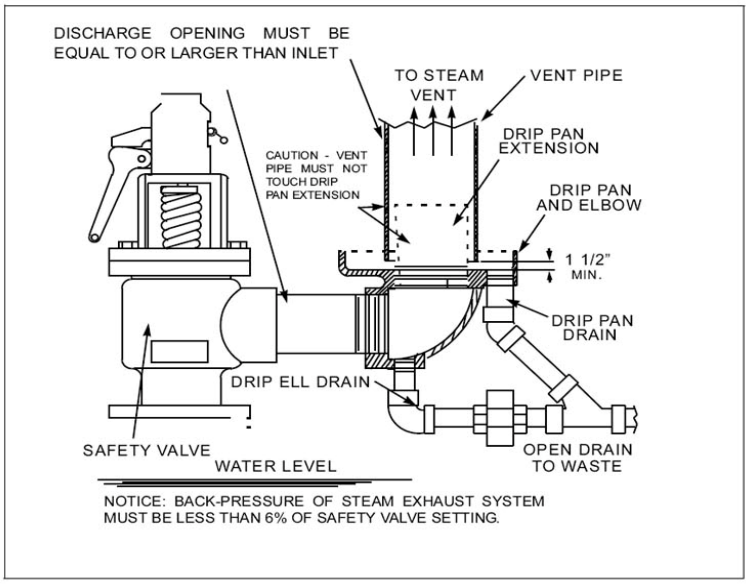


FIGURE 1-9. Safety Valve Piping and Safety Valves

⚠ 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 the modulating motor 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 1-10. 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 fourth-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. **IFGR Damper Linkage**: The IFGR damper is positioned by the control linkage. The linkage could consist of a single arm, or it could consist of several arms driven from the jackshaft to provide modulating control.
3. **Over-Travel Mechanism**: The over-travel mechanism has two functions:
   - Allows the linkage to pass through the front door.
   - Allows jackshaft rotation to exceed (over-travel) IFGR linkage movement.

   A set of springs allows the linkage to stay in a fixed position while the jackshaft rotates.
4. **Fuel Changeover Linkage**: When a boiler is equipped to fire either gas or oil (dual-fuel boilers), and the required NOx levels are below 60 ppm on natural gas, a dual linkage arrangement is used to provide the different recirculation rates required for each fuel. Two jackshaft drive arms are provided, one for oil and one for gas. The linkage is manually connected to the appropriate arm, based on the fuel being used.

On dual-fuel boilers with two jackshaft drive arms, as defined above, a proximity switch is used to prove that the correct linkage connection is made. (Refer to the wiring diagram provided with the boiler.)

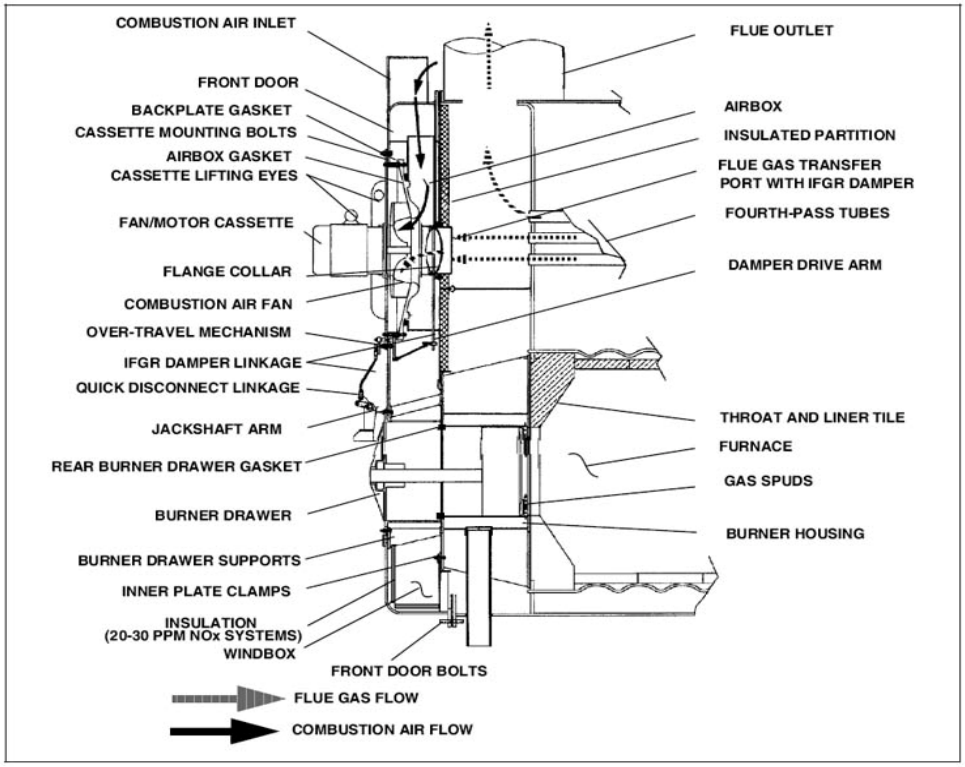


FIGURE 1-11. Cross Section of Front Head

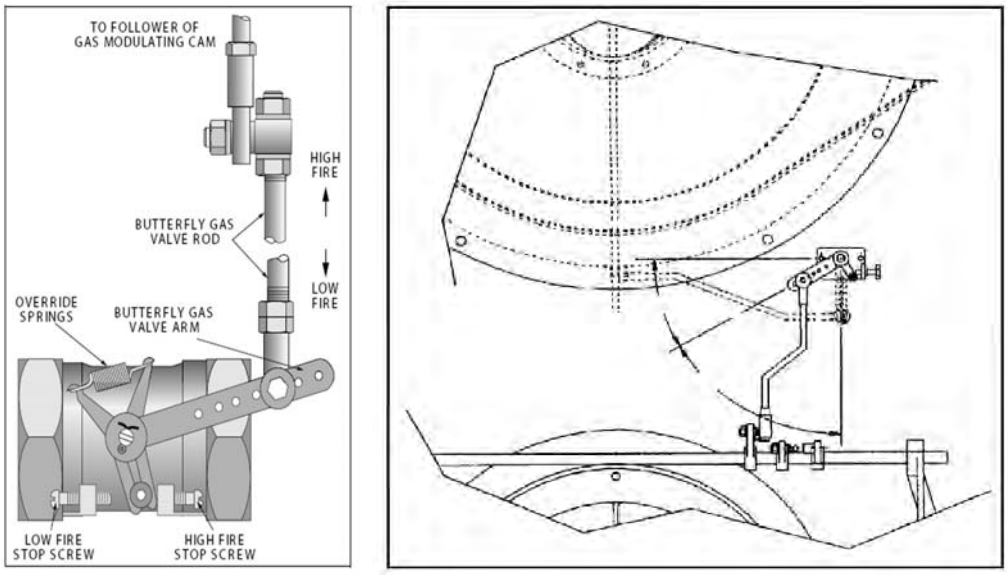


FIGURE 1-12. Over-Travel Mechanism and Fuel Changeover Linkage

5. **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.
6. **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.
7. **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.
8. **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.

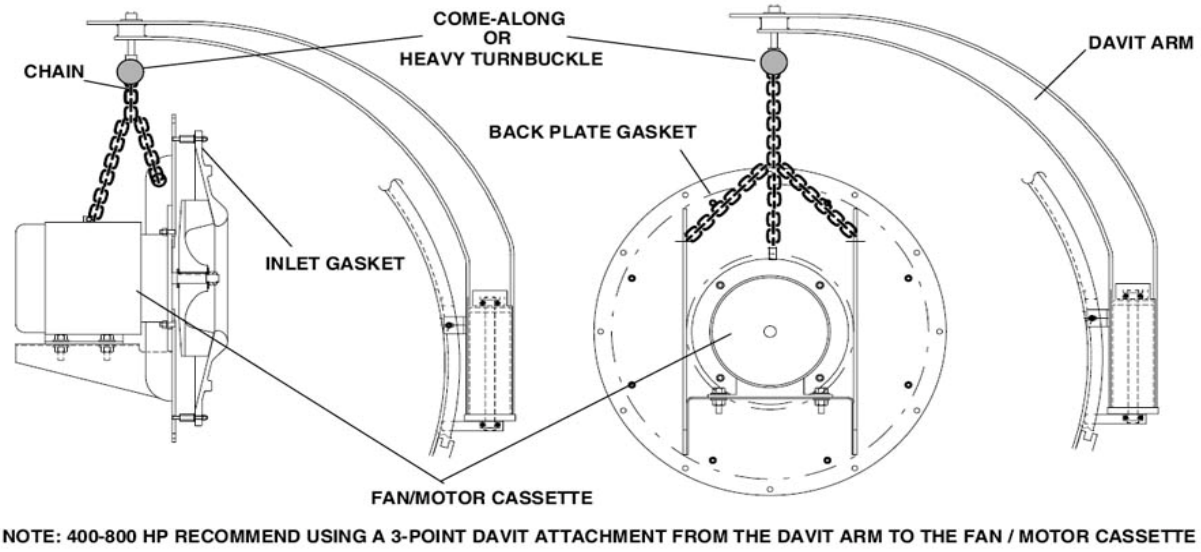


FIGURE 1-13. **Fan/Motor Cassette**

CHAPTER 2

Burner Operation and Control

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 and it is extinguished after the main flame is established.

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

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. High pressure boilers (above 15 psi) can be wired for both low pressure and high pressure modulation, which enables the boiler to operate at lower pressure during off-load hours, but at a somewhat reduced steam output, dependent upon lower steam pressure and steam nozzle sizing.

FIGURE 2-1. Gas/Oil Selector Switch

NOTE: A Series 100 boiler is usually equipped with a light oil pilot, although a gas pilot is also available.

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 programming portion of the control 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, excess steam pressure, or 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, plus temperature proving controls when heated fuel oil is used.

The sequence of burner operation from startup through shutdown is governed by the program relay 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.

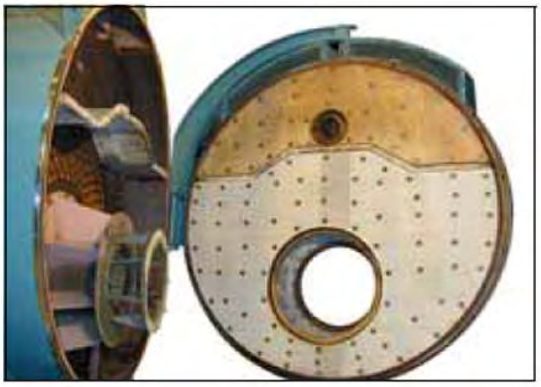


FIGURE 2-2. Open Front Head

All Promethean 4WI 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 motor. The motor also regulates the flow of fuel through a linkage system connected to the gas butterfly valve and/or oil through a cam-operated metering valve. Fuel input and air are thus properly proportioned for most efficient combustion.

2.2 — Controls Common to all Boilers

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.

Indicator lights signaling load demand, fuel valve, low water, and flame failure conditions are standard equipment.

FIGURE 2-3. Control Panel Indicator Lights

In addition to the standard basic controls supplied, other devices may be required to meet specific requirements of an insurance carrier or local code. Refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for the installation to determine the specific controls in the burner and limit control circuits. The function of individual components is outlined in this chapter and the electrical sequence is covered in Chapter 4.

2.3 — Control and Component Function

The term "control" covers the more important valves and components, including, but not limited to electrical controls or those monitored by the Hawk ICS and program relay. The operator must become familiar with the individual functioning of all controls before understanding boiler operation and procedures outlined in this manual.

The actual controls furnished with any given boiler will depend upon the type of fuel for which it is equipped, and whether it is a hot water or steam boiler. Refer to the applicable group or groups within Chapter 2 that apply to the particular boiler.

Boilers with optional features may have control components not listed here.

2.4 — Components Common to all Boilers

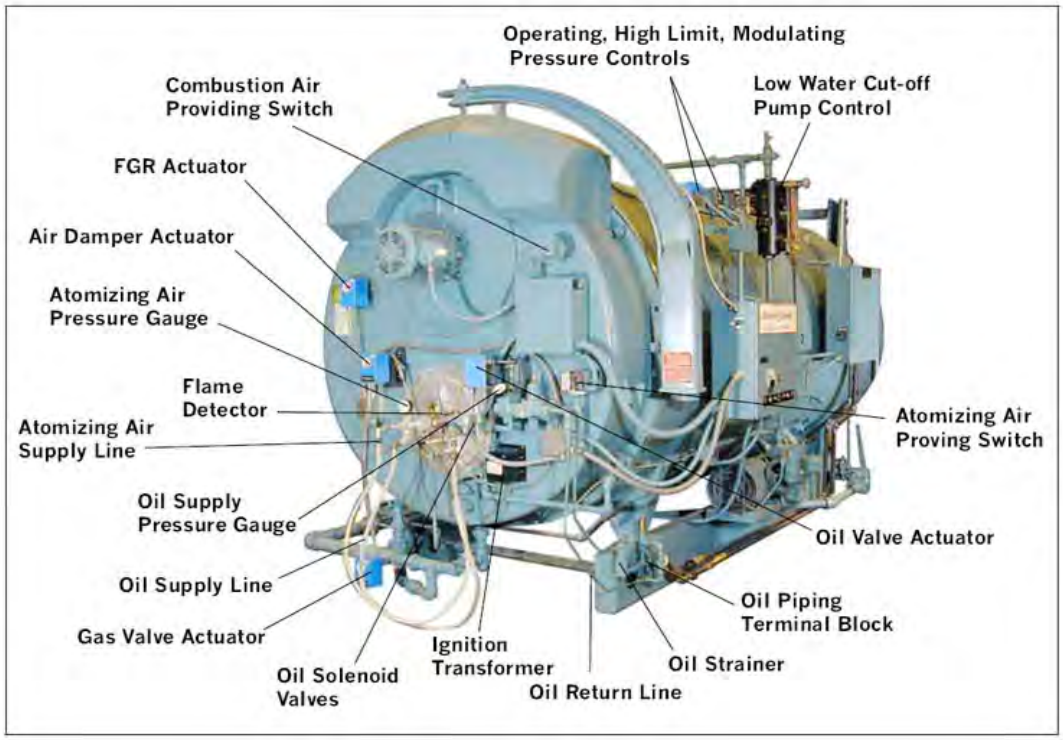


FIGURE 2-4. Steam Boiler Components and Controls

Component/Control	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.

Component/Control	Description
3. Modulating Motor	Operates the rotary air damper and fuel metering valves through a cam and linkage system to provide proper air/fuel ratios under all boiler load conditions.
4. Modulating Motor Transformer	Reduces control circuit voltage (115 Vac) to required voltage (24 Vac) for operation of the modulating motor.
5. Forced Draft Fan Motor Starter	Energizes forced draft fan (blower) motor.
6. Ignition Transformer	Provides high voltage spark for ignition of gas pilot or light oil pilot.
7. Low Fire Switch	An internal auxiliary switch, cam actuated by the motor shaft, which must be closed to indicate that the air damper and fuel metering valve are in the low fire position before an ignition cycle can occur.
8. Atomizing Air Proving Switch	A pressure sensitive switch actuated by air pressure from the Air Pump. Its contacts close to prove presence of atomizing air. The fuel valves cannot be energized unless this switch is satisfied.
9. Manual-Automatic Switch	When set at "automatic," subsequent operation is at the command of the modulating control, which governs the position of the modulating motor in accordance with load demand. When set at "manual," the modulating motor, through the manual flame control, can be positioned at a desired burner firing rate. The primary purpose of the "manual" position is for testing and setting the air/fuel ratio through the entire firing range.
10. Manual Flame Control	A manually operated potentiometer that permits the positioning of the modulating motor to a desired burner firing rate when the manual-automatic switch is set on "manual." It is used primarily for initial or subsequent setting of fuel input throughout the firing range. It has no control over the firing rate when the manual-automatic switch is set on "automatic."
11. Burner Switch	A manually operated start-stop switch for directly starting and stopping operation of the burner.
12. 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.
13. Combustion Air Proving Switch	A pressure sensitive switch actuated by air pressure from the forced draft fan. Its contacts close to prove presence of combustion air. The fuel valves cannot be energized unless this switch is satisfied.
14. Alarm	Sounds to notify the operator of a condition requiring attention. The alarm is available as optional equipment.
15. Stack Thermometer	Indicates temperature of vented flue gases.
16. Diffuser	A circular plate, located at the furnace end of the burner drawer, that imparts a rotary swirling motion to combustion air immediately prior to its entering the flame, thus providing a thorough and efficient mixture with the fuel.
17. Rotary Air Damper	Provides accurate control of combustion air in proportion to fuel input for various load demands. It consists of two concentric cylinders with openings. The outer is stationary. The inner is rotated, under control of the modulating motor, to vary the effective size of the openings where they overlap.

Component/Control	Description
18. Indicator Lights	Provide visual information of boiler operation as follows (indicator lights vary with controls provided): • Flame Failure • Load Demand • Fuel Valve (valve open) • Low Water
19. Program Relay and Flame Safeguard Control	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), and the damper motor. The sequence includes air purge periods prior to ignition and upon burner shutdown.

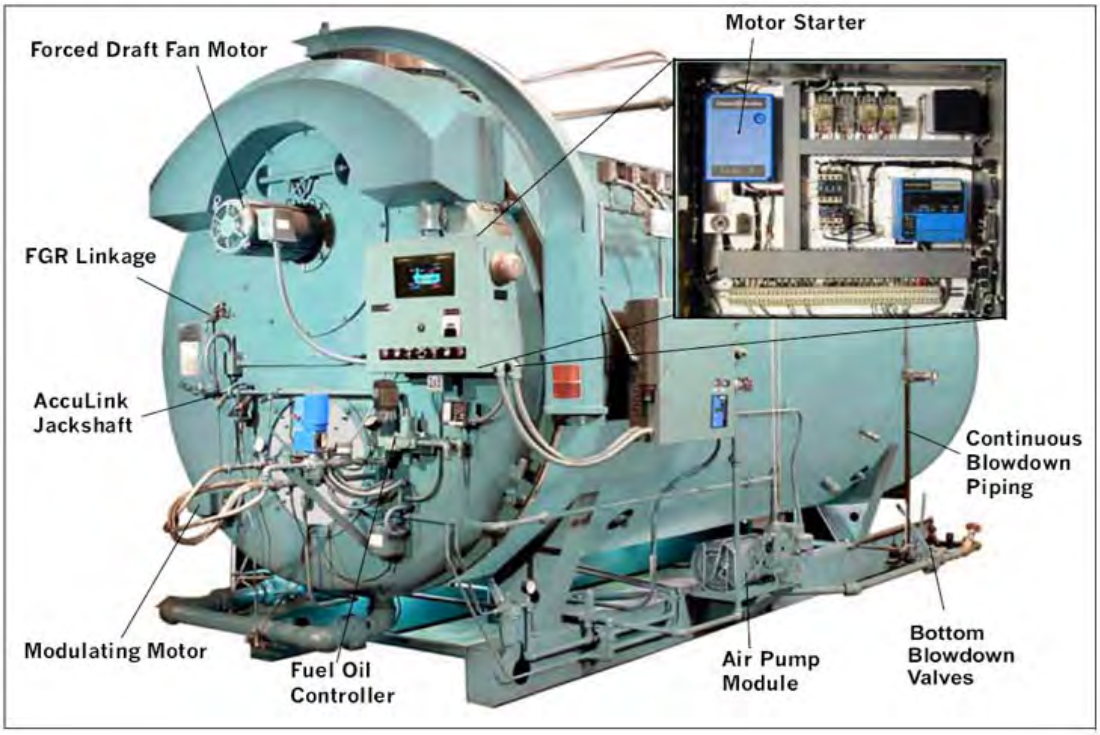


FIGURE 2-5. Components and Controls

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.

2.5 — Controls for Gas Firing

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.

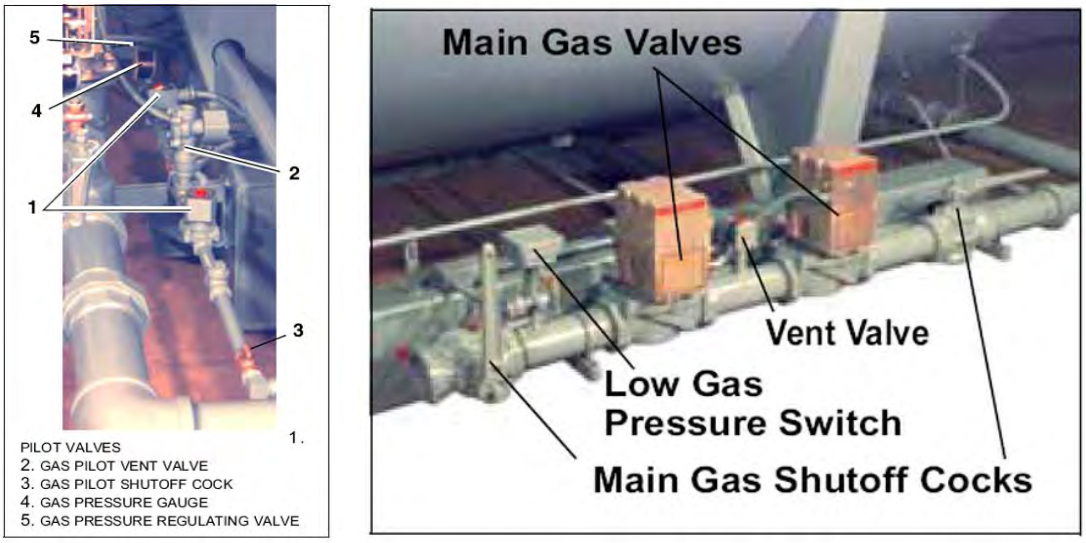


FIGURE 2-6. Pilot Gas Train and Main Gas Train

Component/Control	Description
1. Gas Pilot 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.
2. Gas Pilot Vent Valve	When a second gas pilot valve is required, a normally open vent valve (optional equipment) is installed between them. Its purpose is to vent gas to the atmosphere, should any be present in the pilot line when the pilot valves are closed. The valve closes when the pilot valves are energized.
3. Gas Pilot Shutoff Cock	For manually opening or closing the gas supply to the gas pilot valve.
4. Gas Pressure Gauge	Indicates gas pressure to pilot.
5. Gas Pressure Regulating Valve	Reduces incoming gas pressure to suit the pilot.
6. 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.
7. Main Gas Cock	For manually opening and closing the main fuel gas supply downstream of the main gas line pressure regulator. 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.

Component/Control	Description
8. Main Gas Vent Valve	A normally open solenoid valve installed between the two main gas valves to vent gas to the atmosphere should any be present in the main gas line when the gas valves are de-energized. The vent valve closes when the gas valves are energized.
9. 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.
10. 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.
11. Gas Pilot Aspirator	Provides complete mixing of gas and air to the pilot.
12. Gas Pilot Adjusting Cock	Regulates the size of the gas pilot flame.
13. Gas Modulating Cam	As assembly consisting of a quadrant, a series of adjustable allen-head screws, and a contour spring. Provided for adjustment of gas input at any point in the modulating range.
14. Butterfly Gas Valve	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.
15. 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.

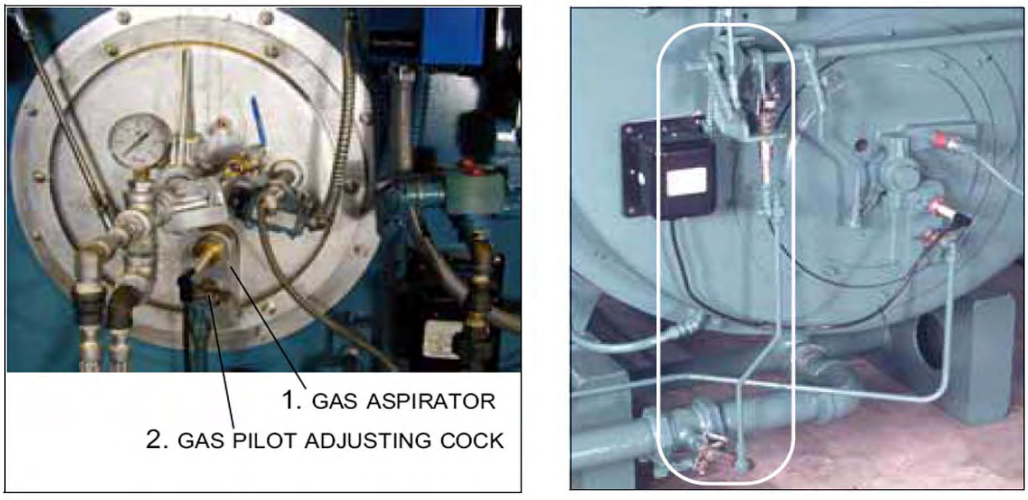


FIGURE 2-7. Burner Drawer Face and Gas Modulating Cam

2.6 — Controls Common to Oil-Fired Boilers (Including Combination)

The following items are applicable to all oil fired or gas and oil fired boilers. Additional controls for No. 6 oil are listed in Section 2.12.

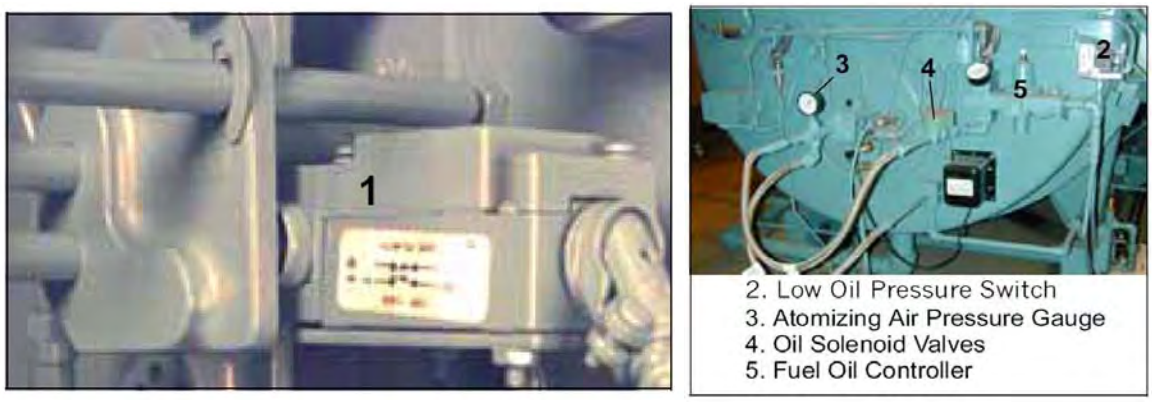
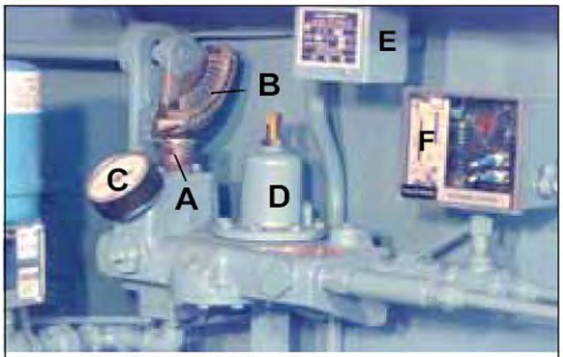


FIGURE 2-8. Oil Drawer Switch and Controls for Oil Firing

Component/Control	Description
1. Oil Drawer Switch	Opens the limit circuit if the oil drawer burner gun is not latched in the forward position required for burning oil.
2. 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.
3. Atomizing Air Pressure Gauge	Indicates the atomizing air pressure at the burner gun.
4. 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.
5. 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. In addition to these, the controller used on a No. 6 oil fired burner has additional components described in Section 2.7. 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 modulating motor through linkage and the oil metering cam. B. Oil Modulating Cam: Assembly consisting of a quadrant, a series of adjustable allen-head screws, and a contour spring provided for adjustment of oil input at any point in the modulating range. C. Oil Burner Pressure Gauge: Indicates pressure of the fuel oil at the metering valve. D. Oil Pressure Regulator: For adjustment of the pressure of oil at the metering valve.

Component/Control	Description
6. Oil Relief Valve	Maintains a constant oil supply pressure to the fuel oil controller by bypassing excess fuel oil.
7. Terminal Block	Provides connections for fuel oil supply piping.
8. Fuel Oil Strainer	Prevents foreign matter from entering the burner system.
9. Gas Pilot	See Section 2.5 for description of the various components.
10. Light Oil Pilot Valve	When a light oil pilot is furnished, a solenoid valve is provided to control flow of fuel to the pilot nozzle. It is energized through programmer contacts. It is de-energized to shut off pilot fuel flow after the main flame is ignited and established.
11. 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).
12. 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.
13. Fuel Oil Pump	Transfers fuel oil from the storage tank and delivers it under pressure to the burner system.



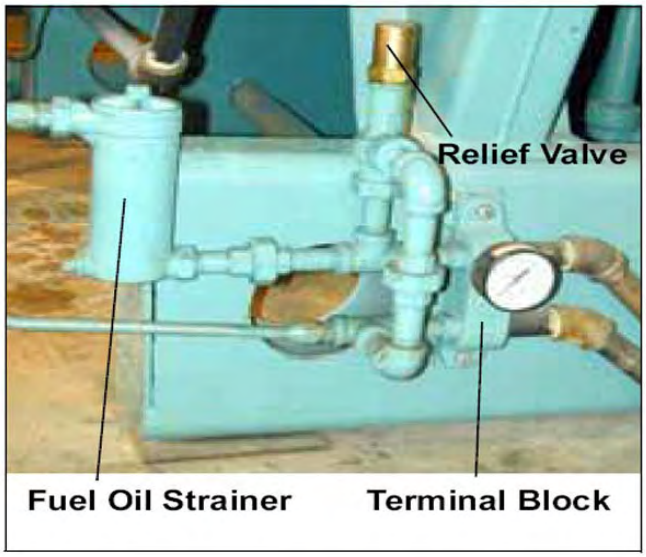


FIGURE 2-9. Fuel Oil Controller and Relief Valve & Terminal Block

12. 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. It includes components: 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.

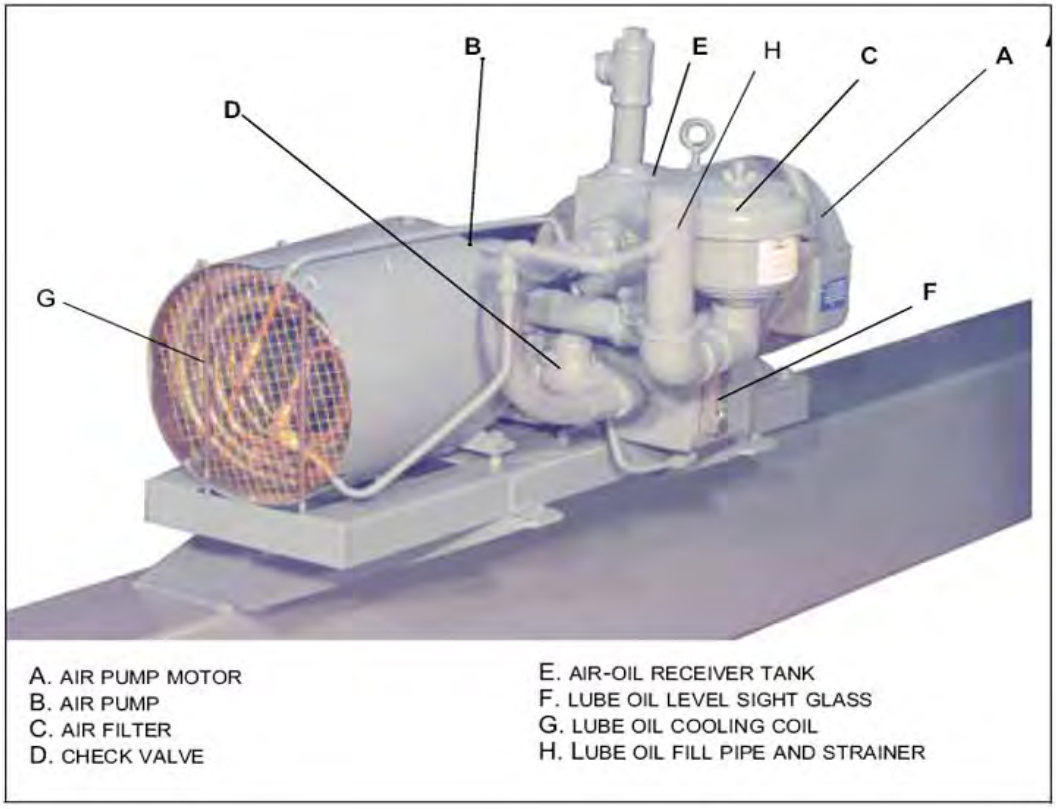


FIGURE 2-10. Air Pump (Primary Air)

2.7 — *Additional Controls for Heavy Oil*

The oil heater steam is provided to heat heavy oil to the point where it can be effectively atomized and burned. Most heavy oil heaters utilize an electric heater to reduce the viscosity of the heavy oil until the point where either steam or hot water is available. Heavy oil heaters operating with hot water will have additional controls not shown in Figure 2-11.

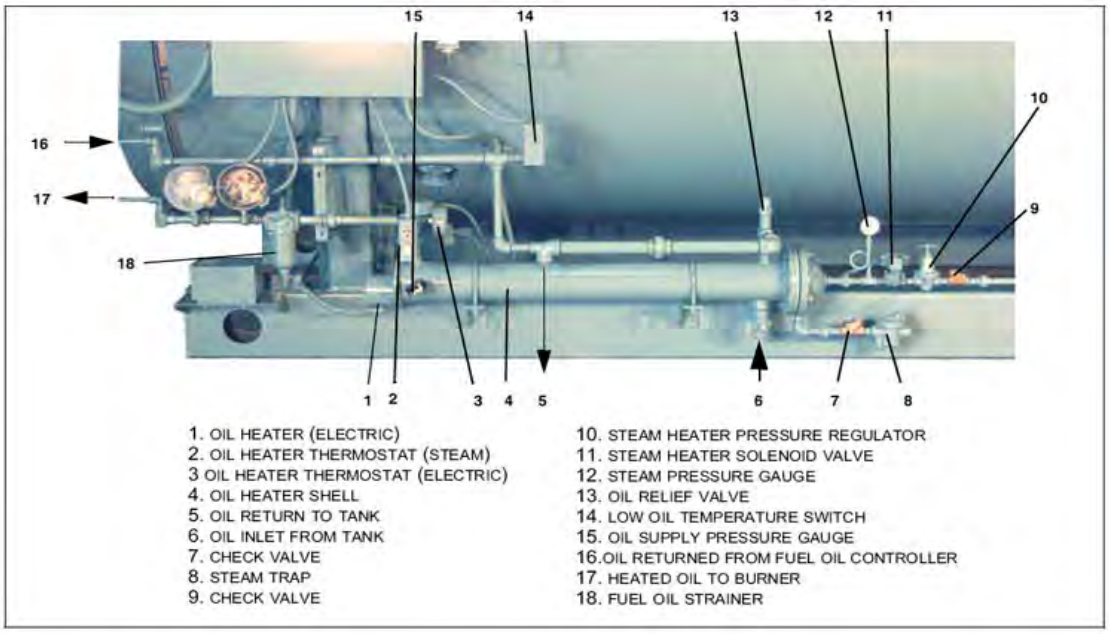


FIGURE 2-11. Oil Heating Assembly (Steam)

Component	Description
Heater Switch (not shown)	Manually provides power to the oil heater system.
1. Oil Heater (Electric)	Used for heating sufficient fuel oil for low-fire flow during cold starts before steam or hot water is available for heating. The heater must be turned off during extended boiler lay up, or at any time the fuel oil transfer pump is stopped.
2. Oil Heater Thermostat (Steam)	Senses fuel oil temperature and controls the opening and closing of the steam heater valve to maintain the required temperature of the fuel oil.
3. Oil Heater Thermostat (Electric)	Senses fuel oil temperature and energizes or de-energizes the electric oil heater to maintain required temperature of the fuel oil.
4. Oil Heater Shell (Steam/Hot Water)	Heats fuel oil through medium of steam or hot water. electric heater is housed in the steam heater, but is housed separately on a hot water heater. Steam oil heaters on 15 psi boilers operate at boiler pressure. Steam oil heaters furnished on high pressure boilers are to be operated at less than 15 psi. Operation is accomplished with a steam pressure regulator valve.
5. Oil Return to Tank	Excess oil returned to the heavy oils supply tank.
6. Oil Inlet from Supply Tank	Heavy oil inlet from the supply tank.

Component	Description
7. Steam Heater Check Valve	Prevents oil contamination of the waterside of pressure vessel should any leakage occur in the oil heater.
8. Steam Trap	Drains condensate and prevents loss of steam from the steam oil heater. Condensate must be piped to a safe point of discharge.
9. Check Valve (Discharge)	Prevents air entry during shutdown periods when cooling action may create vacuum within steam heater.
10. Steam Heater Pressure Regulator	Adjust to provide reduced (usually less than 15 psi) steam pressure to the heater to properly maintain the required fuel oil temperature. The regulator and the pressure gauge are not furnished on 15 psi units.
11. Steam Heater Solenoid Valve	A normally open solenoid valve opened by the steam oil heater thermostat to allow flow of steam to the steam heater to maintain temperature of fuel oil.
12. Steam Pressure Gauge	Indicates steam pressure entering the heater.
13. Oil Relief Valve	Allows release of excessive pressure to the return side of the oil line piped to the tank.
14. Low-Oil-Temperature Switch	Thermostatic switch that prevents burner from starting, or stops burner firing if fuel oil temperature is lower than required for oil burner operation.
15. Oil Supply Pressure Gauge	Indicates fuel oil pressure in the oil heater and supply pressure to the fuel oil controller's pressure regulator.
16. Oil Return	Oil return from the fuel oil controller.
17. Heated Oil to Burner	Heated oil for heavy oil firing.
18. Fuel Oil Strainer	Oil to burner cleaned through strainer.

In addition to the components of the fuel oil controller mentioned in this section, the following are used with a heavy-oil-fired burner:

Component	Description
A. High-Oil-Temperature Switch (optional)	Switch contacts open when fuel oil temperature raises above a selected temperature. Switch will interrupt the limit circuit in the event fuel oil temperature rises above the selected point.
B. Hot Water Oil Heater Thermostat	Used on a hot water boiler to sense fuel oil temperature and control the starting and stopping of the booster water pump.
C. Booster Water Pump	Started and stopped by the hot water thermostat to regulate the flow of hat water through the hot water oil heater to maintain temperature of fuel oil.
D. Fuel Oil Thermometer	Indicates temperature of fuel oil being supplied to the fuel oil controller.
E. Back Pressure Valve	For adjustment of oil pressure on the downstream side of the metering valve. Also regulates rate of return oil flow.
F. Oil Return Pressure Gauge	Indicates oil pressure on the return side of the fuel oil controller.
G. Manual Bypass Valve	Provided as a time saver in establishing oil flow. When open, it permits circulation of oil through the supply and return lines. The valve **must** be closed prior to initial light off.

Component	Description
H. Orifice Oil Control Valve	Valve may be opened prior to startup to aid in establishing fuel oil flow through the controller. The valve must be closed prior to initial light off. Its disc has an orifice to permit a continuous circulation of hot fuel oil through the controller.
I. Air Purge Valve	Solenoid valve opens simultaneously with closing of oil solenoid valve at burner shutdown, allowing compressed air to purge oil from the burner nozzle and adjacent piping. The oil is burned by the diminishing flame, which continues burning for approximately 4 seconds after the oil solenoid valve closes.
J. Air Purge Orifice Nozzle	Limits purging air to proper quantity for expelling unburned oil at normal delivery rate.
K. Air Purge Orifice Nozzle Filter	Filters the purging air of any particles that might plug the air purge orifice nozzle.
L. Air Purge Check Valve	Valve check prevents fuel oil from entering the atomizing air line.
M. Air Purge Relay	When energized, controls operation of the air purge valve.

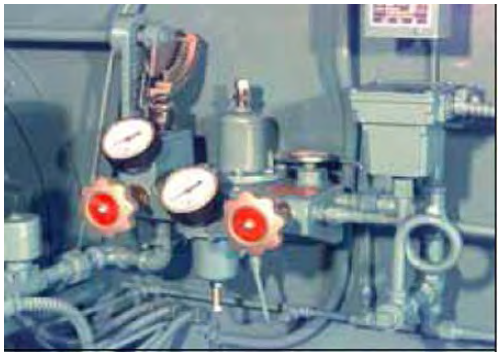
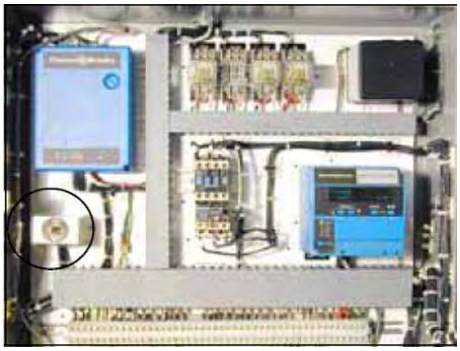


FIGURE 2-12. Heavy Oil Controller

2.8 — 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 mechanical functions of each fuel system.

FIGURE 2-13. Control Panel with Gas-Oil Selector Switch

2.9 — 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.

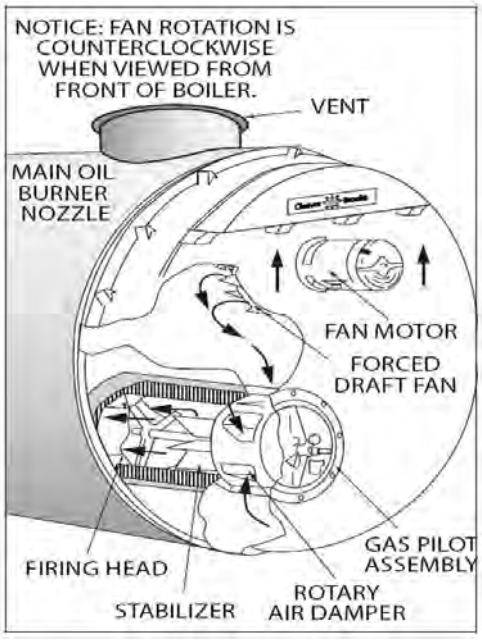


FIGURE 2-14. Secondary Air Flow Diagram

2.10 — Automatic Ignition

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

The series 100 burner usually is equipped with a pilot fired with light oil fuel. All other 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. Either pilot serves the same function.

At the beginning of the ignition cycle, and governed by the program relay and the Hawk ICS 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 required 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.

Fuel for a light-oil pilot is provided from the line that supplies oil under pressure for the main flame. A solenoid actuated valve controls flow of oil to the pilot nozzle. The valve is energized simultaneously with the ignition transformer at the beginning of the ignition cycle and is de-energized after main flame is ignited and established.

2.11 — 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.

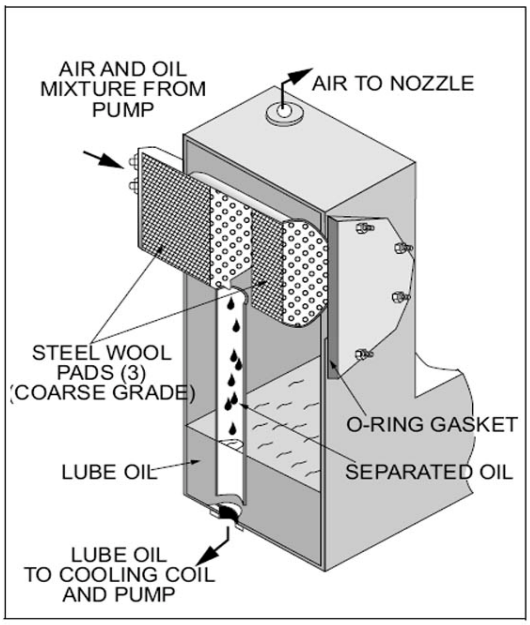


FIGURE 2-15. Air-Oil Receiver Tank

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.

2.12 — Oil Fuel Flow: Light Oil

In Figure 2-16 the oil flow is indicated by arrows and the pertinent controls are identified.

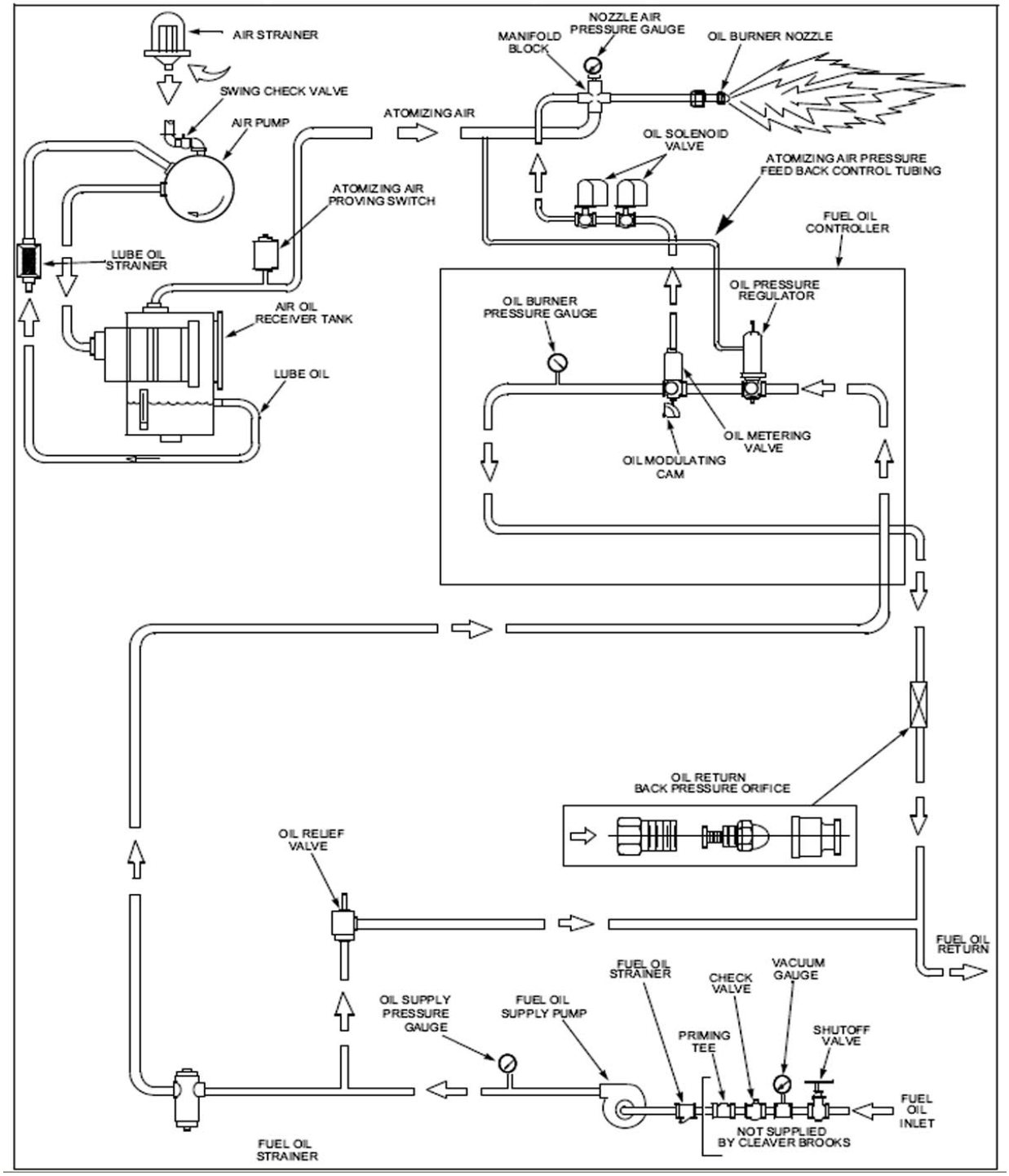


FIGURE 2-16. Diagram for Light Oil Flow

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 the modulating motor to proportion combustion air and fuel for changes in load demand.

2.13 — Oil Fuel Flow: Heavy Oil

In Figure 2.17 the heavy oil fuel flow and circulating system is shown and the pertinent controls are identified.

Fuel oil is delivered into the system by the fuel oil supply pump which delivers part of its discharge to the oil heater. The remainder of the fuel oil returns to the oil storage tank through a fuel oil relief valve and oil return line.

The combination electric and steam oil preheater is controlled by thermostats. The electric oil heater thermostat energizes the electric heater, which is provided to supply heated oil on cold starts. The steam heater thermostat controls operation of the steam solenoid valve to permit a flow of steam to the heater when steam is available.

A hot water boiler is equipped to heat the oil with hot water from the boiler, unless other preheating equipment is utilized. The electric heater, which is housed separately, is sized to provide heated oil on a cold start. The hot water thermostat controls the operation of a pump that supplies hot water to the oil heater when hot water is available.

The heated oil flows through a fuel oil strainer to prevent any foreign matter from entering the control valves and nozzle.

The fuel oil controller contains, in a single unit, the necessary valves, regulators, and gauges to regulate the pressure and flow of oil to the burner.

The program relay energized or de-energizes the solenoid oil valve to permit or cut off oil flow to the burner. The oil solenoid is closed when de-energized. It cannot be opened (energized) unless the combustion air proving switch, the atomizing air proving switch, and the low oil-temperature and any pressure switches are closed. They

are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan, pressurized air from the air pump, and sufficient oil temperature and pressure.

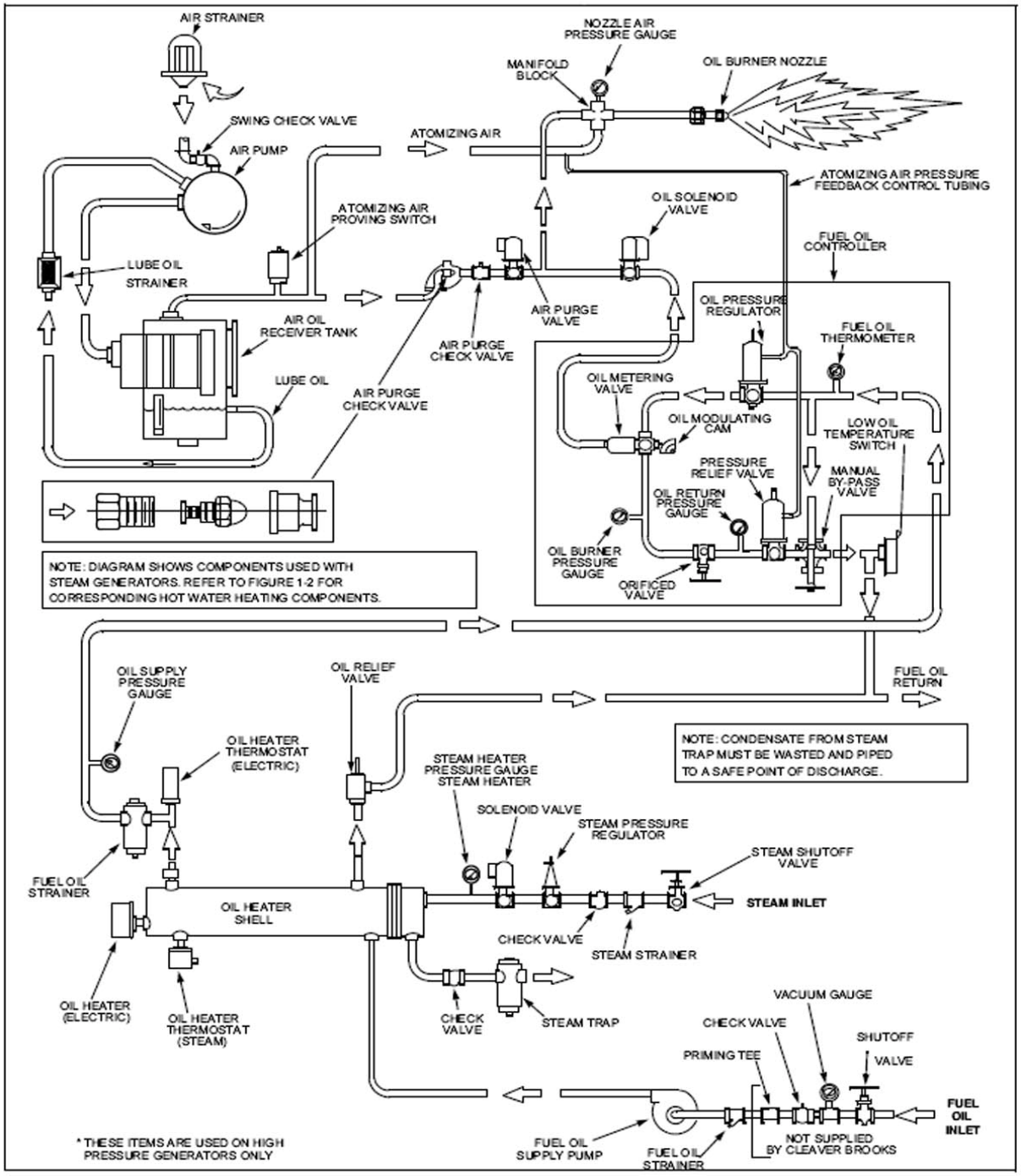


FIGURE 2-17. Diagram for No. 6 Heavy Oil Flow (Steam-Electric Heater)

Oil flow to the burner is controlled by the movement of the metering stem of 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 the modulating motor to proportion combustion air and fuel for changes in load demand.

Oil is purged from the burner gun upon each burner shutdown. The air purge solenoid valve opens as the fuel valve closes, diverting atomizing air through the oil line. The air assures a clean nozzle and line for subsequent restart.

2.14 — 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.

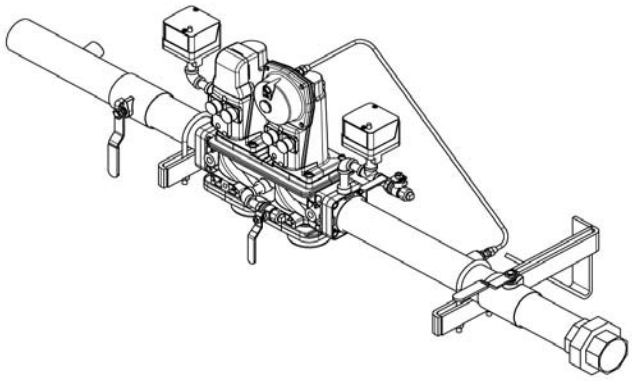


FIGURE 2-18. Gas Train

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 modulating cam. The butterfly gas valve, and the air control damper are controlled simultaneously by the modulating motor 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.

2.15 — Modulating Firing

The modulating motor, through a linkage arrangement, controls the air damper and the butterfly gas valve, or the oil metering valve, to maintain a constant air/fuel ratio throughout the firing range.

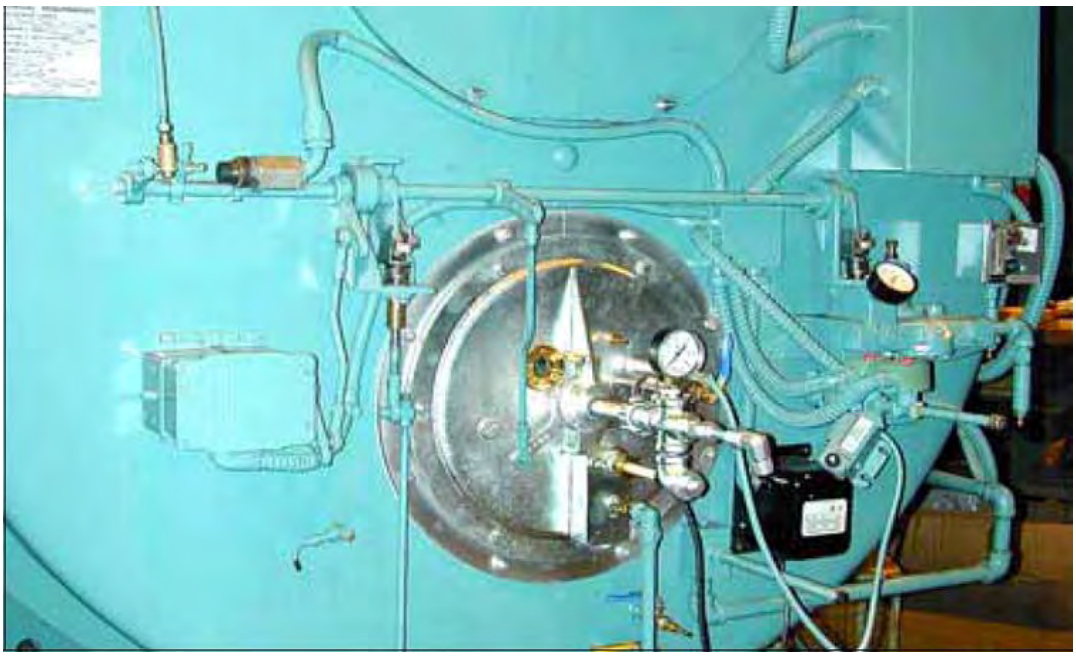


FIGURE 2-19. Burner Drawer and Fuel Linkage Assembly

During burner operation, the motor is controlled by a modulating pressure control on a steam boiler, or by a modulating temperature control on a hot water boiler. A manually operated potentiometer is provided to permit positioning of the motor at the desired burner firing rate. The potentiometer is used primarily for initial or subsequent checking and setting of fuel input. Normal operation should be with the manual-automatic switch in the "automatic" position and under the control of the modulating control.

The modulating motor (commonly called a damper motor) is reversible. It has an internal limit switch that restricts shaft rotation to 90°. During normal operation the motor will move in either direction or stop at any position within the range.

The motor potentiometer is electrically connected to a matching potentiometer in the modulating control. Changing steam pressure or water temperature alters the electrical resistance of the modulating controller potentiometer. The change in resistance compels an integral balancing relay to start, stop, or reverse the motor rotation. Rotation in either direction continues until the resistance ratio of the two potentiometers is equal.

When the resistance ratio is equal, the motor stops in a position that allows the proper fuel and combustion air flow to meet operating demands.

A feature designed into the circuitry maintains the modulating motor in the low-fire position during ignition and keeps it there until the main flame is established. A low-fire switch, integral to the motor, is actuated by the rotation

of the motor. The switch must be closed to establish that the damper and fuel metering valves are in the low-fire position before the programmer commences into the ignition period. During this time, neither the manual flame control nor the modulating control have any control over the damper motor, regardless of their setting.

An optionally equipped boiler uses a second integral switch to establish that the motor has driven the damper to an open position during the pre-purge period. The second integral switch closes, as high-fire position is approached, to complete an internal circuit in the programmer to allow continuation of the programming cycle.

CHAPTER 3

Waterside Care and Requirements

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, as a part of a hot water system, 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 ave different operating requirements, circulation rates, temperatures, etc.

3.2 — Water Requirements

3.2.1 — Hot Water Boilers

3.2.1.1 — 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.

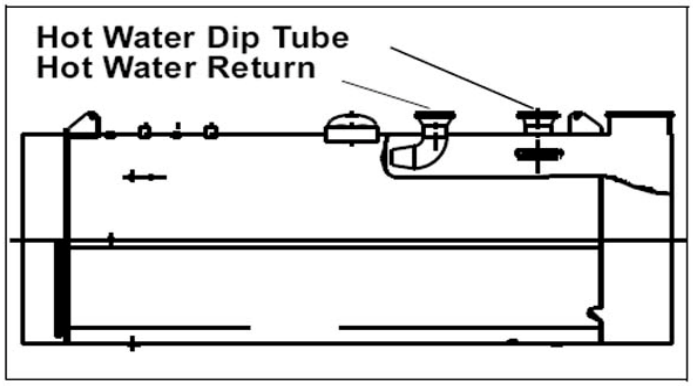


FIGURE 3-1. Dip Tube

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.

3.2.1.2 — 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.

A temperature of 170º F is also recommended in order to provide a sufficient "temperature head" when No. 6 fuel oil is to be heated to the proper atomizing temperature by the boiler water in a safety-type oil preheater. (The electric preheater on the boiler must provide additional heat to the oil if boiler water temperature is not maintained above 200º F.)

3.2.1.3 — 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.

3.2.1.4 — 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 (200º F if used to preheat No. 6 oil) 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.

3.2.1.5 — 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

3.2.1.6 — 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.

3.2.1.7 — 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.

3.2.1.8 — 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.

3.2.1.9 — 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.

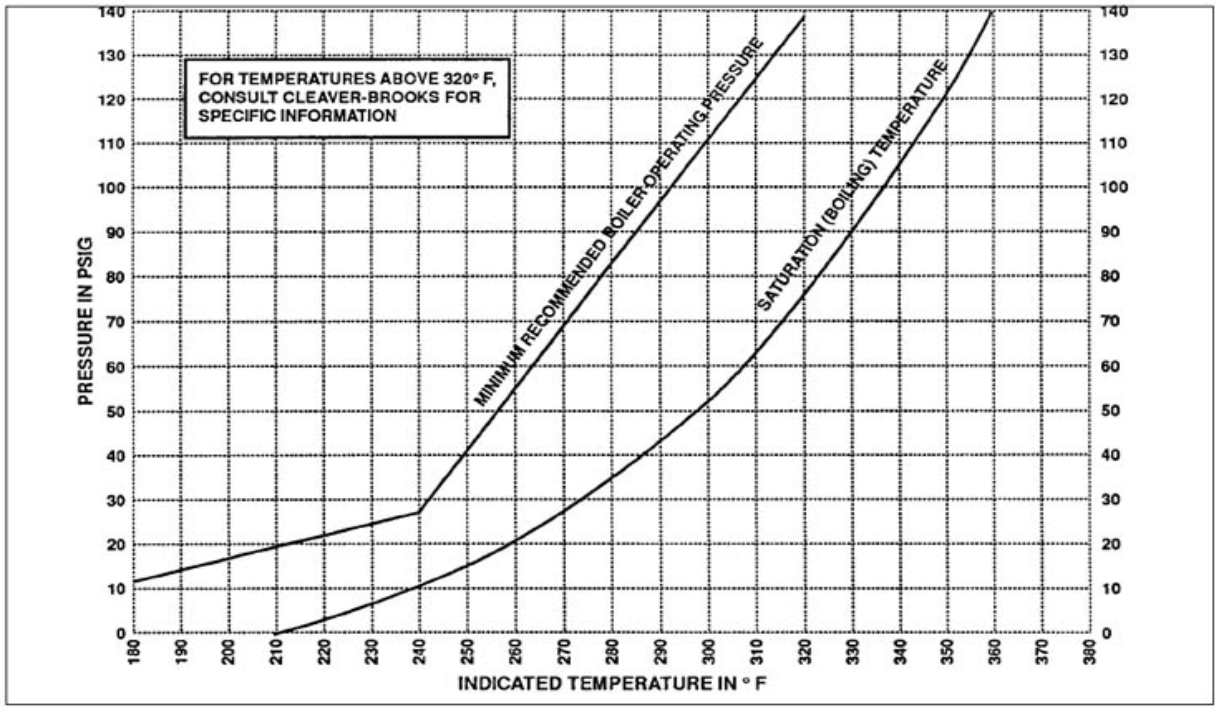


FIGURE 3-3. Internal Boiler Pressure

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 Boiler

3.2.2.1 — 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 or installed, it must be established that the valves are open and seated 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.

3.2.2.2 — Water Feeder (optional) Operation

Water feeder operation is usually applicable to boilers operating at 15 psi steam or less. It is only necessary to open the water supply line valve and the water feeder discharge valve.

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 condition 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

4WI				
	Steam		Hot Water	
	Lbs.	Gal.	Lbs.	Gal.
100	5867	703.5	6888	825.9
125	7310	876.5	8569	1027.4
150	7625	914.3	8857	1062.0
200	9996	1198.6	11590	1389.7
250	12587	1509.2	14746	1768.1
300	14848	1780.3	17368	2082.5
350	16025	1921.5	19212	2303.6
400	17953	2152.6	21507	2578.8
500	21053	2524.3	26251	3147.6
600	25352	3039.8	31571	3785.5
700	28700	3441.2	35878	4301.9
800	28700	3441.2	35878	4301.9

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 Chapter 8, Section 8-17 for valve installation instructions.)
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 120º 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 180º 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.

3.7.1.1 — 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. The valves and necessary piping are not normally furnished with the boiler. but supplied by others. All piping must be routed to a safe point of discharge. Piping must be properly supported and fee to expand.

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

If a quick opening valve and globe type of 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.

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 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 blowoff valve be left open and the operator should never leave until the blowdown operation is completed and the valves are closed.

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.

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

> **NOTE:** The make or model of the program relay provided will vary depending upon job specifications. The following sequence applies regardless of the make or model. Please refer to the Wiring Diagram (WD) prepared by Cleaver-Brooks for your specific installation.

The 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.
- The load demand light glows.
- 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 heater relay (if provided).

  d. Oil pump motor starter (if provided).

Chapters 6 and 7 contain operating instructions and specific information on setting and adjusting the controls.

4.2 — Circuit and Interlock Controls

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

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

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

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) • Gas-oil selector switch (GOS) - combination burner only • Oil drawer switch (ODS) - oil burner • Low oil temperature switch (LOTS) - Nos. 5 and 5 oil only • Low gas pressure switch (LGPS) • High gas pressure switch (HGPS) • LE Proximity switch interlock • 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)
Low Fire Proving Circuit	• Low fire switch (LFS)
Pilot Ignition Circuit	• Gas pilot valve (GPV) • Ignition transformer (IT) • Gas pilot vent valve (GPVV) - if provided

Circuit	Components/Controls
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)
Firing Rate Circuit	• Damper motor transformer (DMT) • Modulating damper motor (MDM) • Manual-automatic switch (MAS) • Manual flame control (MFC) • Modulating control (MC)
High Fire Proving Circuit	• High fire switch (HFS)

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

4.3 — 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 (PR) input terminals and with all other operating conditions satisfied.

4.3.1 — 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. The air purge valve (APV) (Nos. 5 and 6 oil only) remains de-energized.

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

On certain boilers the circuitry will include a high fire switch (HFS). The purpose of the switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle. In this instance, the "high fire proving circuit" is utilized.

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

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

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

4.3.2 — 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 lame is sensed at this time.

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

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

The pilot flame must be established and proven by the flame detector (FD) within a 10 second period in order for the ignition cycle to continue. If for any reason this does not happen, the system will shut down and safety 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 4.4) 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, and 15 seconds for heavy oil. 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.

4.3.3 — Run Cycle

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

With the manual-automatic switch (MAS) set at automatic, subsequent modulated firing will be at the command of the modulating control (MC), which governs the position of the modulating damper motor (MDM). The air damper and fuel valves are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

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.

4.3.4 — Burner Shutdown: Post-Purge

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

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

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

On a No. 6 oil burner, the air purge valve (APV) is powered from the blower motor start circuit via the contacts of the air purge relay (APR) to provide an air purge of the oil nozzle. The damper motor returns to the low-fire position if it is not already in that position.

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 not 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.

4.4 — Flame Loss Sequence

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

The control will prevent startup or ignition if limit circuit controls or fuel valve interlocks are open. The control will lockout 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.
2. **The Blower Motor Will be De-energized:** The lockout switch must be manually reset before operation can be resumed.
3. **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.
4. **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.

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

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

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 all linkage for full and free movement of the damper and metering valves and cams. The check can be done by loosening the linkage at the damper motor connecting arm and manipulating the linkage by hand.

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.

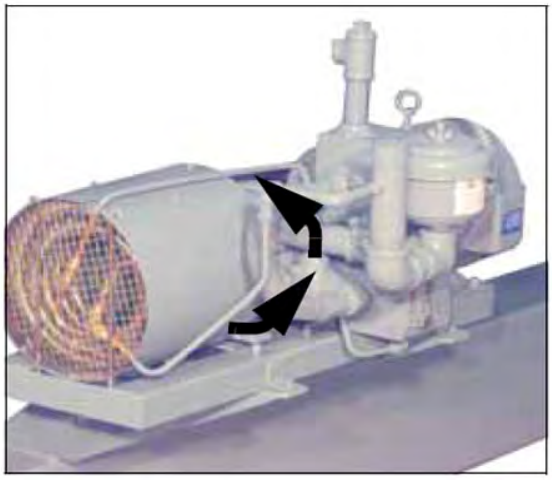


FIGURE 5-1. Air Compressor Motor Rotation

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 10% 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.

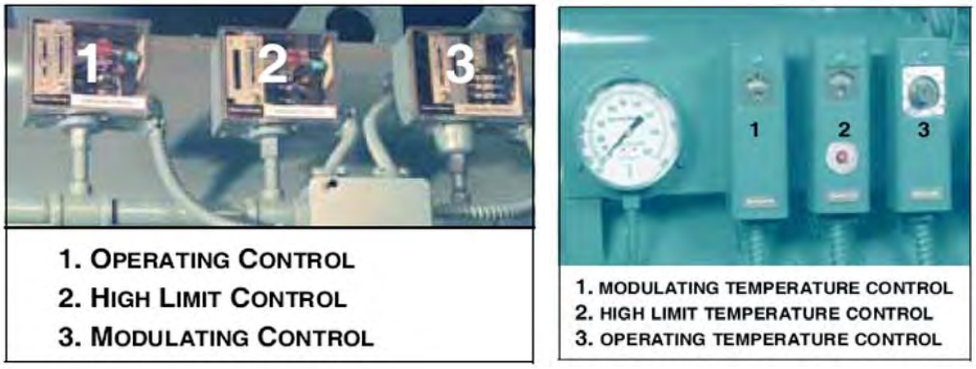


FIGURE 5-2. Steam Controls and Hot Water Controls

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 5º F to 10º F above the operating limit temperature control setting but within the limits of the design pressure of the pressure vessel.

   Inspect the modulating control for proper setting.

> **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 setting son 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.

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

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

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

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

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

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.

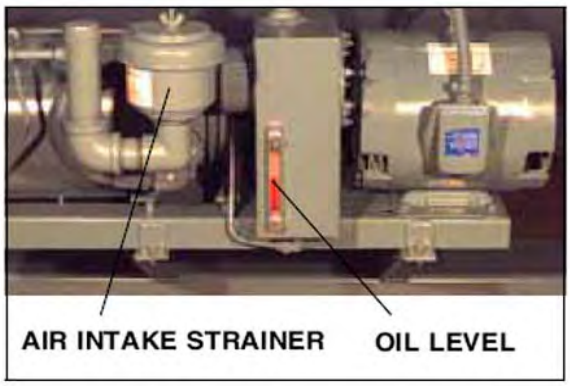


FIGURE 5-3. Atomizing Air Pump

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.

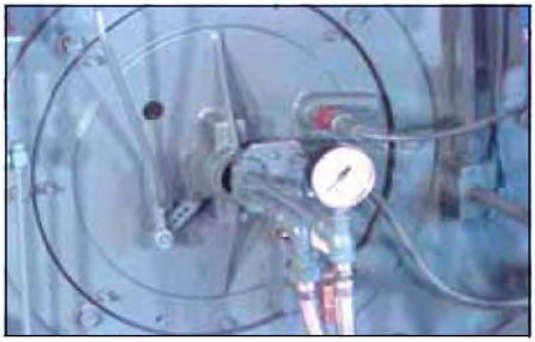


FIGURE 5-4. Burner Drawer with Air Pressure Gauge

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 tube 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 5-5. 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.

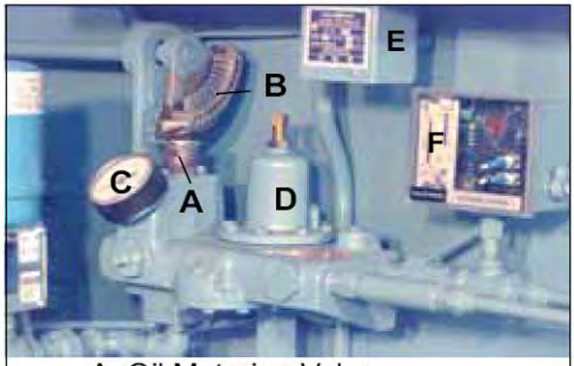
A standard equipped boiler has a selector switch incorporated in the oil pump motor starter. Momentarily energize the starter to check for proper pump rotation. With the rotation verified, operate the pump to determine that oil circulation exists. Observe the oil burner pressure gauge for indication 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 5-6. 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.



A. Oil Metering Valve
B. Oil Modulating Cam
C. Oil Burner Pressure Gauge
D. Oil Pressure Regulator
E. Atomizing Air Proving Switch
F. Low Oil Pressure Switch

FIGURE 5-7. Fuel Oil Controller

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.

Final regulation of oil flow to the nozzle can be done later, if necessary, by adjusting the metering cam screws as outlined in Chapter 6.

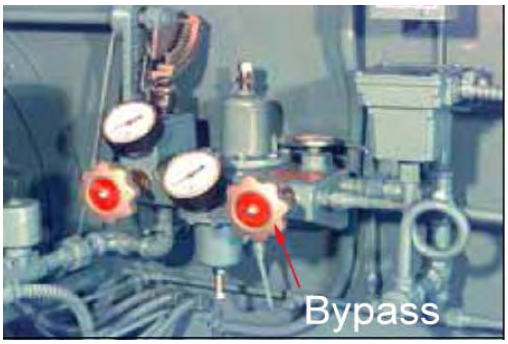
When all the conditions covered above and in Sections 5.1, 5.2, 5.3, 5.4, and 5.5 are assured, the burner is ready for firing. Refer to Section 5.8 for further starting and operating information.

5.6 — Firing Preparation for No. 6 Oil (Series 400-600)

Prior to initial firing, oil flow, pressure and temperature 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 boiler is a combination fuel model, be certain that the main gas shutoff cock is closed and set the gas/oil selector to "oil." Insert the burner drawer gun into its most forward position and latch it in place, depressing the oil drawer switch.

5.6.1 — Oil Flow



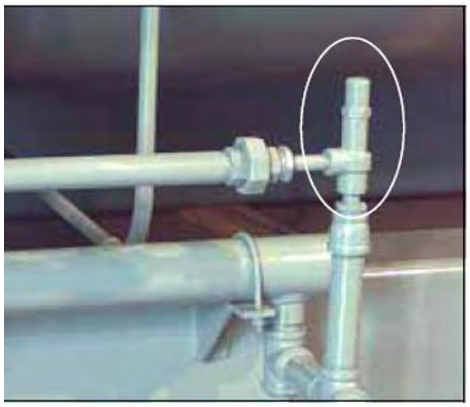
Open all valves in the oil suction and oil return lines. Open the bypass valve on the fuel oil controller until oil flow is established. Normally, the orifice valve is left in a closed position. However, on cold starts, it may be opened for brief periods to aid in establishing oil flow. The bypass and orifice valves must be returned to their closed positions as soon as oil flow is established as indicated by a reading on the oil supply pressure gauge. Do not attempt to set pressures while valves are open.

FIGURE 5-8. Heavy Oil Controller

Momentarily energize the fuel oil pump starter to check for proper pump rotation. With the rotation verified, prime the suction line strainer with oil and turn the fuel oil pump switch to the "on" position. Check the oil supply pressure gauge for indication that oil flow is established. If no pressure shows on the gauge after a few moments, stop the oil pump and re-prime. Heavy oil in the storage tank must be at a temperature to provide oil viscosity to permit flow through the oil pump and suction line. If oil flow is not established after several attempts, the conditions preventing oil flow must be determined and corrected to avoid damage to the pump's internal mechanism.

A vacuum gauge should be installed in the oil suction line and its reading observed and recorded for future guidance.

5.6.2 — Oil Pressure



Oil pressure is regulated at several points. The first is at the relief valve at the oil heater. The relief valve should be set so that at maximum firing rate a minimum reading of 75 psi is obtained on the oil supply pressure gauge.

The other pressure adjustments are to the regulators on the fuel oil controller. Both the pressure regulating and the back pressure relief valves are 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 adjustments can be made. Without the air supply, adjust the fuel oil pressure regulator so that the burner oil gauge registers approximately 35 psi. Adjust the back pressure relief valve so that its gauge reads about 10 psi less than the burner gauge.

FIGURE 5-9. Heavy Oil Pressure Relief Valve

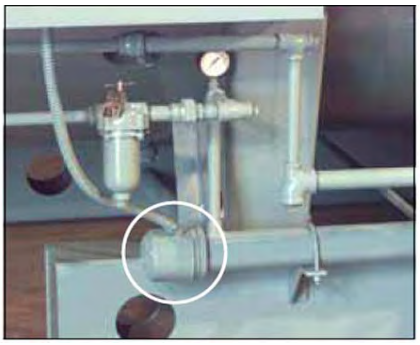
After the burner is firing, further adjustments can be made to the valves, if necessary.

The pressure gauges will indicate higher readings when a flame is present. The pressure will increase as the firing rate increases. The pressure reading on the two gauges on the controller will, despite the fluctuation, retain a nearly constant difference of 10 psi.

Final regulation of oil flow to the nozzle can be done, if necessary, by adjusting the metering cam screws as outlined in Chapter 6.

5.6.3 — Oil Temperature

After determining that the heater shell is filled and that fuel oil circulation exists, turn the oil heater switch to "on." Adjust the electric oil heater thermostat to maintain oil temperature at approximately 200º F.



The electric heater on burners equipped for No. 6 fuel oil is sized so that it is capable of supplying heated oil at a rate no greater than that required for low-fire operation and is primarily supplied for convenience on cold starts. Heating coils utilizing either steam or hot water are supplied to provide sufficient heat so that higher rates of firing can be accomplished once steam or hot water is available. In normal operation, the thermostat governing the electric heating element is kept at a lower setting than the thermostat governing admission of steam to the heater, or of hot water, so that heating is not performed electrically except when steam or hot water is not available.

FIGURE 5-10. Electric Module (Heavy Oil Heater)

⚠ Caution

Before turning on the electric oil heater switch, be certain that the heater shell is filled with fuel oil and the flow is established. Failure to follow these instructions could result in equipment damage.

Set the steam thermostat or the hot water thermostat to maintain an oil temperature of 220º - 230º F. The electric heater will be turned off as soon as steam or hot water provides heat.

Close the manual bypass valve after the temperature rise on the fuel oil controller thermometer is noted. Be certain that hot oil is moving through the controller. The orifice gate valve must also be closed. If the temperature drops, open the orifice gate valve until a rise is noted, then close it.

Once the correct setting of the heater thermostats has been established, set the low oil temperature switch at approximately 30º F lower than the normal burning temperature. If the system is equipped with a high oil temperature switch, it should be set to open at 20º - 30º F higher than normal burning temperature.

NOTE: The temperatures listed are tentative. The composition of the fuel oil in a given grade can vary, necessitating a higher or lower preheating temperature. The viscosity of the oil at the nozzle should be between 55 and 100 SSU, approximately. The actual temperature of the oil at the burner should be determined by flame appearance and good combustion based on a stack analysis.

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

5.7 — Firing Preparations for Gas (Series 200-400-700)

- 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.

FIGURE 5-11. **Oil Gun in the Lock-Out Position**

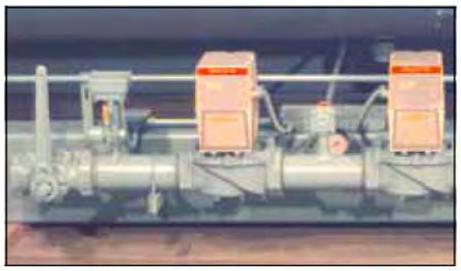
- If the burner is a combination fuel model, set the gas/oil switch to "gas." Withdraw the oil burner gun and latch it in its rearward (lock-out) position.
- On initial startup, it is recommended that the main gas shutoff cock remains closed until the programmer has cycled through pre-purge and pilot 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.

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 alter the system or to take any action that might circumvent the 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 5-12. 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 in Section 5.7 and in Sections 5.1, 5.2, and 5.3 are assured, the burner is ready for firing. Refer to Section 5.8 for further starting and operating information.

5.8 — Induced Flue Gas Recirculation (IFGR) Setup

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

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

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

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

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

4. Start and warm the boiler as described in this manual.
5. Adjust the boiler components as described in this manual to achieve proper boiler operation.

Refer to Chapter 8, Section 8.13 for instructions on cassette removal and installation.

5.9 — 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.

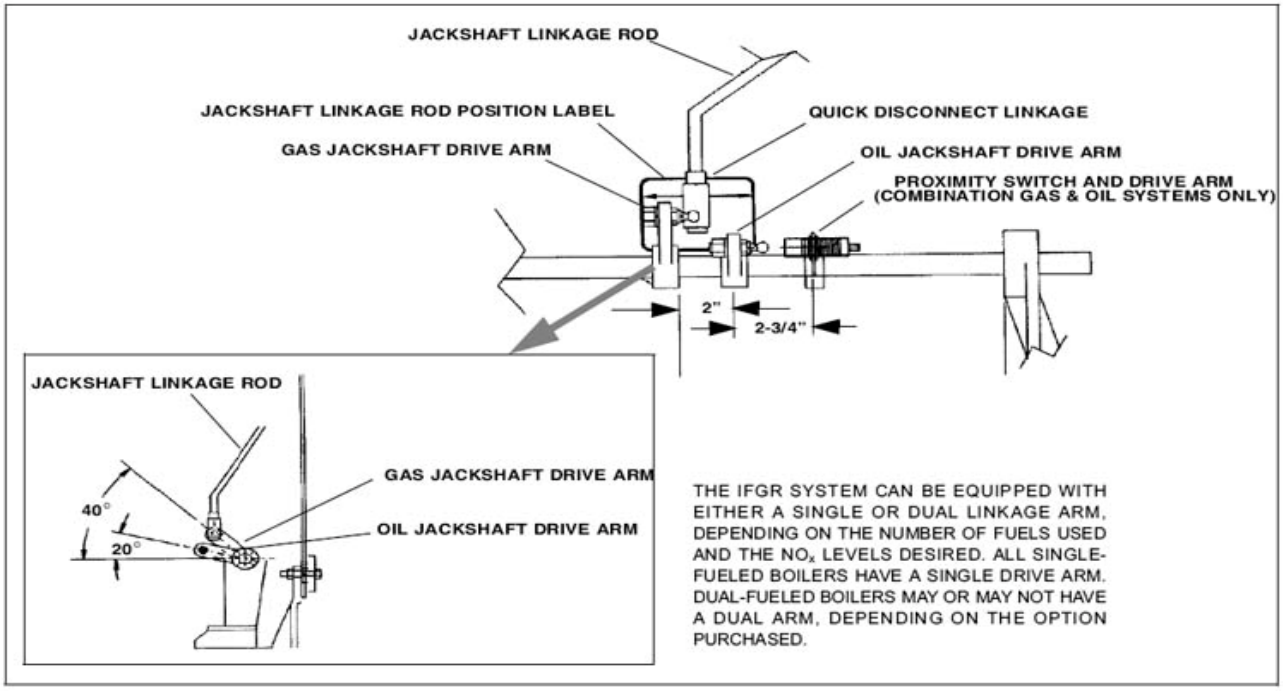


FIGURE 5-13. Jackshaft Linkage Settings

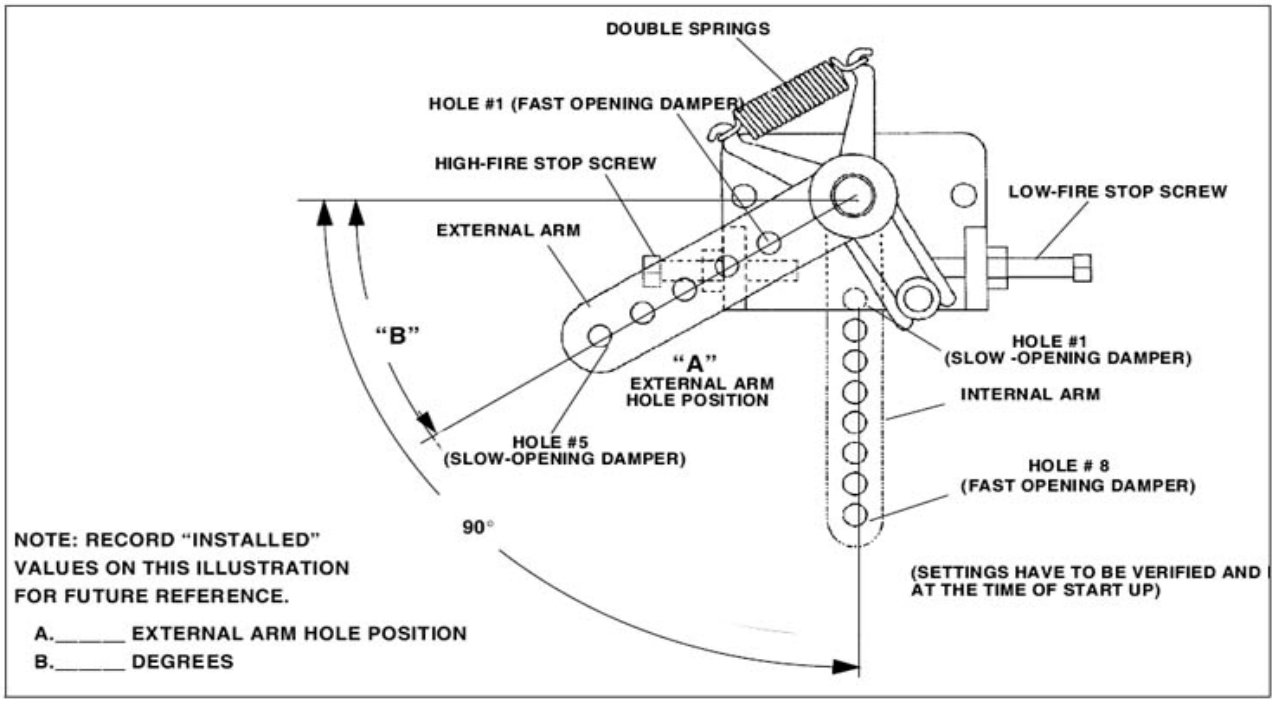


FIGURE 5-14. Overtravel Linkage Settings

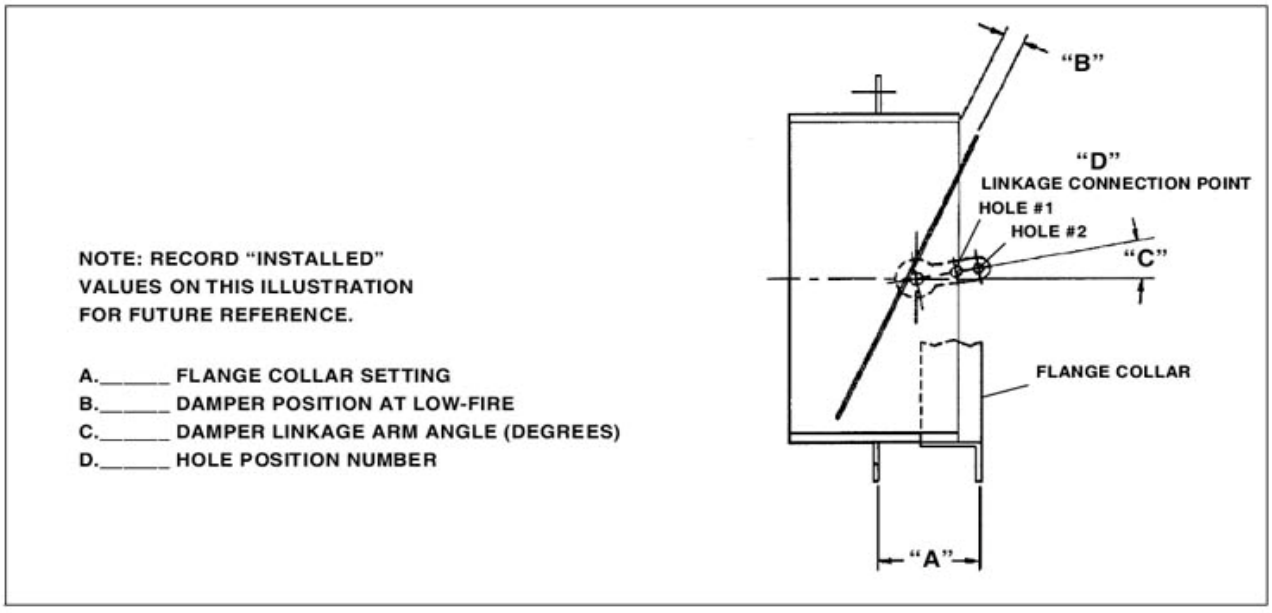


FIGURE 5-15. Flange Collar and Damper Settings (Top View)

Set the manual-automatic switch to "Manual" and turn the manual flame control to "Close."

Turn the burner switch to "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. See Chapter 4 for sequence details.

⚠ 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 hen 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.

5.9.1 — Operating

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

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

The burner will continue to operate 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 no longer glows.

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. Refer to the "troubleshooting" section in Chapter 7.

5.9.2 — 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. See 5.10 — Control Operational Test and Checks

5.10 — Control Operational Test and Checks

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

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

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

Refer to the adjustment procedures and maintenance instructions given in Chapters 6 and 8.

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 the various grades of oil.

In order to reduce stress on boiler components and to improve boiler operating efficiency, burners have been designed for enhanced fuel turndown capabilities. A burner is equipped to fire light oil (Series 100), heavy oil (Series 600), or gas (Series 700), or both, Series 200 (for light oil and gas), and Series 400 (for heavy oil and gas). Air and fuel inlets, the diffuser, and the air damper control linkage have been modified for these burners.

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

NOTE: Observe that proper air damper linkage and fuel metering adjustment procedures are followed for standard (Series 400 or 600) or HTB (Series 100, 200, or 700) burners to avoid damage to the equipment. The burner series is identified on the boiler data plate affixed to the front head of the boiler.

For example: 4WI (model), 700 (fuel), 250 (HP), 150 (pressure)

6.2 — Linkage: Modulating Motor and Air Damper

The linkage consists of various arms, connecting rods, and swivel ball joints that transmit motion from the modulating motor to the oil metering cam(s), to the rotary air damper, and to the gas butterfly valve, if used.

When properly adjusted, a coordinated movement of the air damper and metering cams within the limits of the modulating motor travel is attained to provide proper fuel-air ratios through the firing range.

In linkage adjustments there are several important factors that must serve as guides:

1. The modulating motor must be able to complete its full travel range.
2. Initial adjustment should be made with the motor in full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.
3. The closer the connector is to the drive shaft, the less the arm will travel — the closer the connector is to the driven shaft, the farther that arm will travel.

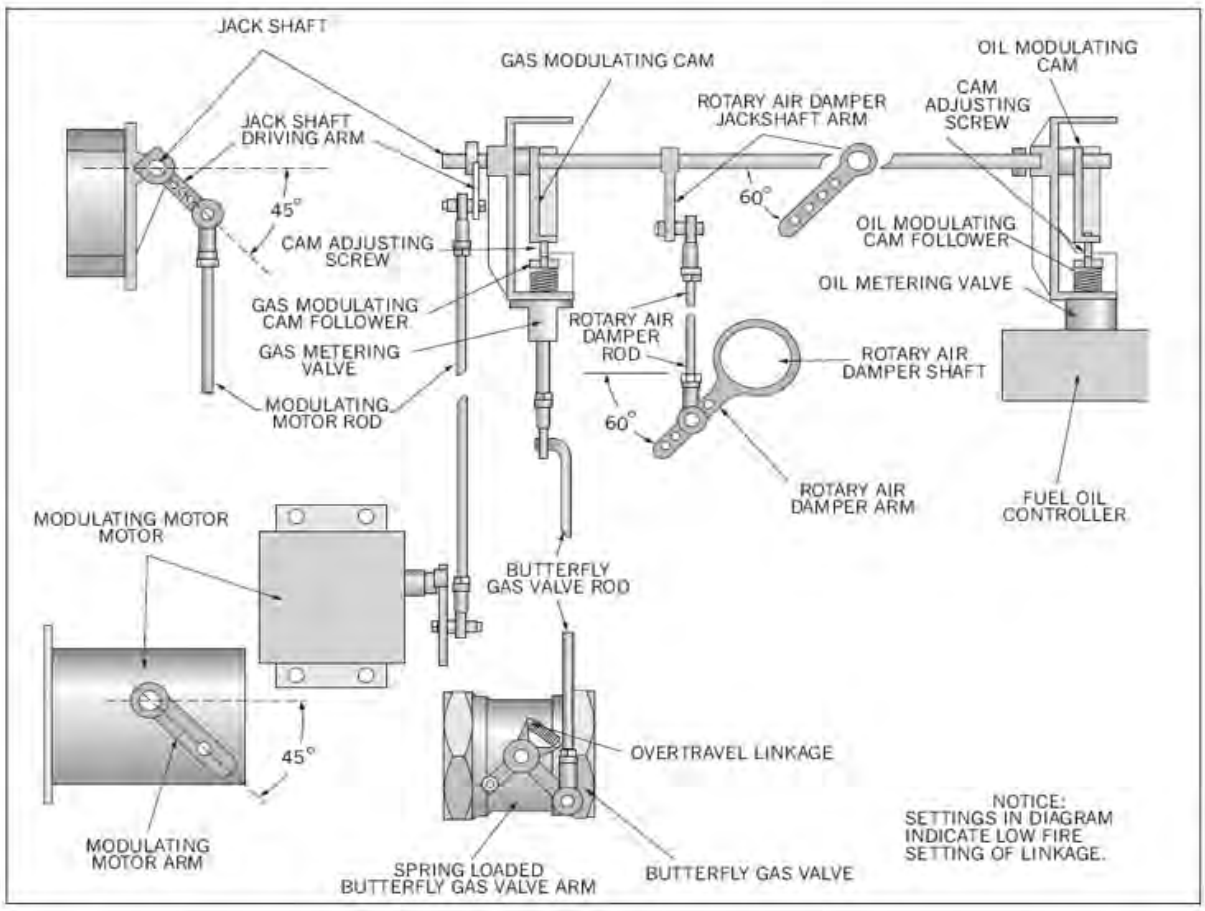


FIGURE 6-1. Complete Linkage Assembly: Combination Gas and Oil

4. Overtravel linkage, where used, should not be required to extend its spring to the fullest stretch.

5. With the modulating motor in the low fire position, the arm on its shaft should be at an angle of 45º below the horizontal. The driven arm on the jackshaft should also be 45º below horizontal. Secure both arms and fit the connecting linkage rod in place between them.
6. Position the oil and/or gas modulating cams on the jackshaft so that the cam follower assembly is between the first and second cam adjusting screws. In this position, fuel delivery is at low-fire rate. Tighten the setscrews to secure the cams on the jackshaft.

⚠ Caution

Do not restrict the full travel of the modulating motor. Failure to follow these instructions could result in equipment damage.

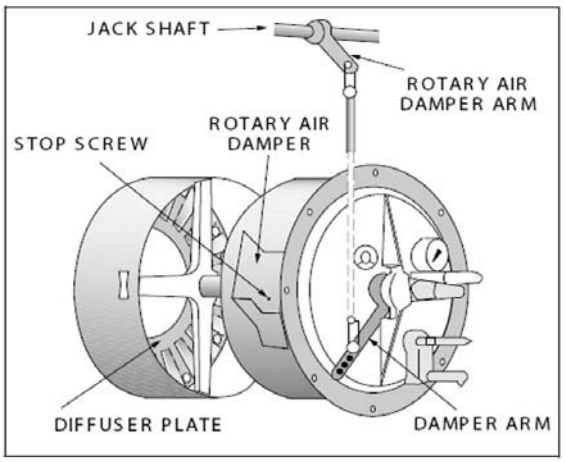


FIGURE 6-2. Rotary Air Damper

7. The stop screw in the rotary air damper limits damper travel at both closed (low-fire) and fully opened (high fire) positions. The screw is provided so that it is possible to tell, even with the burner in place, whether the damper rotor is in fully opened or closed position. Rotating the damper clockwise to the stopscrew closes the damper. Rotating the damper counterclockwise to the stopscrew opens the damper. Normally, the rate of flow of air through the damper with the rotor in low-fire position is about one-third of maximum for a standard burner or one-sixth for a HTB.
8. The amount of angular movement controlling the rate of air flow is determined by the location of the ends of the rotary air damper rod in both the jackshaft arm and the air damper arm. When the air damper is in low-fire position, the jackshaft arm should be at 45º (47-1/2º for HTB) and the rotary air damper arm should be at an angle of approximately 60º below the horizontal. This will ensure that the angular movement of the damper starts slowly, increasing in rate as the high-fire position is approached.
9. Prior to initially firing a boiler, it is advisable to check for free movement of the linkage. The damper motor must be allowed to complete its full stroke and the damper must move freely from low- to high-fire position. Adjustment of linkage connected to a gas butterfly valve is described in Section 6.17.

6.3 — Modulating Motor

FIGURE 6-3. Modulating Motor

The modulating motor has a 90º shaft rotation. The motor manufacturer also provides a 160º stroke model for other applications. If a replacement is obtained from someone other than a Cleaver-Brooks Service or Parts representative, it may have an incorrect stroke. To prevent damage, determine the 90º stroke prior to installing a replacement.

The stroke may be determined by powering the motor and connecting terminal R-B to actually determine the stroke as the motor drives to an open position.

6.4 — Modulating Motor Switches: Low-Fire and High-Fire

The modulating motor contains either one or two internal switches depending upon application. The microswitches are actuated by adjustable cams attached to the motor shaft.

Factory replacement motors have the cams preset. The low-fire start switch is set to make the red and yellow leads at approximately 8º on motor closing. The high-fire purge air proving switch (located in the modulating motor) is set to make red and blue tracer leads at approximately 60º on motor opening. Normally, the settings are left as is, but job conditions may require readjustment. If the cams require adjustment or resetting, follow the instructions in the manufacturer's technical manual.

6.5 — Burner Operating Controls: General

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

The standard boiler operating control package consists of three separate controls:

- Operating Limit Control
- High Limit Control
- Modulating Control

1. **Operating Limit Control:** Senses temperature or pressure 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 hot water temperature or steam pressure. 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

FIGURE 6-4. Steam Operating Controls

3. **Modulating Control:** Senses changes in the hot water temperature or steam pressure and signals the modulating motor to control the flow of fuel and air to the burner. With either steam or hot water boilers, the modulating control must be set to ensure the burner is at its minimum low-fire position before the operating limit control either starts or stops the burner.

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.

FIGURE 6-5. Hot Water 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.

Separate and independent controls affect modulated firing and burner on-off cycling. The Firing Graph 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.

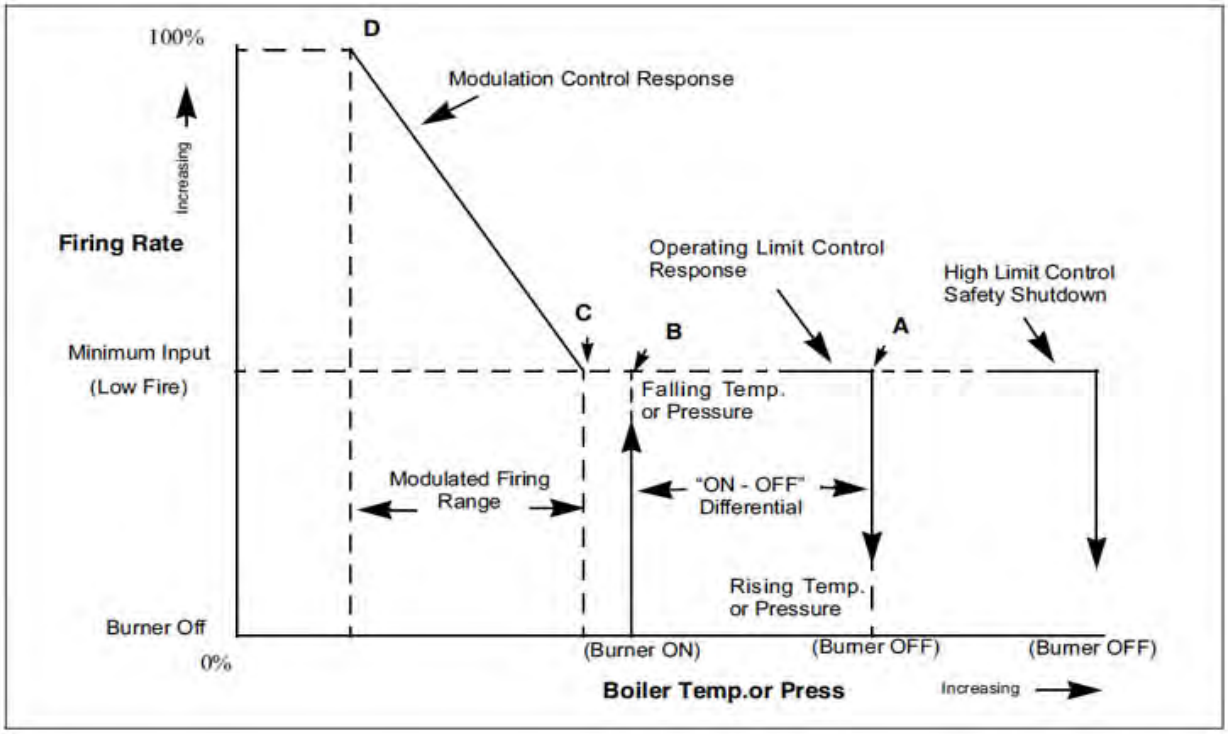


FIGURE 6-6. Firing Graph

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 modulating control will signal the modulating motor to be in a low-fire position. If the load demands exceed the low-fire input potential, the modulating control will increase the firing rate proportionately as pressure or temperature falls toward point **D**. The modulating motor will stop at any intermediate point between **C** and **D** whenever the fuel input balances the load requirement.

As the load requirement changes, the firing rate will change accordingly. This 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.

When firing a cold boiler, it is recommended that the burner be kept at low-fire, under manual flame control, until normal operating pressure or temperature is reached. If the burner is not under manual control on a cold start, it will immediately move toward high-fire as soon as the program control releases the circuit that holds the burner in low-fire. The modulating control will be calling for high-fire and the burner will move to that position as rapidly as the damper motor can complete its travel.

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 substatially 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 modulating control range and operating control range.

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

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

When the modulating control is set and the burner is in full high-fire, the scale setting of the modulating pressure control on a steam boiler will indicate the low point of the modulating range. The scale setting of the modulating temperature control on a hot water boiler will have a reading that indicates the midpoint of the modulating range.

The operating limit control should now be adjusted and the differential established. In an installation that does not require a very close control of steam pressure or water temperature the adjustable differential (**A** to **B**) should be set as wide as conditions permit, since a wide setting will provide less frequent burner cycling.

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

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 motor to travel from low- to high-fire. The time lag may allow pressure or temperature to drop below desirable limits.

6.6 — Modulating Pressure Control: Steam

Turn the adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between the low point and a higher point equal to the modulating range of the particular control. In 0-15 psi controls the range is 1/2 lb; in 5-150 psi controls the range is 5 lbs; in 10-300 psi controls the range is 12 lbs.

FIGURE 6-7. Modulating Pressure Control

⚠ Caution

To prevent burner shutdown at other than low-fire setting, adjust the modulating pressure control to modulate to low-fire before the operating limit pressure control shuts off the burner. Failure to follow these instructions could result in damage to the equipment.

6.7 — Operating Limit Pressure Control: Steam

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

6.8 — High Limit Pressure Control: Steam

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 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.

6.9 — Modulating Temperature Control: Hot Water

FIGURE 6-8. Hot Water Controls

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

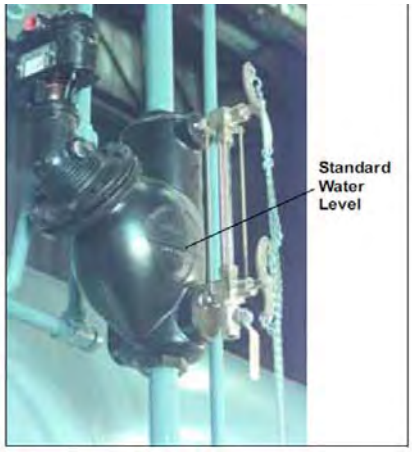
6.10 — High Limit Temperature Control: Hot Water

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 240º 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.

6.11 — 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. The differential is adjusted from 5º to 30º F.

6.12 — Low Water Cutoff Devices: Steam and Hot Water



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

FIGURE 6-9. Low Water Cutoff

6.13 — 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 6-10. 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.

6.14 — 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 6-11. 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.

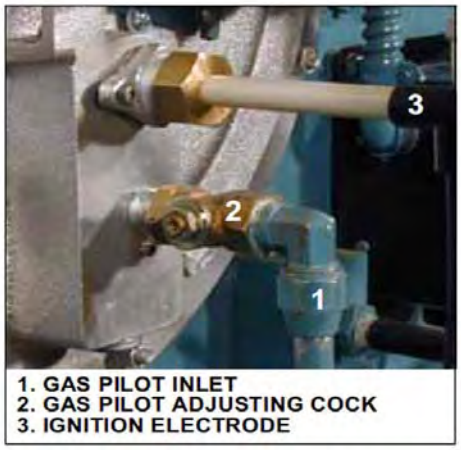
NOTE: On a combination fuel fired burner, firing gas, the fuel selector switch could be set at "gas" to eliminate the atomizing air proving switch from the circuitry.

6.15 — 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 or the Hawk ICS manual 750-197.



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" and the program control to "close." Open both the pilot cut-off 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.

FIGURE 6-12. Gas Pilot Adjusting Cock and Electrode

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 program switch 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 10 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 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.

6.16 — 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.

6.16.1 — 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 Net Regulated Gas Pressure for Rated Boiler Output

Boiler HP	Std. Pipe Size (inches)	Pressure Required (WC)
100	2	7.3
125	2-1/2	12
150	2-1/2	10.5

TABLE 6-1. Minimum Net Regulated Gas Pressure for Rated Boiler Output

Boiler HP	Std. Pipe Size (inches)	Pressure Required (WC)
200	2-1/2	19
250	3	23
300	3	32.5
350	3	48.5
400	3	60
500	4	43
600	4	56
700	4	62
800	4	83

The pressure 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.

TABLE 6-3. 4-Pass Wetback Boilers with Integral Burner (4WI) Firing Rates

	Natural Gas, 1000 Btu/hr		No. 2 Oil, GPM	
Boiler HP	**Low-Fire**	**High-Fire**	**Low-Fire**	**High-Fire**
100	1021	4082	7.3	29.2
125	1276	5103	9.1	36.4
150	1531	6124	10.9	43.7
200	2041	8165	14.6	58.3
250	1021	10206	9.1	72.9
300	1225	12247	10.9	87.5
350	1428	14280	12.8	102.1
400	1633	16329	14.6	116.6
500	2042	20415	18.2	145.8
600	2449	24494	21.9	175.0
700	2858	28576	25.5	204.1
750	3062	30617	27.3	218.7
800	3266	32659	29.2	233.3
NOTE: Fuel input rates are based on nominal 82% efficiency. No. 2 Oil = 140,000 Btu/gal.				

6.16.2 — 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.

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

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

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

6.16.3 — Pressure Correction

The flow rate outlined in Section 6.17 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 6.4.

TABLE 6-4. 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.

Btu/hr input = CFH (Cubic feet/hour)
Btu/cu. ft.

or

25,100,000 = 25,100 CFH (at 14.7 lb, atmospheric base 1,000 pressure)

then

25,100 = 21,271 CFH
1.18

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.

6.16.4 — 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.

Final adjustment of the gas fuel is carried out by means of the adjusting screws in the gas modulating cam, while performing a combustion efficiency analysis. See Section 6.18 for details.

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.

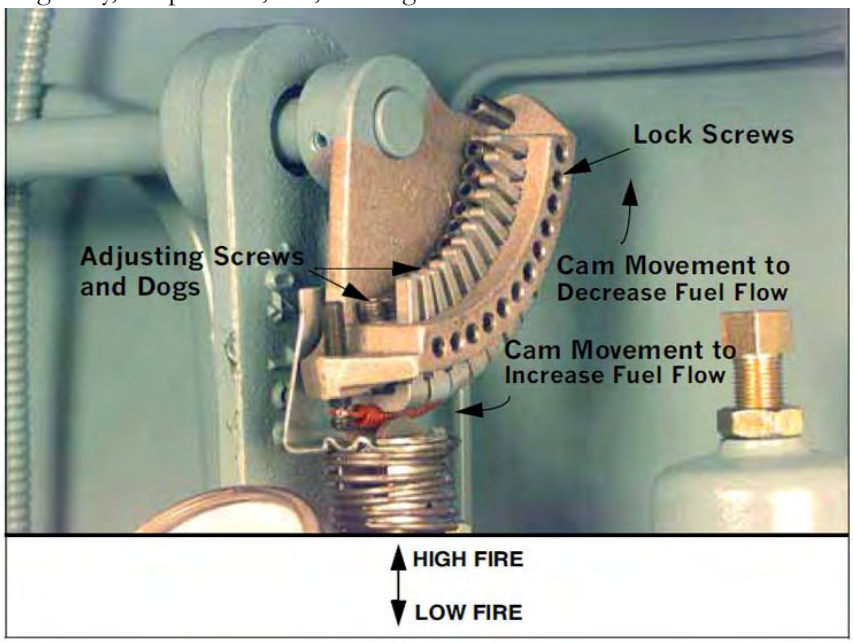


FIGURE 6-13. Fuel Modulating Cam

6.17 — Gas Fuel Combustion Adjustment

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

Burner efficiency is measured by the amount or percentage of O_2 present in the flue gas. O_2 readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion is a term used to describe a condition when there is the exact amount, molecule for molecule, of air for the fuel burned. This can be accomplished under laboratory conditions, however, it's not practical to attempt to meet this condition in a boiler. Stoichiometric combustion, however, is the reference point used when setting fuel/air ratios in a boiler.

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

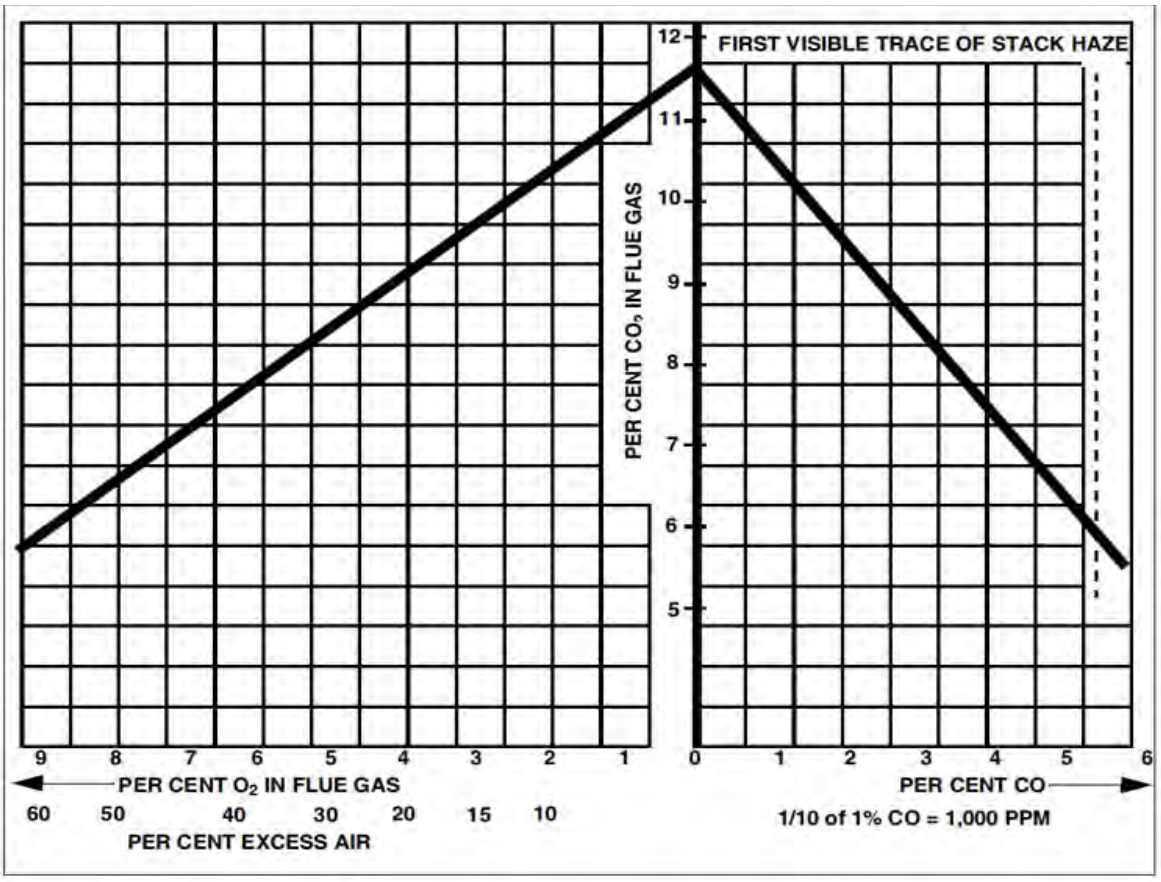


FIGURE 6-14. Flue Gas Analysis Chart for Natural Gas

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion or flue gas analyzer. The appearance or color of the gas flame is not an indication of its efficiency, because an efficient gas flame will vary from transparent blue to translucent yellow.

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

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

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding, Figure 6-14 shows the relationship between O_2 levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

One of the products of combustion is CO_2 (carbon dioxide). This is shown in percentage.

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

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

It is generally recommended that O_2 readings of between 3% to 4% be attained with less than 400 ppm CO at high-fire.

Using information from Section 6.16, determine the standard conditions of gas pressure and flow for the size boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.

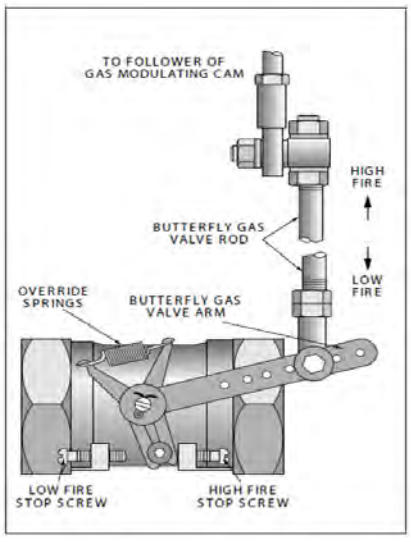


FIGURE 6-15. Butterfly Gas Valve

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

In initially setting the linkage, back off the low-fire stopscrew on the butterfly valve so that the valve is closed. Then run the screw out to touch the arm, and give it two complete turns. Adjust the connecting rod so that the override tension is released and so that the arm is now just touching the stopscrew. Tighten the locknuts on all ball joints.

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

To reach the high-fire rate, turn the manual flame control switch toward "Open" in minor increments while monitoring combustion for overly rich or lean conditions.

At high-fire, the gas butterfly valve should be wide open as indicated by the slot on the end of the shaft. Set and lock the high-fire stopscrew so that it is just touching the valve arm.

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

When proper gas flow is obtained, take a flue gas reading. The O_2 should be between 3% and 4% at high-fire.

If the fuel input is correct, but the O_2 values do not fall within this range, the air damper travel may need to be adjusted. Adjustment of the air damper linkage is described in Section 6.2.

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

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

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

NOTE: Do not use any lubricant on the adjusting setscrews. The setscrews have a nylon locking insert intended to provide locking torque and resistance to loosening and a lubricant could cause damage.

Using the manual flame control switch, position the cam so that the adjusting screw adjacent to the end or high-fire screw contacts the cam follower. Perform a combustion analysis at this point. If an adjustment is necessary, turn the adjustment screw accordingly to increase or decrease fuel flow. Take a combustion reading. Repeat as necessary until the desired results are obtained. Repeat the process, stopping at each adjusting screw, until the low-fire adjusting screw is reached.

6.17.1 — Burner Low-Fire Adjustment

The fuel input should be adjusted using the low-fire cam screw, to approximately 25% (100-200 HP) or 10% (250-800 HP) of that at high-fire. At low-fire the O_2 flue gas reading should be between 5-7%.

It may be necessary to readjust the setting of the low-fire stop screw in order to obtain the proper air/fuel ratio at low-fire. To ensure that the low-fire position of the gas butterfly valve is always the same, allow a half turn of the stopscrew for overtravel.

If the air damper must be reset to meet the low-fire air/fuel requirements, combustion at higher firing rates must be rechecked.

The second cam adjusting screw may need to be adjusted in order to maintain a smooth cam profile. If all screws are properly adjusted, none will deviate from the general overall contour of the cam face.

6.18 — Low-Gas-Pressure Switch

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

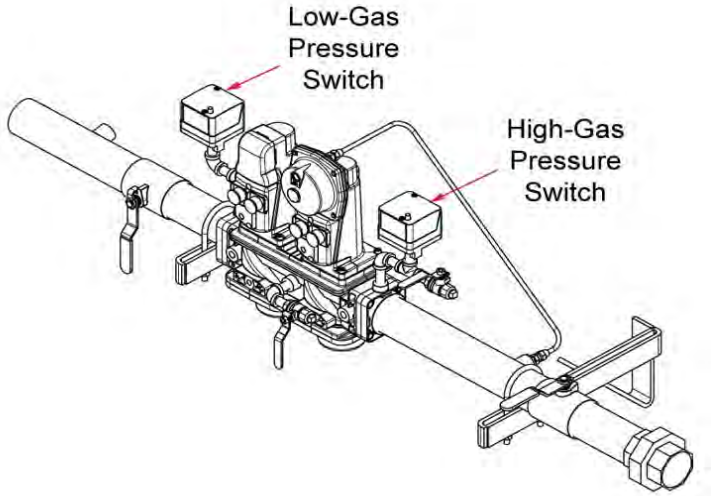


FIGURE 6-16. Gas Train Pressure Switches

6.19 — 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. Be sure that the mercury switch equipped control is level.

6.20 — Fuel Oil Pressure and Temperature: General

Variations in burning characteristics of the fuel oil may occasionally require adjustments to assure highest combustion efficiency. The handling and burning characteristics may vary from one delivery of oil to another. Therefore, it

is recommended that the oil system be inspected from time to time to verify that pressures and viscosity are at the proper operating levels.

Because of variation in oils, including chemical content, source, blends, and viscosity characteristics, the temperatures and pressures listed in Chapter 5, and mentioned in the adjusting of the controls in the subsequent paragraphs, will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. The oil viscosity chart (Figure 6-17) may be used as a guide, although your oil supplier will be able to give you more exact information based on an analysis of the oil.

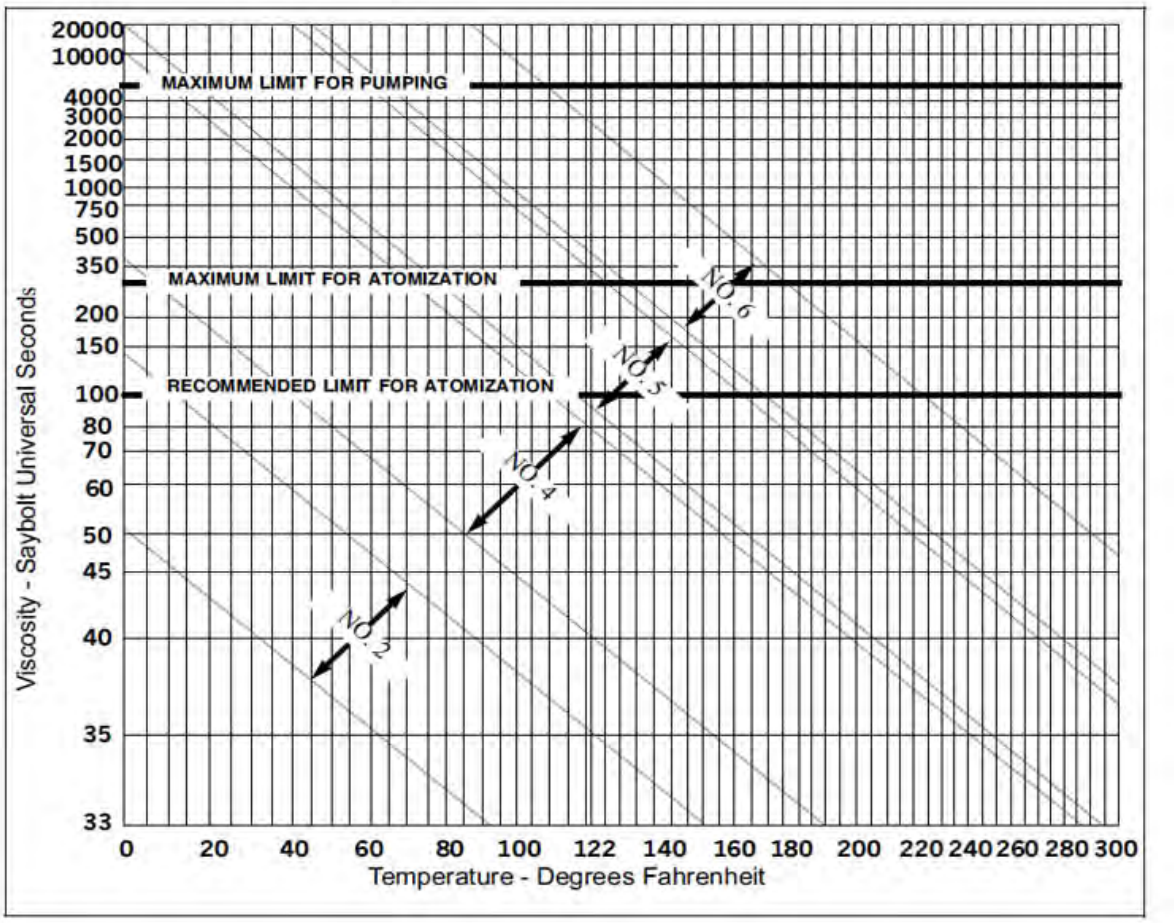


FIGURE 6-17. Oil Viscosity Chart

Review of the applicable maintenance instructions given in Chapter 8 will aid in maintaining an efficient fuel system.

NOTE: To prevent oil heater coking, the fuel oil pump must be in operation during all times that an oil heater is in service. During any time that the oil pump is not operating, the oil heating system must be electrically shut down by manually turning the oil heater switch to the "off" position.

When the boiler is shut down, or switched over to gas firing, the pump must operate for a sufficient period of time to cool the oil heater. Similarly, if an electric, steam, or hot water oil heater is removed for servicing, the temperature of the heater should be reduced by circulating oil until it has cooled.

6.21 — Fuel Oil Combustion Adjustment

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

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

It is required to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure, temperature, or burning properties of oil. 15% to 20% excess air is considered reasonable. This would result in an O_2 reading of 3% to 4% at high-fire.

Final adjustment to fuel input must be made to produce a minimum of smoke. A maximum smoke spot density of a No. 2 for light oil, or a No. 4 for heavy oil is acceptable, as measured in conformance to ASTMD 2156-63T.

Through the use of the manual flame control, slowly bring the unit to high-fire by stages while monitoring combustion for overly rich or lean conditions. At the high-fire position, the air damper should be fully opened and the air and oil pressure readings should be on the order of the readings given in Chapter 5.

Take a flue gas analysis reading. If necessary, adjust the fuel oil controller to increase or decrease oil pressure. Adjustments to the pressure should be done before attempting to adjust the screws in the metering cam. Ideally, the cam profile spring should be as close to the cam casting as practical. It is more desirable to lower the oil pressure to reduce flow, if necessary, than to extend the adjusting screws to an extreme position in an effort to cut back flow.

After being certain that the air control damper and its linkage are operating properly, final adjustment can be made, if necessary, to the oil modulating cam to obtain constant fuel/air ratios through the entire firing range.

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

If oil pressure, primary air pressure, and linkages are properly adjusted, the metering cam should require minimal adjustment.

Using the manual control switch, position the cam so that the adjusting screw adjacent to the end, high-fire screw, contacts the cam follower. Make a combustion analysis at this point.

If an adjustment is necessary, turn the cam adjustment screw accordingly to increase or decrease fuel flow. Take a combustion reading to verify input. Repeat as necessary until the desired flow is obtained. Continue this process, stopping at each adjusting screw, until the low-fire position is reached.

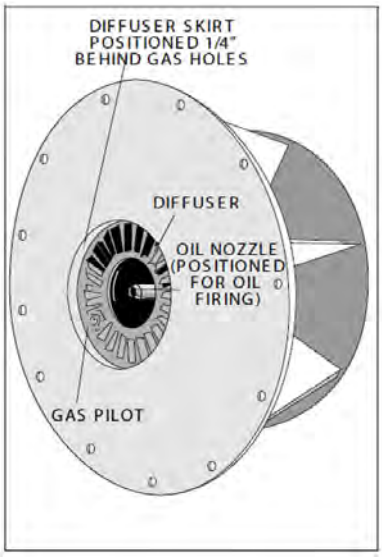
6.21.1 — Standard Burner Low-Fire Adjustment 100-200 HP

The fuel input should be adjusted with the low-fire cam screw to approximately 25% of that at high-fire. At low fire the O_2 flue gas reading should be between 5% and 7%.

6.21.2 — Burner Low-Fire Adjustment 250-800 HP

Fuel input at low-fire should be approximately 12.5% of that at high-fire. The low-fire screw should be adjusted to obtain the necessary input for the fuel turndown required. At low-fire the O_2 flue gas reading should be between 5% and 7%. The second cam adjusting screw may need to be adjusted in order to maintain a smooth cam profile.

6.22 — Burner Drawer Adjustment



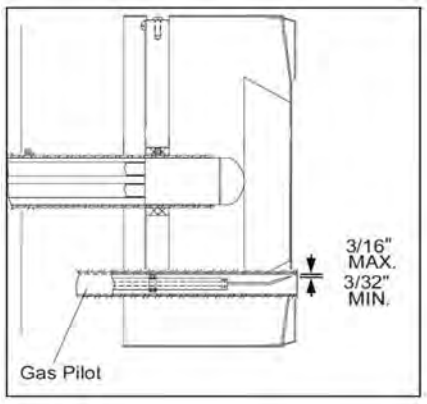
There are relatively few adjustments that can be made to the burner, however, a check should be made to assure that all components are properly located, and that all holding screws are properly tightened.

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 6-18. Burner Drawer in Burner Housing

Check the setting of the ignition electrode(s) for proper gap and position. See Figure 6-19 for the gas pilot electrode and Figure 6-20 for the light oil pilot. 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. See Chapter 8, Section 8.7 for additional nozzle tip information.

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

FIGURE 6-19. Gas Pilot Electrode

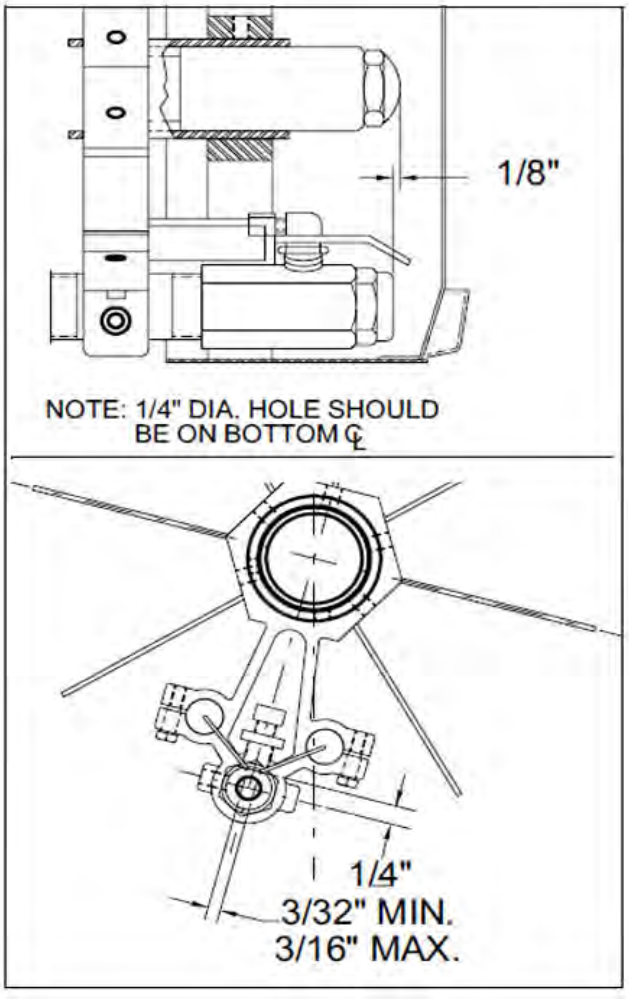


FIGURE 6-20. Light Oil Pilot Settings

6.23 — 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.

6.24 — Low-Oil-Temperature Switch: Heavy Oil

The LOTS prevents the burner from starting, or stops its operation, if the temperature of the oil is below normal operating temperature.

To adjust the control, insert a screwdriver into the center slot in the control cover and turn the dial until the fixed (center) pointer is approximately 30º F lower than the oil heater thermostat setting. Turn the differential adjusting screw (located above the dial) until the movable indicator is approximately 5º F above the setting on the main scale.

On a hot water boiler, the LOTS is an integral part of the electric oil heater. The switch is non-adjustable and is factory set at approximately 40º F below the maximum operating temperature of the heater.

6.25 — High-Oil-Temperature Switch: Optional

The HOTS prevents the burner from starting, or stops its operation, if the temperature of the oil exceeds the normal operating temperature.

To adjust, turn the dial until the pointer is approximately 25º F above the normal operating temperature. The controls generally have a set differential and will close 5º F below the setpoint.

6.26 — Low-Oil-Pressure Switch: Optional

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

6.27 — Electric Oil Heater Thermostat: 400 and 600 Series (Steam)

The maximum temperature setting of the control is stamped on the dial. The maximum temperature setting is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of this thermostat should be at a temperature approximately 15º F lower than the steam heater thermostat. This eliminates the electric heater operation when the steam heater is functioning. The electric heater is sized to provide sufficient heated oil for low-fire operation on cold starts before steam is available.

6.28 — Steam Oil Heater Thermostat: No. 6 Oil, 400 and 600 Series (Steam)

The maximum temperature setting of the control is stamped on the dial. The maximum temperature setting is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of the thermostat should provide oil at a sufficient temperature for efficient combustion based on flue gas analysis. There is no need to heat the oil in excess of the temperature required for proper flow.

6.29 — Hot Water Oil Heater Thermostat: 400 and 600 Series

To adjust the thermostat, insert a screwdriver into the center slot in the control cover and turn the dial until the pointer is at the desired temperature level. The control generally has a set differential, and will close 5º F below the setpoint.

The thermostat contacts close to energize the booster water pump, which pumps water from the boiler through the heater. On cold starts, it is normal practice to manually close the valve in the pump discharge line until the boiler water temperature exceeds the temperature of fuel oil entering the heater.

The electric oil heater on a hot water boiler burning No. 6 oil and equipped with a hot water oil heater has a built-in adjustable thermostat. The maximum temperature setting is stamped on its dial. The desired temperature can be obtained by turning the adjusting screw. The thermostat should be set at a temperature approximately 15 degrees lower than the hot water heater thermostat. Such a temperature prevents the electric heater from operation when the water heater is functioning. The electric heater is sized to provide sufficient heated oil for low-fire operation on cold starts before hot water is available.

CHAPTER 7 Troubleshooting

7.1 — Introduction

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 the contents of this manual. Failure to follow these instructions could result in serious injury or death.

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

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

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

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

⚠ Warning

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

7.2 — 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 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. E. Heavy oil fired unit - oil temperature below minimum settings.
	4. Fuel valve interlock circuit not completed. A. Fuel valve auxiliary switch not closed.

Problem	Possible Cause(s)
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 or linkage binding.
	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.
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.** Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor.
	4. Defective modulating control.
	5. Binding or loose linkage, cams, setscrews, etc.

Problem	Possible Cause(s)
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.
MODULATING MOTOR DOES NOT OPERATE	**1.** Manual-automatic switch in wrong position.
	2. Linkage loose or jammed.
	3. Motor does not drive to open or close during pre-purge or close on burner shutdown: A. Motor defective. B. Loose electrical connection. C. Damper motor transformer defective.
	4. Motor does not operate on demand: A. Manual-automatic switch in wrong position. B. Modulating control improperly set or inoperative. C. Motor defective. D. Loose electrical connection. E.Damper motor transformer 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 (indoor/outdoor) 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 cams	Inspect refractory	Check operation of safety valves
Record feedwater pressure/temperature	Check for tight closing of fuel valves	Remove and clean oil preheater	
Record flue gas temperature	Check fuel and air linkage	Check air pump coupling alignment	
Record oil pressure and temperatures	Check indicating lights and alarms	Inspect/repair burner housing to refractory seal	
Record gas pressure	Check operating and limit controls		
Treat water according to the established program	Check safety and interlock controls		
Record atomizing air pressure	Check for leaks, noise, vibration, unusual conditions, etc.		
	Check low water cutoff operation		

8.1.1 — Periodic Inspection

Insurance regulations and local laws require periodic inspection of the pressure vessel by an authorized inspector. Section H of Chapter 3 contains information relative to the inspection.

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.

A total protection plan includes a Planned Maintenance Program that covers many of the items included in this chapter.

For information regarding a total protection plan, contact your local Cleaver-Brooks authorized representative.

NOTE: Cleaver-Brooks genuine parts should be used to ensure proper operation. Contact your local Cleaver-Brooks representative for parts information and ordering.

8.2 — Fireside Cleaning

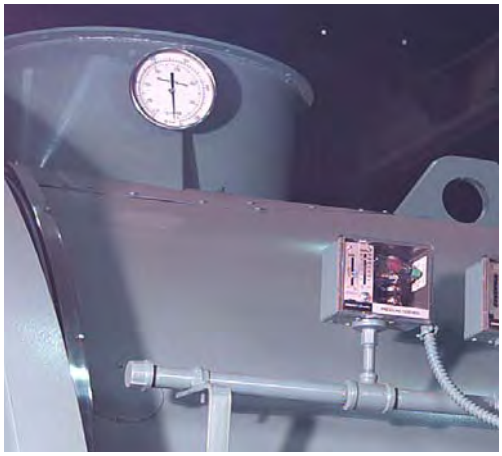


FIGURE 8-1. Stack Thermometer

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.

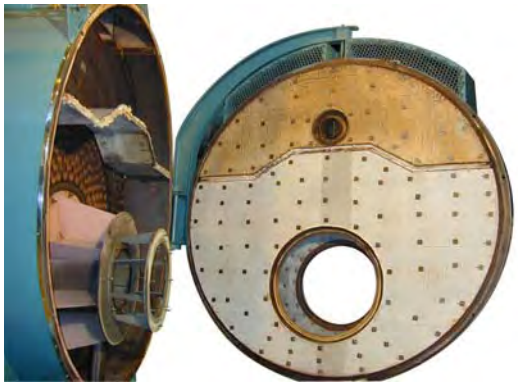


FIGURE 8-2. Front Head Open

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.

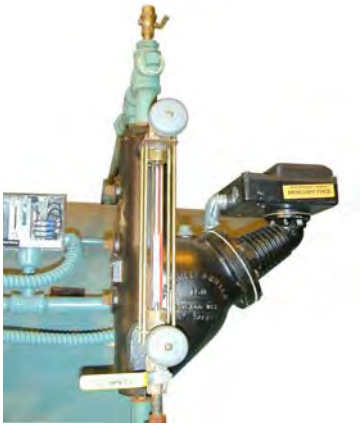
Refer to Section 8.17 for instructions on properly closing rear heads.

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.



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 Sections 3.7 and 3.8 for blowdown instructions and internal inspection procedures.

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

FIGURE 8-3. Low Water Cutoff

8.3.1 — Steam Boiler

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

FIGURE 8-4. Replica of 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.

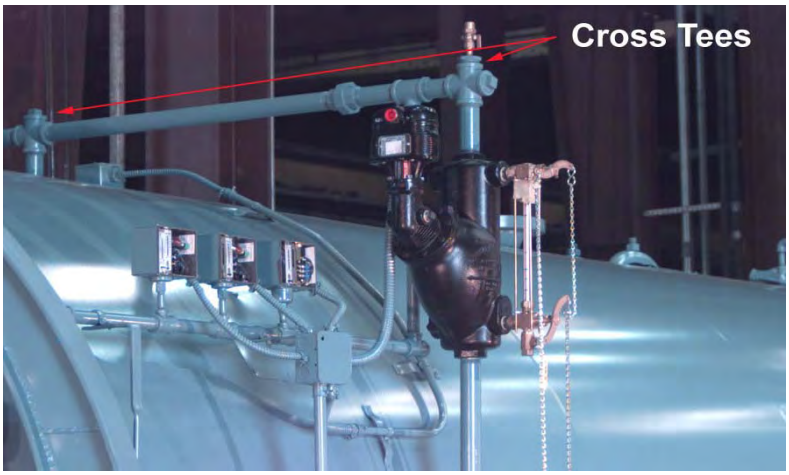


FIGURE 8-5. Low Water Cutoff Piping

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 blowdown 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 8-6. 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.

FIGURE 8-7. Operating Controls

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.

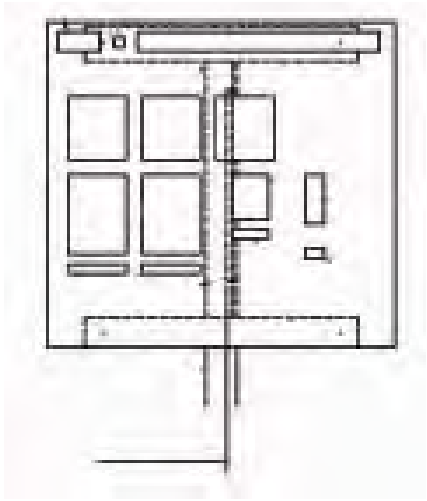


FIGURE 8-8. **Entry Box**

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, OIL HEATER, & 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
2 KW HEATER	FRN-20	FRN-12	FRN-7	FRN-7		FRS-4-1/2	FRS-3-2/10
3 KW HEATER	FRN-30	FRN-15	FRN-10	FRN-10	FRS-6-1/4	FRS-5-6/10	FRS-4-1/2
5 KW HEATER	FRN-50	FRN-25	FRN-15	FRN-15	FRS-10	FRS-8	FRS-6-1/4
7-1/2 KW HEATER			FRN-25	FRN-25	FRS-15	FRS-12	FRS-10
10 KW HEATER			FRN-30	FRN-30	FRS-25	FRS-17-1/2	FRS-12
15 KW HEATER			FRN-45	FRN-45	FRS-35	FRS-25	FRS-20

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

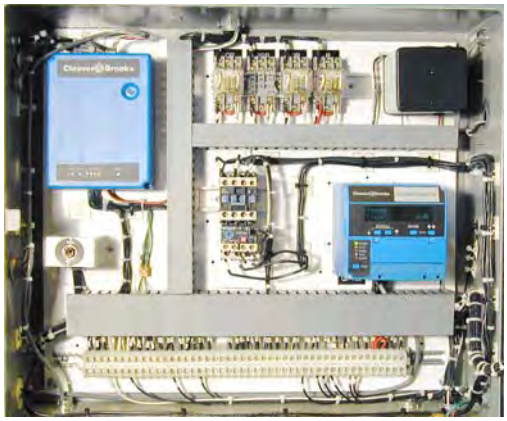
CONSULT CLEAVER-BROOKS ELECTRICAL ENGINEERING DEPT. FOR "FUSETRON" FUSE SIZE FOR POWER SYSTEMS WITH VOLTAGE, FREQUENCY OR PHASE NOT MENTIONED ABOVE.

FIGURE 8-9. 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 shutdown (e.g., seasonal), the active control should be removed and stored. Moisture can cause problems with control operation.

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

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

FIGURE 8-10. Control Panel Open

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.

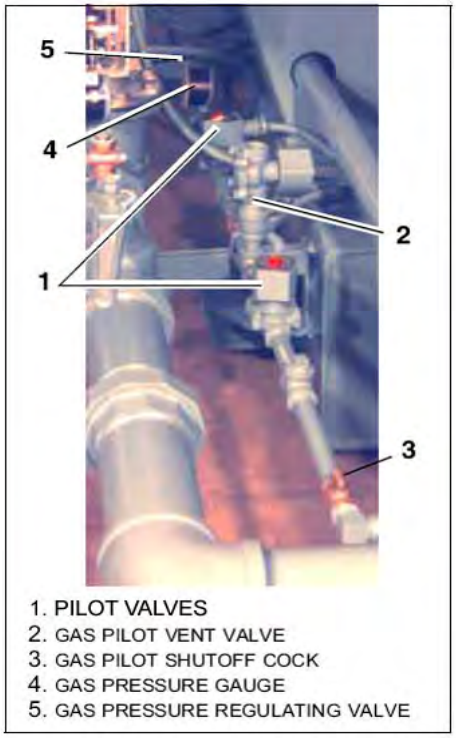


FIGURE 8-11. Gas Pilot Shutoff Cock

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.

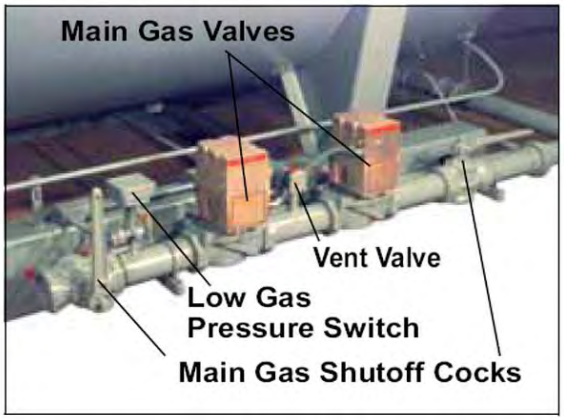
Turn the burner switch off. Reset the safety switch. Re-establish main fuel supply.

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 8-12. Main Gas Train

8.7 — Oil Burner Maintenance

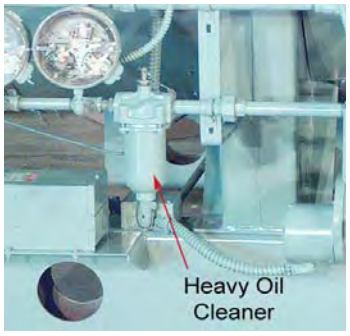
The burner should be inspected for evidence of damage due to improperly adjusted combustion. Any soot buildup on the diffuser or the oil nozzle should be removed. The positioning of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked. See Section 6.20 in Chapter 6.

8.7.1 — Light Oil Strainers

NOTE: All oil strainer, light and heavy, 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 — Heavy Oil Strainers



Keep the cartridge of the oil strainer clear by regularly giving the exterior handle one complete turn in either direction. Do this often until experience indicates cleaning frequency necessary to maintain optimum conditions of flow. If the handle turns hard, rotate the handle back and forth until it can be turned through a complete revolution. Do not force it with a wrench or other tool.

Drain the sump as often as experience indicates the necessity. Remove the sump, or the head and cartridge assembly, for thorough cleaning and inspection at frequent intervals. Exercise care not to damage the cartridge discs or the cleaner blades. Wash the cartridge in solvent. Do not attempt to disassemble the cartridge.

FIGURE 8-13. Heavy Oil Cleaner

8.7.3 — Cleaning the Oil Nozzle

The design of the burner, together with the oil purge system on a heavy oil burner, keep it 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.

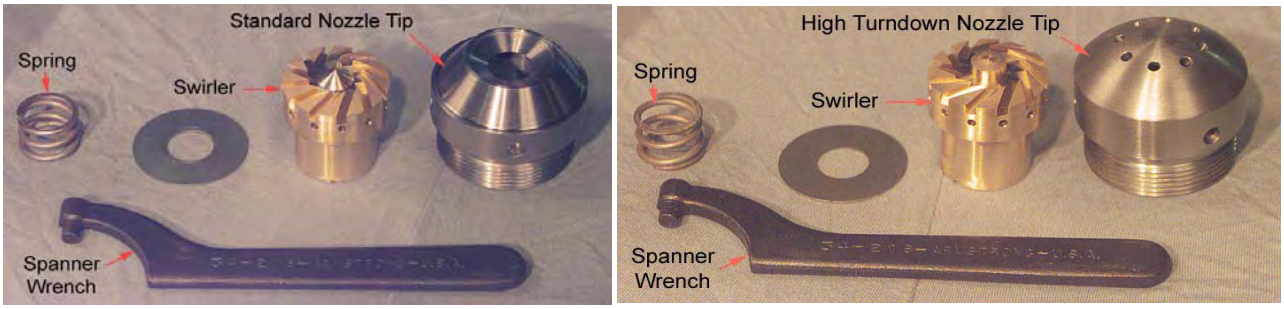


FIGURE 8-14. Standard and High Turndown Burner Nozzle Components

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.

8.7.4 — Cleaning Air Purge Nozzle (No. 6 Oil) and Back Pressure Orifice Nozzle (No. 2 Oil)

The air purge nozzle and its strainer should be inspected periodically and cleaned. The nozzle consists of a tip and internal core. Clean all internal surfaces of the tip and the slotted parts of the core using a wood splinter to avoid damage from scratching. Replace the core, setting it tightly but not excessively so.

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.

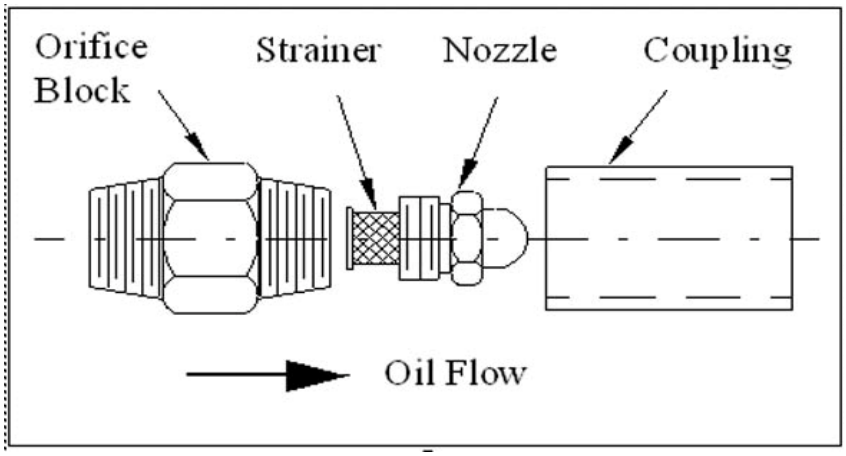
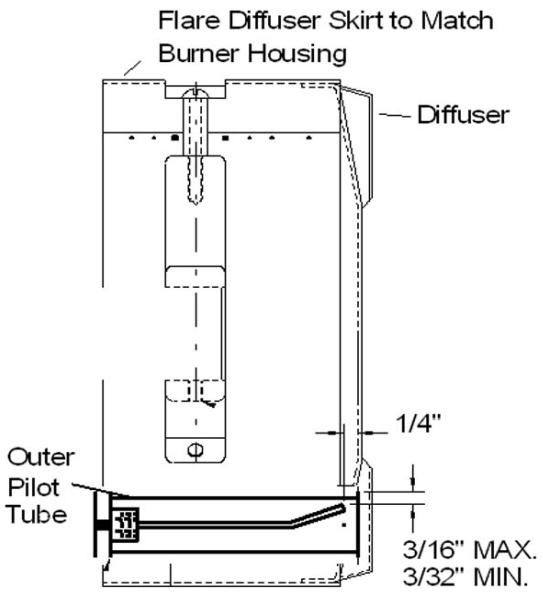


FIGURE 8-15. Back Pressure Orifice

8.7.5 — 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 8-16. 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. See Section 6.20 in Chapter 6.

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. See Section 6.22 in Chapter 6 for more information.

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.

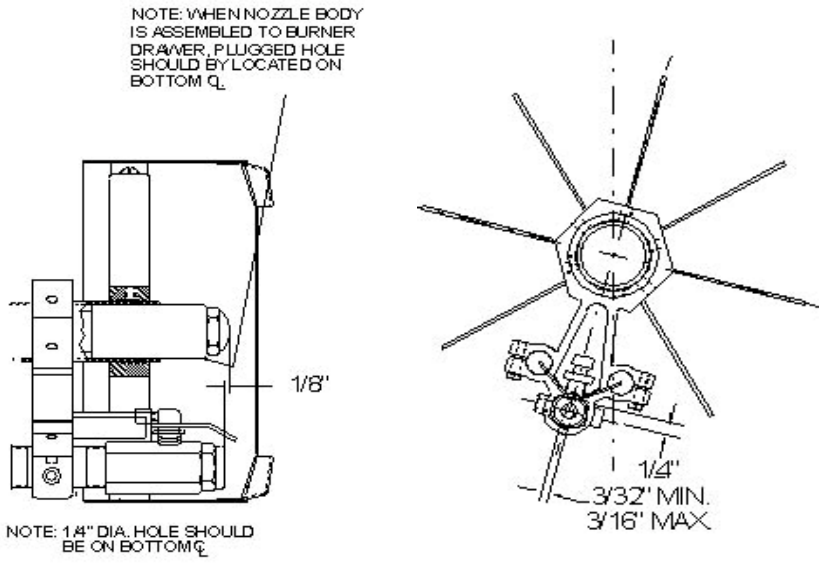


FIGURE 8-17. Oil Pilot Electrode Settings

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 (Hydramotor) operating mechanism is completely immersed in oil and little maintenance is required because of the sealed design. However, proper operation should be checked on a routine periodic basis.

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

FIGURE 8-18. Motorized Gas Valves

The packing gland is of the O-ring type. If oil is noticed around the operator base or if leakage occurs, repair by replacing any leaking O-rings and refilling the actuator with oil.

If the actuator is sluggish or fails to operate, even after the oil level is checked, replace the entire operator portion.

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, Linkage and Cam Spring*

The burner air control damper should be checked for free movement as a part of the monthly inspection. With the burner off and the jackshaft damper control rod disconnected, 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.

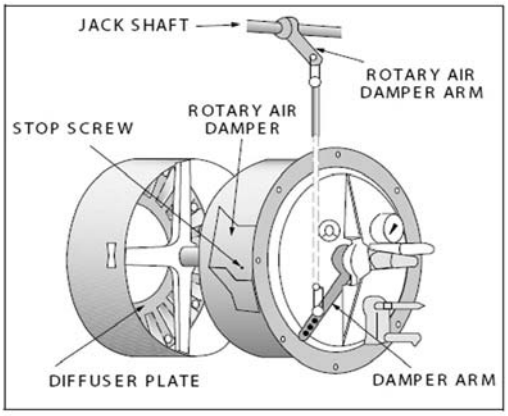


FIGURE 8-19. Rotary Air Damper

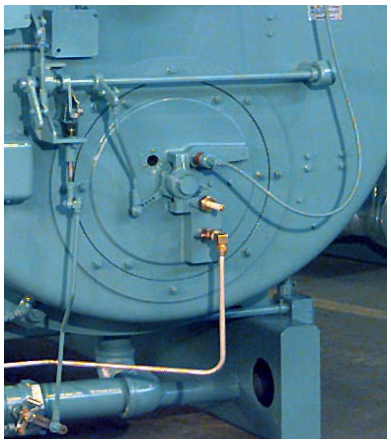
The overall tightness of the linkage assembly should be checked monthly. If necessary, tighten the setscrews and the connections at the uniballs. Check the uniballs for wear and replace if necessary.

The linkage assembly should be tight but should not bind. If the linkage assembly is binding, determine the cause of the binding and correct as necessary.

Linkage rod end attachment points should be marked on the variable displacement linkage arms as an aid in subsequent reassembly.

⚠ 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 and linkage bearings should be performed on a more frequent basis if the boiler is operating in a dirty environment.

The fuel cam profile spring should be inspected monthly for wear, scoring or distortion. If any of the questionable conditions are found, the spring must be replaced immediately to avoid the possibility of breakage in service. Use care to avoid damaging the cam or spring during installation.

FIGURE 8-20. Front Linkage and Oil Cam

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 8-21.
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.

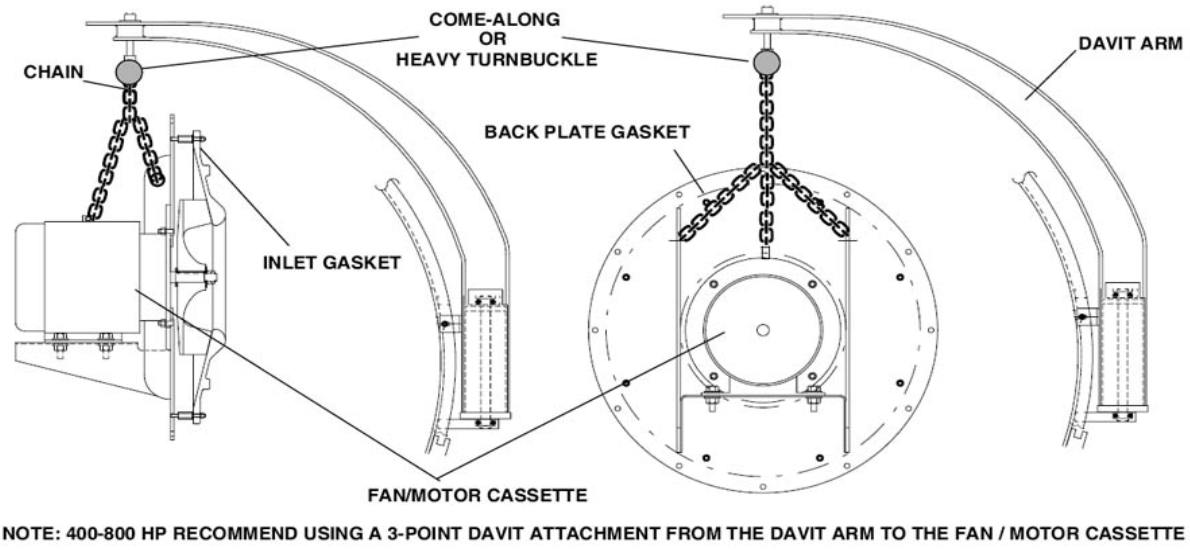


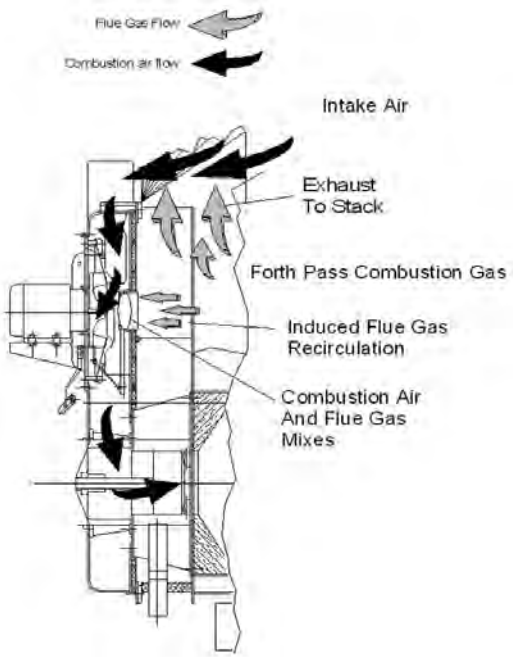
FIGURE 8-21. Fan/Motor Cassette

⚠ 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 — 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, loose linkages, 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.

FIGURE 8-22. Induced Flue Gas Recirculation (IFGR) Air Flow

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. To check for free movement of the linkage, separate the external linkage from the jackshaft drive arm(s) and cycle the exterior linkage through its range of movement.
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 25 PPM	20 PPM
.040 ± .010	.050 + .010/ - .005	.060 + .005/ - .000

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 180° apart.

C. Adjust the retainers for correct clearance at the housing attachment points 90° 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

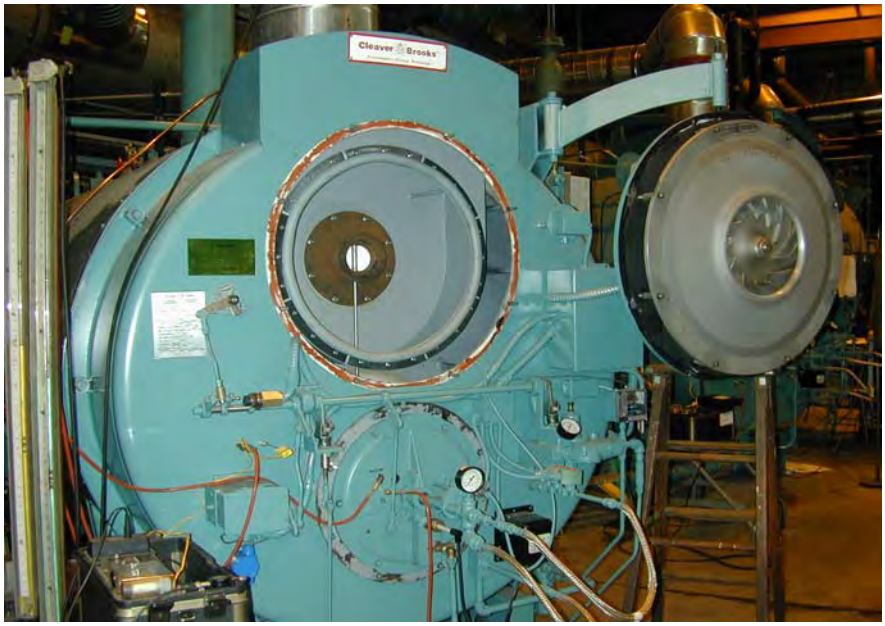


FIGURE 8-23. Fan/Motor Cassette Open

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 as outlined in Section 8.13.

8.15 — 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.

FIGURE 8-24. Safety Valves

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 reseat as it would in normal service.

Do not hand operate the valve with less than 75% of the stamped set pressure exerted on the underside of the disc. When hand operating, be sure 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.

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.

FIGURE 8-25. Operating Safety Valves

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, Adjusting and Relief Valves

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.

FIGURE 8-26. Fuel Stem Packing Kit

If replacement of the metering valve packing is necessary, procure **Kit P/N 880-370** (Figure 8-26) 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.
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 in Figure 8-27. 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.

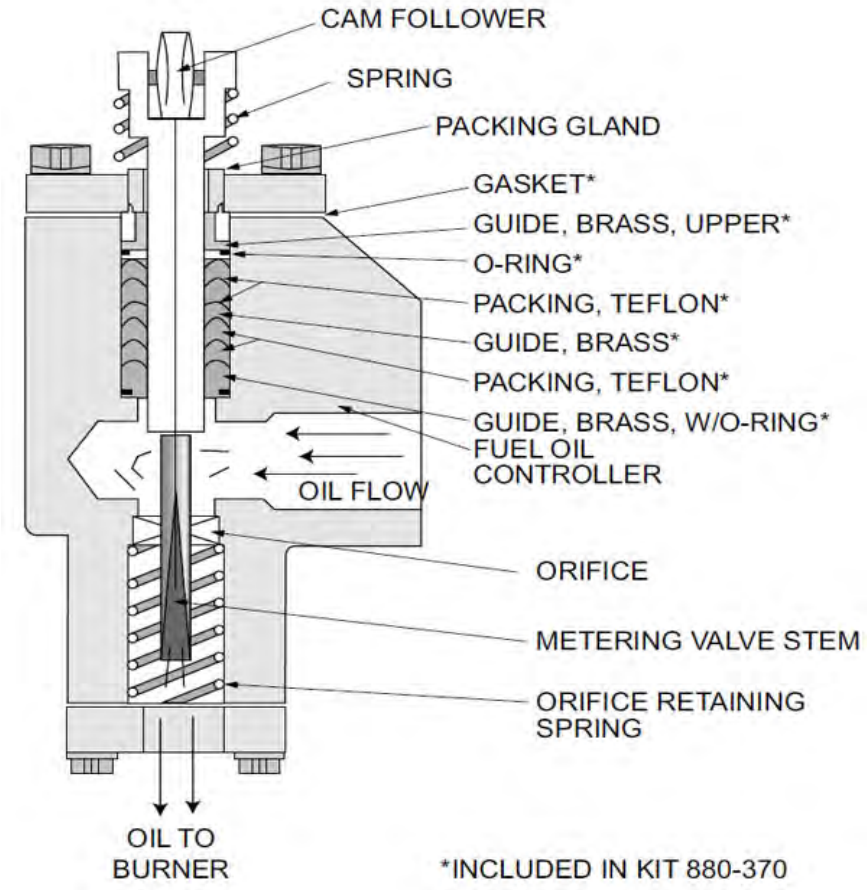


FIGURE 8-27. Fuel Stem Packing, Cross-Section

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. Restor 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.

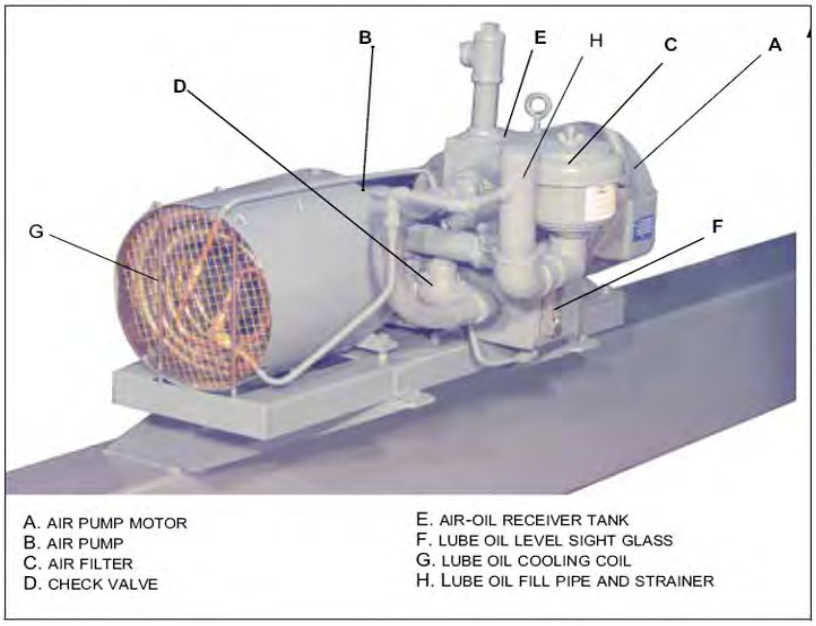


FIGURE 8-28. Air Pump

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.

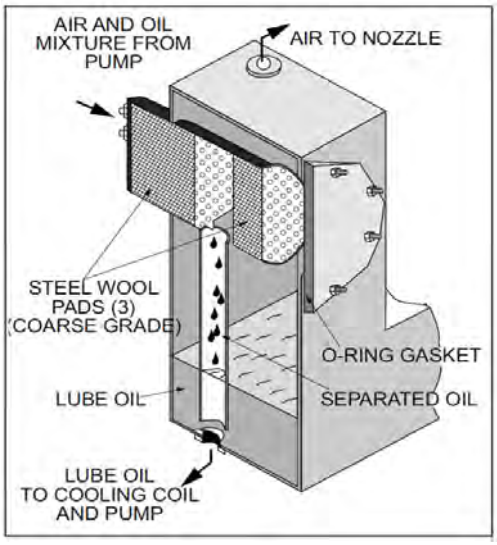
8.17.3 — Lubricating Oil Strainer and Cooling Coil

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 8-29. Air-Oil Receiver Tank

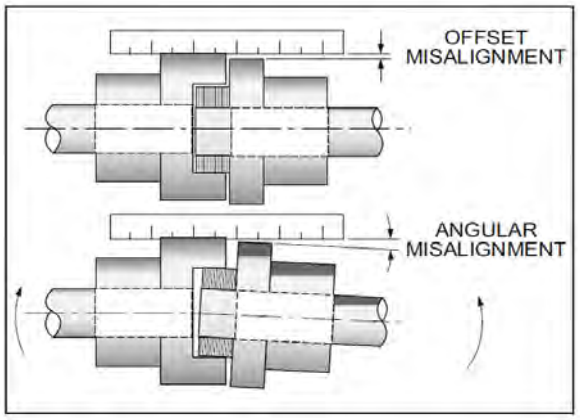
8.17.5 — Air Cleaner

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 — Lube Oil Cooling Coil

The fins on the tubing must be kept clean and free of any dust or dirt that would resist air flow and cause overheating. Use an air hose to blow away debris. Internal cleaning of the tubes is seldom required if a good quality lube oil is used.

8.17.7 — 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 8-30. 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 90º 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

Refer to Chapter 9 for identification of various components and use the following procedures when replacing the pump. Be sure to tag the motor leads if disconnected to simplify reconnection.

8.17.8.1 — 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) (see Figure 8-31) and lift tubing "A" high enough to prevent drainage of lubricating oil from the tank.

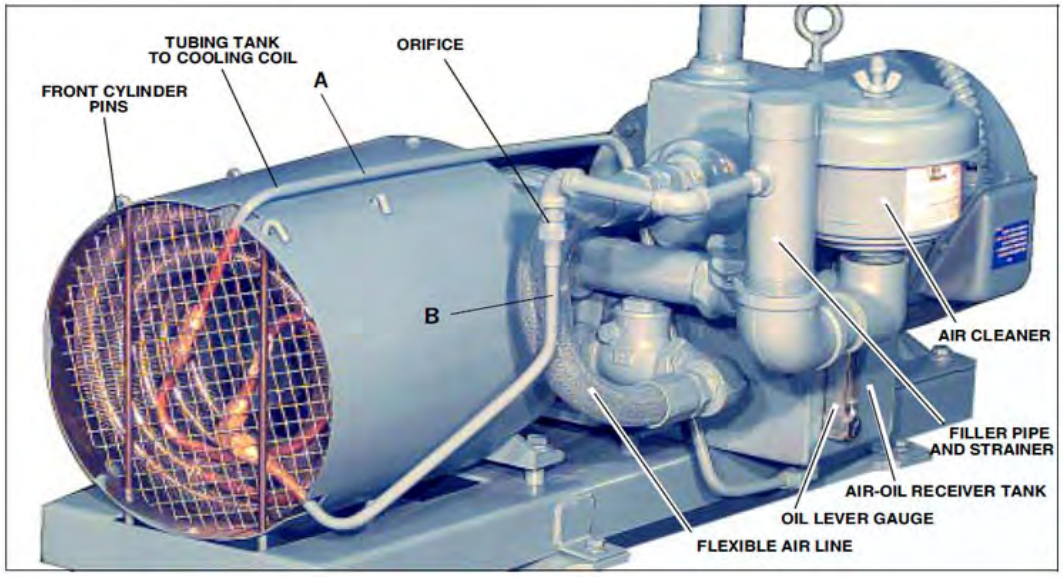


FIGURE 8-31. Air Pump Components

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.

8.17.8.2 — 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.

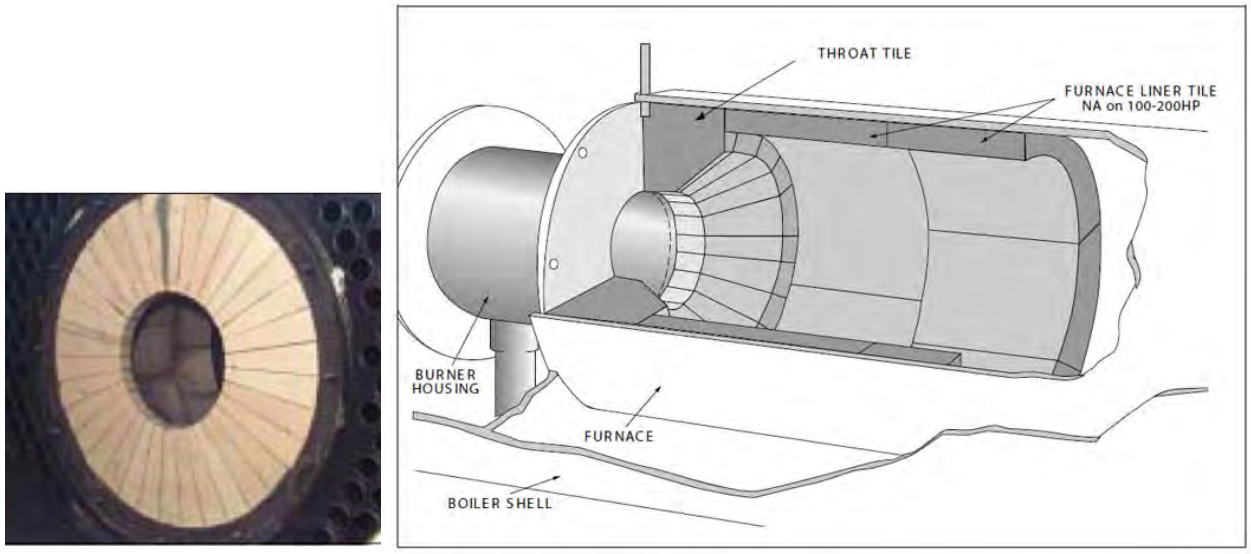


FIGURE 8-32. Throat Tile and Furnace Liner

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

(Liner tiles not required for 100-200 HP.)

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 with the exception of steps 6, 7, and 8 — disregard any reference to these steps when working with plain furnaces.

Refer to Figure 8-33.

1. Install studs, bricking tool, cerafelt, bottom and top arch bricks as shown on DETAIL "A" to check for correct fit up. If interference is present at the arch brick, measure this distance and trim inside diamter (I.D.) of all bricks.
2. Install the bottom half of arch bricks as shown on DETAIL "B".
3. Mix the vee block to a mortar-like consistency (per manufacturer's instructions) and pack the front (3) valleys of the funace 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" (see note #7 on Figure 8-33).

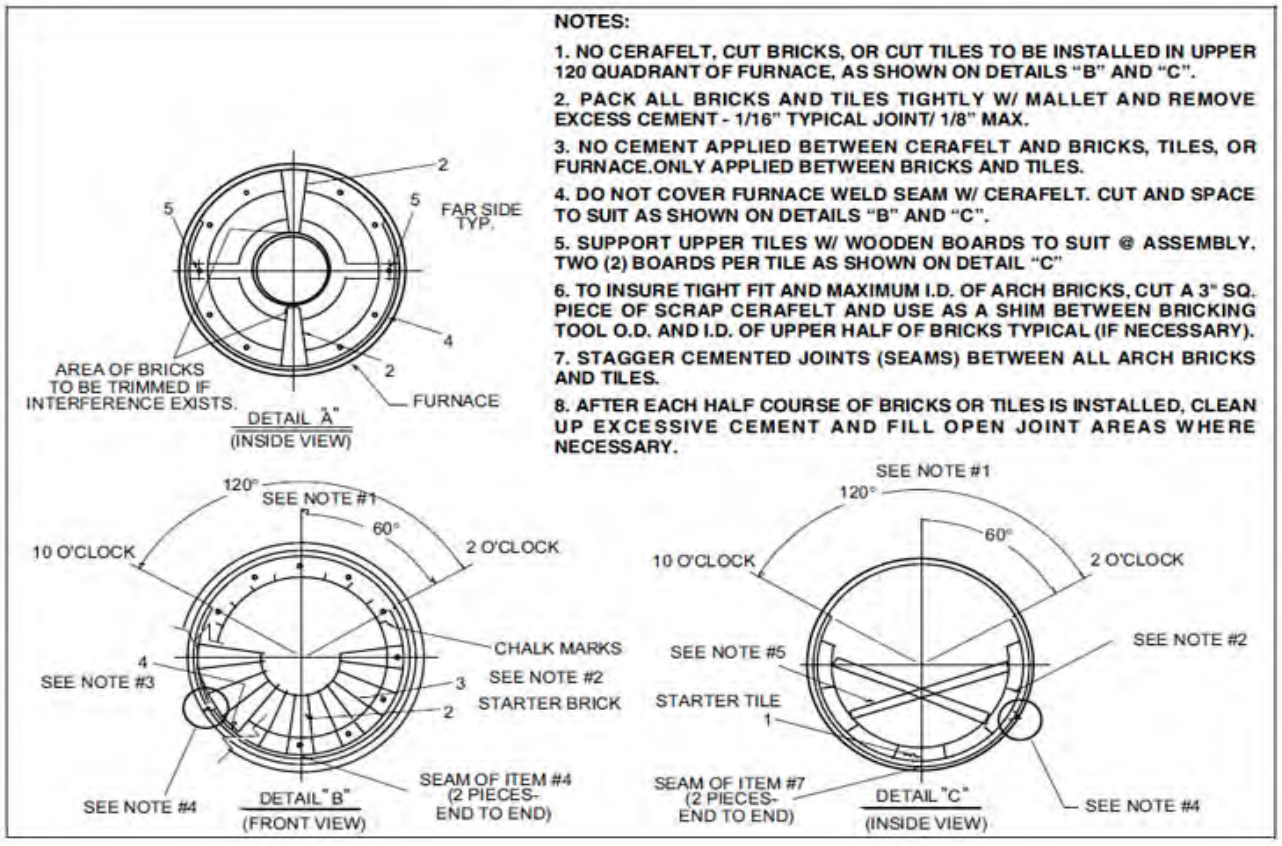


FIGURE 8-33. Throat Tile and Furnace Liner Installation

4. 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 8-33). 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 8-33).
5. 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 8-33).
6. 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.
7. Install both pieces of cerafelt and continue laying furnace tiles to complete the last two rows (see note #7 on Figure 8-33).
8. After joint cement hardens (approximately 2 hours), remove bricking tool, wooden tile supports, and discard cerafelt shims.

8.18.4 — Rear Door

The rear door is a steel shell lined with insulation material and refractory board.

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble, but may be an indication of other conditions such as:

- Leaking gaskets.
- Improper seal.
- door retaining bolts insufficiently or unevenly tightened.
- Repainted with other than heat resistant paint.

Therefore, before assuming that the refractory requires reworking:

- Check condition of the gasket.
- Check for cracks in refractory material.
- Check tightness of door bolts.

It is normal for refractories exposed to hot gases to develop thin "hairline" cracks. This by no means indicates improper design or workmanship. Since refractory materials expand and contract to some extent with changes in temperature, they should be expected to show minor cracks due to contraction/expansion, recessing themselves when the refractory cools. Cracks up to approximately 1/8" across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8" to 1/4" in width), clean and fill them with high temperature bonding mortar.

After opening the rear door, clean the flange surface of the door with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Remove all dried sealing material. Wash-coat the lower half of the rear door refractory prior to closing, caring not to apply too thickly.

8.19 — Opening and Closing Doors

8.19.1 — Opening Front or Rear Door

Before opening the doors, tighten the nut on the davit arm to create slight tension. This will minimize sagging and facilitate opening of the door. After opening either door, check the gaskets and seating surfaces. Replace the door gaskets if they are hard or brittle. Clean the sealing surfaces of the door and tube sheet.

FIGURE 8-34. Tighten the Davit Nut

8.19.2 — Rear Access Plug

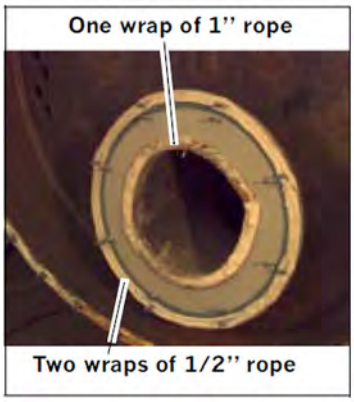
Access to the first to second pass turn around area is accomplished through the removal of the rear plug. The access plug for the 78" and 96" firetube weighs approximately 120 pounds. The 60" firetube rear plug weighs approximately 95 pounds. Two people make the handling of the access plug easier. When resealing the access plug area, be sure the sealing area is clean and free of old gasket material and rust. Secure 2" blanket insulation to the inside of the plug with a 2" overlap around the circumference of the plug refractory. Attach one wrap of 1" rope to the inner access sealing area, and two wraps of 1/2" rope to the outside area. Insert the plug and tighten evenly.

FIGURE 8-35. Removing Rear Access Plug

⚠ Caution

The rear access plug is made up of cast in place refractory. When removing, two boiler technicians should be on hand to assist with removal.

8.19.3 — Closing and Sealing Doors



Swing the door to the closed position and run all retaining bolts in until snug. Tighten the bolts uniformly, starting at the top center and alternating between the top and bottom bolts until both are tight. Do not over-tighten. Tighten alternate bolts until all are secure and the door is gas tight.

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

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

FIGURE 8-36. Rope Gasket on Rear Access

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

⚠ Warning

Be certain that the davit arm is under tension before opening. Failure to follow these instructions could result in serious injury or death.

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 8-37. 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 and incompatible grease to 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 (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 — Control Linkage

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

8.20.3 — Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

8.20.4 — IFGR Lubrication

Motors should be lightly lubricated at startup, using the grease specified above or equivalent. Lubricate the motor as follows:

⚠ Warning

Disconnect and lockout electrical power to the boiler before lubricating the fan motor. Failure to follow these instructions could result in serious injury or death.

1. Turn boiler off.
2. Disconnect and lockout electrical power to the boiler.
3. Wipe clean all grease fittings (fill and drain fittings).
4. Remove the fill and drain plugs from the motor end cap.
5. Free the drain hole of any hard grease (use a piece of wire, if necessary).
6. Add grease using a low pressure grease gun.

NOTE: The amount and type of grease is very important. Only enough grease should be added to replace the grease used by the bearing. Either too much or too little grease can be harmful. The grease cavity should be filled 1/3 to 1/2 full, using Chevron SRI 2 grease or equivalent. Shell Dolium R is a suitable substitute lubricant.

7. With the fill and drain plugs still removed, apply electric power to the boiler, start the motor, and let it run for approximately 30 minutes.
8. Turn the boiler off and disconnect and lockout electrical power to the boiler.
9. Wipe excess grease from the motor, and install the fill and drain plugs. Motor is ready for operation.
10. Reconnect electrical power.

8.21 — Oil Heaters: Electric, Steam, Hot Water

An annual maintenance of the heaters consists primarily of removing the heating element from the shell and scraping any accumulation of carbonized oil or sludge deposits that may have collected on the heat exchanging surfaces.

Before breaking any of the electrical connections to the electric heating elements, mark all wires and terminals to assure rapid and correct replacement of wires.

Finish the cleaning process with a cleaning solvent to cut all hardened deposits from the heater element. Because of the insulating effect of carbon and sludge, periodic cleaning is necessary to prevent overheating of the elements. If operation of the heater becomes sluggish, examine the elements at once and clean as required.

The condensate from steam oil heaters must be safely discharged to waste. The waste should be checked periodically for any traces of oil that would indicate leaking tubes within the heater.

The hot water oil heater contains a heat transfer solution. Oil flows through an inner tube while boiler water surrounds the outer tube. The space between the two tubes is filed with the heat transfer solution and is connected to an expansion chamber on the rear of the heater. A visual indicator on the chamber reveals the presence of any oil if an oil leak occurs.

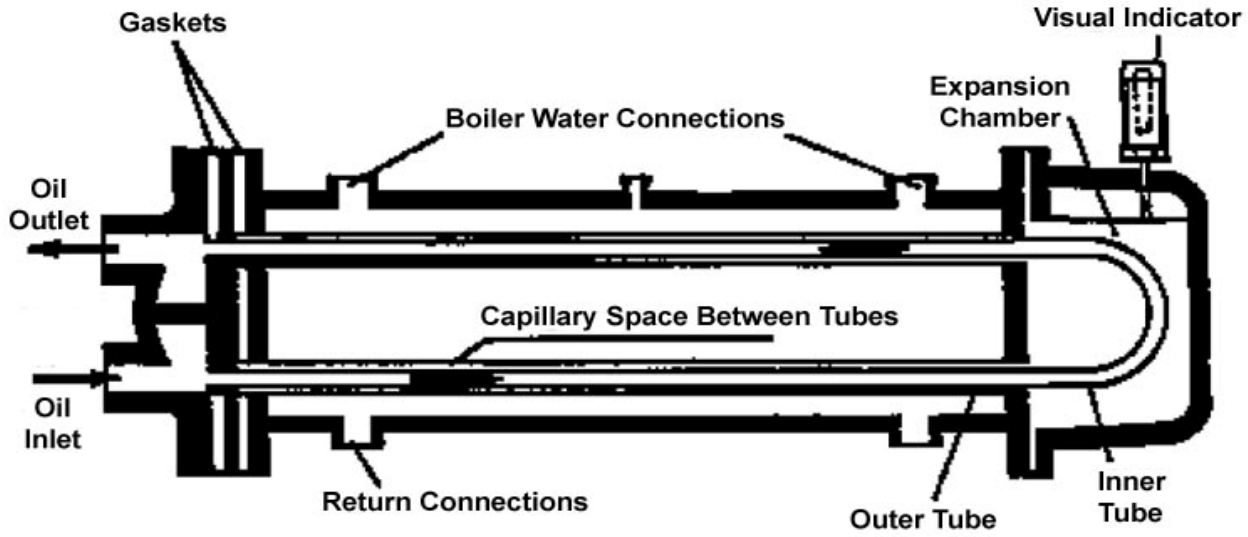


FIGURE 8-38. Circuit Layout for Hot Water Oil Heater

A 50/50 solution of permanent antifreeze and water is generally used as the heat transfer solution. If there is no danger of freezing, plain water may be used as a replenishment if necessary to refill.

Evidence of oil in either the steam heater condensate or in the water heater indicator demands prompt repairs.

8.22 — Combustion

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. Any time maintenance is performed on the burner linkage, the air-fuel ratio should be checked.

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

9.1 — Ordering Parts

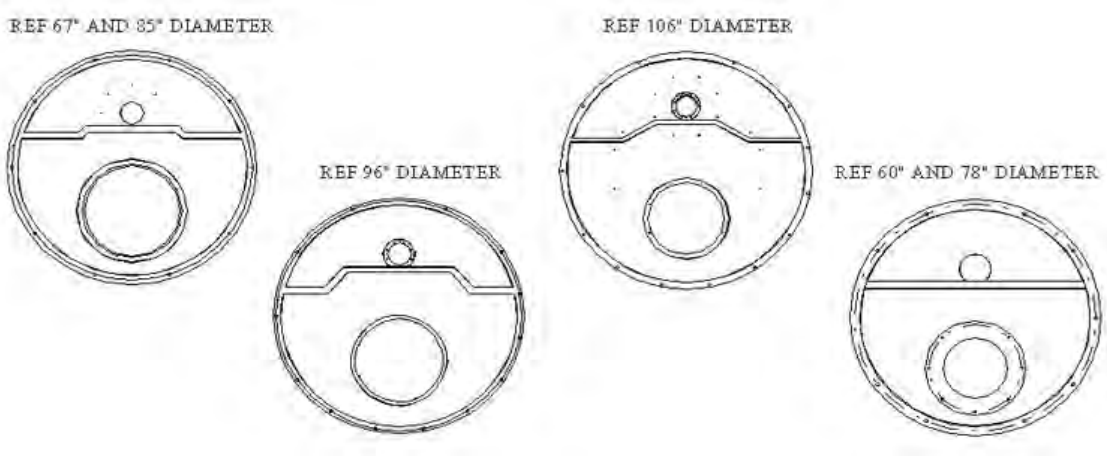
Furnish complete information when ordering parts by giving the item number, description, and the quantity of parts desired, together with the complete nameplate data, including all electrical requirements.

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

9.2 — Parts

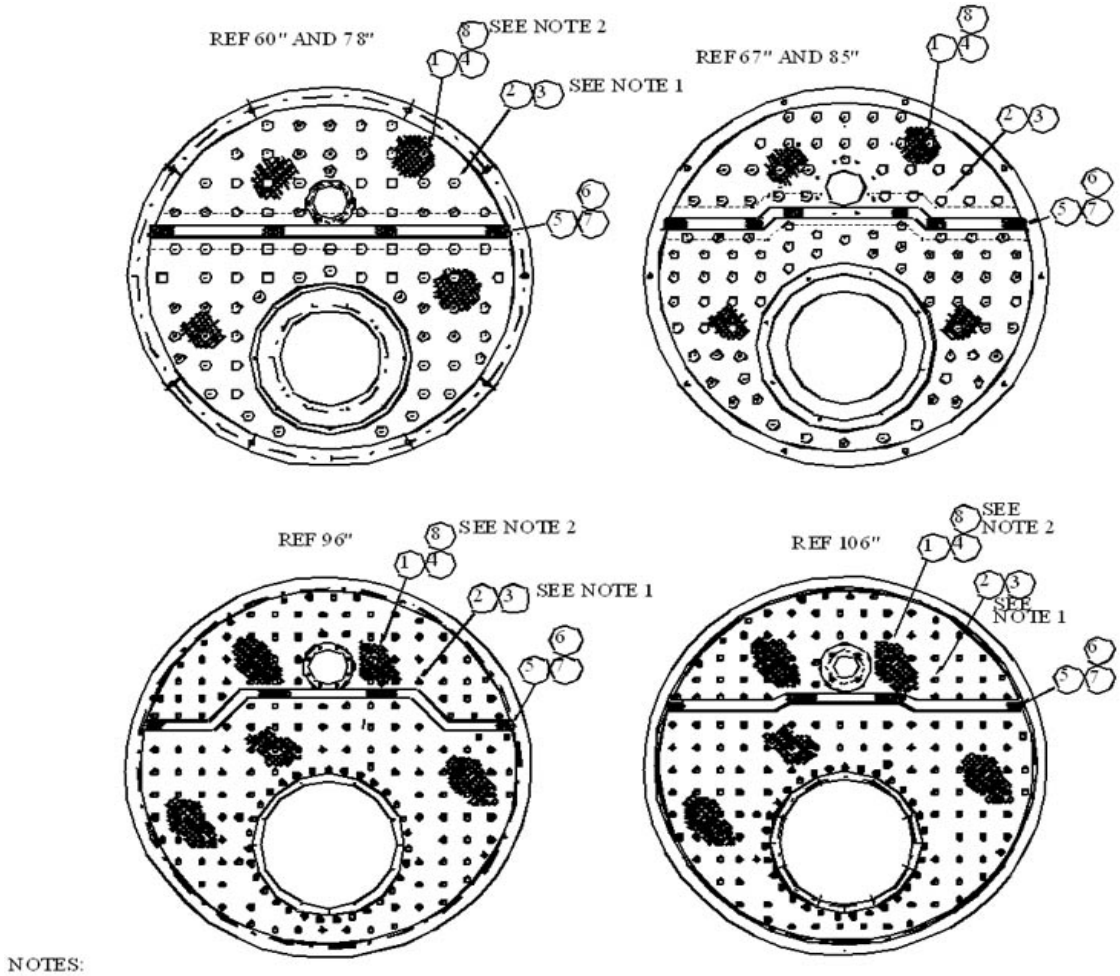
9.2.1 — Front Door Insulated Head

BOILER DIA	PPM RATE	FRONT HEAD ASSEMBLY	
60"	30	132-02338	LH
		132-02337	RH
	60	132-02427	LH
		132-02426	RH
67"	30	132-02418	LH
		132-02417	RH
	60	132-02431	LH
		132-02430	RH
78"	30	132-02404	LH
		132-02403	RH
	60	132-02391	LH
		132-02390	RH
85"	30	132-02411	LH
		132-02410	RH
	60	132-02308	LH
		132-02307	RH
96"	30	132-02408	LH
		132-02407	RH
	60	132-02398	LH
		132-02397	RH
106"	30	132-02316	LH
		132-02315	RH
	60	132-02429	LH
		132-02428	RH



9.2.2 — Front Door Exterior Insulation Component List

ITEM	QTY 60"	QTY 67"	QTY 78"	QTY 85"	QTY 96"	QTY 106"	PART NO.	DESCRIPTION
1	15 SQ FT	21 SQ FT	30 SQ FT	36 SQ FT	43 SQ FT	54 SQ FT	872-00500	BULK INSULATION, BLANKET
2	65	95	120	175	200	250	903-00297	PIN, WELDING
3	65	95	120	175	200	250	828-00039	CLIP, WELDING ST. STL
4	90 oz	150 oz	180 oz	260 oz	260 oz	260 oz	872-00443	RIGIDIZER
5	59.5"	70"	74"	83"	100"	107"	872-00362	BULK, INSULATION BLANKET
6	12 oz	12 oz	16 oz	16 oz	16 oz	16 oz	797-01813	ADHESIVE
7	59.5"	70"	74"	83"	100"	107"	904-00012	GASKET, TAPE
8	15 SQ FT	21 SQ FT	30 SQ FT	36 SQ FT	43 SQ FT	54 SQ FT	930-00135	SCREEN ST. STL

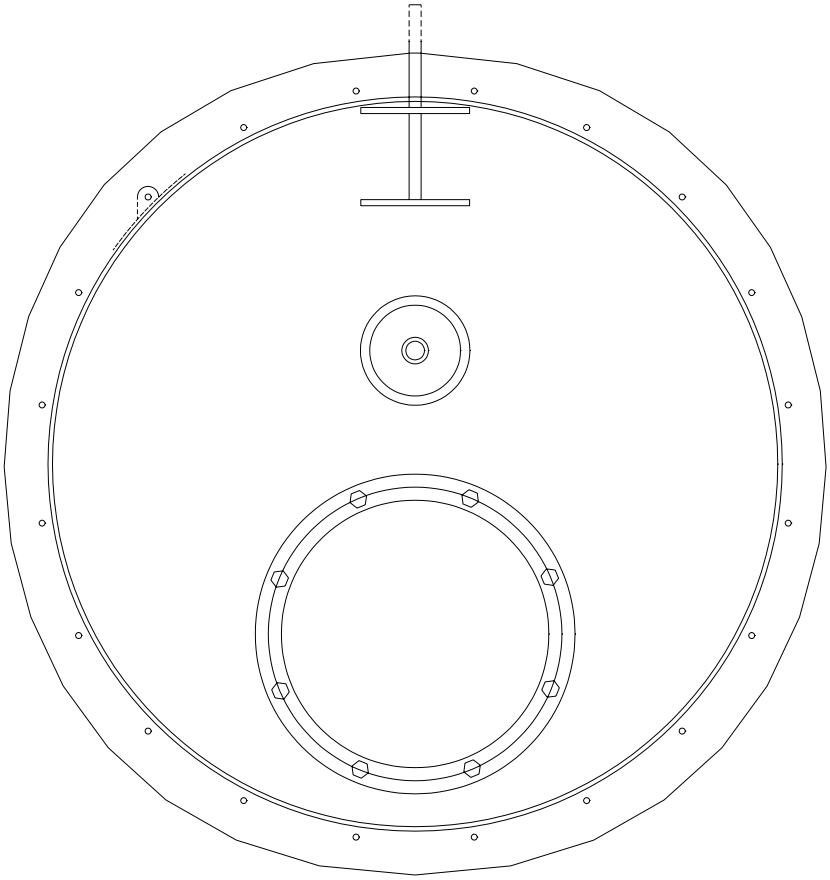


NOTES:

1. ITEM #2 PINS TO BE SPACED ON 4" TO 5" MAX. CENTERS.
2. ITEM #4 RIGIDIZER MUST BE DILUTED W/ EQUAL AMOUNT OF WATER TO A 50:50 SOLUTION PRIOR TO APPLYING TO SURFACE OF INSULATING BLANKET AND SCREENING.
3. INSTALL ITEM 5 FIRST, THEN COVER WITH ITEM 7.
4. IF ITEM #7 IS MADE FROM MORE THAN ONE PIECE, ADJOINING EDGES MUST OVERLAP.

9.2.3 — Rear Door Insulated Assembly

BOILER DIA	REAR DOOR INSULATED	PART NO
60"	WITHOUT COMBUSTION DOOR	457-03445
	WITH COMBUSTION DOOR	457-03446
67"	WITHOUT COMBUSTION DOOR	457-03441
	WITH COMBUSTION DOOR	457-03442
78"	WITHOUT COMBUSTION DOOR	457-03449
	WITH COMBUSTION DOOR	457-03450
85"	WITHOUT COMBUSTION DOOR	457-03453
	WITH COMBUSTION DOOR	457-03454
96"	WITHOUT COMBUSTION DOOR	457-03447
	WITH COMBUSTION DOOR	457-03448
106"	WITHOUT COMBUSTION DOOR	457-03451
	WITH COMBUSTION DOOR	457-03452

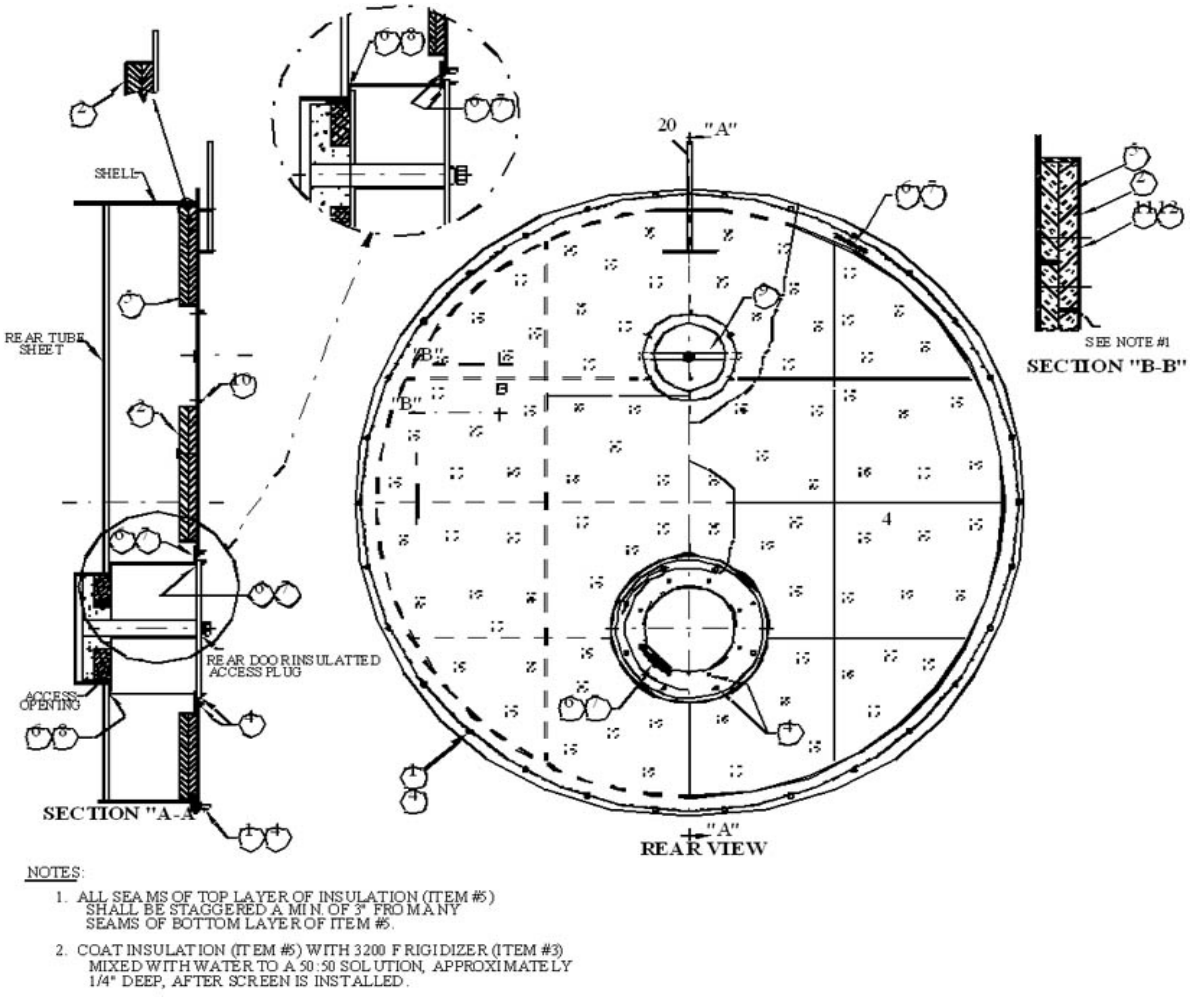


NOTE:

REAR DOOR INSULATED ACCESS PLUG NOT INCLUDED,
FOLLOWIG PAGE FOR PART NUMBER.

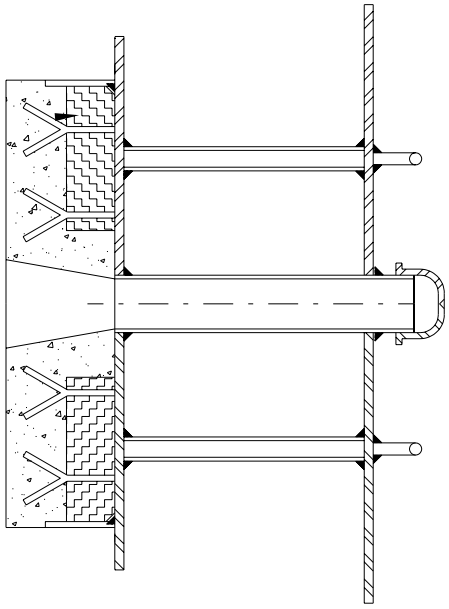
9.2.4 — Rear Door Insulation Component List

ITEM	QTY 60"	QTY 67"	QTY 78"	QTY 85"	QTY 96"	QTY 106"	PART NO.	DESCRIPTION
1	20	20	24	24	30	30	868-00102	BOLT, HEX
2	58.75" DIA	65.75" DIA	76.75" DIA	83.75" DIA	94.75 DIA	104.75" DIA	930-00057	SCREEN
3	30 OZ	30 OZ	30 OZ	30 OZ	30 OZ	30 OZ	872-00443	RIGIDIZER
4	36	36	40	40	46	46	869-00029	NUT, HEX
5	38 SQ FT	47 SQ FT	71 SQ FT	78 SQ FT	100 SQ FT	123 SQ FT	872-00678	INSULATION
6	1	1	1	1	1	1	797-01813	ADHESIVE
7	350"	375"	432"	432"	466"	497"	872-00622	ROPE GASKET 1/2"
8	72"	72"	72"	72"	72"	72"	872-00651	ROPE GASKET 1"
9	1	1	1	1	1	1	004-00026	BAR, MOUNTING
10	6	6	6	6	6	6	868-00158	CAPSCREW, HEX
11	35	44	70	75	80	90	903-00182	PIN, WELDING
12	35	44	70	75	80	90	828-00039	CLIP, WELD PIN



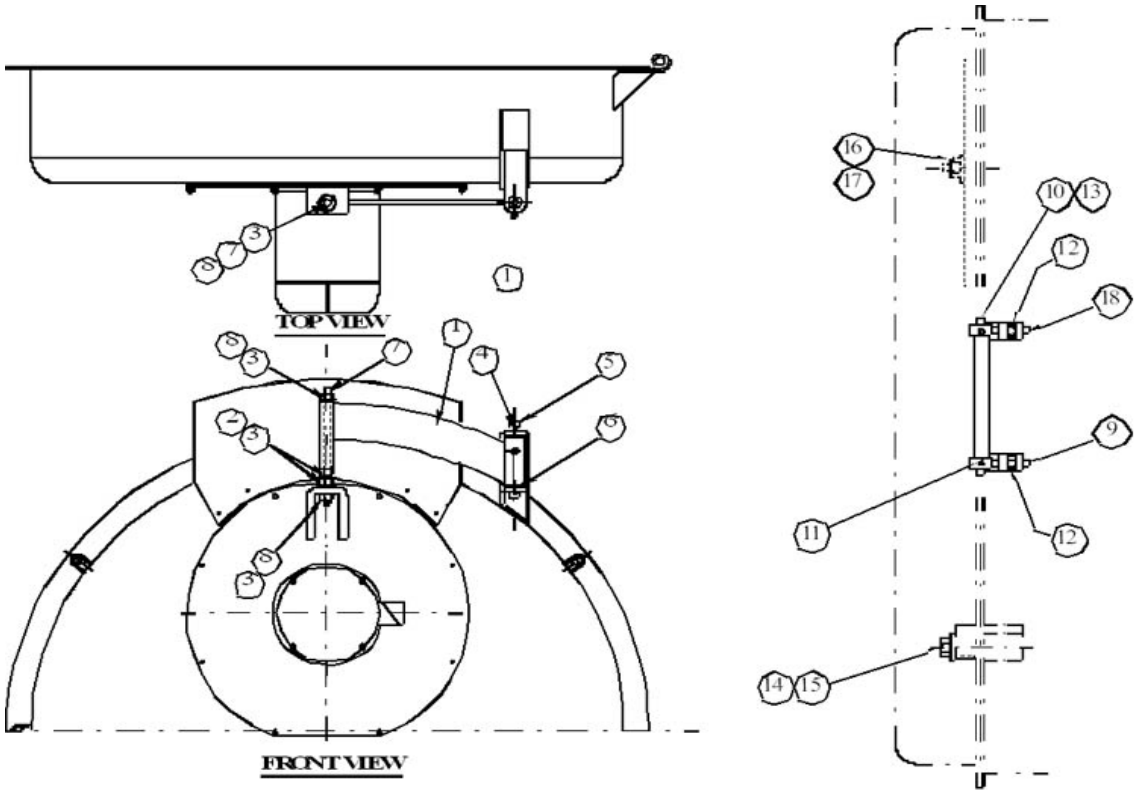
9.2.5 — Rear Door Insulated Access Plug

BOILER DIAMETER	PLUG ASSEMBLY PART NO.
60" & 67"	465-02389
78" & 85"	465-02372
96" & 106"	465-02380



9.2.6 — Front Head Assembly 60” Diameter

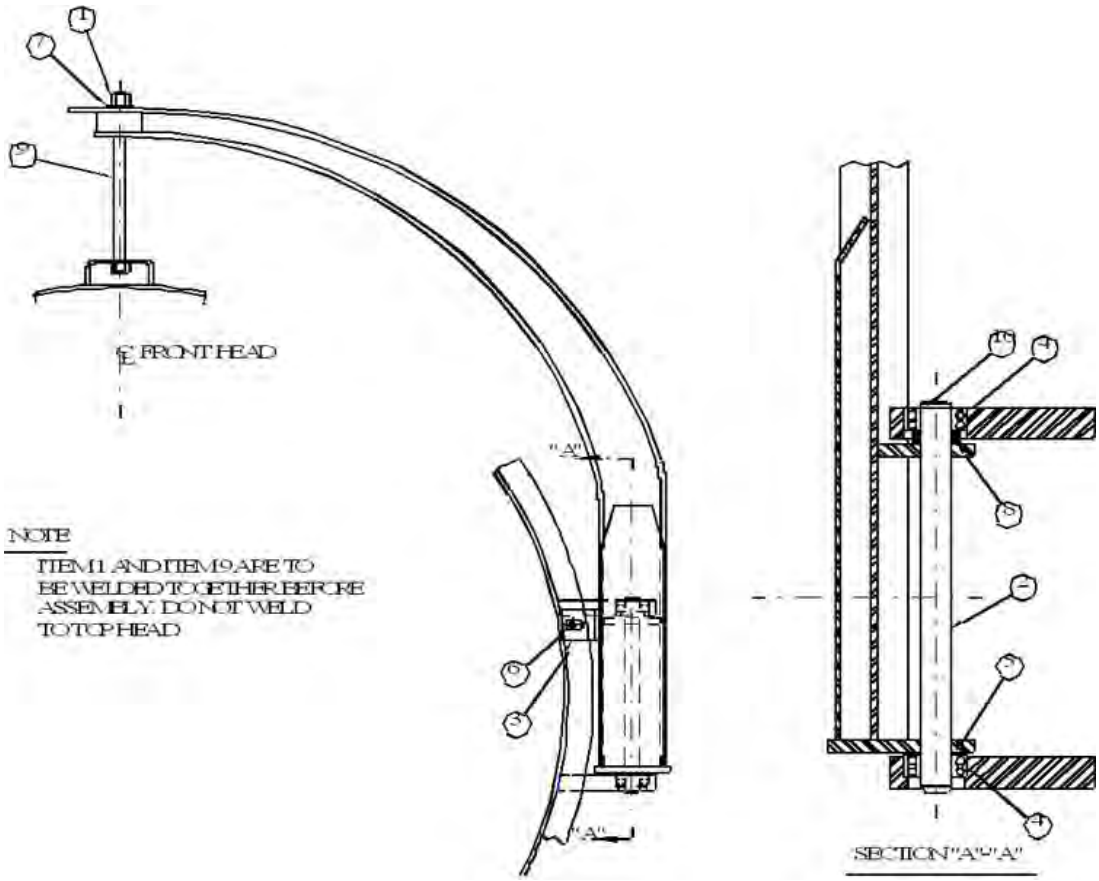
ITEM	QTY	PART NO.	DESCRIPTION
1	1	287-00052	DAVIT ARM ASSY
2	2	869-00100	NUT, JAM
3	4	952-00239	WASHER, FLAT
4	1	903-00266	ROLL PIN
5	1	056-00043	PIN, DAVIT
6	1	952-00194	WASHER, FLAT
7	1	841-01047	THREADED ROD
8	2	869-00160	NUT, HEX
9	1	007-00061	EYEBOLT, DOOR HINGE (LOWER)
10	1	914-00147	RING, RETAINING
11	1	860-00236	SETSCREW, SOCKET HD
12	2	869-00154	NUT, HEX, JAM
13	1	056-00002	PIN, HINGE
14	9	952-00230	WASHER, SPECIAL
15	9	868-00094	CAPSCREW, HEX HD
16	2	952-00106	WASHER
17	2	869-00030	NUT, HEX
18	1	007-00058	EYEBOLT, DOOR HINGE (UPPER)



9.2.7 — Front Davit Assembly

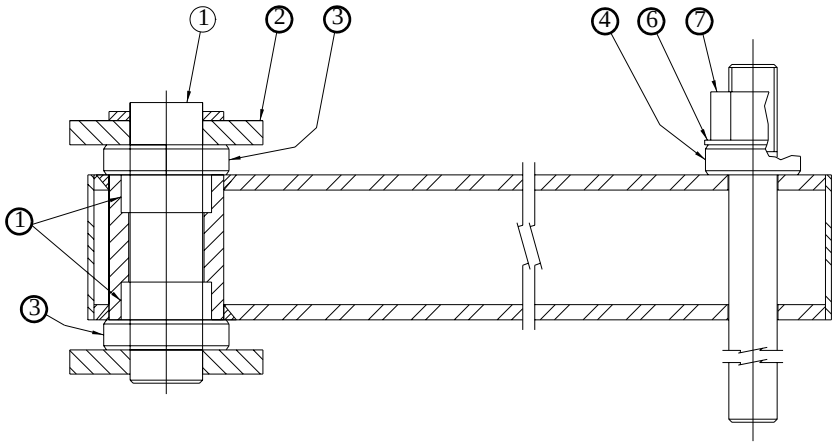
R.H. & L.H. 67”, 78”, 85”, 96”, 106”

ITEM	QTY	PART NO. 67" & 78"	QTY	PART NO. 85",96", & 106"	DESCRIPTION
1	1	869-00320	1	869-00399	NUT, HEX
2	1	056-00026	1	056-00027	PIN, HINGE, FRONT
3	1	011-00114	1	011-00115	TAB, RESTRAINT FRONT HEAD
4	2	807-00031	2	807-00324	BEARING, BALL DOUBLE
5	1	952-00245	1	952-00250	WASHER
6	1	868-00093	1	868-00102	CAP SCREW, HEX
7	1	952-00194	1	952-00193	WASHER, FLAT, BRASS
8	1	077-00386	1	077-00386	WASHER, SPACER
9	1	841-01594		————	STUD 67" & 78"
		————	1	841-01585	STUD 85" & 96"
		————	1	841-01682	STUD 106"
10	1	914-00158	—	————	RETAINER RING



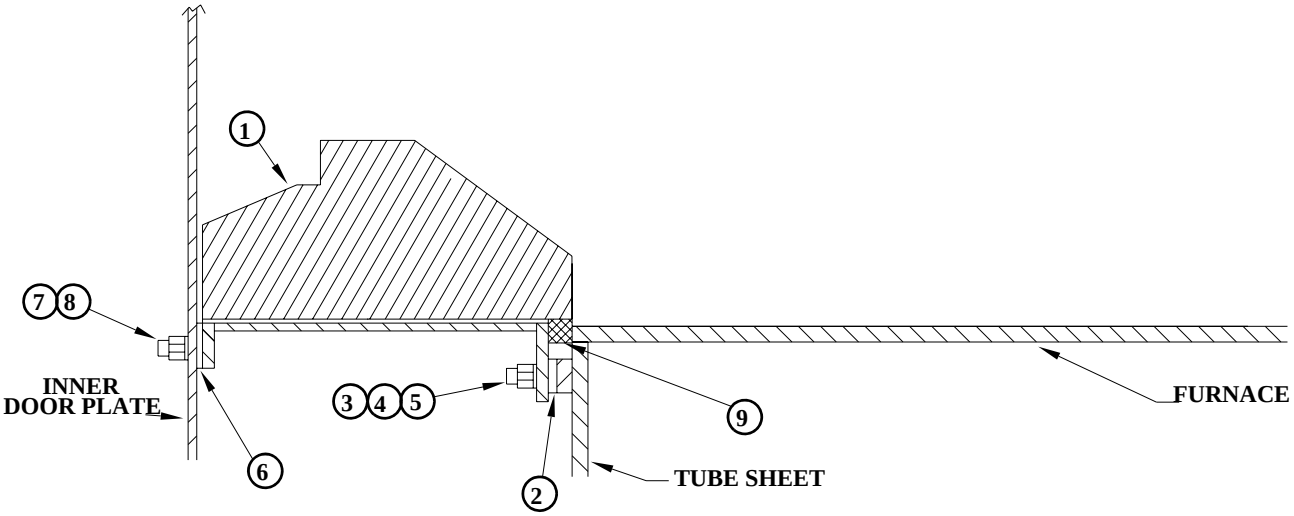
9.2.8 — Rear Door Davit Parts List

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	135-03633	SIZED ROD	60" - 96"
	1	135-03634	SIZED ROD	106"
2	1	066-00573	RING, RETAINER, PEDESTAL PIN, REAR DOOR	ALL
3	2	807-00439	BEARING, BALL THRUST	ALL
4	1	807-00438	BEARING, BALL THRUST	ALL
5	2	807-00440	BEARING, NEEDLE ROLLER	ALL
6	1	952-00132	WASHER, FLAT, 1"	ALL
7	1	869-00157	NUT, SELF LOCKING HEX- 1"-8UNC	ALL



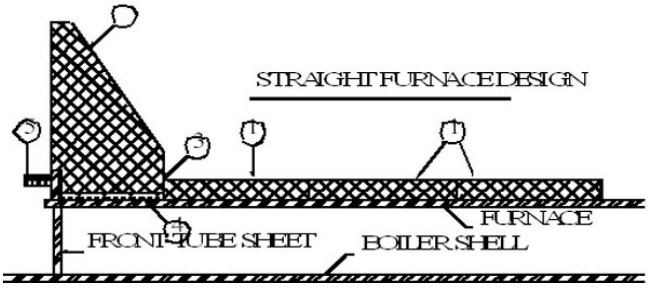
9.2.9 — Refractory Throat Materials for 60”

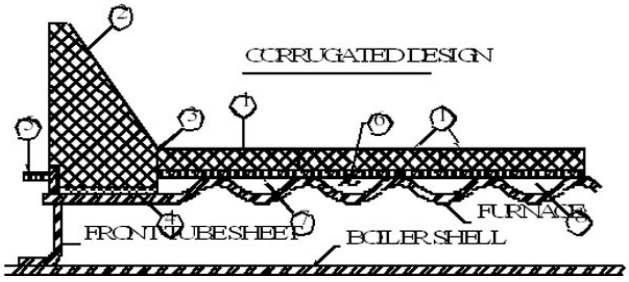
ITEM	QTY	PART NO.	DESCRIPTION
1	1	459-00526	OVEN, DRY, PRECAST
2	1	032-00107	GASKET, DRY OVEN
3	8	841-00513	STUD, MACH.
4	8	952-00108	WASHER, STD 1/2"
5	8	859-00029	NUT, HEX, BRASS 1/2"-13
6	1	032-00106	GASKET, DRY OVEN
7	8	952-00106	WASHER, STD 3/8"
8	8	869-00037	NUT, HEX BRASS 3/8"-16
9	6ft	872-00635	3/4" SQ FIBERGLASS ROPE



9.2.10 — Refractory Throat Materials 67”-106”

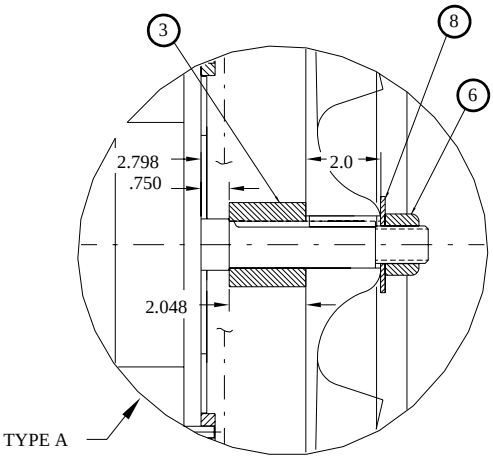
ITEM	BOILER DIAMETER	FURNACE TYPE	QTY	PRESSURE	PART NO.	DESCRIPTION
1	67"		0	———	———————	NO LINER TILE REQUIRED
	78"	STRIGHT	39	ALL	094-00204	TILE
		CORRUGATED	36	ALL		
	85"	STRIGHT	39	ALL	094-00746	TILE
		CORRUGATED	36	ALL		
	96"	STRIGHT	54	ALL	094-00428	TILE
		CORRUGATED	51	ALL		
	106"	STRIGHT	57	ALL	094-00747	TILE
		CORRUGATED	54	ALL		
2	67"	ALL	24	15-30#	094-00751	ARCH BRICK
				125-300#	094-00752	ARCH BRICK
				15-150#	094-00767	ARCH BRICK - NTI BURNER
	78"	ALL	25	15-30#	094-00343	ARCH BRICK
				125-300#	094-00449	ARCH BRICK
	85"	ALL	29	15-30#	094-00643	ARCH BRICK
				125-300#	094-00758	ARCH BRICK
	96"	ALL	35	15-30#	094-00429	ARCH BRICK
				125-300#	094-00451	ARCH BRICK
	106"	ALL	35	15-30#	094-00760	ARCH BRICK
				125-300#	094-00655	ARCH BRICK
3	67"-78"-85"	ALL	10lbs	ALL	872-00390	CEMENT JOINT MORTER
	96"-106"	ALL	25lbs	ALL	872-00390	CEMENT JOINT MORTER
4	ALL	ALL	2	ALL	872-00655	INSULATION
5	67"-78"	ALL	12	ALL	841-00665	STUD 2" LG
	85"-96"-106"	ALL	12	ALL	841-00308	STUD 2.5" LG
6	ALL	ALL	30lbs	ALL	872-00162	REFRACTORY MIX
7	67"	ALL	0	——	———————	NOT REQUIRED
	78"-85"	ALL	2	ALL	872-00657	INSULATION
	96"-106"	ALL	2	ALL	872-00687	INSULATION
8	67"	ALL	0	——	———————	NOT REQUIRED
	78"-85"	ALL	2	ALL	872-00656	INSULATION
	96"-106"	ALL	2	ALL	872-00690	INSULATION

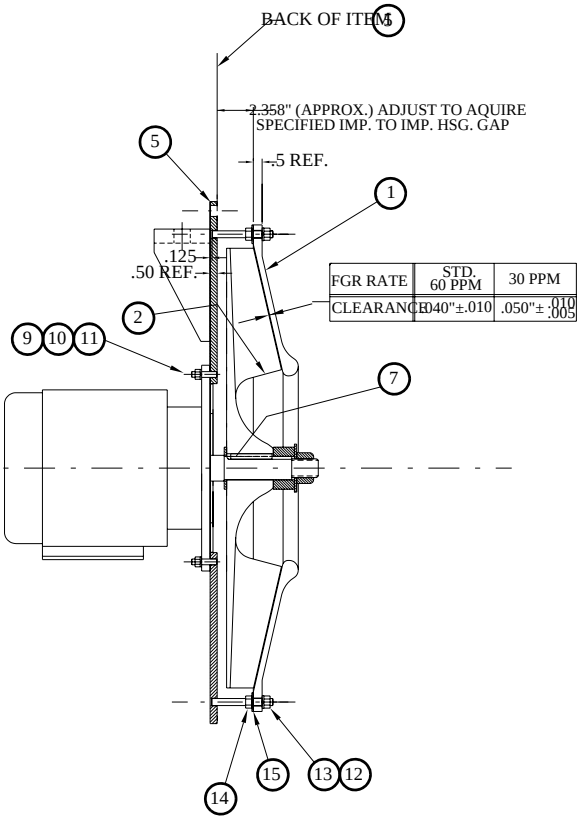




9.2.11 — Motor Cartridge Assembly: 60”

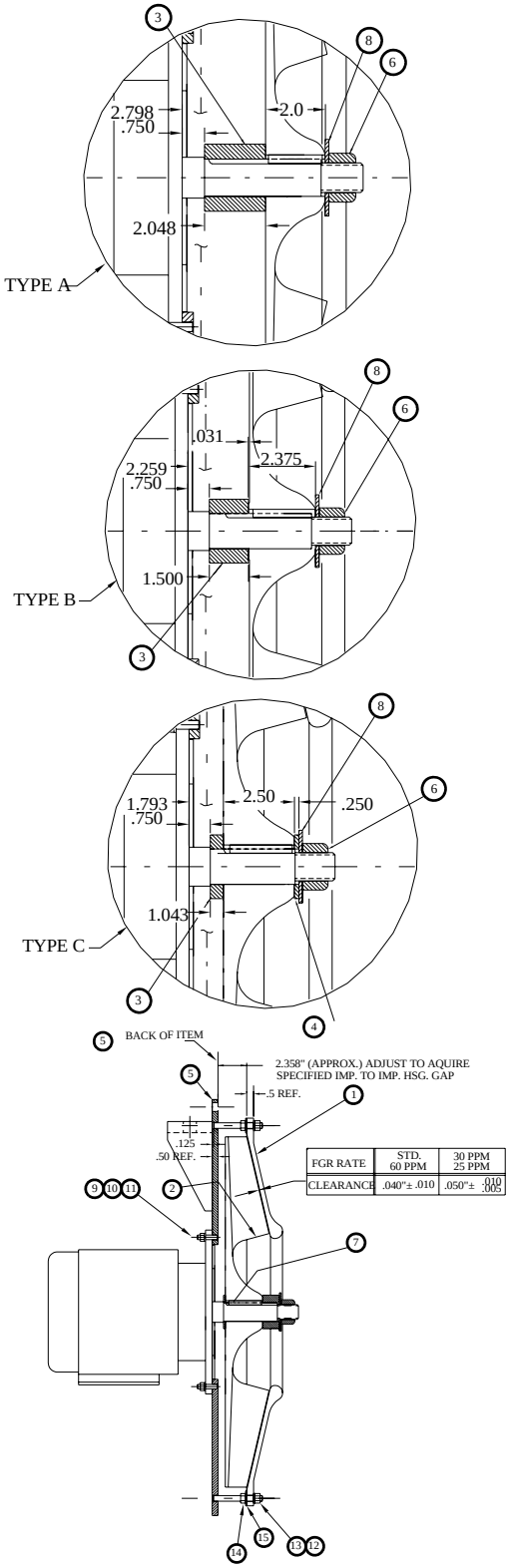
BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
60"	60	2 (100)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00260	1	IMPELLER (TYP A)
			3	077-00438	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		3 (125)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00261	1	IMPELLER (TYP A)
			3	077-00438	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
	30	3 (100)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00261	1	IMPELLER (TYP A)
			3	077-00438	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		5 (125)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00043	1	IMPELLER (TYP A)
			3	077-00438	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT





9.2.12 — Motor Cartridge Assembly: 67”

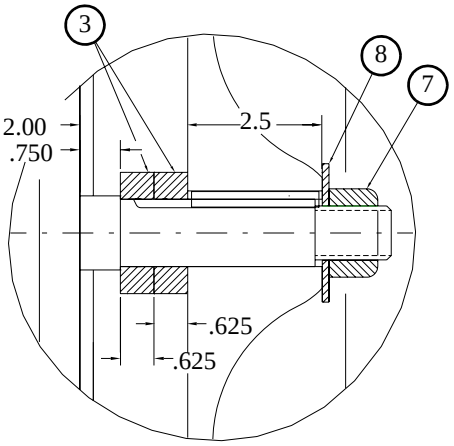
BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
67"	60	5 (150)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00261	1	IMPELLER (TYP A)
			3	077-00435	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		10 (200)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00045	1	IMPELLER (TYP B)
			3	077-00493	1	SPACER, 1.5" THK
			5	407-00062	1	BASE, MOUNTING
			6	869-00177	1	NUT, JAMB
			7	841-01105	1	KEY
			8	952-00225	1	WASHER 2.5" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
	30	7.5 (150)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00043	1	IMPELLER (TYP A)
			3	077-00438	1	SPACER, 2.048" THK
			5	407-00064	1	BASE, MOUNTING
			6	869-00119	1	NUT, JAMB
			7	841-00410	1	KEY
			8	952-00132	1	WASHER 2" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		10 (200)	1	040-00606	1	HOUSING, IMPELLER
			2	192-00086	1	IMPELLER (TYP C)
			3	077-00492	1	SPACER, 2.048" THK
			4	077-00478	1	SPACER, .250" THK
			5	407-00062	1	BASE, MOUNTING
			6	869-00177	1	NUT, JAMB
			7	841-01105	1	KEY
			8	952-00225	1	WASHER 2.5" OD
			9	869-00015	4	NUT, HEX
			10	952-00094	4	LOCKWASHER
			11	887-00027	4oz	NEVER SEEZ
			12	869-00365	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT

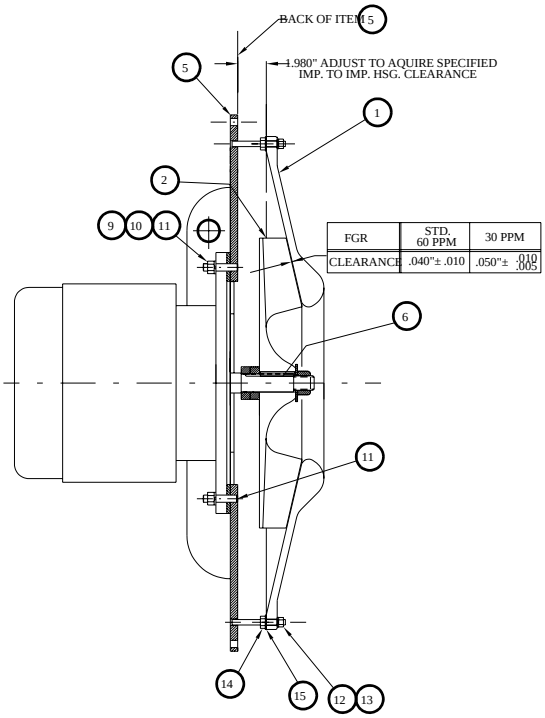


9.2.13 — Motor Cartridge Assembly: 78”

BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
78"	60	7.5 (250)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00080	1	IMPELLER
			3	077-00433	2	SPACER, 5/8" THK
			5	003-01279	1	BASE ASSEMBLY
			6	841-00410	1	KEY
			7	869-00119	1	NUT, JAMB
			8	952-00132	1	WASHER, 2"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		10 (300)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00085	1	IMPELLER
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01279	1	BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
	30	10 (250)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00303	1	IMPELLER
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01279	1	BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		15 (300)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00086	1	IMPELLER
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01279	1	ODP BASE ASSEMBLY
				003-01280	1	TEFC BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT

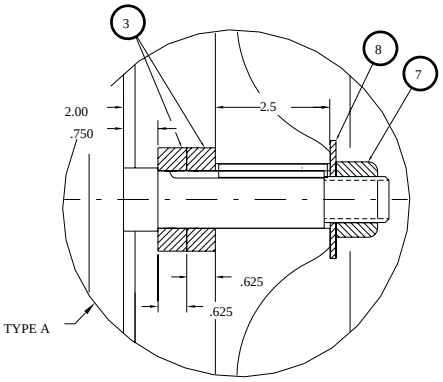
THIS IS PICTORIALLY INCORRECT
FOR 250HP 60PPM 4WI, THERE
ARE ACTUALLY (3) ITEM #8 REQ`D.



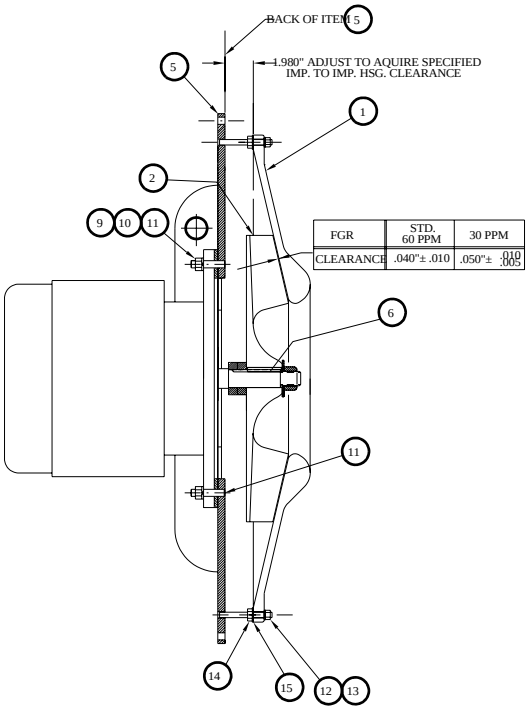


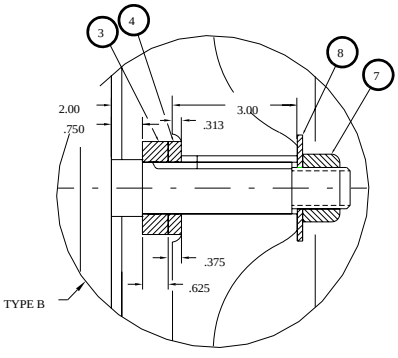
9.2.14 — Motor Cartridge Assembly: 85”

BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
85"	60	15 (350)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00078	1	IMPELLER (TYPE A)
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01279	1	ODP BASE ASSEMBLY
				003-01280	1	TEFC BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		20 (400)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00079	1	IMPELLER (TYPE A)
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01280	1	BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
	30	20 (350)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00079	1	IMPELLER (TYPE B)
			3	077-00445	2	SPACER, 5/8" THK
			5	003-01280	1	BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT
		25 (400)	1	040-00618	1	HOUSING, IMPELLER
			2	192-00087	1	IMPELLER (TYPE B)
			3	077-00445	2	SPACER, 5/8" THK
			4	077-00432	1	SPACER, 3/8" THK
			5	003-01280	1	TEFC BASE ASSEMBLY
			6	841-01105	1	KEY
			7	869-00177	1	NUT, JAMB
			8	952-00225	1	WASHER, 2.5"OD
			12	869-00030	8	NUT, HEX
			13	952-00093	8	LOCKWASHER
			14	869-00101	8	NUT, COUPLING
			15	952-00106	8	WASHER, FLAT



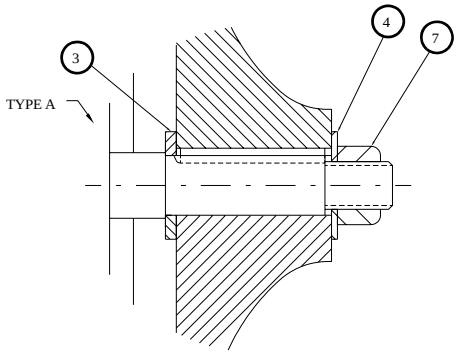
THIS IS PICTORIALLY INCORRECT
FOR 250HP 60PPM 4WI, THERE
ARE ACTUALLY (3) ITEM #8 REQ`D.

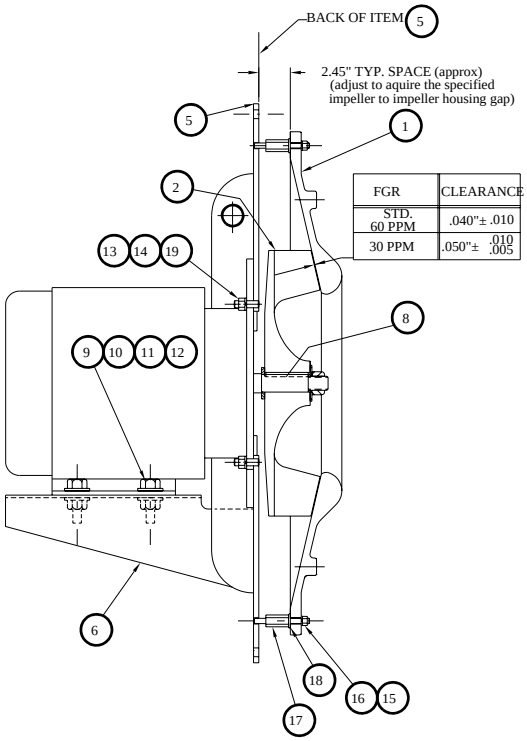


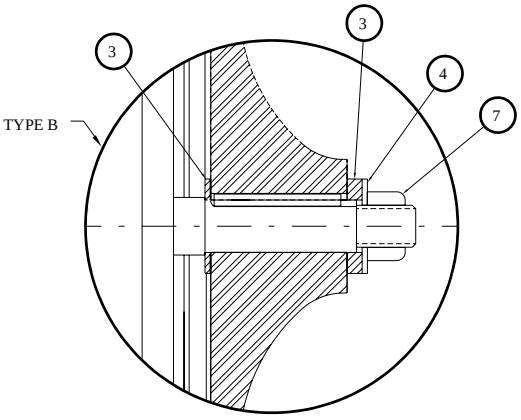


9.2.15 — Motor Cartridge Assembly: 96”

BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
96"	60	15 (500)	1	040-00602	1	HOUSING, IMPELLER
			2	192-00301	1	IMPELLER (TYPE A)
			3	077-00479	1	SPACER, 5/16" THK
			4	077-00488	1	SPACER 1/4" THK
			5	003-01276	1	ODP BASE ASSEMBLY
				003-01277	1	TEFC BASE ASSEMBLY
			7	869-00177	1	NUT, JAMB
			8	841-01105	1	KEY
			13	869-00018	4	NUT, HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	884-00024	5oz	NEVER SEEZ
		25 (600)	1	040-00602	1	HOUSING, IMPELLER
			2	192-00267	1	IMPELLER (TYPE B)
			3	077-00479	2	SPACER, 5/16" THK
			4	077-00488	2	SPACER 1/4" THK
			5	003-01277	1	BASE ASSEMBLY
			7	869-00177	1	NUT, JAMB
			8	841-01105	1	KEY
			13	869-00018	4	NUT, HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	884-00024	5oz	NEVER SEEZ
	30	25 (500)	1	040-00602	1	HOUSING, IMPELLER
			2	192-00267	1	IMPELLER (TYPE B)
			3	077-00479	2	SPACER, 5/16" THK
			4	077-00488	2	SPACER 1/4" THK
			5	003-01277	1	BASE ASSEMBLY
			7	869-00177	1	NUT, JAMB
			8	841-01105	1	KEY
			13	869-00018	4	NUT, HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	884-00024	5oz	NEVER SEEZ
		30 (600)	1	040-00602	1	HOUSING, IMPELLER
			2	192-00268	1	IMPELLER (TYPE B)
			3	077-00479	2	SPACER, 5/16" THK
			4	077-00488	1	SPACER 1/4" THK
			5	003-01277	1	BASE ASSEMBLY
			6	085-03120	1	MOTOR SUPPORT
			7	869-00177	1	NUT, JAMB
			8	841-01105	1	KEY
			9	952-00176	4	CAP SCREW
			10	869-00015	4	NUT, HEX
			11	952-00108	4	WASHER
			12	952-00094	4	LOCKWASHER
			13	869-00018	4	NUT, HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	884-00024	5oz	NEVER SEEZ



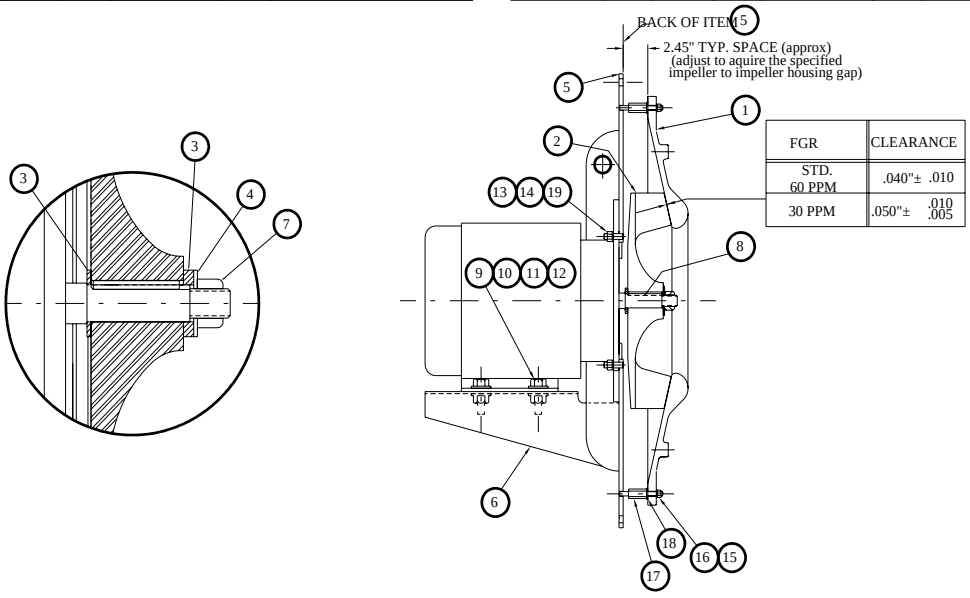




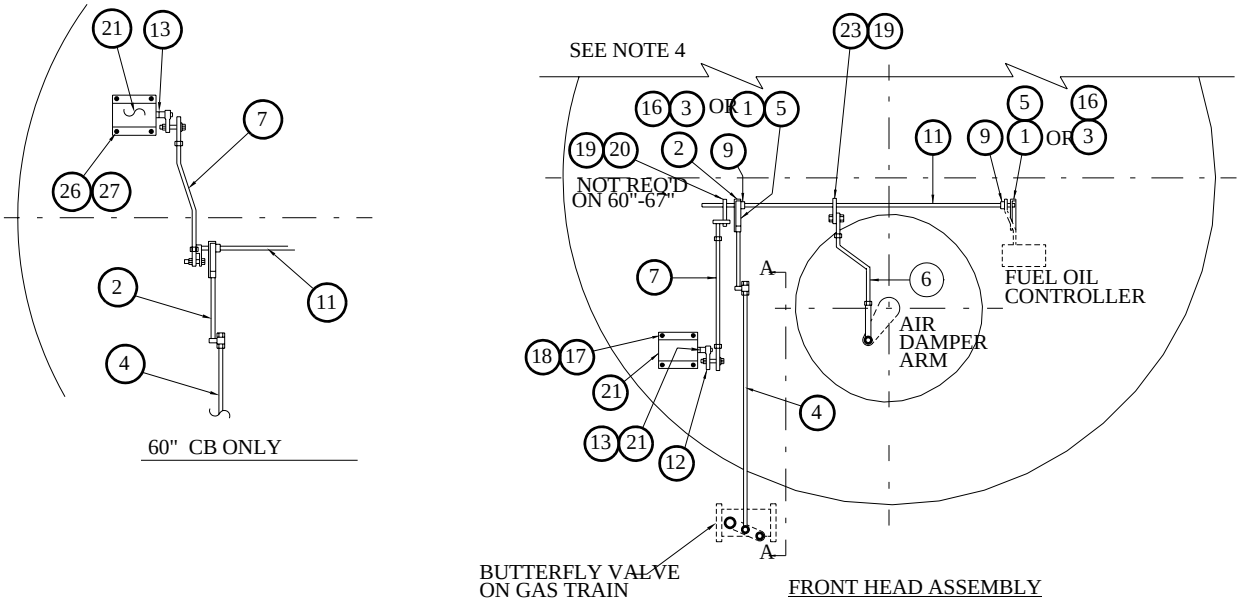
9.2.16 — Motor Cartridge Assembly: 106”

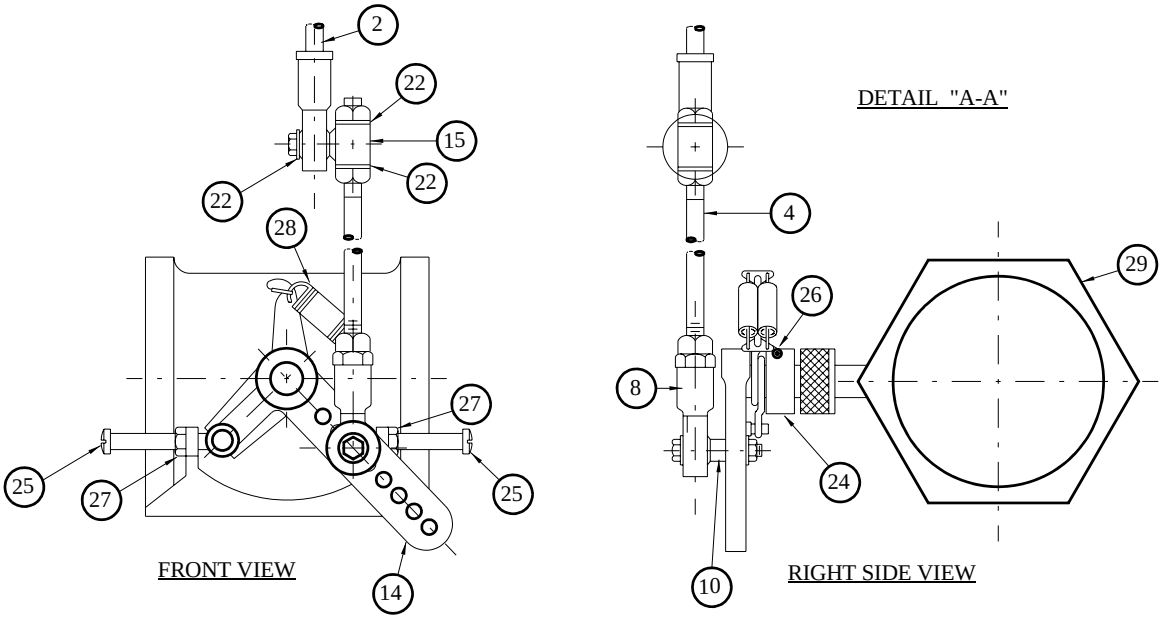
BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
106"	60	30 (700)	1	040-00602	1	HOUSING, IMPELLER
			2	191-00267	1	IMPELLER
			3	077-00479	2	SPACER, 5/16" THK
			4	077-00488	2	SPACER 1/4" THK
			5	003-01277	1	BASE ASSEMBLY
			6	085-03120	1	MOTOR SUPPORT
			7	085-03120	1	NUT, JAMB
			8	085-03120	1	KEY
			9	085-03120	4	CAP SCREW
			10	085-03120	4	NUT, HEX
			11	085-03120	4	WASHER
			12	085-03120	4	LOCKWASHER
			13	869-00018	4	NUT,HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	887-00024	5oz	NEVER SEEZ
		50 (800)	1	040-00602	1	HOUSING, IMPELLER
			2	191-00272	1	IMPELLER
			3	077-00480	2	SPACER, 5/16" THK
			4	077-00338	2	WASHER 2.5" OD x
			5	003-01278	1	BASE ASSEMBLY
			6	085-03121	1	MOTOR SUPPORT
			7	869-00180	1	NUT, JAMB
			8	841-01105	1	KEY
			9	868-00095	4	CAP SCREW
			10	869-00017	4	NUT, HEX
			11	952-00101	4	WASHER
			12	952-00084	4	LOCKWASHER
			13	869-00018	4	NUT,HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	887-00024	5oz	NEVER SEEZ

BOILER DIAMETER	PPM	MOTOR H.P.	ITEM	PART NO.	QTY	DESCRIPTION
106"	30	50 (700)	1	040-00602	1	HOUSING, IMPELLER
			2	191-00274	1	IMPELLER
			3	077-00480	2	SPACER, 5/16" THK
			4	077-00338	2	WASHER 2.5" OD x
			5	003-01278	1	BASE ASSEMBLY
			6	085-03121	1	MOTOR SUPPORT
			7	869-00180	1	NUT, JAMB
			8	841-01105	1	KEY
			9	868-00095	4	CAP SCREW
			10	869-00017	4	NUT, HEX
			11	952-00101	4	WASHER
			12	952-00084	4	LOCKWASHER
			13	869-00018	4	NUT,HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	887-00024	5oz	NEVER SEEZ
		50 (800)	1	040-00602	1	HOUSING, IMPELLER
			2	191-00279	1	IMPELLER
			3	077-00480	2	SPACER, 5/16" THK
			4	077-00338	2	WASHER 2.5" OD x
			5	003-01278	1	BASE ASSEMBLY
			6	085-03121	1	MOTOR SUPPORT
			7	869-00180	1	NUT, JAMB
			8	841-01105	1	KEY
			9	868-00095	4	CAP SCREW
			10	869-00017	4	NUT, HEX
			11	952-00101	4	WASHER
			12	952-00084	4	LOCKWASHER
			13	869-00018	4	NUT,HEX
			14	952-00095	4	LOCKWASHER
			15	869-00030	8	NUT, HEX
			16	952-00093	8	LOCKWASHER
			17	869-00101	8	NUT, COUPLING
			18	952-00106	8	WASHER, FLAT
			19	887-00024	5oz	NEVER SEEZ



9.2.17 — Front Head Linkage: 60”-106”



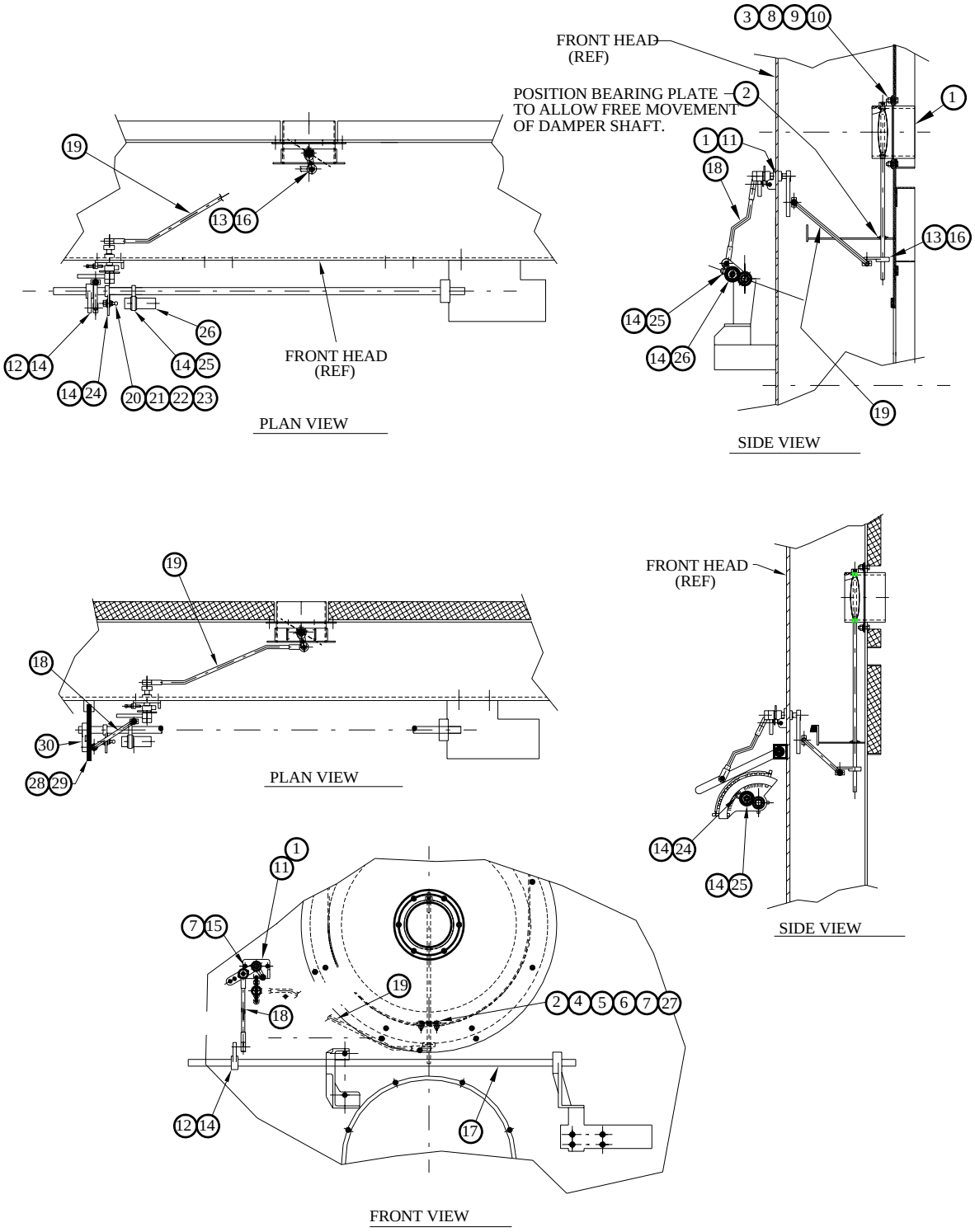


ITEM	QUANTITY			PART NO.	DESCRIPTION	USED ON
	GAS	OIL	CMB			
1	1	1	2	313-00005	CAM ASSEMBLY	ALL
2	1	—	1	295-00099	GAS VALVE STEM ASSEMBLY	60"/67"
	1	—	1	295-00098	GAS VALVE STEM ASSEMBLY	78"/85"/96"/106"
3	1	1	—	085-01926	SUPPORT - JACKSHAFT	ALL
4	1	—	1	067-00017	ROD LINKAGE - GAS VALVE	60"
	1	—	1	067-00906	ROD LINKAGE - GAS VALVE	67"
	1	—	1	067-00800	ROD LINKAGE - GAS VALVE	78"
	1	—	1	067-00802	ROD LINKAGE - GAS VALVE	85"
	1	—	1	067-00926	ROD LINKAGE - GAS VALVE	96"
	1	—	1	067-00832	ROD LINKAGE - GAS VALVE	106"
5	1	1	2	853-00454	GASKET	ALL
6	1			476-00054	AIR DAMPER LINKAGE	60"/67"
	1			476-00260	AIR DAMPER LINKAGE	78"
	1			476-00208	AIR DAMPER LINKAGE	85"/96"/106"
7	1			476-00053	MOTOR TO SHAFT LINKAKE	60"/67"
	1			476-00261	MOTOR TO SHAFT LINKAKE	78"
	1			476-00102	MOTOR TO SHAFT LINKAKE	85"/96"/106"
8	1			883-00017	BALL JOINT	ALL
9	2			824-00021	COLLAR	ALL
10	1			010-00288	BUSHING-BALL JOINT	ALL
11	1			074-00211	JACKSHAFT	60"/67"
	—	1	1	074-00204	JACKSHAFT	78"
	1	—	—	074-00205	JACKSHAFT	78"
	1			074-00218	JACKSHAFT	85"
	1			074-00498	JACKSHAFT	96"/106"
12	—			—	NOT REQUIRED	60"/67"
	1			002-00047	DRIVE ARM-MODUTROL MOTOR	78"/85"/96"/106"
13	1			010-00091	BUSHING	ALL
14	1			287-00024	GAS VALVE & ARM DAMPER	ALL
15	1			068-00032	ROD END LINKAGE	ALL
16	2			077-00371	CAM SPACERS	ALL
17	4			952-00092	LOCKWASHER	ALL
18	4			868-00137	BOLT, HEX HD 1" LG	ALL
19	4			860-00101	SET SCREW	ALL
20	—			—	NOT REQUIRED	60"/67"
	1			002-00047	DRIVE ARM	78"/96"
21	1			506-00479	MOD MOTOR	60"/67"
	1			894-03471	MOD MOTOR	78"/85"/96"/106"
22	3			952-00093	LOCKWASHER 3/8"	ALL
23	—			—	NOT REQUIRED	60"/67"
	1			002-00310	DRIVE ARM	85"/106"
24	1			287-00005	ACTUATING ARM	ALL
25	2			866-00034	SCREW	ALL
26	2			860-00082	SET SCREW	ALL
27	2			859-00021	NUT	ALL
28	1			882-00015	KIT SPRING MTG PLATE	ALL
29	1			SEE TABLE	BUTTERFLY GAS VALVE	

BUTTERFLY GAS VALVE

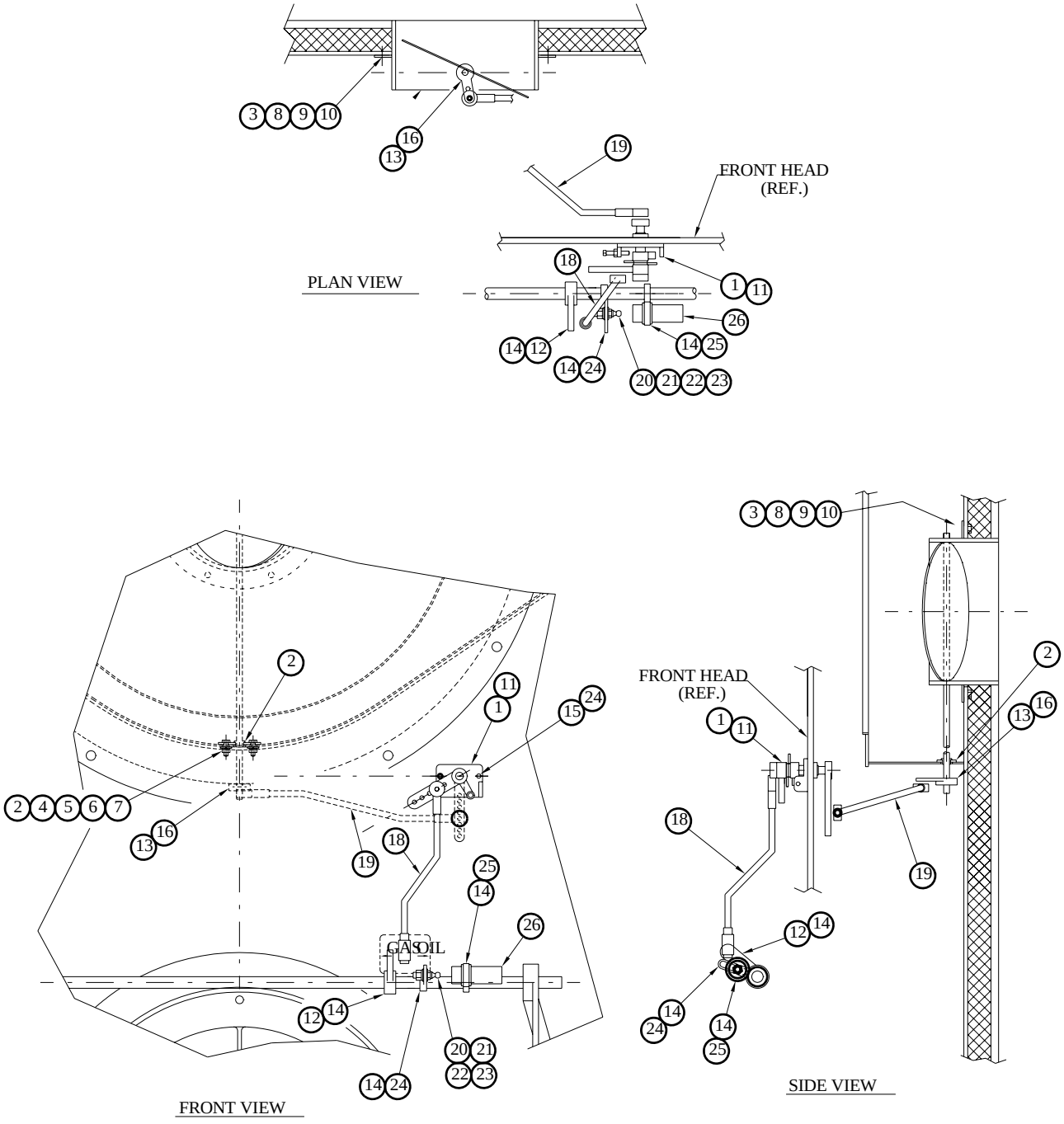
SIZE	PART NUMBER
1-1/2"	940-00132
2"	940-00231
2-1/2"	940-00133
3"	940-00134
4"	940-00165

9.2.18 — Front Head, FGR Linkage: 60”-85”



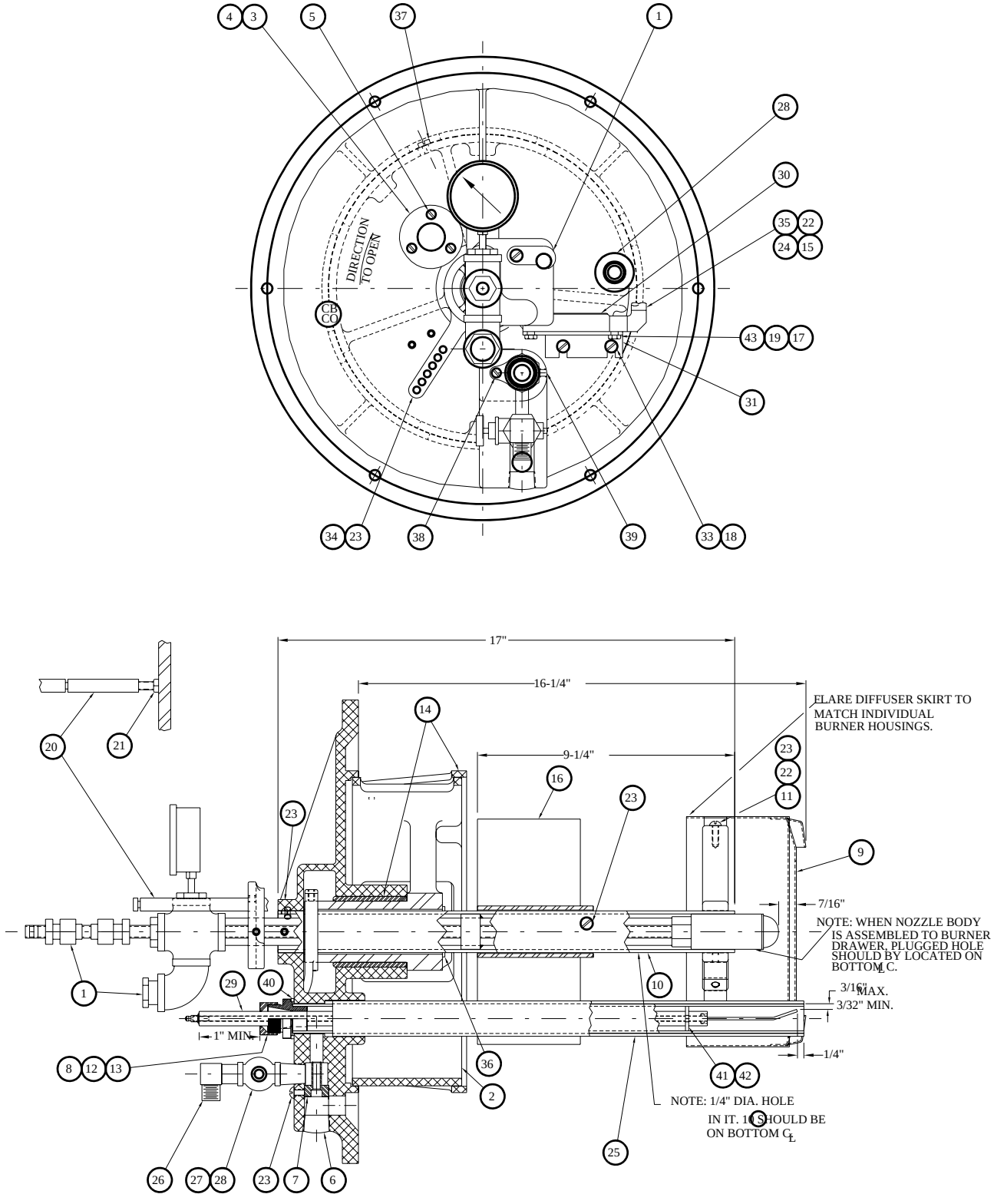
ITEM	QTY	PART NO	DESCRIPTION
1	1	032-02557	GASKET, IFGR LINKAGE ASSEMBLY
2	1	306-00079	BEARING PLATE ASSEMBLY
	1	059-07557	IF APPLICABLE, BEARING PLATE COVER
3	1	032-02556	GASKET, DAMPER IFGR
4	2	868-00405	CAP SCREW, HEX
5	2	869-00021	NUT, HEX
6	2	952-00294	WASHER, FLAT
7	4	952-00092	LOCKWASHER
8	8	869-00036	NUT, HEX
9	8	952-00297	WASHER, FLAT
10	8	952-00114	LOCKWASHER
11	1	427-00251	DAMPER, CONTROL SHAFT ASSEMBLY
	1	059-07558	IF APPLICABLE, DAMPER CONTROL HOLE COVER PLATE
12	1	002-00331	60 PPM DRIVE ARM JACKSHAFT
	1	002-00332	30 PPM DRIVE ARM JACKSHAFT
13	1	287-00050	DRIVE ARM, DAMPER
14	3	860-00039	SETSCREW
15	2	868-00136	CAPSCREW
16	2	860-00101	SETSCREW
17	1	074-00222	60" BOILER DIA, JACKSHAFT 3/4" DIA
	1	074-00178	67" BOILER DIA, 60 PPM JACKSHAFT 3/4"
	1	074-00222	67" BOILER DIA, 30 PPM JACKSHAFT 3/4"
	1	074-00221	78" & 85" BOIER DIA, JACKSHAFT 3/4"
18	1	067-00797	60" BOILER DIA, 60 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00799	60" BOILER DIA, 30 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00905	67" BOILER DIA, LINKAGE ASSY, JACKSHAFT
	1	067-00917	78" BOILER DIA, 60 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00918	78" BOILER DIA, 30 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00896	85" BOILER DIA, 60 PPM, LINKAGE ASSY, JACKSHAFT
	1	0670-0897	85" BOILER DIA, 30 PPM, LINKAGE ASSY, JACKSHAFT
19	1	476-00230	LINKAGE ASSY DAMPER
20	1	883-00078	BALL SCREW FOR QUICK DISCONNECT
21	1	869-00022	NUT, HEX
22	1	952-00093	LOCKWASHER
23	2	952-00106	WASHER, FLAT
24	1	002-00333	DRIVE ARM, JACKSHAFT
25	1	002-00334	ARM, JACKSHAFT PROXIMITY SWITCH
26	1	836-01031	PROXIMITY SWITCH
27	1	032-02555	GASKET, BEARING PLATE
28	1	476-00320	CAMFOLLOWER ASSEMBLY
29	2	868-00210	CAPSCREW SOCKETHEAD
30	1	313-00023	CAM ASSEMBLY L.H.

9.2.19 — Front Head, FGR Linkage: 96” & 106”



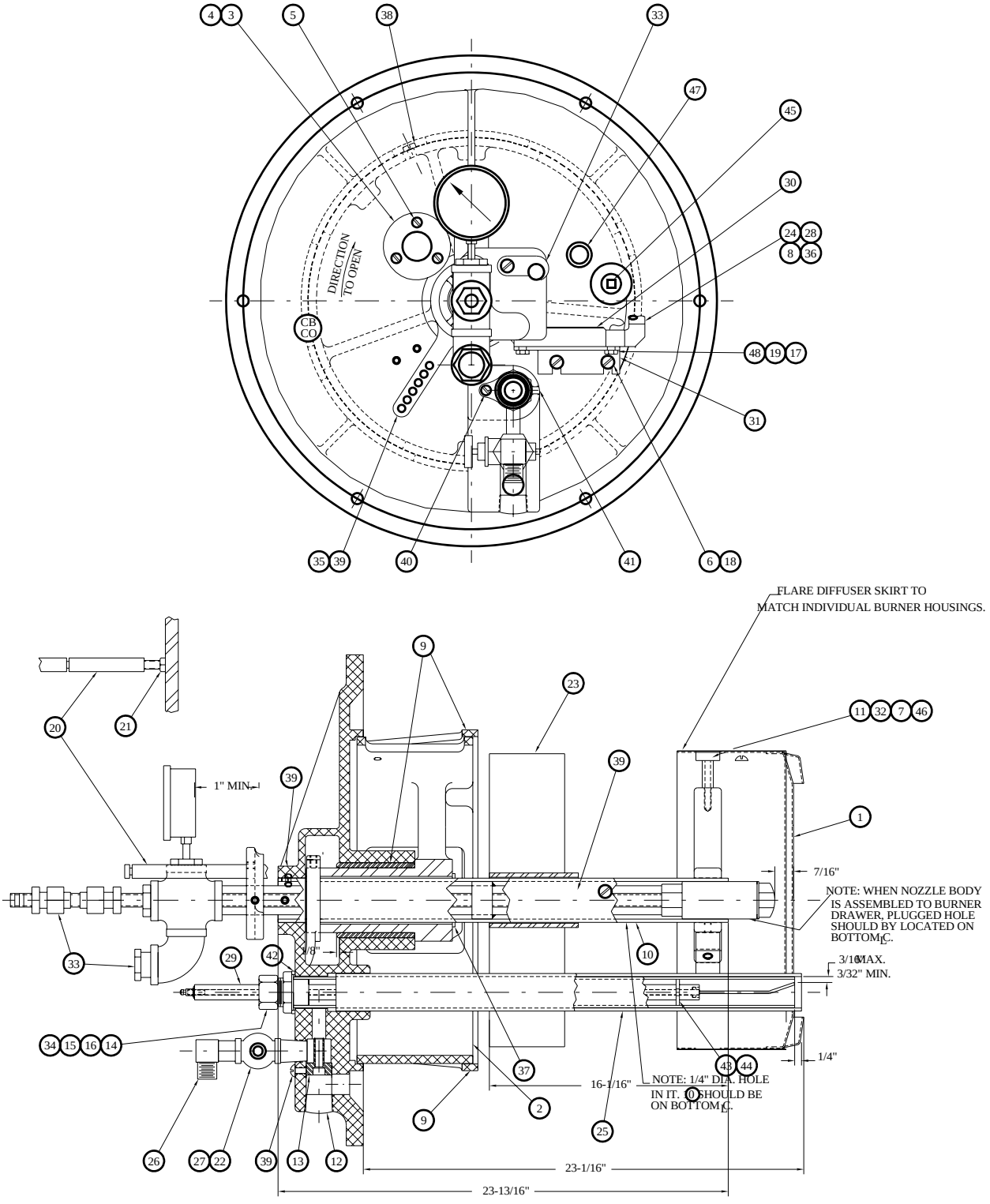
ITEM	QTY	PART NO	DESCRIPTION
1	1	032-02557	GASKET, IFGR LINKAGE ASSEMBLY
2	1	306-00079	BEARING PLATE ASSEMBLY
3	1	032-02556	GASKET, DAMPER IFGR
4	2	868-00405	CAP SCREW, HEX
5	2	869-00021	NUT, HEX
6	2	952-00294	WASHER, FLAT
7	4	952-00092	LOCKWASHER
8	8	869-00036	NUT, HEX
9	8	952-00297	WASHER, FLAT
10	8	952-00114	LOCKWASHER
11	1	427-00251	DAMPER, CONTROL SHAFT ASSEMBLY
12	1	002-00331	60 PPM DRIVE ARM JACKSHAFT
	1	002-00332	30 PPM DRIVE ARM JACKSHAFT
13	1	287-00050	DRIVE ARM, DAMPER
14	3	860-00039	SETSCREW
15	2	868-00136	CAPSCREW
16	2	860-00101	SETSCREW
17	—	————	————
18	1	067-00914	96" BOILER DIA, 60 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00915	96" BOILER DIA, 30 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00901	106" BOILER DIA, 30 PPM, LINKAGE ASSY, JACKSHAFT
	1	067-00902	106" BOILER DIA, 60 PPM, LINKAGE ASSY, JACKSHAFT
19	1	476-00222	LINKAGE ASSY DAMPER
20	1	883-00078	BALL SCREW FOR QUICK DISCONNECT
21	1	869-00022	NUT, HEX
22	1	952-00093	LOCKWASHER
23	2	952-00106	WASHER, FLAT
24	1	002-00333	DRIVE ARM, JACKSHAFT
25	1	002-00334	ARM, JACKSHAFT PROXIMITY SWITCH
26	1	836-01031	PROXIMITY SWITCH
27	1	032-02555	GASKET, BEARING PLATE

9.2.20 — 60” Burner Drawer, Gas Pilot, Models 100-600, 100-125 HP



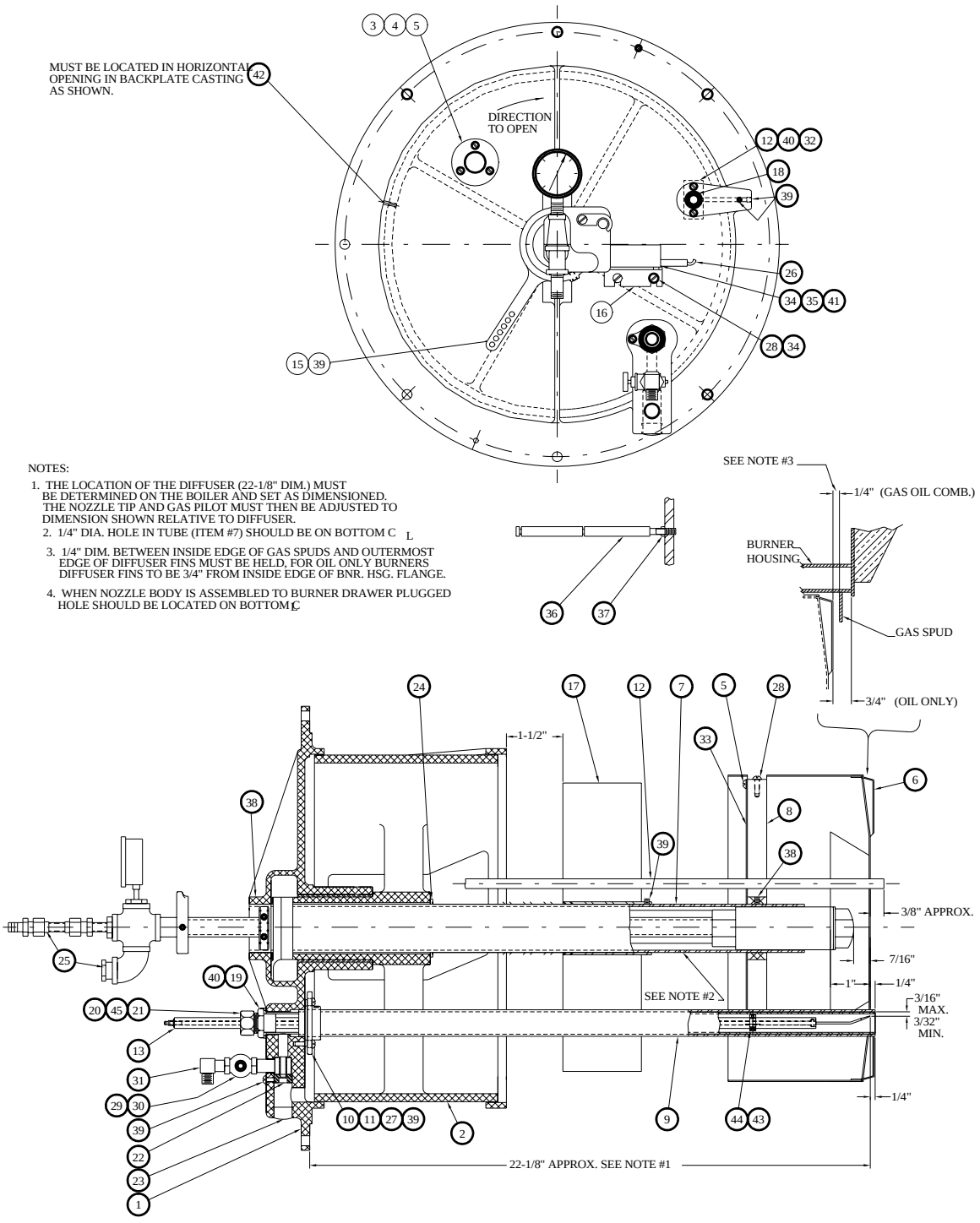
ITEM	QTY	PART NO	DESCRIPTION
1	1	251-00221	NOZZLE-GUN ASSEMBLY
2	1	108-00047	DAMPER
3	2	851-00077	MICA, SHEET, PORT HOLE, #36 GA. X 1-1/2" DIA.
4	1	065-00011	RETAINER SIGHT HOLE
5	3	860-00176	MACHINE SCREW, RD. HD. 10-24 X 1/4" LG.
6	1	858-00310	PLUG, PIPE, COUNTER SUNK, 3/4"
7	1	048-00098	VENTURI, GAS PILOT
8	1	904-00036	GROMMET, RUBBER
9	1	275-00063	60", 100HP, 60 PPM, DIFFUSER ASSEMBLY
	1	275-00082	60", 100HP, 30 PPM, DIFFUSER ASSEMBLY
	1	275-00082	60", 125HP, 30 & 60 PPM, DIFFUSER ASSEMBLY
10	1	090-01512	TUBE, BURNER DRAWER
11	1	134-00047	SPIDER
12	1	034-00007	GLAND, PACKING
13	1	090-01708	TUBE & ADAPTER ASS'Y, GAS PILOT
14	1	059-05768	PLATE, BACK BEARING ASSEMBLY (SEE 59-A-918)
15	1	827-00006	BULK CONDUIT, GREENFIELD 3/8" X 11" LG
16	1	022-00122	DIFFUSER, AIR STABILIZER
17	2	860-00091	MACHINE SCREW, RD. HD. #10-32 X 1-1/2" LG.
18	3	952-00092	LOCKWASHER, 1/4"
19	2	869-00009	NUT, HEX #10-32
20	1	056-00021	PIN-LOCKING
21	1	869-00036	NUT, HEX 5/16"-18
22	5	860-00158	SETSCREW, SOCKET HD. 1/4"-20 X 5/16" LG
23	9	860-00039	SETSCREW, SOCKET HD. 1/4"-20 X 3/8" LG
24	2	848-00100	BUSHING FIBER
25	1	090-01709	TUBE GAS PILOT
26	1	845-00194	ELBOW, MALE, 5/8" ODC X 1/2" NPT X 90°
27	1	825-00030	COCK, GAS, TEE HEAD
28	2	857-00153	NIPPLE, 1/2" X 1-1/2" LG
29	1	435-00036	ELECTRODE, IGNITION ASS'Y
30	1	836-00996	SWITCH, LIMIT
31	1	008-03057	BRACKET, LIMIT SWITCH
32	1	848-00002	CONNECTOR, BOX, SQUEEZE TYPE
33	6	860-00007	MACH, SCREW-RD. HD. 1/4"-20 X 1/2" LG
34	1	002-00031	ARM, DAMPER
35	1	848-00016	CONNECTOR, BOX, SQUEEZE TYPE
36	1	073-00026	SEALER, RING
37	1	868-00210	CAPSCREW, SOCKET HD. 1/4"-20 X 1/2" LG
38	1	860-00201	MACHINE SCREW, 10-24 NC RD. H. X 1/8"
39	1	860-00161	SET SCREW-SOCKET HD. 5/16"-18 NC X 1/2"
40	1	853-00001	O-RING
41	1	134-00053	HOLDER-ELECTRODE
42	1	860-00244	SET SCREW-SOCKET HD. 6-32 X 1/8"
43	2	952-00117	LOCKWASHER #10

9.2.21 — 67” Burner Drawer, Gas Pilot, Models 101-600, 150-200 HP



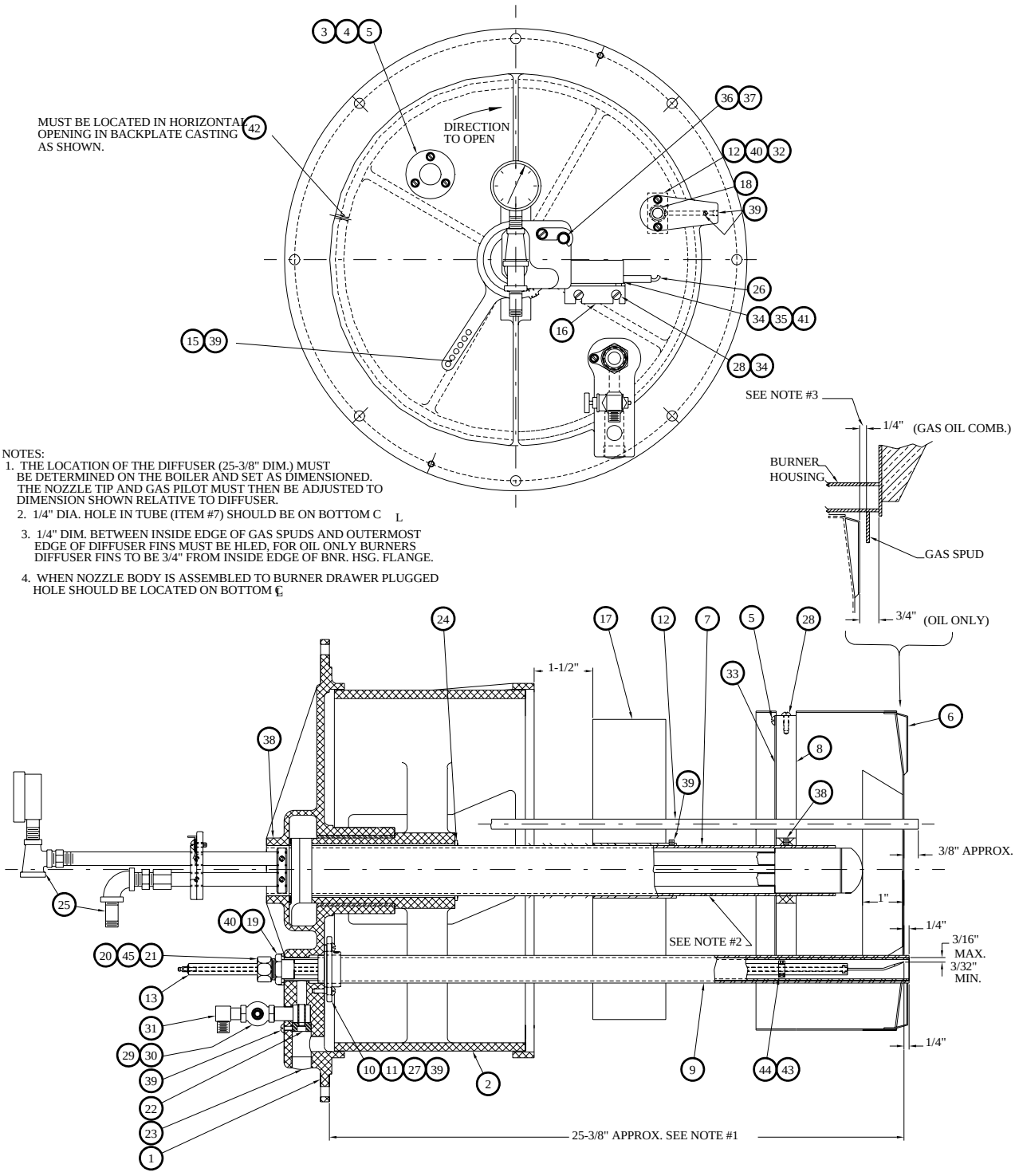
ITEM	QTY	PART NO.	DESCRIPTION
1	1	275-00276	DIFFUSER, BURNER ASS'Y
2	1	108-00047	DAMPER
3	2	851-00077	MICA, SHEET, PORT HOLE, #36 GA. X 1-1/2" DIA.
4	1	065-00011	RETAINER SIGHT HOLE
5	3	860-00176	MACHINE SCREW, RD. HD. 10-24 X 1/4" LG.
6	3	860-00007	MACH. SCREW RD. HD. 1/4"-20 X 1/2" LG.
7	4	860-00158	SETSCREW, SOCKET HD. 1/4"-20 X 5/16" LG.
8	2	848-00100	BUSHING, FIBER
9	1	059-05414	PLATE, BACK, BEARING ASS'Y
10	1	090-01895	TUBE, BURNER DRAWER
11	1	134-00047	SPIDER
12	1	858-00310	PLUG, PIPE 3/4" NPT
13	1	048-00098	VENTURI, GAS PILOT
14	1	904-00036	GROMMET, RUBBER, CABLE GRIP
15	1	034-00007	GLAND, PACKING, PILOT GAS BURNER
16	1	090-01899	ADAPTER, GAS PILOT
17	2	860-00091	MACHINE SCREW, RD. HD. #10-32 X 1-1/2" LG.
18	3	952-00092	LOCKWASHER, 1/4"
19	2	869-00009	NUT, HEX #10-32
20	1	056-00021	PIN-LOCKING-LONG BURNER DRAWER
21	1	869-00036	NUT, HEX 5/16"-18
22	1	857-00153	NIPPLE, 1/2" X 1-1/2" LG.
23	1	022-00412	DIFFUSER, AIR STABILIZER
24	1	848-00016	CONNECTOR BOX, SQUEEZE TYPE
25	1	090-01896	TUBE GAS PILOT
26	1	845-00194	ELBOW, MALE, 5/8" ODC X 1/2" NPT X 90°
27	1	825-00030	COCK, GAS
28	1	827-00006	BULK CONDUIT 3/8" X 11" LG.
29	1	435-00144	ELECTRODE, IGNITION ASS'Y
30	1	836-00996	SWITCH, LIMIT
31	1	008-03057	BRACKET, LIMIT SWITCH
32	3	860-00220	MACH. SCREW, RD. HD. 1/4"-20 X 1-1/2" LG.
33	1	251-00217	67", 150 HP, NOZZLE GUN ASSEMBLY
	1	251-00218	67", 200 HP, NOZZLE GUN ASSEMBLY
34	1	853-00001	O-RING
35	1	002-00031	ARM, DAMPER
36	1	848-00002	CONNECTOR, BOX, SQUEEZE TYPE
37	1	073-00026	SEALER, RING BURNER
38	1	868-00210	CAPSCREW, SOCKET HD. 1/4"-20 X 1/2" LG
39	9	860-00039	SETSCREW, SOCKET HD. 1/4"-20 X 3/8" LG.
40	1	860-00201	MACH. SCREW, 10-24 NC. RD. HD. X 1/8"
41	1	860-00161	SETSCREW-SOCKET HD. 5/16"-18 N.C. X 1/2"
42	1	853-00001	O-RING
43	1	134-00053	HOLDER-ELECTRODE
44	1	860-00244	SETSCREW-SOCKET HD. 6-32 X 1/8"
45	1	090-01897	SCANNER TUBE ASS'Y
46	3	900-00002	SPACER, PIPE, 1/8" SCH. 40 X 1" LG.
47	1	858-00091	PLUG, PIPE, 1/2" NPT
48	2	952-00117	LOCKWASHER #10

9.2.22 — 78" Burner Drawer, Gas Pilot, HI-TD, 250-300 HP



ITEM	QTY	PART NO.	DESCRIPTION
1	1	059-05770	BACKPLATE AND BEARING ASSEMBLY
2	1	108-00118	DAMPER
3	2	851-00077	MICA-PORT HOLE 1-1/2" O.D.
4	1	065-00011	RETAINER-SIGHT HOLE
5	6	860-00176	SCREW-MACH. RD. HD. 10-24 X 1/4"LG.
6	1	275-00253	DIFFUSER ASSEMBLY, 78", 60 PPM, 250-300 HP
	1	275-00254	DIFFUSER ASSEMBLY, 78", 30 PPM, 250-300 HP
7	1	090-00164	TUBE-BURNER DRAWER
8	1	134-00049	SPIDER-DIFFUSER
9	1	090-01474	PIPE-GAS PILOT OUTER
10	1	001-00197	ADAPTER, GAS PILOT
11	1	073-00032	SEAL RING, GAS PILOT
12	1	090-01424	TUBE, SCANNER ASS'Y
13	1	435-00052	ELECTRODE, IGNITION
14	2	860-00064	MACH. SCREW RD. HD., 1/4"-20 X 3/4" LG.
15	1	002-00037	ARM, DAMPER
16	1	008-03057	BRACKET, LIMIT SWITCH
17	1	022-00131	STABILIZER
18	1	857-00153	NIPPLE, 1/2" X 1-1/2"LG.
19	1	090-01476	TUBE AND ADAPTER ASSEMBLY (INNER)
20	1	853-00001	"O" RING
21	1	904-00036	GROMMET, RUBBER
22	1	048-00098	VENTURI, GAS PILOT
23	1	858-00310	PLUG, HEX., SOCKET HD. 3/4" NPT
24	1	073-00031	SEAL RING, DAMPER
25	1	251-00038	NOZZLE-GUN ASSEMBLY
26	1	848-00002	CONNECTOR, BOX SQUEEZE TYPE
27	2	860-00064	MACH. SCREW RD. HD. 1/4"-20 X 3/4"LG.
28	3	860-00007	MACH. SCREW RD. HD. 1/4"-20 X 1/2"LG.
29	1	857-00151	NIPPLE, CLOSE 1/2" X 1-1/8"LG.
30	1	825-00030	GAS CPCL TEE HEAD 1/2" NPT
31	1	845-00194	FLARED ELBOW 90° X 1/2" NPT X 5/8" O.D.C.
32	1	032-00497	GASKET SCANNER TUBE
33	1	080-00088	RING, DIFFUSER
34	5	952-00092	LOCKWASHER, 1/4"
35	3	869-00021	NUT, HEX, 1/4"-20
36	1	056-00021	PIN, LOCKING, BURNER DRAWER
37	1	869-00036	NUT, HEX, 5/16"-18
38	6	860-00039	SETSCREW, SOCKET HD. 1/4"-20 X 3/8"LG.
39	10	860-00158	SETSCREW, SOCKET HD. 1/4"-20 X 5/16"LG.
40	2	860-00201	SCREW, MACH. R.H. #10-24 X 3/8"LG.
41	1	836-00996	MICRO LIMIT-SWITCH
42	1	868-00207	CAPSCREW, SOC HD. #10-24 X 1/2"LG.
43	1	134-00053	ELECTRODE HOLDER
44	1	860-00244	SETSCREW-SOCKET HEAD-6-32 X 1/8"
45	1	034-00007	GALND, PACKING

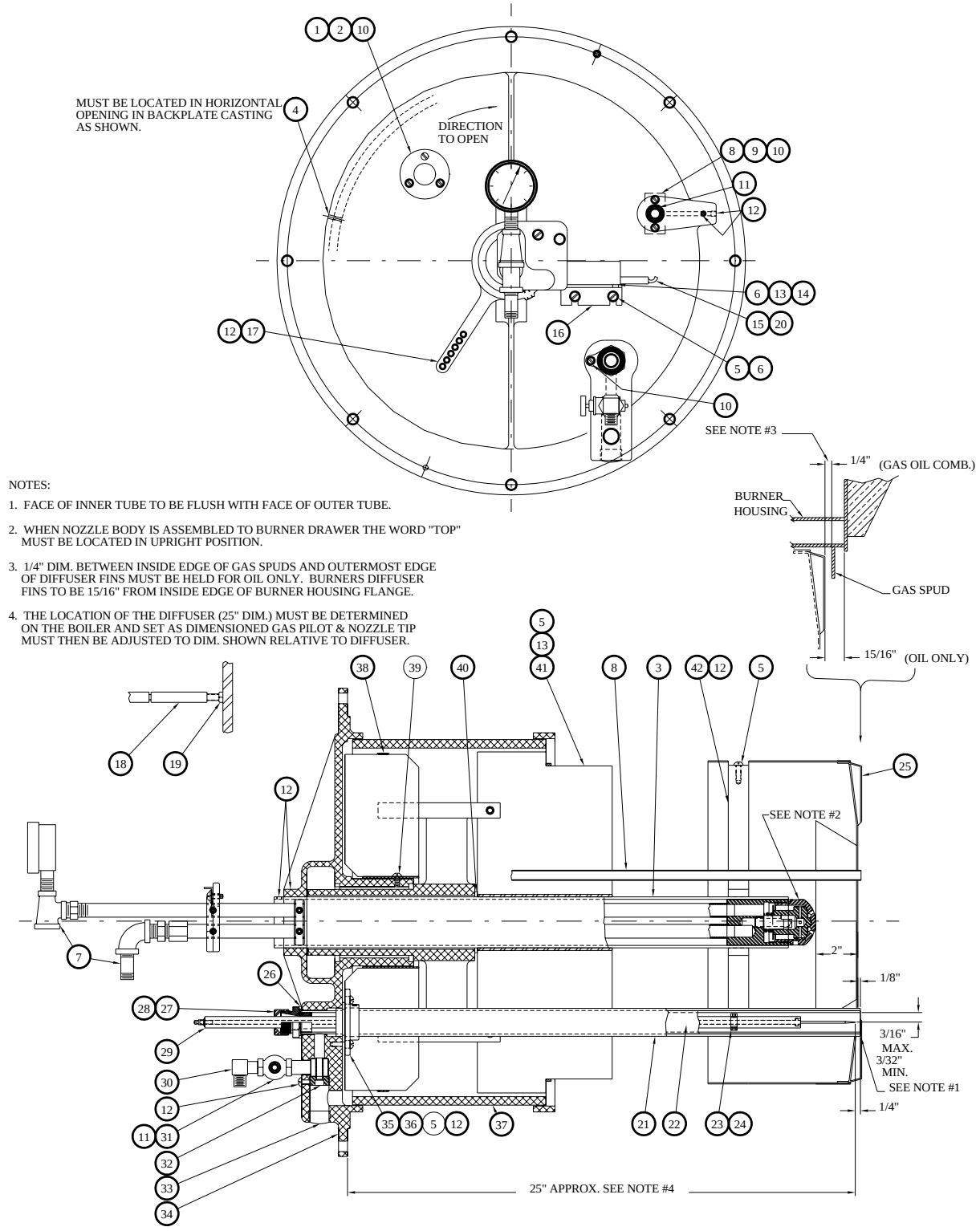
9.2.23 — 85" Burner Drawer, Gas Pilot, Models 100-200, 350-400 HP



NOTES:
1. THE LOCATION OF THE DIFFUSER (25-3/8" DIM.) MUST BE DETERMINED ON THE BOILER AND SET AS DIMENSIONED. THE NOZZLE TIP AND GAS PILOT MUST THEN BE ADJUSTED TO DIMENSION SHOWN RELATIVE TO DIFFUSER.
2. 1/4" DIA. HOLE IN TUBE (ITEM #7) SHOULD BE ON BOTTOM C L
3. 1/4" DIM. BETWEEN INSIDE EDGE OF GAS SPUDS AND OUTERMOST EDGE OF DIFFUSER FINS MUST BE HLED, FOR OIL ONLY BURNERS DIFFUSER FINS TO BE 3/4" FROM INSIDE EDGE OF BNR. HSG. FLANGE.
4. WHEN NOZZLE BODY IS ASSEMBLED TO BURNER DRAWER PLUGGED HOLE SHOULD BE LOCATED ON BOTTOM ℄

ITEM	QTY	PART NO.	DESCRIPTION
1	1	059-05770	BACKPLATE AND BEARING ASSEMBLY
2	1	108-00118	DAMPER
3	2	851-00077	MICA-PORT HOLE 1-1/2" O.D.
4	1	065-00011	RETAINER-SIGHT HOLE
5	6	860-00176	SCREW-MACH. RD. HD. 10-24 x 1/4" LG.
6	1	275-00254	DIFFUSER
7	1	090-01883	TUBE-BURNER DRAWER
8	1	134-00049	SPIDER-DIFFUSER
9	1	090-01885	PIPE-GAS PILOT OUTER
10	1	001-00197	ADAPTER, GAS PILOT
11	1	073-00032	SEAL RING, GAS PILOT
12	1	090-01884	TUBE, SCANNER ASS'Y
13	1	435-00071	ELECTRODE, IGNITION
14	2	860-00064	MACH. SCREW RD. HD., 1/4"-20 x 3/4" LG.
15	1	002-00037	ARM, DAMPER
16	1	008-03057	BRACKET, LIMIT SWITCH
17	1	022-00131	STABILIZER
18	1	857-00153	NIPPLE, 1/2" x 1-1/2" LG.
19	1	090-01887	TUBE AND ADAPTER ASSEMBLY (INNER)
20	1	853-00001	"O" RING
21	1	904-00036	GROMMET, RUBBER
22	1	048-00098	VENTURI, GAS PILOT
23	1	858-00310	PLUG, HEX., SOCKET HD. 3/4" NPT
24	1	073-00031	SEAL RING, DAMPER
25	1	251-00216	OIL GUN ASSEMBLY
26	1	848-00002	CONNECTOR, BOX SQUEEZE TYPE
27	2	860-00064	MACH. SCREW RD. HD. 1/4"-20 x 3/4" LG.
28	6	860-00007	MACH. SCREW RD. HD. 1/4"-20 x 1/2" LG.
29	1	857-00151	NIPPLE, CLOSE 1/2" x 1-1/8" LG.
30	1	825-00030	GAS CPCL TEE HEAD 1/2" NPT
31	1	845-00194	FLARED ELBOW 90° x 1/2" NPT x 5/8" O.D.C.
32	1	032-00497	GASKET SCANNER TUBE
33	1	080-00088	RING, DIFFUSER
34	5	952-00092	LOCKWASHER, 1/4"
35	3	869-00021	NUT, HEX, 1/4"-20
36	1	056-00021	PIN, LOCKING, BURNER DRAWER
37	1	869-00036	NUT, HEX, 5/16"-18
38	6	860-00039	SETSCREW, SOCKET HD. 1/4"-20 x 3/8" LG.
39	10	860-00158	SETSCREW, SOCKET HD. 1/4"-20 x 5/16" LG.
40	3	860-00201	SCREW, MACH. R.H. #10-24 x 3/8" LG.
41	1	836-00996	MICRO LIMIT-SWITCH
42	1	868-00207	CAPSCREW, SOC HD. #10-24 x 1/2" LG.
43	1	134-00053	ELECTRODE HOLDER
44	1	860-00244	SETSCREW-SOCKET HEAD-6-32 x 1/8" LG.
45	1	034-00007	GLAND, PACKING

9.2.24 — 96”-106” Burner Drawer, Gas Pilot, Models 101 & 200, 500-800 HP

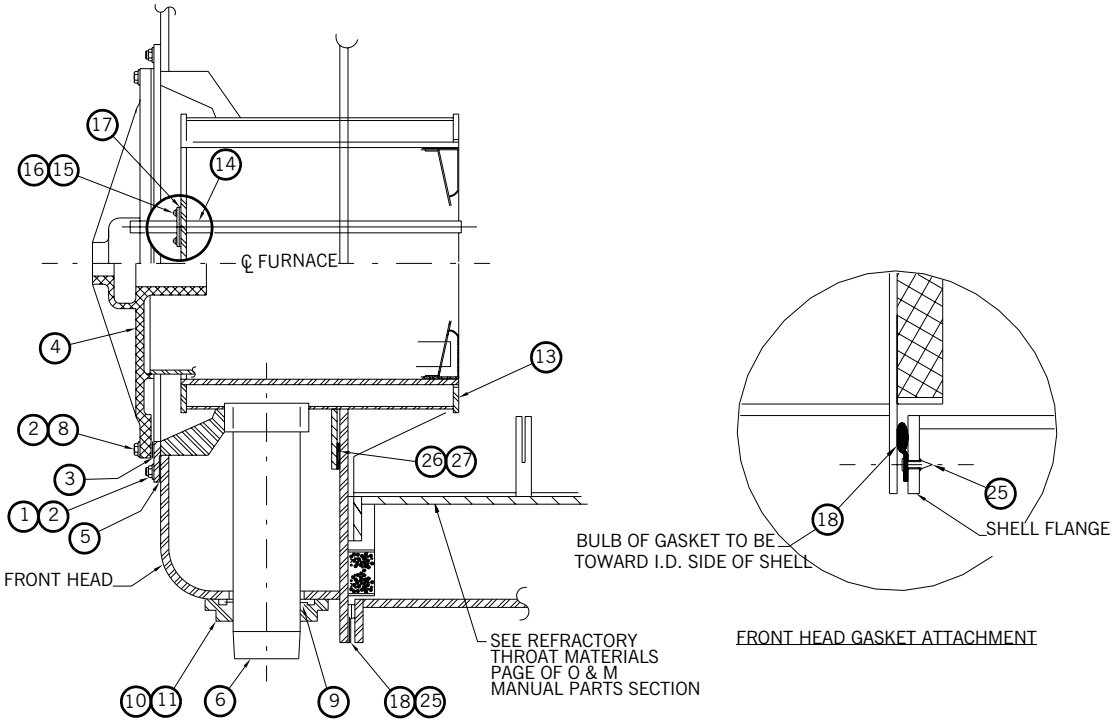


NOTES:

1. FACE OF INNER TUBE TO BE FLUSH WITH FACE OF OUTER TUBE.
2. WHEN NOZZLE BODY IS ASSEMBLED TO BURNER DRAWER THE WORD "TOP" MUST BE LOCATED IN UPRIGHT POSITION.
3. 1/4" DIM. BETWEEN INSIDE EDGE OF GAS SPUDS AND OUTERMOST EDGE OF DIFFUSER FINS MUST BE HELD FOR OIL ONLY. BURNERS DIFFUSER FINS TO BE 15/16" FROM INSIDE EDGE OF BURNER HOUSING FLANGE.
4. THE LOCATION OF THE DIFFUSER (25" DIM.) MUST BE DETERMINED ON THE BOILER AND SET AS DIMENSIONED GAS PILOT & NOZZLE TIP MUST THEN BE ADJUSTED TO DIM. SHOWN RELATIVE TO DIFFUSER.

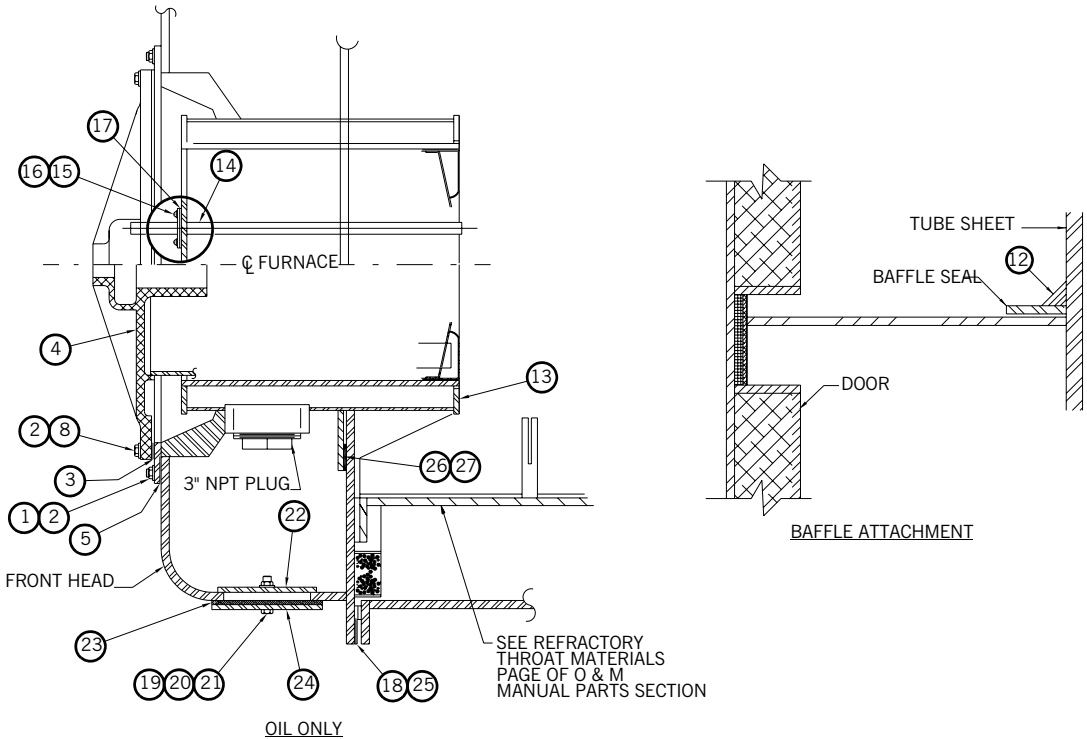
ITEM	QTY	PART NO.	DESCRIPTION
1	2	851-00077	MICA-SHEET, PORT HOLE
2	1	065-00011	RETAINER, SIGHT HOLE
3	1	090-01599	TUBE, BURNER DRAWER
4	1	868-00207	CAPSCREW, SOC. HD. #10-24 X 1/2" LG.
5	10	860-00090	MACH. SCREW RD. HD., 1/4"-20 X 5/8" LG.
6	4	952-00092	WASHER-LOCK 1/4"
7	1	251-00183	NOZZLE GUN ASS'Y
8	1	090-01596	TUBE-SCANNER ASS'Y
9	1	032-00497	GASKET MTG. PLATE SCANNER TUBE
10	5	860-00201	MACH, SCREW RD. HD., #10-24 X 3/8" LG.
11	2	857-00153	NIPPLE, 1/2" X 1-1/2" LG.
12	3	860-00158	SET SCREW, 1/4"-20 X 5/16" LG.
13	2	869-00021	NUT-HEX., 1/4"-20
14	2	860-00064	MACH. SCREW RD. HD., 1/4"-20 X 3/4" LG.
15	1	836-00996	SWITCH-LIMIT
16	1	008-03057	BRACKET-LIMIT SWITCH
17	1	002-00369	ARM-DAMPER
18	1	056-00021	PIN-LOCKING
19	1	869-00036	NUT-HEX., 5/16"-18
20	1	848-00002	CONNECTOR, 3/8" X 45°
21	1	090-01600	TUBE-GAS PILOT
22	1	090-01597	TUBE AND ADAPTER ASS'Y
23	1	134-00053	NOZZLE-ELECTRODE
24	1	860-00244	SETSCREW-SOCKET HD. NO. 6-32 X 3/16" LG.
25	1	275-00256	DIFFUSER-ASS'Y
26	1	853-00001	GASKET, 3 RING
27	1	034-00007	GLAND-PACKING
28	1	904-00036	GROMMET, RUBBER CABLE
29	1	435-00129	ELECTRODE-IGNITION
30	1	845-00194	ELBOW-MALE, 5/8" ODC X 1/2" NPT
31	1	825-00030	COCK-GAS TEE HEAD
32	1	048-00098	VENTURI, GAS PILOT
33	1	858-00310	PLUG-PIPE, 3/4"
34	1	059-07073	BACKPLATE & BEARING ASS'Y
35	1	001-00197	ADAPTER-GAS PILOT
36	1	073-00032	SEAL-RING, GAS PILOT
37	1	108-00134	DAMPER (108 00133)
38	1	022-00133	DIFFUSER-AIR STABILIZER, FRONT
39	1	860-00088	MACH. SCREW RD. HD., 1/4"-20 X 3/8" LG.
40	1	073-00041	SEAL-RING DAMPER
41	1	022-00132	DIFFUSER-AIR STABILIZER, REAR
42	1	134-00050	SPIDER-DIFFUSER

9.2.25 — Burner Housing Support: 60”



GAS AND COMBINATION

FRONT HEAD GASKET ATTACHMENT



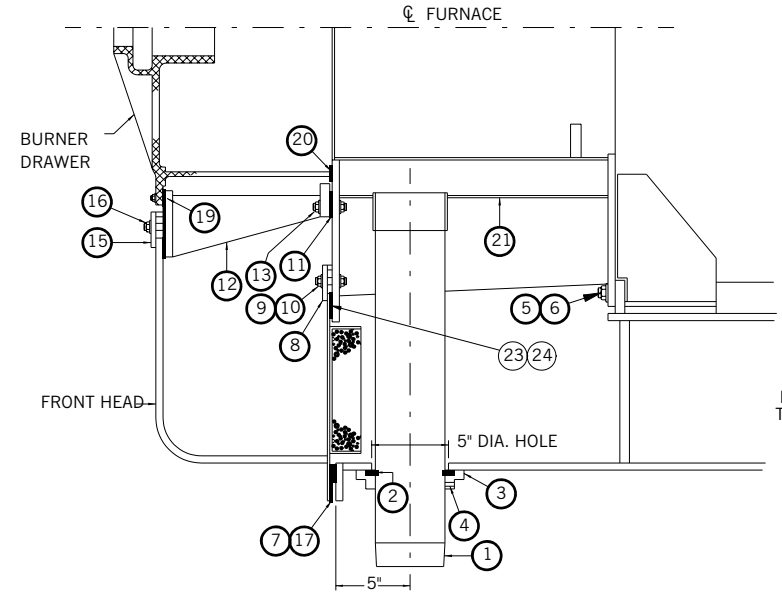
OIL ONLY

BAFFLE ATTACHMENT

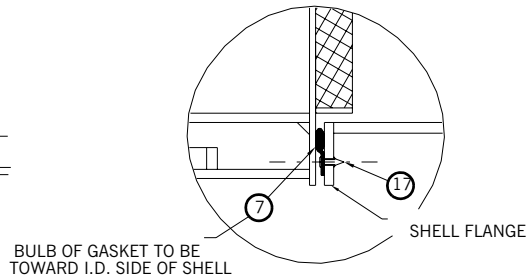
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	8	869-00030	NUT, HEX.	
2	14	952-00093	WASHER	
3	1	032-00605	GASKET, BURNER DRAWER TO HOUSING	
4	1	SEE TABLE	BURNER DRAWER	
5	1	032-00603	GASKET, BURNER HOUSING TO FRT. HEAD	
6	1	057-01772	SIZED PIPE, 3"	NAT. GAS/COMB.
7	-	- - -	NOT USED	
8	6	868-00157	CAPSCREW, HEX HD	
9	1	853-00348	BULK PACKING	NAT. GAS/COMB.
10	1	065-00704	RETAINER, MACHINING	NAT. GAS/COMB.
11	3	860-00015	SETSCREW, SOC HD	NAT. GAS/COMB.
12	6 OZ	872-00558	THERMO SILICATE CEMENT	
13	1	040D00614	BURNER HOUSING, WELDMENT	
14	1	090-00146	TUBE, SCANNER ASSEMBLY	
15	2	860-00007	MACH. SCREW,	
16	4	952-00092	LOCKWASHER	
17	1	032-00497	GASKET, MOUNTING PLATE SCANNER TUBE	
18	1	032-02602	GASKET,FRONT HD.	
19	1	869-00030	NUT, HEX.	OIL ONLY
20	1	952-00093	LOCKWASHER	OIL ONLY
21	1	868-00157	CAPSCREW HEX HD	OIL ONLY
22	1	065-00142	RETAINER, FRONT HEAD COVER	OIL ONLY
23	1	032-00765	GASKET, FRONT HEAD COVER	OIL ONLY
24	1	019-00156	COVER, FRONT HEAD PLATE	OIL ONLY
25	21	841-00507	FASTENER	
26	1	032-00109	GASKET, BURNER HOUSING	
27	10	841-00551	RIVET, SPLIT	

ITEM 4 BURNER DRAWER			
FUEL SERIES	BOILER HP	PPM NOX	BURNER DRAWER P/N
100 (OIL PILOT)	100 - 125	30	429-01494
	100	60	429-01495
	125	60	429-01494
100-600 (GAS PILOT)	100 - 125	30	429-01492
	100	60	429-01493
	125	60	429-01492
700	100 - 125	30	429-01363
700	100	60	429-01386
700	125	60	429-01363

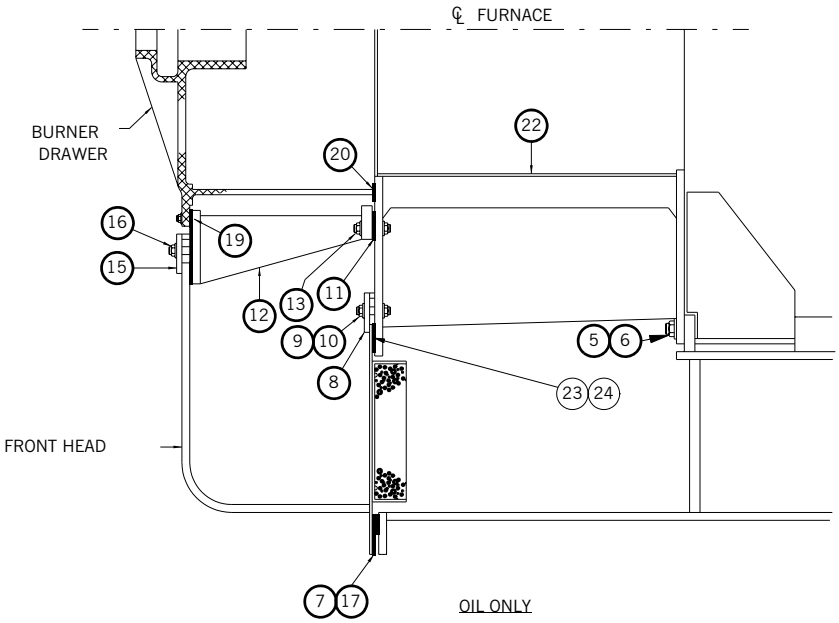
9.2.26 — Burner Housing Support: 67”-106”



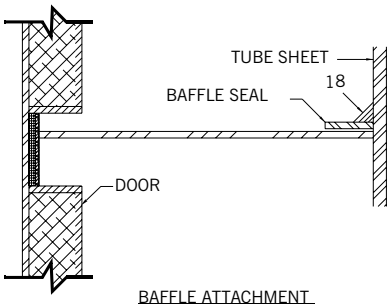
GAS AND COMBINATION



FRONT HEAD GASKET ATTACHMENT



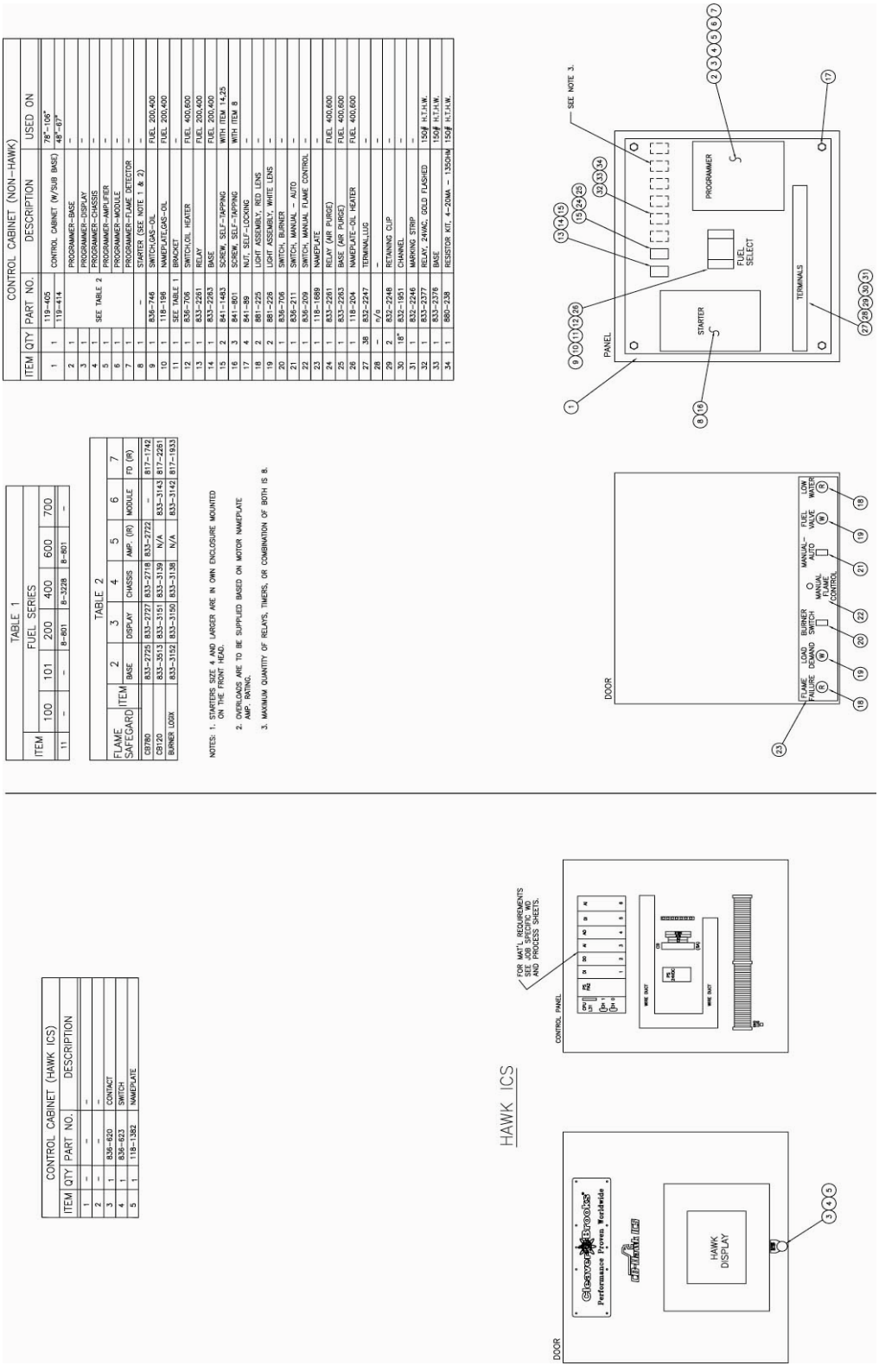
OIL ONLY



BAFFLE ATTACHMENT

ITEM	QTY	PART NO	DESCRIPTION	USED ON
1	1	057-01844	BULK PIPE 3"	67"
	1	057-01125	BULK PIPE 4"	78"
	1	057-01761	BULK PIPE 4"	85"
	1	057-01850	BULK PIPE 4"	96"
	1	057-01764	BULK PIPE 4"	106"
2	1	853-00348	BULK PACKING	
3	1	065-00177	RETAINER GASKET	
4	3	860-00015	SETSCREW SOCKET HEAD	
5	20	952-00286	WASHER	67" & 78"
	12	952-00287	WASHER	85"-96" & 106"
6	20	869-00029	NUT, HEX	67" & 78"
	12	869-00002	NUT, HEX	85"-96" & 106"
7	1	032-02602	GASKET, FRONT HEAD	67"
	1	032-00899	GASKET, FRONT HEAD	78"
	1	032-02598	GASKET, FRONT HEAD	85"
	1	032-00901	GASKET, FRONT HEAD	96"
	1	032-02599	GASKET, FRONT HEAD	106"
8	8	296-00019	CLAMP, INNER PLATE	
9	8	952-00108	WASHER	
10	8	869-00029	NUT, HEX.	
11	1	032-02618	GASKET, BURNER HOUSING SUPPORT	67"
	1	032-00928	GASKET, BURNER HOUSING SUPPORT	78" & 85"
	1	032-01253	GASKET, BURNER HOUSING SUPPORT	96" & 106"
12	1	085-03337	SUPPORT, BURNER HOUSING	67"
	1	085-00444	SUPPORT, BURNER HOUSING	78" & 85"
	1	040-00594	SUPPORT, BURNER HOUSING	96" & 106"
13	8	869-00029	NUT, HEX.	
14	-	- - -	NOT USED	
15	1	015-00159	FLANGE RING	67"
	1	015-00039	FLANGE RING	78" & 85"
	1	015-00041	FLANGE RING	96" & 106"
16	8	869-00015	NUT, HEX.	
17	21	841-00507	FASTENER	67"
	34	841-00507	FASTENER	78"
	33	841-00507	FASTENER	85", 96" & 106"
18	6oz	872-00558	THERO CEMENT HIGH TEMP	
19	1	032-02617	GASKET, BURNER SUPPORT FRONT HEAD	67"
	1	032-02625	GASKET, BURNER SUPPORT FRONT HEAD	78" & 85"
	1	032-02531	GASKET, BURNER SUPPORT FRONT HEAD	96" & 106"
20	1	853-01251	GASKET	67", 78" & 85"
	1	853-01252	GASKET	96" & 106"
21	1	040-00698	BURNER HOUSING, NATURAL GAS	67"
	1	040-00691	BURNER HOUSING, NATURAL GAS	78"
	1	040-00683	BURNER HOUSING, NATURAL GAS	85"
	1	040-00593	BURNER HOUSING, NATURAL GAS	96"
	1	040-00684	BURNER HOUSING, NATURAL GAS	106"
22	1	040-00700	BURNER HOUSING, OIL ONLY	67"
	1	040-00692	BURNER HOUSING, OIL ONLY	78"
	1	040-00701	BURNER HOUSING, OIL ONLY	85"
	1	040-00601	BURNER HOUSING, OIL ONLY	96"
	1	040-00702	BURNER HOUSING, OIL ONLY	106"
23	8	841-00551	RIVET, SPLIT	67", 78", 85", 96", & 106"
24	1	032-02619	GASKET, INNER DOOR TO BURNER HOUSING	67"
	1	032-00898	GASKET, INNER DOOR TO BURNER HOUSING	78"
	1	032-00993	GASKET, INNER DOOR TO BURNER HOUSING	85", 96", & 106"

9.2.27 — General Control Panel: 60”-106”, 100-800 HP



9.2.28 — Entrance Box & Fuses: 60”-1-6”, 100-800 HP

(SHEET 1 OF 3 SHEETS)

ITEM	QTY	PART NO.	DESCRIPTION
1	**	832-00749	TERMINAL LUG
2	1	118-01865	PLATE, I.D. FOR TERM. STRIP
3	1	884-00078	GROUND LUG
4	1	SEE SHEETS 2 & 3	FUSE BLOCK, CONTROL CIRCUIT
5	1	118-00297	NAMEPLATE, DECAL CONTROL CIRCUIT
6	1	SEE SHEETS 2 & 3	FUSE, CONTROL CIRCUIT
7	1	848-01083	ENT. BOX (18 X 15 X 6) (PULL BOX)
	1	848-00338	ENT. BOX (24 X 18 X 6) (PULL BOX)
	1	848-00375	ENT. BOX (24 X 24 X 6) (PULL BOX)
	1	848-01091	ENT. BOX (30 X 24 X 6) (PULL BOX)
8	1	SEE TABLE BELOW	MAIN POWER TERMINAL BLOCK
9	3	SEE SHEETS 2 & 3	BLOWER MOTOR FUSE
10	*	SEE SHEETS 2 & 3	BLOWER MOTOR FUSE BLOCK
11	3	SEE SHEETS 2 & 3	AIR COMPRESSOR MOTOR FUSE

ITEM	QTY	PART NO.	DESCRIPTION
12	*	SEE SHEETS 2 & 3	
13	1	SEE SHEETS 2 & 3	AIR COMPRESSOR MOTOR STARTER
14	1	118-01667	AIR COMPRESSOR EMBLEM
15	3	SEE SHEETS 2 & 3	OIL HEATER FUSE
16	*	SEE SHEETS 2 & 3	OIL HEATER FUSE BLOCK
17	1	833-02197	OIL HEATER CONTACTOR
18	1	118-00299	OIL HEATER EMBLEM
19	1	817-02924	CONTROLLER, TEMP, (HTHW ONLY)
20	**	832-00753	MARKING STRIP
21	1	118-00303	CHROMA-GLO EMBLEM
22	**	832-00750	CHANNEL
23	2	832-00752	RETAINING CLIP
24	1	832-00751	END BARRIER

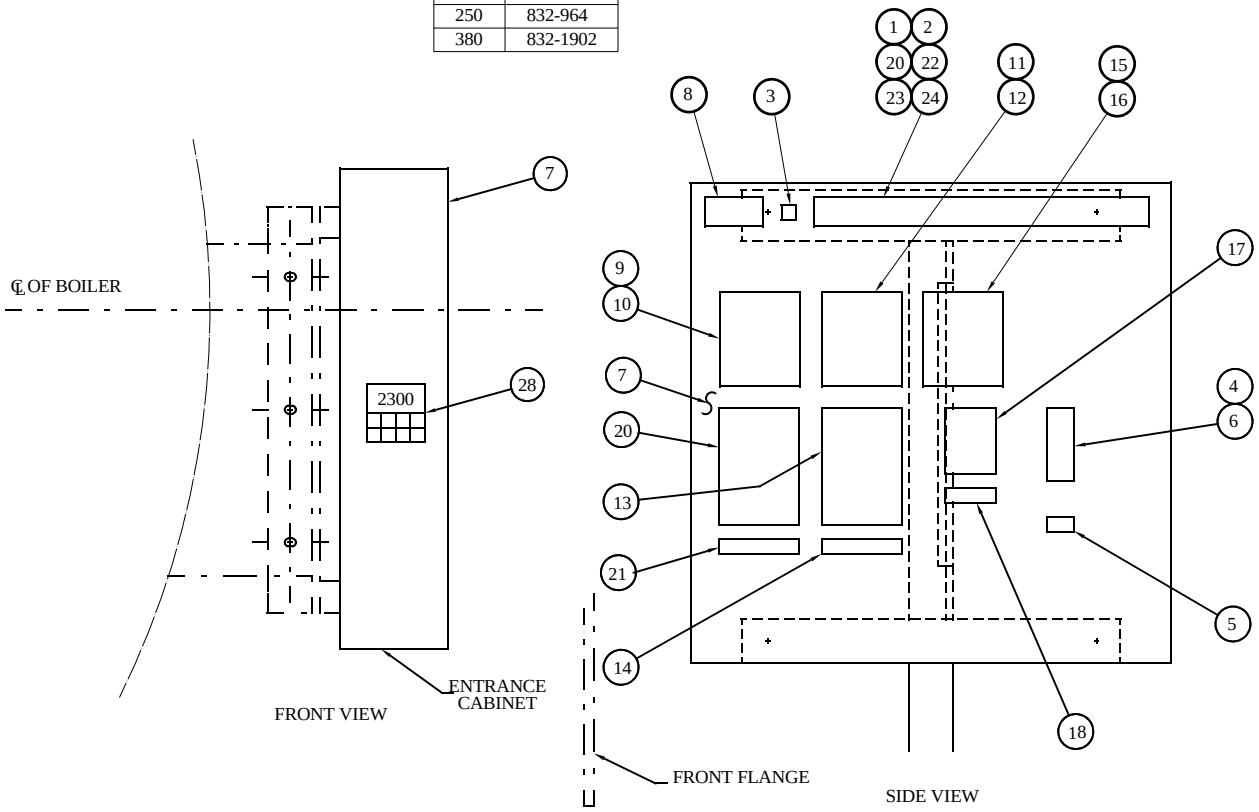
*QTY 1 ON VOLTAGE 240, QTY 3 OTHERWISE

*QTY 1 ON VOLTAGE 240, QTY 3 OTHERWISE

** QTY IS AS REQ`D.

MAIN POWER TERMINAL BLOCK PART NO.S

AMPS	PART NO.
30	832-780
70	832-781
125	832-782
250	832-964
380	832-1902



FUSE SIZING (SHEET 2 OF 3 SHEETS)

BLOWER MOTOR FUSE SIZING

ELECTRICAL LOAD MOTOR HP	SINGLE PHASE 50/60 HERTZ		THREE PHASE 50/60 HERTZ				
	110-120V	220-240V	200-208V	220-240V	346-416V	440-480V	550-660V
1/4	10	5-6/10	1-8/10	1-8/10		1	8/10
1/3	12	6-1/4	1-8/10	1-8/10		1	8/10
1/2	17-1/2	9	4-1/2	4	2	2	1-6/10
3/4	20	10	7	5-6/10	3-2/10	2-8/10	2-1/4
1	25	12	9	8	4-1/2	4	3-2/10
1-1/2	35	17-1/2	12	10	6-1/4	5-6/10	4-1/4
2	40	20	15	12	7	6-1/4	5
3	60	30	20	17-1/2	10	9	7
5		50	30	30	15	15	12
7-1/2		60	40	40	20	20	17-1/2
10		90	60	50	30	25	20
15			80	60	45	35	30
20			110	80	50	50	40
25			125	100	60	60	50
30			175	125	70	70	60
40			200	175	100	80	70
50			300	200	125	100	80
60			350	300	175	150	110
75			400	350	200	175	150
100			500	400	250	200	175
125			600	500	300	300	200
150				600		350	250

FUSE SIZES ABOVE ARE CLASS RK5 OR J DUAL ELEMENT, TIME DELAY.
TABLE BELOW SHOWS VENDOR TYPES

		BUSSMAN	GOULD	LITTELFUSE
CLASS RK5	0-250V	FRN	TR	FLN
	251-600V	FRS	TRS	FLS
CLASS J	0-600V	LPJ	AJT	JTD

TRANSFORMER FUSE SIZING

VA RATING	PRIMARY FUSE					SECONDARY FUSE
	200-208V	220-240V	346-416V	440-480V	550-600V	
150	1-8/10	1-1/2	8/10	6/10	6/10	2
300	3-1/2	3	1-8/10	1-1/2	1	4
500	4	3-1/2	2-8/10	2-1/2	2	5-6/10
750	7	6-1/4	3-1/2	3	2-8/10	10
1000	8	7	4	3-1/2	3-1/2	10
1500	12	10	6-1/4	5-6/10	4-1/2	15
2000	15	12	8	7	5-6/10	20
3000	25	20	12	12	9	30

XFMR MOUNTED FUSES ARE CLASS CC TIME DELAY.
PANEL MOUNTED FUSES ARE CLASS RK5 OR J DUAL ELEMENT TIME DELAY. SEE CHART BELOW FOR TYPE.

VENDOR	PANEL MOUNTED		XFMR MOUNTED 0-600V	
	0-250V	251-600V	PRI	SEC
BUSSMAN	FRN	FRS	FNQR	FNQ
GOULD	TR	TRS	ATQR	ATQ
LITTELFUSE	FLN	FLS	KLDR	FLQ

ALL CONTROL WIRING THAT HAS AN AMP RATING OF 10 OR LESS IS TO USE 16 GA. WIRE. UNLESS OTHERWISE NOTED.

PUMP, AIR COMP. & OIL HEATER FUSE SIZING

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

FUSE SIZES ABOVE ARE CLASS RK5 OR J DUAL ELEMENT, TIME DELAY.
TABLE BELOW SHOWS VENDOR TYPES

		BUSSMAN	GOULD	LITTELFUSE
CLASS RK5	0-250V	FRN	TR	FLN
	251-600V	FRS	TRS	FLS
CLASS J	0-600V	LPJ	AJT	JTD

HEATER KW	SINGLE PHASE 50/60 HZ		THREE PHASE 50/60 HERTZ				
	110-120V	220-240V	200-208V	220-240V	346-416V	440-480V	550-660V
2	20	12	7	7		4-1/2	3-2/10
3	30	15	10	10	6-1/4	5-6/10	4-1/2
5	50	25	15	15	10	8	6-1/4
7-1/2			25	25	15	12	10
10			30	30	25	17-1/2	12
15			45	45	35	25	20

CONSULT CLEAVER-BROOKS PARTS DEPT. FOR FUSE SIZING ON POWER SYSTEMS WITH VOLTAGE, FREQUENCY OR PHASE NOT LISTED ON THIS SHEET.

FUSE PART NUMBERS (SHEET 3 OF 3 SHEETS)

CLASS CC DUAL ELEMENT TIME DELAY (MOTOR)

FUSE TYPE	
BUSSMAN	LPCC
GOULD	ATDR
LITTELFUSE	CCMR

AMP RATING	0-600 V
1	832-01866
1.25	832-01867
1.4	832-01868
1.6	832-01869
1.8	832-01870
2.25	832-01871
2.5	832-01872
2.8	832-01873
3	832-01874
3.2	832-01875
3.5	832-01876
4	832-01877
4.5	832-01878
5	832-01879
5.6	832-01880
6	832-01881
6.25	832-01882
7	832-01883
8	832-01884
9	832-01885
10	832-01886
12	832-01887
15	832-01888
20	832-01889
25	832-01890
30	832-01891

CLASS CC DUAL ELEMENT TIME DELAY (TRANSFORMER)

FUSE TYPE	
BUSSMAN	FNQR
GOULD	ATQR
LITTELFUSE	KLDR

CLASS CC, FNQ-R TIME DELAY FUSES

AMP RATING	0-600 V
0.6	832-02006
0.8	832-02007
1.0	832-02008
1.4	832-02009
1.5	832-02010
1.6	832-02011
1.8	832-02012
2	832-01804
2.5	832-01805
2.8	832-01806
3	832-01807
3.2	832-01808
3.5	832-01809
4	832-01810
5	832-01811
5.6	832-01908
6	832-01812
6.25	832-01813
7	832-01915
7.5	832-01814
8	832-01815
9	832-01816
10	832-01817
12	832-01916

FUSE BLOCK (CLASS CC)

AMP RATING	0-600 V	
	# POLES	PART NO.
0-30	3	832-01892
0-30	2	832-01147

CLASS CC, FNQ TIME DELAY FUSES

AMP RATING	0-600 V
2.5	832-01918
4	832-01919
5.6	832-01917
12	832-01920

NOTE: REJECTION TYPE FUSES (FNQ-R) CAN BE USED IN PLACE OF FNQ, BUT NOT VISE VERSA

CLASS J TIME DELAY

FUSE TYPE	
BUSSMAN	LPJ
GOULD	AJT
LITTELFUSE	JTD

AMP RATING	0-600 V
1	832-01818
1.25	832-01819
1.6	832-01820
1.8	832-01821
2	832-01822
2.25	832-01823
2.5	832-01824
2.8	832-01825
3	832-01826
3.2	832-01827
3.5	832-01828
4	832-01829
4.5	832-01830
5	832-01831
5.6	832-01832
6	832-01833
6.25	832-01933
7	832-01834
8	832-01835
9	832-01836
10	832-01837
12	832-01838
15	832-01839
17.5	832-01840
20	832-01841
25	832-01842

AMP RATING	0-600 V
30	832-01843
35	832-01844
40	832-01845
45	832-01846
50	832-01847
60	832-01848
70	832-01849
80	832-01850
90	832-01851
100	832-01852
110	832-01853
125	832-01854
150	832-01855
175	832-01856
200	832-01857
225	832-01858
250	832-01859
300	832-01860
350	832-01861
400	832-01862

FUSE BLOCK (CLASS J)

AMP RATING	0-600 V	
	# POLES	PART NO.
0-30	1	848-01148
0-30	2	848-01149
0-30	3	848-01150
31-60	3	848-01151
61-100	3	848-01152
101-200	1	848-01153
201-400	1	848-01154

CLASS RK5 DUAL ELEMENT TIME DELAY

FUSE TYPE		
VENDOR	250V	600V
BUSSMAN	FRN	FRS
GOULD	TR	TRS
LITTELFUSE	FLN	FLS

AMP RATING	250 V	600 V
.8		832-0491
1	832-01211	832-0141
1.4		832-0492
1.8	832-00480	832-0493
2	832-00151	832-0497
2.25	832-00279	832-0494
2.5	832-00482	832-0495
2.8	832-00460	832-0416
3.2	832-00483	832-0142
3.5	832-00484	832-0433
4	832-00662	832-0441
4.25	832-00152	832-0496
4.5	832-00299	832-0442
5	832-00485	832-0143
5.6	832-00421	832-0472
6.25	832-00135	832-0498
7	832-00402	832-0144
8	832-00636	832-0332
9	832-00486	832-0366
10	832-00136	832-0145
12	832-00481	832-0471
15	832-00347	832-0146
17.5	832-00137	832-0448
20	832-00298	832-0147
25	832-00461	832-0148

AMP RATING	250 V	600 V
30	832-00627	832-0626
35	832-00138	832-0149
40	832-00653	832-0499
45	832-00139	832-0622
50	832-00487	832-0500
60	832-00574	832-01115
70	832-00140	832-0501
80	832-00477	832-0502
100	832-00476	832-0847
110	832-00488	832-0443
125	832-00489	832-01002
150	832-00478	832-01026
175	832-00490	832-01104
200	832-01025	832-01040
225		832-01033
250	832-00621	832-0444
300	832-01034	832-01041
350	832-01035	832-0619
400	832-01036	832-0616
450	832-01037	
500	832-01038	
600	832-01039	

FUSE BLOCK (CLASS RK5)

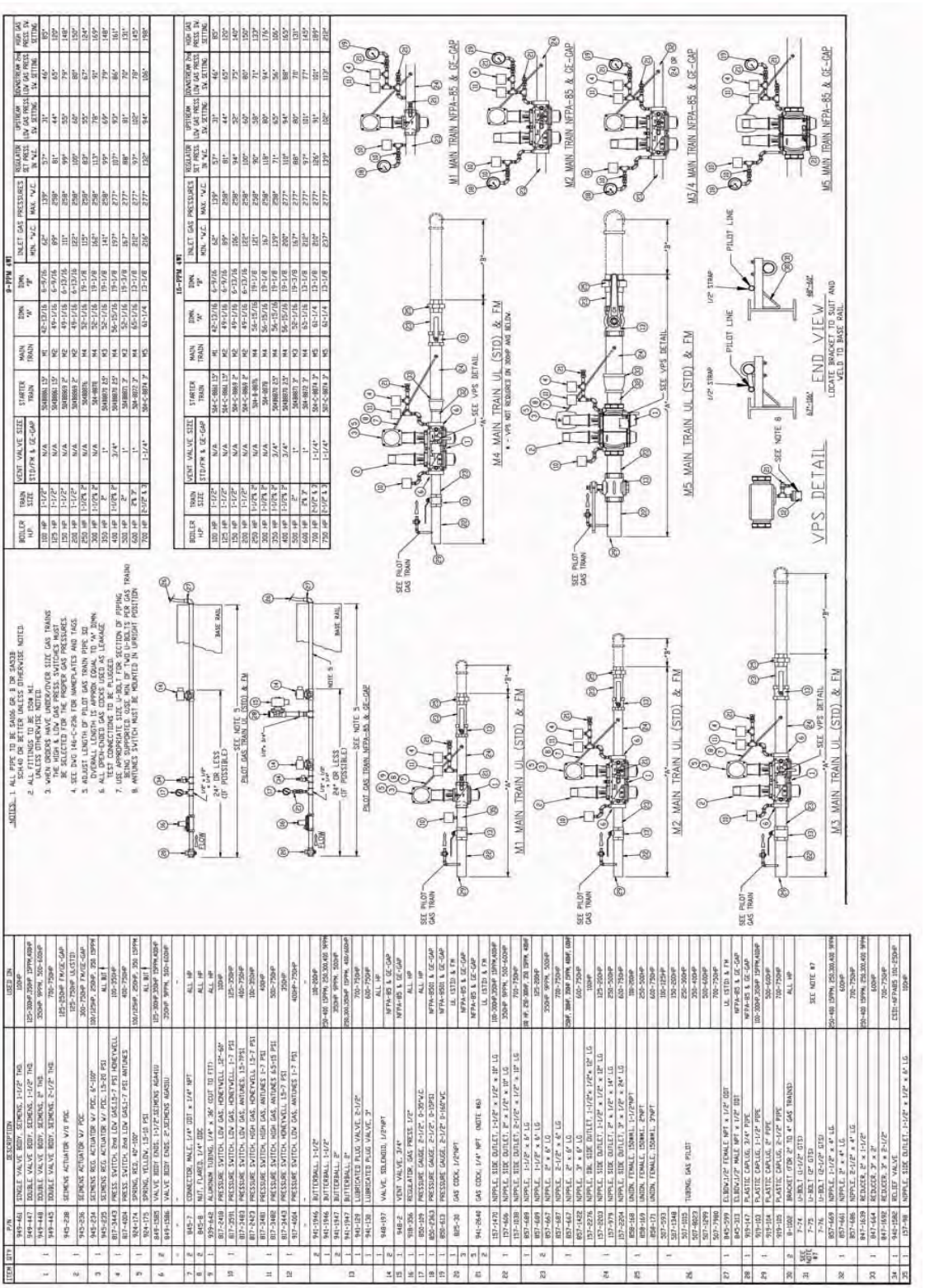
AMP RATING	250 V		600 V	
	# POLES	PART NO.	# POLES	PART NO.
0-30	3	848-00206	1	848-00210
31-60	3	848-00207	1	848-00209
61-100	3	848-00208	1	848-00222
101-200	1	848-00221	1	848-00714
201-400	1	848-00715	1	848-00711
401-600	1	848-00733	1	848-00485

FUSE REDUCER (CLASS RK5)

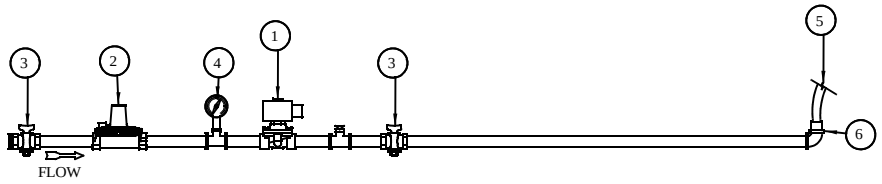
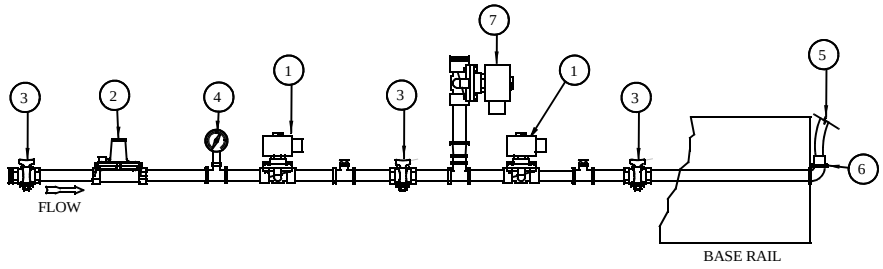
FUSE AMP RATING	PART NO.	USAGE
0-30	832-01126	ALLOWS 0-30 AMP FUSE TO FIT IN 31-60 AMP BLOCK
31-60	832-01125	ALLOWS 31-60 AMP FUSE TO FIT IN 61-100 AMP BLOCK
61-100	832-01124	ALLOWS 61-100 AMP FUSE TO FIT IN 101-200 AMP BLOCK

NOTE: 2 REDUCERS REQUIRED PER FUSE.

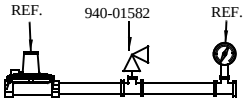
9.2.29 — Main Gas Train: 60”-106”, 100-800 HP



9.2.30 — Pilot Gas Train: 60”-106”, 100-800 HP

INSURANCE	PILOT GAS TRAIN
STD OR FM	
IRI OR F&I	
NFPA-8501	

RELIEF VALVE
REQUIRED ON CSD-1 WHEN
SUPPLY PRESSURE IS GREATER
THAN 5 PSI.



			INSURANCE					
			STD OR FM		IRI OR F&I		NFPA-8501	
ITEM	DESCRIPTION		QTY	PART #	QTY	PART #	QTY	PART #
1	VALVE SOLENOID 1/2"		1	948-00197	1	948-00197	2	948-00197
2	PILOT REGULATOR		1	918-00356	1	918-00356	1	918-00356
3	SHUT-OFF COCK, 1/2"		1	825-00030	2	825-00030	3	825-00030
4	PRESSURE GAUGE		1	850-00109	1	850-00109	1	850-00109
5	PILOT TUBING	100 HP	1	507-00593	1	507-00593	1	507-00593
		125-200 HP	1	507-01348	1	507-01348	1	507-01348
		250-350 HP	1	507-01015	1	507-01015	1	507-01015
		400-800 HP	1	507-01299	1	507-01299	1	507-01299
6	ELBOW, FLARED	100 HP	1	845-00314	1	845-00314	1	845-00314
		125-800 HP	1	845-00194	1	845-00194	1	845-00194
7	VALVE, VENT, 3/4"		-	-	-	-	1	948-00002

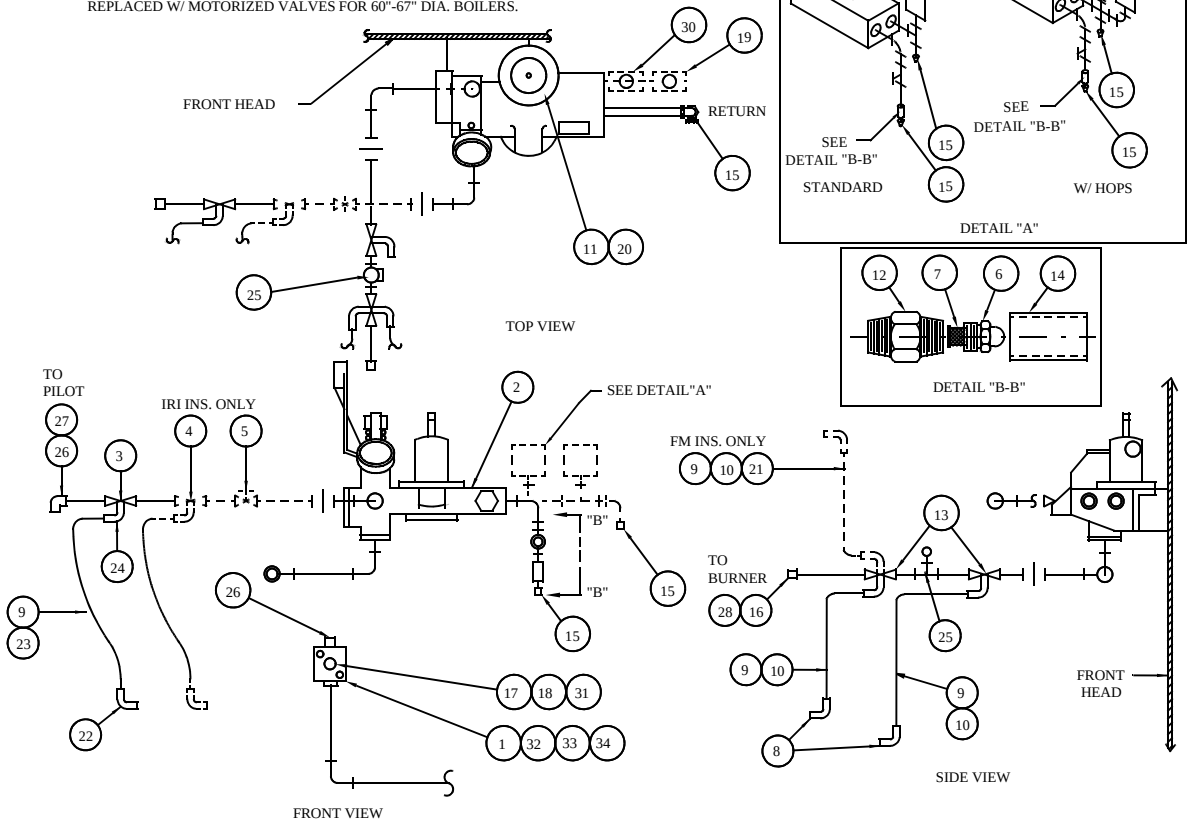
9.2.31 — Front Head #2 Oil/Air Piping: 60”-67”, 100-200 HP

ITEM	QTY OIL	QTY COM	PART NO.	DESCRIPTION	USED ON
1	1		106-00118	AIR MANIFOLD BLOCK	-
2	1		880-00904	VALVE ASSEMBLY	100 HP
	1		880-00905	VALVE ASSEMBLY	125-150 HP
	1		880-00906	VALVE ASSEMBLY	200 HP
3	1		948-00153	VALVE, SOLENOID	MDL. 100
4	1		948-00153	VALVE, SOLENOID	MDL. 100, IRI INS. ONLY
5	1		941-00914	VALVE, GATE	MDL. 100, IRI INS. ONLY
6	1		899-00051	NOZZLE	-
7	1		899-00014	STRAINER	-
8	1		848-00002	CONNECTOR, SQUEEZE TYPE	MDL. 101/200
	2		848-00002	CONNECTOR, SQUEEZE TYPE	MDL. 100
9	6	4	848-00100	BUSHING	ADD QTY. 2 IF FM INS.
10	3	2	827-00006	GREENFIELD (CUT TO FIT)	ADD QTY. 1 IF FM INS.
11	4		952-00093	LOCKWASHER	-
12	1		106-00049	ORIFICE BLOCK	-
13	2		948-00153	VALVE, SOLENOID	-
14	1		157-00201	COUPLING, STEEL	-
15	2		845-00312	CONNECTOR, MALE NPT x ODC	-
16	1		847-00526	COUPLING, RED.	100-150 HP
	1		847-000527	COUPLING, RED.	200 HP
17	1		036-00026	CAM BODY GUIDE	-
18	1		082-0083	SPRING, COMPRESSION	-
17	1		861-00438	FLEXIBLE HOSE	100-150 HP
	1		861-00439	FLEXIBLE HOSE	200 HP
18	1		847-00423	BUSHING, HEX,	100-150 HP
	1		847-00152	BUSHING, HEX,	200 HP
19	1		817-00922	HIGH OIL PRESSURE SWITCH	KEMPER INS. ONLY

ITEM	QTY OIL	QTY COM	PART NO.	DESCRIPTION	USED ON
20	4		868-00157	CAPSCREW, HEX HD.	-
21	1		848-00002	CONNECTOR, SQUEEZE TYPE	FM INS. ONLY
22	1		848-00016	CONNECTOR, SQUEEZE TYPE	MDL. 100
23	1		827-00006	GREENFIELD (CUT TO FIT)	MDL. 100
24	3	2	848-00003	CONNECTOR, 2 SCREW	-
25	1		940-06599	RELIEF VALVE	-
26	2		845-00009	ELBOW, ODC X NPT	MDL. 100
27	1		507-01616	TUBING, OIL TO PILOT	MDL. 100
28	1		861-00438	FLEXIBLE HOSE	100-150 HP
	1		861-00439	FLEXIBLE HOSE	200 HP
29	1		008-03418	BRACKET (SEE NOTE #1)	-
30	1		817-01264	LOW OIL PRESSURE SWITCH	ALL INS.
31	1		857-00106	NIPPLE	100-150 HP
	1		857-00085	NIPPLE	200 HP
32	1		507-00715	TUBING, AIR TO PILOT	MDL. 100
33	2		868-00387	CAPSCREW, HEX HD.	-
34	2		952-00092	LOCKWASHER	-

DEFINITIONS:
MDL. 100 - #2 OIL W/ OIL PILOT
MDL. 101 - #2 OIL W/ GAS PILOT
MDL. 200 - #2 OIL & GAS
COM - COMBINATION FUEL, #2 OIL & GAS
INS. - INSURANCE

NOTE: #1. ITEM #29 IS USED WHEN SOLENOID VALVES ARE REPLACED W/ MOTORIZED VALVES FOR 60"-67" DIA. BOILERS.

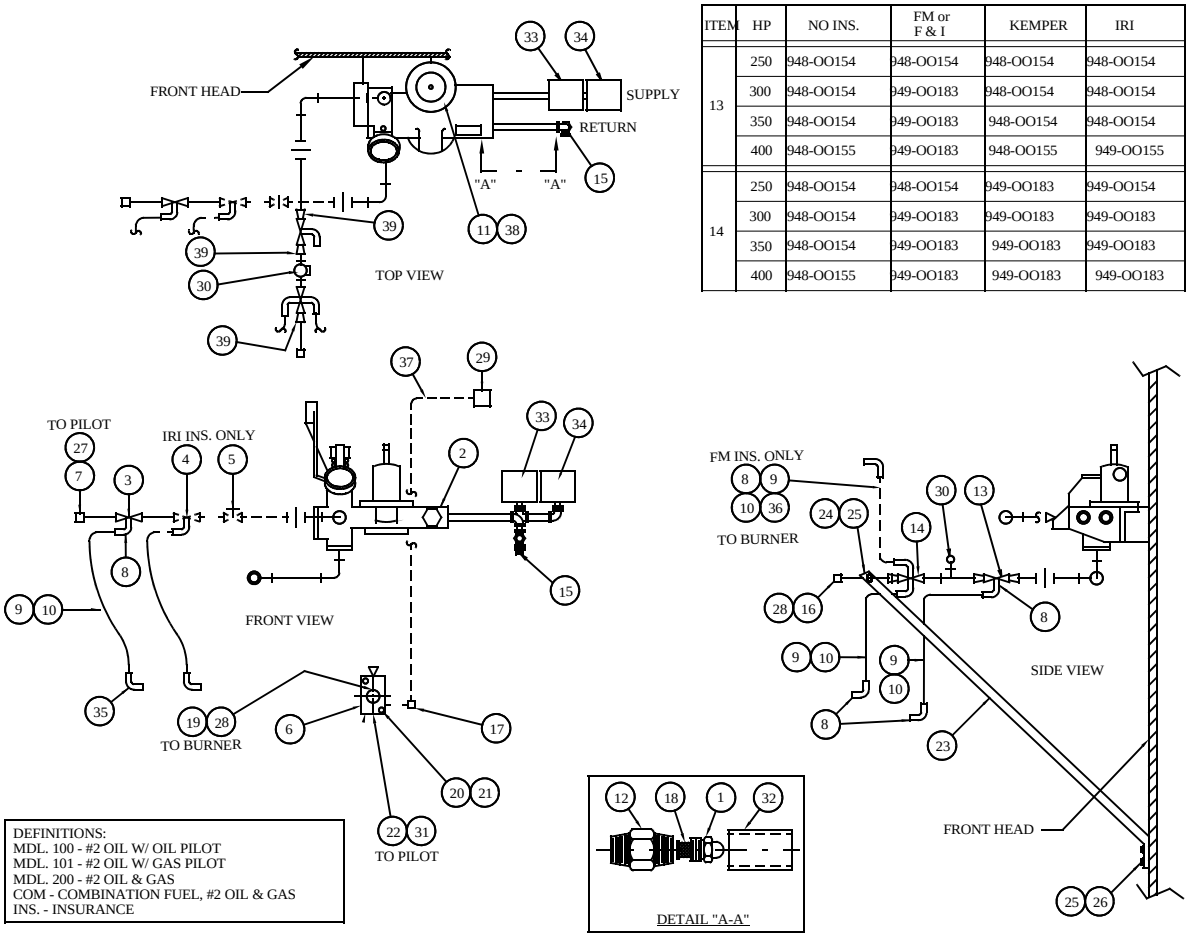


9.2.32 — Front Head #2 Oil/Air Piping: 78”-85”, 250-400 HP

ITEM	QTY TOL	QTY COM	PART NO.	DESCRIPTION	USED ON
1	1		899-00051	NOZZLE	-
2	1		880-00907	VALVE ASSEMBLY	250-350 HP
	1		880-00908	VALVE ASSEMBLY	400 HP
3	1		948-00153	VALVE - SOLENOID (OIL PILOT)	MDL. 100
4	1		948-00153	VALVE - SOLENOID (OIL PILOT)	MDL. 100, IRI INS. ONLY
5	1		941-00914	VALVE, GATE	MDL. 100, IRI INS. ONLY
6	1		106-00118	AIR MANIFOLD BLOCK	-
7	1		845-00007	CONNECTOR MALE, NPT x ODC	MDL. 100
8	5	4	848-00003	CONNECTOR, SCREW TYPE	ADD QTY. 1 IF FM INS.
9	6	4	848-00100	BUSHING	ADD QTY. 2 IF FM INS.
10	3	2	827-00006	GREENFIELD (CUT TO FIT)	ADD QTY. 1 IF FM INS.
11	4		952-00093	LOCKWASHER	-
12	1		106-00049	ORIFICE BLOCK	-
13	1		SEE TABLE	VALVE, OIL SHUT-OFF	SEE TABLE
14	1		SEE TABLE	VALVE, OIL SHUT-OFF	SEE TABLE
15	2		845-00312	CONNECTOR, MALE, NPT x ODC	-
16	1		858-00360	COUPLING , FULL	-
17	1		845-00137	ELBOW, NPT X ODC	-
18	1		899-00014	STRAINER	-
19	1		057-01867	SIZED PIPE, TBE.	-
20	2		868-00387	CAPSCREW, HEX HD.	-

ITEM	QTY TOL	QTY COM	PART NO.	DESCRIPTION	USED ON
20	2		868-00387	CAPSCREW, HEX HD.	-
21	2		952-00092	LOCKWASHER	-
22	1		845-00009	ELBOW, NPT X ODC	MDL. 100
23	1		008-02204	BRACKET	-
24	1		841-01119	U-BOLT WITH NUTS	-
25	4		952-00092	WASHER	-
26	2		868-00136	CAPSCREW	-
27	1		507-01581	TUBING, OIL TO PILOT	MDL. 100
28	2		861-00439	FLEXIBLE HOSE	-
29	1		507-02072	ATOMIZING AIR SWITCH	-
30	1		940-06599	RELIEF VALVE	-
31	1		507-01582	TUBING, AIR TO PILOT	MDL. 100
32	1		157-00201	COUPLING, STEEL	-
33	1		817-01264	LOW OIL PRESSURE SWITCH	-
34	1		817-00922	HIGH OIL PRESSURE SWITCH	KEMPER INS. ONLY
35	1		848-00002	CONNECTOR, SQUEEZE TYPE	MDL. 100
36	1		848-00016	CONNECTOR, SQUEEZE TYPE	FM INS. ONLY
37	1		507-07644	TUBING, AIR SWITCH TO MANIFOLD	-
38	4		868-00157	CAPSCREW, HEX HD.	-
39	3		847-00420	BUSHING	-

ITEM	HP	NO INS.	FM or F & I	KEMPER	IRI
13	250	948-OO154	948-OO154	948-OO154	948-OO154
	300	948-OO154	949-OO183	948-OO154	948-OO154
	350	948-OO154	949-OO183	948-OO154	948-OO154
	400	948-OO155	949-OO183	948-OO155	949-OO155
14	250	948-OO154	948-OO154	949-OO183	949-OO154
	300	948-OO154	949-OO183	949-OO183	949-OO183
	350	948-OO154	949-OO183	949-OO183	949-OO183
	400	948-OO155	949-OO183	949-OO183	949-OO183

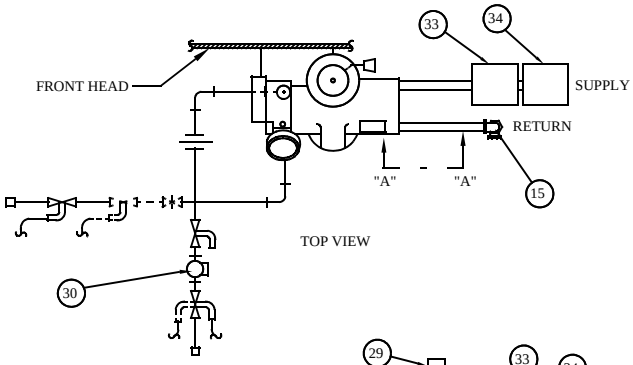


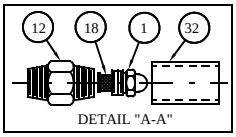
9.2.33 — Front Head #2 Oil/Air Piping: 96”-106”, 500-800 HP

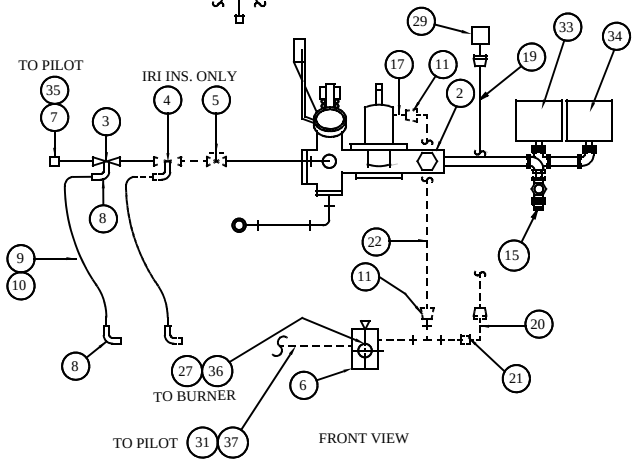
ITEM	QTY OIL	QTY COM	PART NO.	DESCRIPTION	USED ON
1	1		899-00051	NOZZLE	-
2	1		880-00909	VALVE ASSEMBLY	500-700 HP
	1		880-00910	VALVE ASSEMBLY	800 HP
3	1		948-00153	VALVE, SOLENOID	MDL. 100
4	1		948-00153	VALVE, SOLENOID	MDL. 100, IRI ONLY
5	1		941-00914	VALVE, GATE	MDL. 100, IRI ONLY
6	1		106-00118	AIR MANIFOLD BLOCK	-
7	1		845-00009	ELBOW, NPT X ODC	MDL. 100, IRI INS.
	1		845-00007	CONNECTOR MALE, NPT x ODC	MDL. 100, STD/FM INS.
8	6	4	848-16	CONNECTOR, SQUEEZE TYPE	ADD QTY. 2 IF FM INS.
9	6	4	848-100	BUSHING, ARMORED CABLE	ADD QTY. 2 IF FM INS.
10	3	2	827-00006	GREENFIELD (CUT TO FIT)	ADD QTY. 1 IF FM INS.
11	2		845-429	CONNECTOR, MALE, ODC x NPT	-
12	1		106-00049	ORIFICE BLOCK	-
13	1		948-00155	VALVE, SOLENOID	ALL EXCEPT FM INS.
14	1		948-00155	VALVE, SOLENOID	STD. & KEMPER INS.
	1		949-00183	HYDROMOTOR VALVE	IRI INS. ONLY
	2		949-00183	HYDROMOTOR VALVE	FM INS. ONLY
15	2		845-00312	CONNECTOR, MALE, NPT x ODC	-
16	1		858-00360	COUPLING, FULL	-

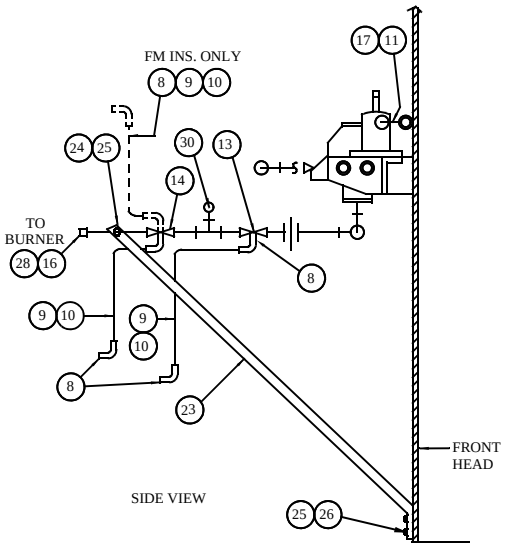
ITEM	QTY OIL	QTY COM	PART NO.	DESCRIPTION	USED ON
17	1		859-00115	ELBOW, STREET	-
18	1		899-00014	STRAINER	-
19	1		507-02847	TUBING, ASSEMBLY	-
20	1		845-00042	ELBOW, ODC x NPT	-
21	1		858-00113	COUPLING	-
22	1		507-02845	TUBING, ASSEMBLY	-
23	1		008-02204	BRACKET	-
24	1		841-01119	U-BOLT WITH NUTS	-
25	4		952-00092	WASHER	-
26	2		868-00136	CAPSCREW	-
27	1		861-00436	FLEXIBLE HOSE	-
28	1		861-00439	FLEXIBLE HOSE	-
29	1		507-02072	ATOMIZING AIR SWITCH	-
30	1		940-06599	RELIEF VALVE	-
31	1		507-01309	TUBING, AIR TO PILOT	MDL. 100
32	1		157-00201	COUPLING, STEEL	-
33	1		817-01264	LOW OIL PRESSURE SWITCH	-
34	1		817-00922	HIGH OIL PRESSURE SWITCH	KEMPER INS. ONLY
35	1		507-01571	TUBING, OIL TO PILOT	MDL. 100
36	1		057-05112	PIPE, T.B.E.	-
37	1		845-00007	CONNECTOR, NPT X ODC.	MDL. 100

DEFINITIONS:
MDL. 100 - #2 OIL W/ OIL PILOT
MDL. 101 - #2 OIL W/ GAS PILOT
MDL. 200 - #2 OIL & GAS
COM - COMBINATION FUEL, #2 OIL & GAS
INS. - INSURANCE





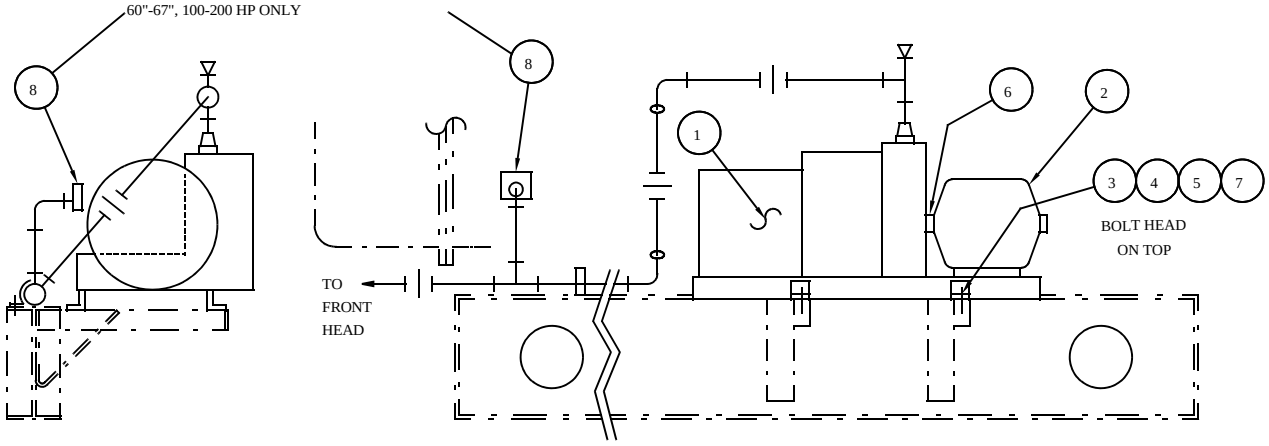




9.2.34 — Air Compressor Piping: 60”-106”, 100-800 HP

BILL OF MATERIAL				
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	505-00113	COMPRESSOR ASSEMBLY	60"-85", 100-400 HP
		505-00120		96"-106", 500-800 HP
2	1	SEE TABLE	MOTOR	60"-106", 100-800 HP
3	4	868-00431	CAPSCREW, HEX. HD.	60"-85", 100-400 HP
	4	868-00104	CAPSCREW, HEX. HD.	96"-106", 500-800 HP
4	4	952-00114	LOCKWASHER	60"-106", 100-800 HP
5	4	952-00133	WASHER	60"-106", 100-800 HP
6	1	SEE TABLE	COUPLING, HALF	60"-106", 100-800 HP
7	4	869-00036	NUT	60"-106", 100-800 HP
8	1	836-00418	SWITCH, PRESSURE	60"-67", 100-200 HP

TABLE ITEMS 2 & 6, 60"-106", 100-800 HP					
ITEM	MTR TYPE	200-208V (60 HZ)	230/460V (60 HZ)	600V (60 HZ)	USED ON
2	3HP ODP	894-03430	894-03653	894-03432	60"-85", 100-400 HP
	3HP TEFC	894-04021	894-02573	894-04022	
6		819-00158	819-00158	819-00158	
2	7.5HP ODP	894-03657	894-03655	894-03386	96"-106", 500-800 HP
	7.5HP TEFC	894-03672	894-03673	894-04020	
6		819-00227	819-00227	819-00227	



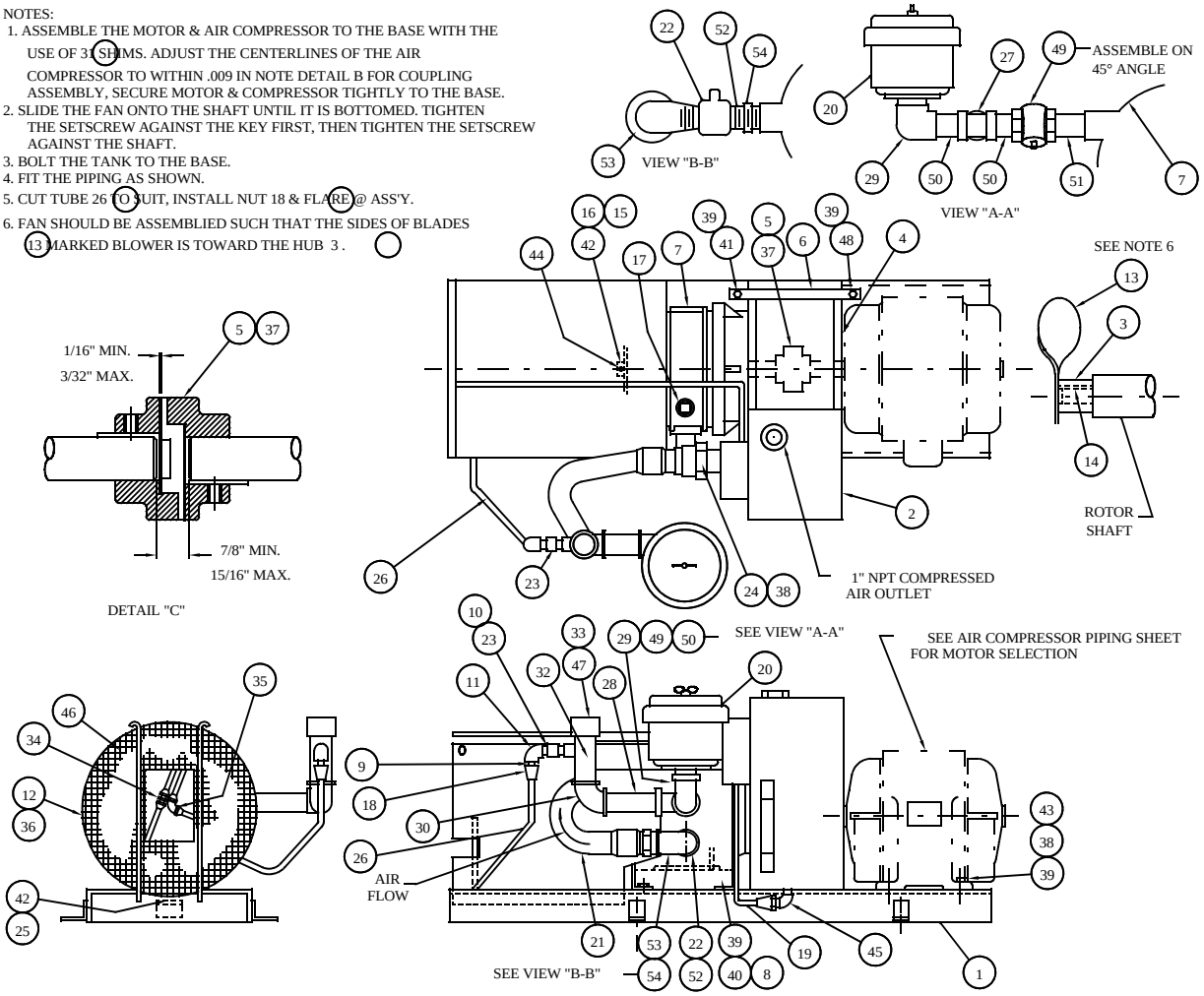
FRONT VIEW

SIDE VIEW

9.2.35 — Air Compressor: 60”-85”, 100-400 HP

ITEM	REQ.	PART NO.	DESCRIPTION	ITEM	REQ.	PART NO.	DESCRIPTION
1	1	003-00585	BASE, COMPRESSOR	28	1	857-00166	NIPPLE
2	1	538-00125	AIR & OIL TANK ASSEMBLY	29	1	859-00081	ELBOW
3	1	813-00124	FAN BUSHING	30	1	847-01628	ELBOW, REDUCING
4	1	035-00322	COUPLING GUARD	31	12	927-00017	SHIM, HORSESHOE
5	1	819-00136	PUMP, HALF W/ KEY WAY	32	1	157-01217	FITTING ASSY, PIPE FILTER FOR COMPRESSOR.
6	1	015-00048	CLAMP, AIR OIL TANK	33	1	919-00194	CAP
7	1	505-00108	PUMP, AIR ASSEMBLY	34	1	845-00073	UNION, ODC
8	2	008-01869	BRACKET, COMPRESSOR	35	1	845-00426	UNION, ELBOW, ODC
9	1	845-00043	NUT, FLARED	36	4	056-00277	PIN-CYLINDER
10	1	857-00129	NIPPLE	37	1	819-00056	INSERT
11	1	845-00202	ELBOW , FLARED, ODC x NPT.	38	1	847-00468	BUSHING
12	1	651-00261	HEAT EXCHANGER, LUBE OIL FOR COMP.	39	10	952-00093	LOCKWASHER
13	1	813-00146	FAN	40	8	868-00056	CAPSCREW, HEX. HD.
14	1	841-00060	KEY	41	1	868-00450	CAPSCREW, HEX. HD.
15	1	952-00144	WASHER, FLAT	42	2	952-00117	LOCKWASHER
16	1	841-00354	SCREW-SELF-TAPPING	43	2	015-00147	CLAMP, COMPRESSOR
17	1	858-00088	PIPE PLUG	44	1	008-01874	BRACKET-HEAT EXCHANGER
18	1	845-00043	NUT, ODC	45	1	845-00263	ELBOW, MALE ODC X NPT.
19	1	507-03442	TUBING ASSY TANK TO FIN TUBING	46	1	072-00048	SCREEN, FINNED TUBING
20	1	923-00079	FILTER AIR	47	1	171-00114	FILTER BASKET OIL TO COMPRESSOR
21	1	861-00345	HOSE, FLEXIBLE, W/FITTINGS	48	1	868-00158	CAPSCREW, HEX. HD.
22	1	940-03656	VALVE, SWING CHECK	49	1	825-00104	GAS COCK, TEE HANDLE
23	1	277-00172	ORIFICE	50	2	857-00163	NIPPLE
24	1	861-00347	ADAPTER, MPT x MALE THD.	51	2	857-00167	NIPPLE
25	1	868-00136	CAPSCREW, HEX HD.	52	1	857-00151	NIPPLE
26	1	507-05637	TUBING ASSMEBLY TO COMPRESSOR	53	1	859-00106	STREET ELBOW
27	1	859-00025	TEE	54	1	847-00152	BUSHING

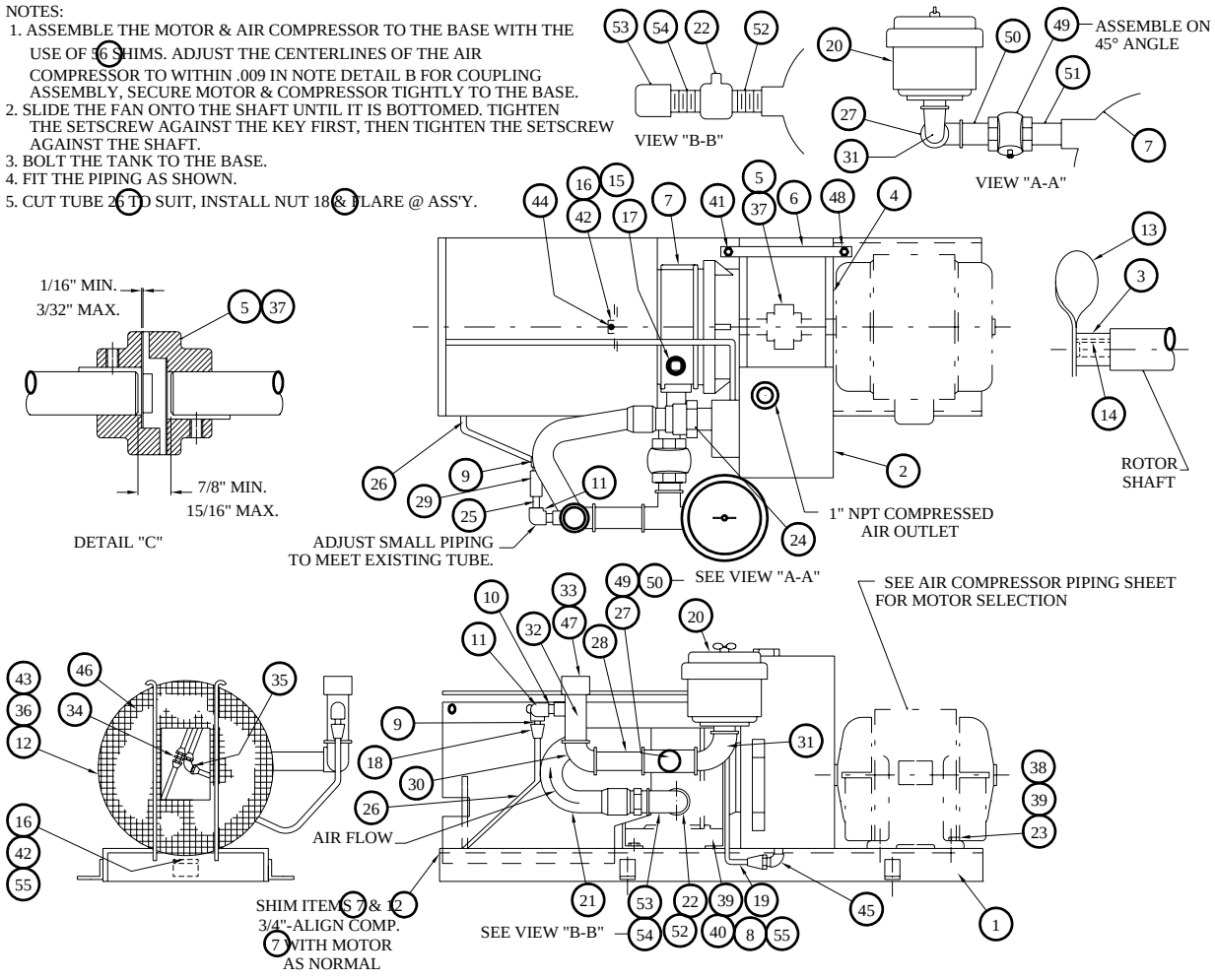
NOTES:
1. ASSEMBLE THE MOTOR & AIR COMPRESSOR TO THE BASE WITH THE USE OF 31 SHIMS. ADJUST THE CENTERLINES OF THE AIR COMPRESSOR TO WITHIN .009 IN NOTE DETAIL B FOR COUPLING ASSEMBLY, SECURE MOTOR & COMPRESSOR TIGHTLY TO THE BASE.
2. SLIDE THE FAN ONTO THE SHAFT UNTIL IT IS BOTTOMED. TIGHTEN THE SETSCREW AGAINST THE KEY FIRST, THEN TIGHTEN THE SETSCREW AGAINST THE SHAFT.
3. BOLT THE TANK TO THE BASE.
4. FIT THE PIPING AS SHOWN.
5. CUT TUBE 26 TO SUIT, INSTALL NUT 18 & FLARE @ ASS'Y.
6. FAN SHOULD BE ASSEMBLIED SUCH THAT THE SIDES OF BLADES 13 MARKED BLOWER IS TOWARD THE HUB 3 .



9.2.36 — Air Compressor: 96”-106”, 500-800 HP

ITEM	REQ.	PART NO.	DESCRIPTION	ITEM	REQ.	PART NO.	DESCRIPTION
1	1	003-00540	BASE, COMPRESSOR	29	1	277-00172	ORFICE
2	1	538-00125	AIR & OIL TANK ASSEMBLY	30	1	847-00557	ELBOW, REDUCING
3	1	813-00124	FAN BUSHING	31	1	859-00109	STREET ELBOW
4	1	035-00322	COUPLING GUARD	32	1	157-01217	PIPE-NEW OIL IN COMPRESSOR
5	1	819-00136	PUMP, HALF W/ KEY WAY	33	1	919-00194	CAP
6	1	015-00048	CLAMP, AIR OIL TANK	34	1	845-00073	UNION, ODC
7	1	505-00098	PUMP, AIR ASSEMBLY	35	1	845-00426	UNION, ELBOW, ODC
8	2	008-01869	BRACKET, COMPRESSOR	36	4	056-00277	PIN-CYLINDER
9	1	845-00202	CONNECTOR ELBOW, MALE ODC X NPT.	37	1	819-00056	INSERT
10	1	857-00132	NIPPLE	38	4	868-00063	CAPSCREW, HEX. HD.
11	1	859-00078	ELBOW	39	12	952-00093	LOCKWASHER
12	1	023-00124	CYLINDER-FINNED TUBING	40	4	868-00159	CAPSCREW, HEX. HD.
13	1	813-00146	FAN	41	1	868-00454	CAPSCREW, HEX. HD.
14	1	841-00060	KEY	42	2	952-00117	LOCKWASHER
15	2	952-00144	WASHER, FLAT	43	1	090-00941	TUBING, FOR HEAT EXCHANGER
16	2	841-00804	SCREW-SELF-TAPPING	44	1	008-01874	BRACKET-HEAT EXCHANGER
17	1	858-00089	PIPE PLUG	45	1	845-00263	ELBOW, MALE ODC X NPT.
18	1	845-00183	NUT, ODC	46	1	072-00048	SCREEN, FINNED TUBING
19	1	507-03260	TUBING ASSEMBLY TANK TO FIN TUBING	47	1	171-00114	FILTER BASKET OIL TO COMPRESSOR
20	1	843-00082	FILTER AIR	48	1	868-00063	CAPSCREW, HEX. HD.
21	1	861-00346	HOSE, FLEXIBLE, W/FITTINGS	49	1	825-00366	GAS COCK, TEE HANDLE
22	1	940-03617	VALVE, SWING CHECK	50	2	857-00184	NIPPLE
23	2	015-00055	CLAMP,COMPRESSOR MOTOR	51	1	857-00191	NIPPLE
24	1	861-00348	ADAPTER	52	1	857-00175	NIPPLE
25	1	857-00726	NIPPLE	53	1	859-00082	ELBOW, FEMALE
26	1	507-05637	TUBING ASSMEBLY TO COMPRESSOR	54	1	857-00177	NIPPLE
27	1	859-00026	TEE	55	5	077-00503	SPACER
28	1	857-00186	NIPPLE	56	12	927-00017	SHIM, HORSESHOE

NOTES:
1. ASSEMBLE THE MOTOR & AIR COMPRESSOR TO THE BASE WITH THE USE OF 16 SHIMS. ADJUST THE CENTERLINES OF THE AIR COMPRESSOR TO WITHIN .009 IN NOTE DETAIL B FOR COUPLING ASSEMBLY, SECURE MOTOR & COMPRESSOR TIGHTLY TO THE BASE.
2. SLIDE THE FAN ONTO THE SHAFT UNTIL IT IS BOTTOMED. TIGHTEN THE SETSCREW AGAINST THE KEY FIRST, THEN TIGHTEN THE SETSCREW AGAINST THE SHAFT.
3. BOLT THE TANK TO THE BASE.
4. FIT THE PIPING AS SHOWN.
5. CUT TUBE 26 TO SUIT, INSTALL NUT 18 & FLARE @ ASS'Y.



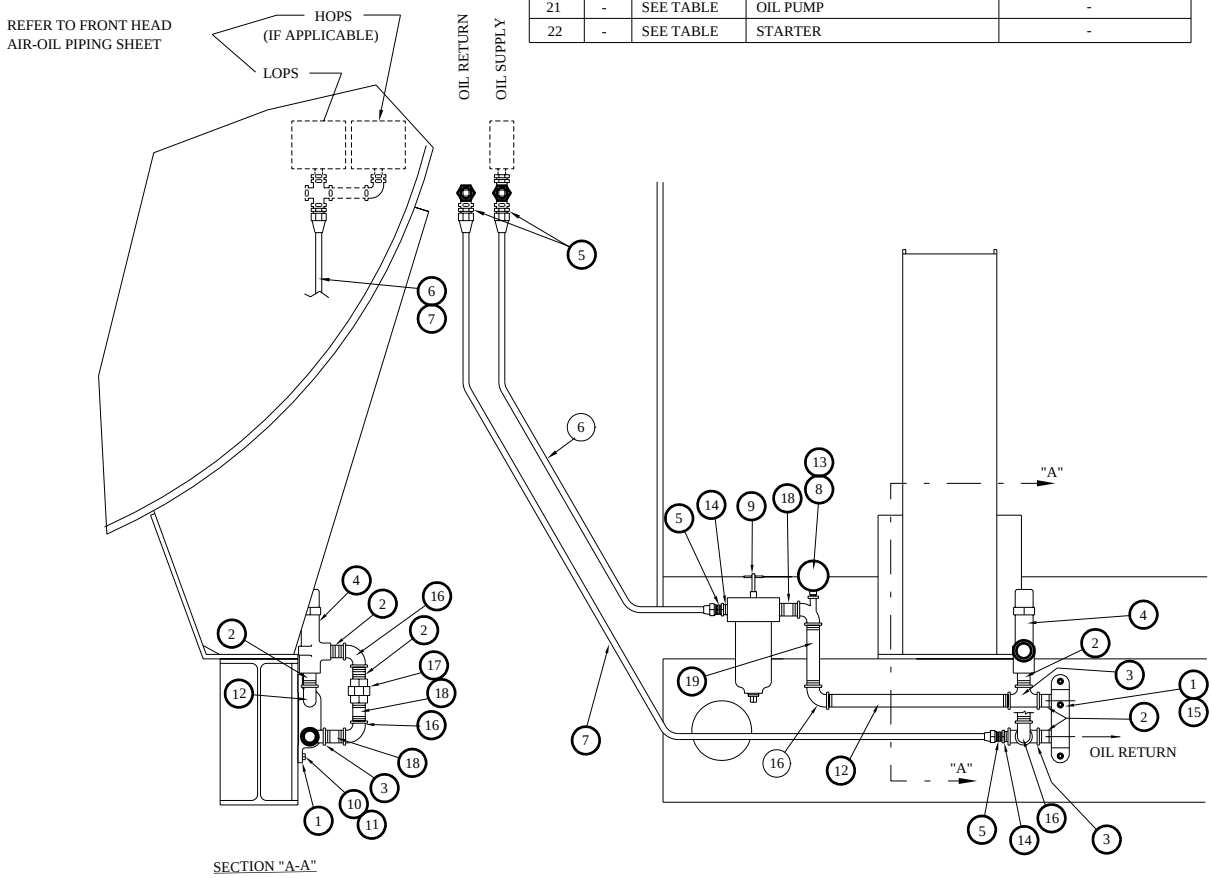
9.2.37 — Light Oil Piping: 78”-106”, 250-800 HP

250 HP				
ITEMS 18-20 (NOT SHOWN ON DWG)				
ITEM	QTY	PART NO.	ITEM	USED ON
20	1	529-00011	STRAINER	-
21	1	506-00508	OIL PUMP	50 HZ
	1	905-01342	OIL PUMP	60 HZ
22	1	833-00494	STARTER	-

300-600 HP				
ITEMS 18-20 (NOT SHOWN ON DWG)				
ITEM	QTY	PART NO.	ITEM	USED ON
20	1	843-00252	STRAINER	-
21	1	506-00509	OIL PUMP	50 HZ
	1	905-01340	OIL PUMP	60 HZ
22	1	833-00494	STARTER	-

700-800 HP				
ITEMS 18-20 (NOT SHOWN ON DWG)				
ITEM	QTY	PART NO.	ITEM	USED ON
20	1	843-00252	STRAINER	-
21	1	506-00403	OIL PUMP	200V
	1	506-00404	OIL PUMP	230/460V
	1	506-00406	OIL PUMP	380V
	1	506-00405	OIL PUMP	600V
22	1	833-00776	STARTER	-

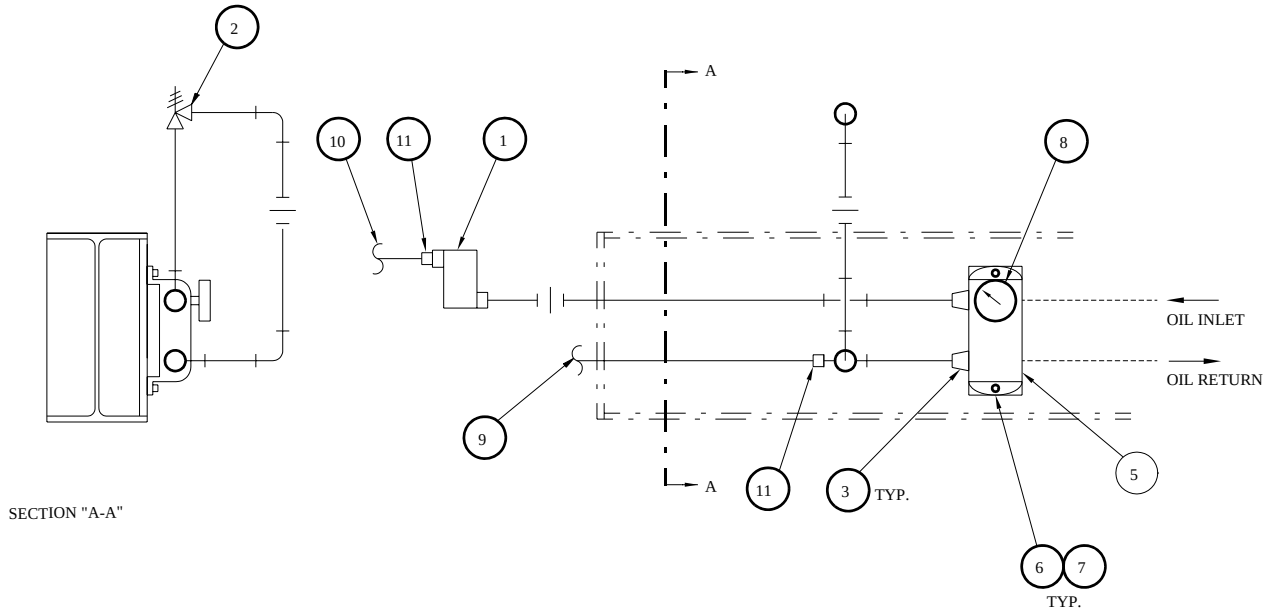
ITEM	QTY	PART No.	DESCRIPTION	USED ON
1	1	106-00012	OIL TERMINAL BLOCK	-
2	5	857-00166	NIPPLE	-
3	2	859-00025	TEE, 3/4"	-
4	1	940-02296	RELIEF VALVE	-
5	4	845-00312	BRASS FITTING, ODC X NPT	-
6	1	507-07603	TUBING, SUPPLY	78", 250-300 HP
	1	507-07749	TUBING, SUPPLY	85", 350-400 HP
	1	507-07604	TUBING, SUPPLY	96", 500-600 HP
	1	507-07756	TUBING, SUPPLY	106", 700-800 HP
7	1	507-07606	TUBING, RETURN	78", 250-300 HP
	1	507-07750	TUBING, RETURN	85", 350-400 HP
	1	507-07612	TUBING, RETURN	96", 500-600 HP
	1	507-07757	TUBING, RETURN	106", 700-800 HP
8	1	850-00061	GAUGE, PRESSURE	-
9	1	843-00252	STRAINER	-
10	2	868-00099	CAPSCREW	-
11	2	952-00114	LOCKWASHER	-
12	1	057-05205	PIPE	-
13	1	847-00261	REDUCING TEE	-
14	2	847-00152	BUSHING	-
15	1	858-00001	PLUG SQ. HEAD	-
16	3	859-00081	ELBOW	-
17	1	858-00165	UNION	-
18	3	857-00167	NIPPLE	-
19	1	857-00174	NIPPLE	-
20	-	SEE TABLE	STRAINER	-
21	-	SEE TABLE	OIL PUMP	-
22	-	SEE TABLE	STARTER	-



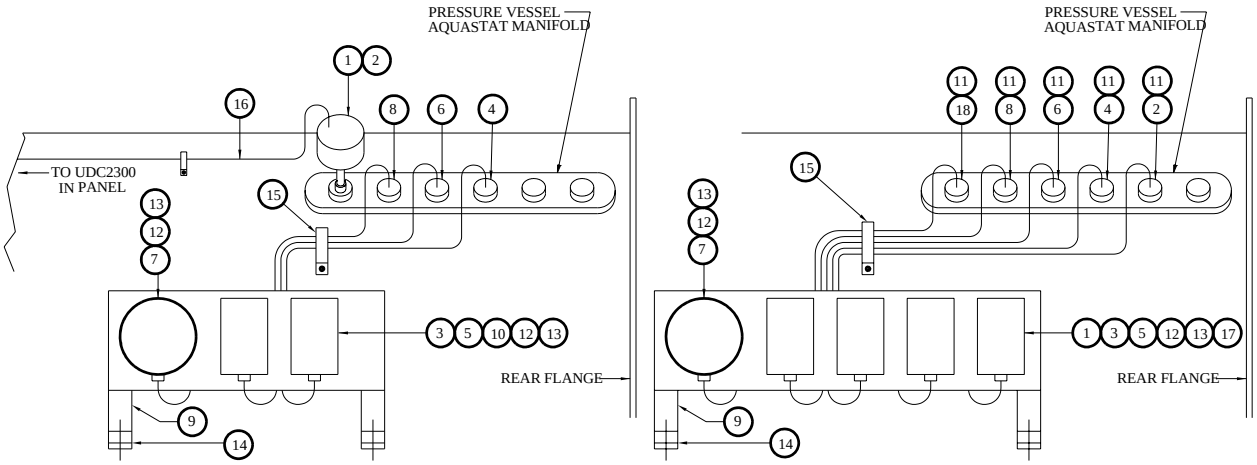
9.2.38 — Light Oil Piping: 60”-67”, 100-200 HP

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	529-00011	STRAINER	-
2	1	940-03898	VALVE, RELIEF	-
3	2	847-00152	BUSHING, RED.	-
4	2	845-00312	CONNECTOR, NPT. x ODC.	-
5	1	106-00012	OIL TERMINAL BLOCK	-
6	2	952-00114	LOCKWASHER	-
7	2	868-00014	CAPSCREW	-
8	1	850-00391	GAUGE	-
9	1	507-07753	TUBING, OIL RETURN	60", 100-125 HP
		507-07754	TUBING, OIL RETURN	67", 150-200 HP
10	1	507-07752	TUBING, OIL RETURN	60", 100-125 HP
		507-07754	TUBING, OIL RETURN	67", 150-200 HP

ITEMS 11-13 (NOT SHOWN ON DWG)				
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
11	1	905-01341	OIL PUMP	100 HP 60 HZ
	1	905-01342	OIL PUMP	125-200 HP 60 HZ
	1	506-00507	OIL PUMP	100 HP 50 HZ
	1	506-00508	OIL PUMP	125-200 HP 50 HZ
12	1	833-00494	STARTER	-
13	1	529-00011	STRAINER	

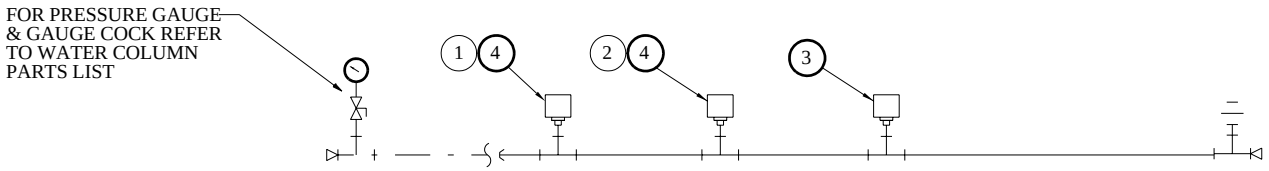


9.2.39 — Hot Water Temperature Controls: 60”-106”, 100-800 HP



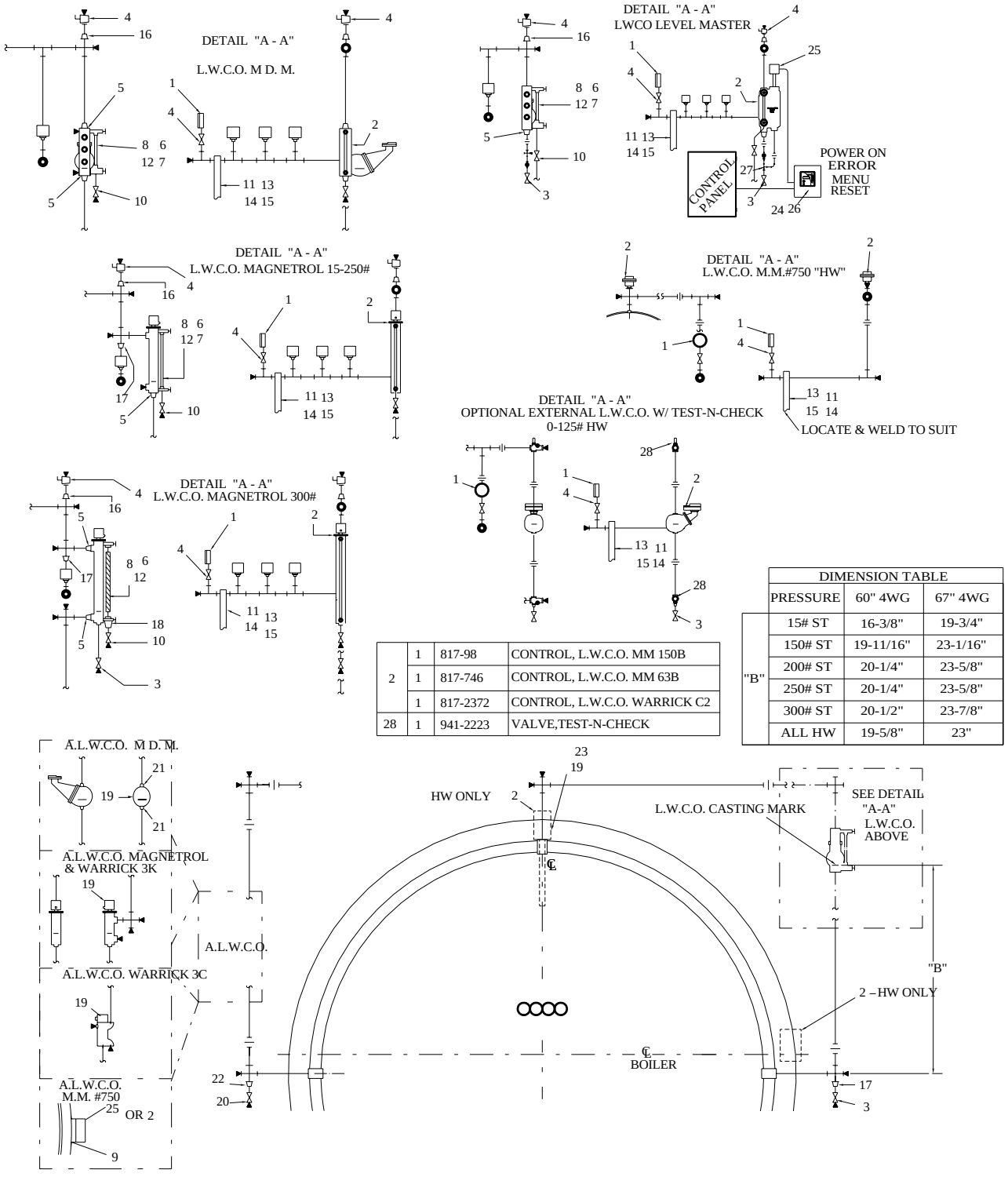
281-360 DEG F. HTHW	240-280 DEG F. HTHW	30-125# HW	BILL OF MATERIAL				
			ITEM	QTY	PART NO.	DESCRIPTION	USED ON
832-02091	832-02091	817-01244	1	1	SEE TABLE	TEMPERATURE CONTROL, MODULATING (MC)	-
937-00772	937-00772	817-00378	2	1	SEE TABLE	WELL, SEPARABLE	
817-01257	817-01281	817-02402	3	1	SEE TABLE	TEMPERATURE CONTROL, HIGH LIMIT (HLC)	-
817-00699	817-00699	817-00399	4	1	SEE TABLE	WELL, SEPARABLE	
817-00700	817-00698	817-00400	5	1	SEE TABLE	TEMPERATURE CONTROL, OPERATING LIMIT (OLC)	-
817-00699	817-00699	817-00399	6	1	SEE TABLE	WELL, SEPARABLE	
937-00710	937-00710	937-00787	7	1	SEE TABLE	THERMOMETER	60"-67", 100-200 HP
937-00673	937-00673	937-00027			SEE TABLE	THERMOMETER	78"-106", 250-800 HP
937-00658	937-00658	817-03103	8	1	SEE TABLE	WELL, SEPARABLE	60"-67", 100-200 HP
		817-00641			SEE TABLE	WELL, SEPARABLE	78"-106", 250-800 HP
008-00995	008-00995	008-00967	9	1	SEE TABLE	BRACKET, LIMIT CONTROLS	60"-67", 100-200 HP
008-00995	008-00995	008-00995			SEE TABLE	BRACKET, LIMIT CONTROLS	78"-106", 250-800 HP
008-01317	008-01317	-	10	2	SEE TABLE	MOUNTING BRACKET, MERCOID CONTROLS	-
-	-	5	11	SEE TABLE	847-00466	BUSHING, REDUCING, 3/4" x 1/2", F.S.	-
			12	9	860-00004	MACH. SCR. #10-32 x 3/4"	
			13	9	869-00009	NUT, MACH. SCR. #10-32	
			14	4	841-00571	SHT. MTL. SCR. #10-32 x 5/8"	
			15	1	928-00039	STRAP, PIPE	
			16	24 FT	950-00414	WIRE, THERMOCOUPLE, TYPE-J	-

9.2.40 — Steam Pressure Controls: 60”-106”, 100-800 HP



300 #	15# - 250 #	15# - 150 #	15#	BILL OF MATERIAL				
PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817-00111	817-00111	817-00110	817-00016	1	1	SEE TABLE	CONTROL PRESSURE (OLC)	-
817-00900	817-00900	817-00109	817-00415	2	1	SEE TABLE	CONTROL PRESSURE (HLC)	-
817-00234	817-00234	817-00204	817-00251	3	1	SEE TABLE	CONTROL PRESSURE (MC)	-
-	880-00605	-	-	4	2	SEE TABLE	LIMIT STOP ASSEMBLY	UL & / OR CSD-1

9.2.41 — Water Column Piping: 60”-67”, 100-200 HP



2	1	817-98	CONTROL, L.W.C.O. MM 150B
	1	817-746	CONTROL, L.W.C.O. MM 63B
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
28	1	941-2223	VALVE,TEST-N-CHECK

DIMENSION TABLE			
	PRESSURE	60" 4WG	67" 4WG
"B"	15# ST	16-3/8"	19-3/4"
	150# ST	19-11/16"	23-1/16"
	200# ST	20-1/4"	23-5/8"
	250# ST	20-1/4"	23-5/8"
	300# ST	20-1/2"	23-7/8"
	ALL HW	19-5/8"	23"

BILL OF MATERIAL					
ITEM	QTY	PART NO. MCD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-243		PRESSURE GAUGE , 4-1/2"	15# ST
	1	850-122		PRESSURE GAUGE , 4-1/2"	150-200# ST
	1	850-178		PRESSURE GAUGE , 4-1/2"	250# ST
	1	850-217		PRESSURE GAUGE , 4-1/2"	300# ST
	1	850-50		PRESSURE GAUGE , 4-1/2"	30# HW
	1	850-153		PRESSURE GAUGE , 4-1/2"	60# HW
	1	850-114		PRESSURE GAUGE , 4-1/2"	125# HW
	1	850-122		PRESSURE GAUGE , 4-1/2"	150# HW
2	1	817-2406	817-163	LOW WATER CUT-OFF	15# ST
	1	817-2406	817-163	LOW WATER CUT-OFF	150# ST
	1	817-303	817-163	LOW WATER CUT-OFF	200-250# ST
	1	————	817-1962	LOW WATER CUT-OFF	300# ST
	1	817-2305		CONTROL, WATER LEVEL PROBE TYPE, MDL. 750	ALL HW
	1	817-2306		REMOTE SENSOR, PROBE HOLDER, MDL. 750	
	1	067-871		ROD, ELECTRODE, 12"LG,FOR REMOTE SENSOR	
3	1	941-401		VALVE, GLOBE 3/4"	15-300# ST
4	2	825-31		COCK, UNION, BRASS	15-250# ST
	2	————	941-318	VALVE, GLOBE 1/4", BRONZE	300# ST
5	2	847-432	————	BUSHING 1-1/4" X 1"	150# ST CANADA ONLY
	2	847-472	————	BUSHING 1-1/4" X 1"	200-250# ST
	1	————	847-432	BUSHING 1-1/4" X 1"	15-150# ST
	1	————	847-472	BUSHING 1-1/4" X 1"	200-250# ST
	2	————	847-472	BUSHING 1-1/4" X 1"	300# ST
6	1	851-199	851-38	GAUGE GLASS	15-250# ST
	1	————	851-391	GAUGE GLASS	300# ST
7	4	912-85	————	ROD, GAUGE GLASS	15-250# ST
	2	————	912-38	ROD, GAUGE GLASS	15-250# ST
8	1	825-132		SET, GAUGE GLASS	15-200# ST
	1	825-352		SET, GAUGE GLASS	250# ST
	1	————	825-370	SET, GAUGE GLASS	300# ST
9	1	8-1152		BRACKET	M.M. #750
10	1	941-55		VALVE, GLOBE 1/4", BRONZE	15-150# ST
	1	941-318		VALVE, GLOBE 1/4", BRONZE	151-300# ST
11	1	8-A-868		BRACKET, PRESSURE CONTROL	15-300# ST
12	*	830-28		CHAIN SASH	250-300 ST
13	1	869-234		NUT & LOCKWASHER	15-300# ST

* - 6 FT ON 250#, 12 FT ON 300#.

LWCO W/ MODULATING SWITCH 193-7 & 194-7

15-150# ST	817-1100
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

15# ST	817-781
150# ST	817-733
200-250# ST	817-304

OPTIONAL REPLACEMENT FOR ITEM 2

BILL OF MATERIAL					
ITEM	QTY	PART NO. 15-150#	PART NO. 200-250#	PART NO. 300#	DESCRIPTION	USED ON
14	1	928-44			CLAMP, ONE - HOLE	-
15	1	868-136			CAPSCREW HEX. HD. 1/4-20	-
16	1	847-424	847-467		BUSHING, RED. 1" X 1/4"	ALL ST
17	2	847-426	847-469		BUSHING, RED. 1" X 3/4"	MAGNETROL
	1	847-426	847-469		BUSHING, RED. 1" X 3/4"	ALL ST
18	1	-		847-612	BUSHING, RED. 1/2" X 1/4"	MAGNETROL
19	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	
20	1	941-401			VALVE, GLOBE 3/4"	
21	2	847-432	847-472		BUSHING 1-1/4" x 1"	
22	1	847-426	847-469		BUSHING 1-1/4" x 3/4"	

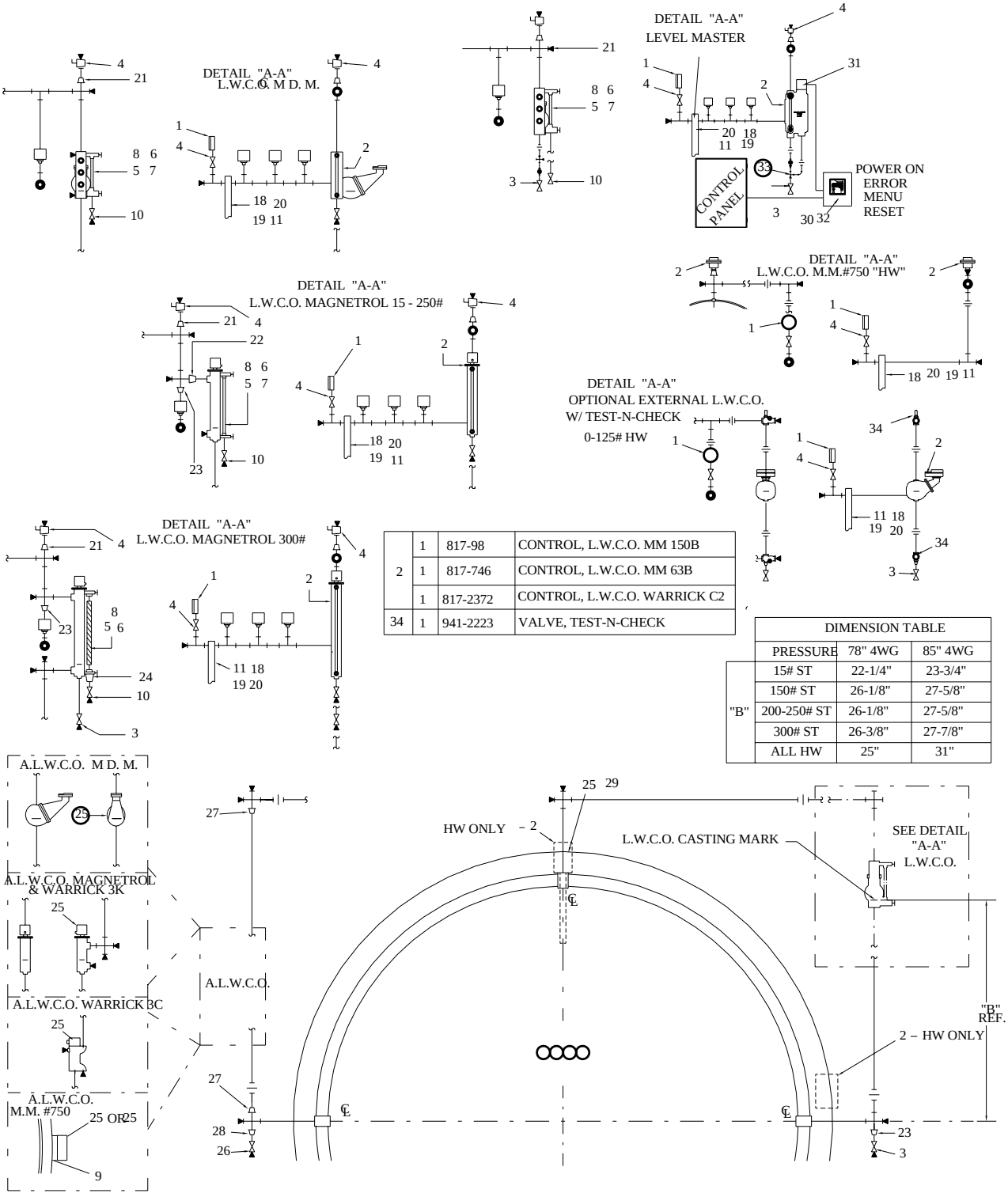
EXTERNAL A.L.W.C.O.					
MDCM.	19	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
MAGNETROL	19	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	19	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#

INTERNAL A.L.W.C.O. (ABOVE 15# ONLY)					
WARRICK	19	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	30#-200#
		1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	30#-200#
		1	817-2305	CONTROL, AUX. L.W.C.O. MM 750-MT120	15#-250#
	23	2	817-2307	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E2B
		3	817-2307	ROD,ELECTRODE, 1/4" DIA X 24" LG.	3E3B
		1	817-2306	REMOTE SENSOR, PROBE HOLDER, McD. 750	
		1	817-2307	PROBE EXT.,24"LG,FOR REMOTE SENSOR, McD. 750	

LEVEL MASTER EQUIPMENT STANDARD FOR 150-250 PSI STEAM CB				
2	1	289-154	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-199	GAUGE GLASS	15#-250#
7	1	912-85	ROD, GAUGE GLASS	15#-250#
17	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
24	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# A.R.
	1	623-117		15#-250# M.R.
25	1	623-163	LEVEL MASTER PROBE	15#-250#
26	1	8-3267	BRACKET	15#-250#
27	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15#-150#
	1	847-986		151#-250#

NOTE 1.
IF REFLEX GAUGE GLASS IS REQ`D REPLACE LWCO P/N 289-154 W/ 289-155 AND USE P/N 851-389 AND 825-369.
2. FOR ALL OTHER TRIM REFER TO STANDARD BOM

9.2.42 — Water Column Piping: 78”-85”, 250-400 HP



2	1	817-98	CONTROL, L.W.C.O. MM 150B
	1	817-746	CONTROL, L.W.C.O. MM 63B
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
34	1	941-2223	VALVE, TEST-N-CHECK

DIMENSION TABLE			
	PRESSURE	78" 4WG	85" 4WG
"B"	15# ST	22-1/4"	23-3/4"
	150# ST	26-1/8"	27-5/8"
	200-250# ST	26-1/8"	27-5/8"
	300# ST	26-3/8"	27-7/8"
	ALL HW	25"	31"

BILL OF MATERIAL					
ITEM	QTY	PART NO. M.D. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-230		PRESSURE GAUGE- 6"	15 ST
	1	850-222		PRESSURE GAUGE- 6"	150-200 ST/150 HTHW
	1	850-320		PRESSURE GAUGE- 6"	250 ST
	1	850-400		PRESSURE GAUGE- 6"	300 ST
	1	850-223		PRESSURE GAUGE- 6"	30 HW
	1	850-221		PRESSURE GAUGE- 6"	125 HW
2	1	817-621	817-163	LOW WATER CUT-OFF	15 ST
	1	817-2405	817-163	LOW WATER CUT-OFF	150 ST
	1	817-303	817-163	LOW WATER CUT-OFF	200 - 250ST
	1	-	817-1962	LOW WATER CUT-OFF	300ST
	1	817-2305		CONTROL, WATER LEVEL PROBE TYPE, MDL. 750	
	1	817-2306		REMOTE SENSOR, PROBE HOLDER, MDL. 750	ALL HW
	1	067-871		ROD, ELECTRODE., 12"LG, FOR REMOTE SENSOR	
3	1	941-401		VALVE, GLOBE 3/4"	15-250 ST
	2	941-401		VALVE, GLOBE 3/4"	300 ST
4	2	825-31	————	COCK, UNION, BRASS	15-250 ST
	2	941-318	————	GLOBE,VALVE	300 ST.
5	9FT	830-28		CHAIN SASH	15-300 ST
6	1	851-44	851-38	GAUGE, GLASS	15-150 ST
	1	851-199	851-38	GAUGE, GLASS	200-250 ST
	1	---	851-391	GAUGE, GLASS	300 ST
7	4	912-34	912-34	ROD, GAUGE GLASS	15-150 ST ONLY
	4	912-85	912-34	ROD, GAUGE GLASS	200-250 ST
8	1	825-132		SET, GAUGE GLASS	15-200 ST
	1	825-352		SET, GAUGE GLASS	250 ST
	1	---	825-370	SET, GAUGE GLASS	300 ST
9	2	8-1152		BRACKET	M.M. #750
10	1	941-55		VALVE, BALL 1/4"	15-200 ST
	1	941-318		VALVE, GLOBE 1/4"	250-300 ST
11	1	971-13		FLAT BAR, 1/8" x 1" x 36"	15-300 ST
ITEMS 12 THRU 17 ARE NOT USED					
18	1	869-234		NUT & LOCKWASHER 1/4"	-
19	1	928-44		ONE-HOLE CLAMP	-
20	1	868-136		CAPSCREW HEX. HD. 1/4-20	-
21	1	847-428	847-470	BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432	847-472	BUSHING 1-1/4" x 1"	MAGNETROL
23	1	847-431	847-471	BUSHING 1-1/4" x 3/4"	ALL ST
	2	847-431	847-471	BUSHING 1-1/4" x 3/4"	MAGNETROL
24	1	847-612		BUSHING 1/2" X 1/4"	300# ONLY
25	1	SEE TABLE		CONTROL, AUX. L.W.C.O.	-
26	1	941-401		VALVE, GLOBE 3/4"	15-300#
27	2	847-432		BUSHING 1-1/4" x 1"	15-150#
	2	847-472		BUSHING 1-1/4" x 1"	200-300#
28	1	847-431		BUSHING 1-1/4" x 3/4"	15-150#
	1	847-471		BUSHING 1-1/4" x 3/4"	200-300#

LEVEL MASTER EQUIPMENT				
2	1	289-155	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-44	GAUGE GLASS	15#-250#
7	1	912-34	ROD, GAUGE GLASS	15#-250#
23	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
30	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# AUTO RESET
	1	623-117		15#-250# MANUAL RESET
31	1	623-163	LEVEL MASTER PROBE	15#-250#
32	1	8-3267	BRACKET	15#-250#
33	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15-150#
	1	847-986		151#-250#
NOTE 1. FOR REFLEX GAUGE GLASS USE P/N 851-389 AND 825-369. 2. FOR ALL OTHER TRIM REFER TO STANDARD BOM				

EXTERNAL A.L.W.C.O.					
M.D. M.	25	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MAN)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MAN)	200-250#
MAGNETROL	25	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	25	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK	15-250#

INTERNAL A.L.W.C.O. (ABOVE 15# ONLY)					
WARRICK	25	1	817-740	CONTROL, AUX. L.W.C.O. WARR	30#-200#
WARRICK		1	817-1020	CONTROL, AUX. L.W.C.O. WARR	30#-200#
M.D. M.		1	817-2305	CONTROL, AUX. L.W.C.O. MM	15#-250#
	29	2	67-873	ROD, ELECTRODE, 1/4" DIA X 24	3E2B
		3	67-873	ROD, ELECTRODE, 1/4" DIA X 24	3E3B

OPTIONAL REPLACEMENT FOR ITEM 2

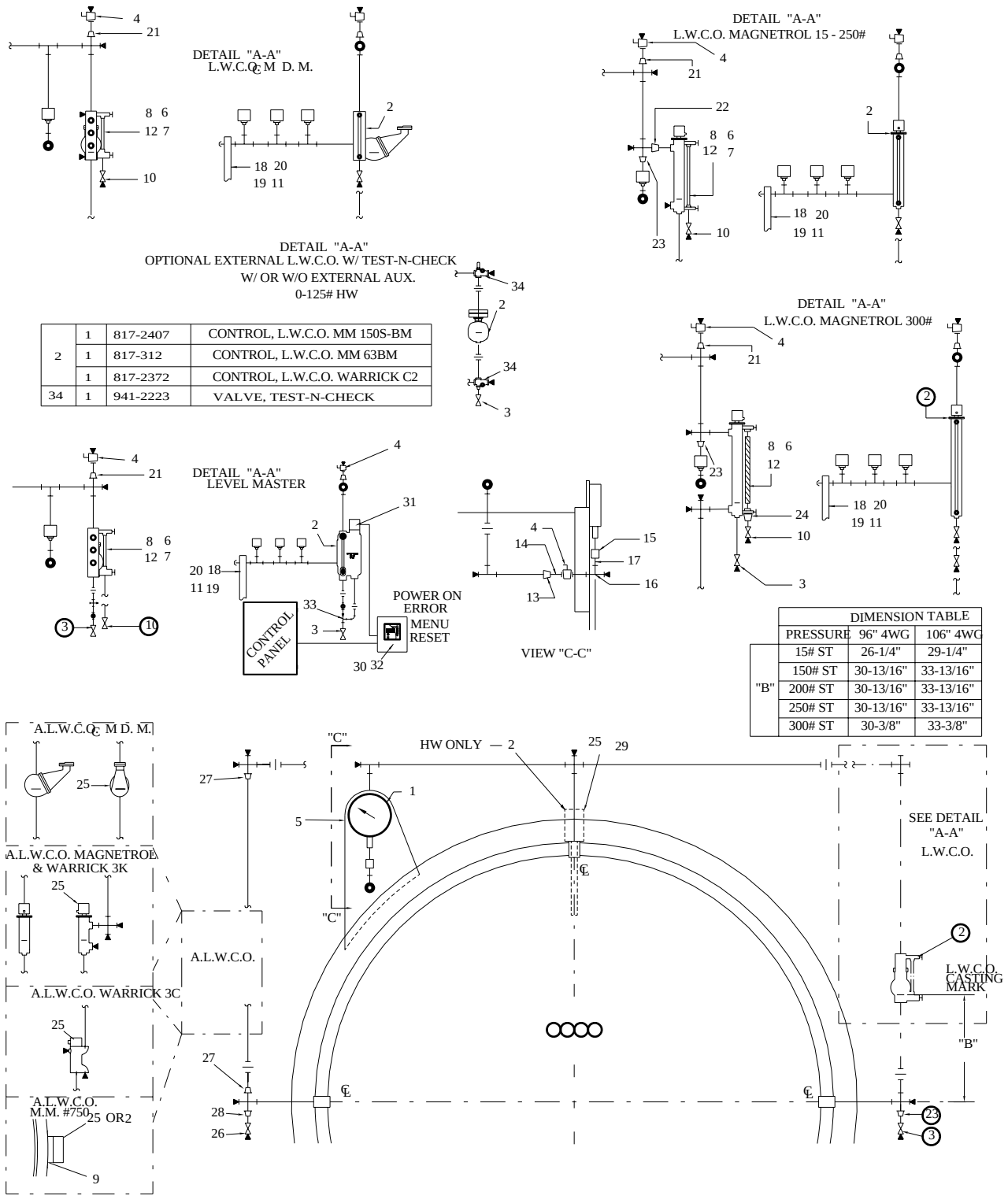
LWCO W/ MODULATING SWITCH 193-7 & 194-7

15-150# ST	817-1307
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304

9.2.43 — Water Column Piping: 96”-106”, 500-800 HP



2	1	817-2407	CONTROL, L.W.C.O. MM 150S-BM
	1	817-312	CONTROL, L.W.C.O. MM 63BM
	1	817-2372	CONTROL, L.W.C.O. WARRICK C2
34	1	941-2223	VALVE, TEST-N-CHECK

DIMENSION TABLE		
PRESSURE	96" 4WG	106" 4WG
15# ST	26-1/4"	29-1/4"
150# ST	30-13/16"	33-13/16"
200# ST	30-13/16"	33-13/16"
250# ST	30-13/16"	33-13/16"
300# ST	30-3/8"	33-3/8"

BILL OF MATERIAL

ITEM	QTY	PART NO. MCD. M.	PART NO. MAGNETROL	DESCRIPTION	USED ON
1	1	850-264		PRESSURE GAUGE- 8-1/2"	15 ST
	1	850-104		PRESSURE GAUGE- 8-1/2"	150-200 ST
	1	850-150		PRESSURE GAUGE- 8-1/2"	250 ST
	1	850-172		PRESSURE GAUGE- 8-1/2"	300 ST
	1	850-101		PRESSURE GAUGE- 8-1/2"	30# HW
	1	850-103		PRESSURE GAUGE- 8-1/2"	125# HW
	1	850-104		PRESSURE GAUGE- 8-1/2"	150# HTHW
2	1	817-621	817-163	LOW WATER CUT-OFF	15 ST
	1	817-2405	817-163	LOW WATER CUT-OFF	150 ST
	1	817-303	817-163	LOW WATER CUT-OFF	200-250 ST
	1	————	817-1962	LOW WATER CUT-OFF	300 ST
	1	817-2305		CONTROL, WATER LEVEL PROBE TYPE	ALL HW
	1	817-2306		REMOTE SENSOR, PROBE HOLDER	
	1	067-871		ROD, ELECTRODE., FOR REMOTE SENSOR	
3	1	941-401		VALVE, GLOBE 3/4"	15-250 ST
	2	941-401		VALVE, GLOBE 3/4"	300 ST
4	2	825-31	————	COCK, UNION, BRASS	15-250 ST
	2	————	941-318	VALVE, GLOBE 1/4", BRASS	300 ST
5	1	8-3340		BRACKET, STEAM GAUGE	STEAM ONLY
6	1	851-44	851-38	GAUGE, GLASS	15-150 ST
	1	851-199	851-38	GAUGE, GLASS	200-250 ST
	1	————	851-391	GAUGE, GLASS	300 ST
7	4	912-34	912-34	ROD, GAUGE GLASS	15-150 ST ONLY
	4	912-85	912-34	ROD, GAUGE GLASS	200-250 ST ONLY
8	1	825-352		SET, GAUGE GLASS	0-250 ST
	1	————	825-370	SET, GAUGE GLASS	300 ST
10	1	941-55		VALVE, BALL 1/4"	15-200 ST
	1	941-318		VALVE, GLOBE, 1/4"	250-300 ST
11	1	971-13		FLAT BAR, 1/8" x 1" x 36"	15-300 ST
12	*	830-28		CHAIN SASH	15-300 ST

EXTERNAL A.L.W.C.O.

MCD. M.	25	1	817-2408	CONTROL, AUX. L.W.C.O. (AUTO)	15#
		1	817-2407	CONTROL, AUX. L.W.C.O. (MAN)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MAN)	200-250#
MAGNETROL	25	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	25	1	817-2372	CONTROL, AUX. L.W.C.O. WARR	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARR	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARR	15-250#

INTERNAL A.L.W.C.O.
(ABOVE 15# ONLY)

WARRICK	25	1	817-740	CONTROL, AUX. L.W.C.O. WARR	30#-200#
WARRICK		1	817-1020	CONTROL, AUX. L.W.C.O. WARR	30#-200#
MCD. M.		1	817-2305	CONTROL, AUX. L.W.C.O. MM 750	15#-200#
	29	2	67-873	ROD,ELECTRODE, 1/4" DIA X 24"	3E2B
		3	67-873	ROD,ELECTRODE, 1/4" DIA X 24"	3E3B
		1	817-2306	REMOTE SENSOR, PROBE HOLDER,	MDL. 750
		1	817-2383	PROBE EXT., 36"LG, REMOTE SENSOR,	MDL. 750

LEVEL MASTER EQUIPMENT
STANDARD FOR 150-250 PSI STEAM

2				
	1	289-155	LOW WATER CUTOFF	15-250#
3	1	941-402	VALVE, GLOBE, 1" NPT	15#-250#
6	1	851-44	GAUGE GLASS	15#-250#
7	1	912-34	ROD, GAUGE GLASS	15#-250#
23	1	847-472	BUSHING, 1-1/4" X 1"	15#-250#
30	1	623-116	LEVEL MASTER CONTROL PANEL	15#-250# AUTO RESET
	1	623-117		15#-250# MANUAL RE
31	1	623-163	LEVEL MASTER PROBE	15#-250#
32	1	8-3267	BRACKET	15#-250#
33	1	847-279	RDCR. TEE, 1" x 1" x 1/2"	15#-150#
	1	847-986		151#-250#

NOTE 1. FOR REFLEX GAUGE GLASS USE P/N 851-389 AND 825-369.
2. FOR ALL OTHER TRIM REFER TO STANDARD BOM

ITEM	QTY	PART NO. 15-150#	PART NO. 200-250#	PART NO. 300#	DESCRIPTION	USED ON
13	1	847-1687	858-1009	858-1009	COUPLING 1" X 1/4"	-
14	1	857-448		857-726	BRASS NIPPLE, 1/4" x 1-1/2"	-
15	1	858-856		858-768	COUPLING 1/4" R.H. THREAD	-
16	1	859-54		859-32	BRASS TEE 1/4"	-
17	1	857-452		857-676	BRASS NPL. (X-HEAVY) 1/4" x 1-1/2"	-
18	1	869-234			NUT & LOCKWASHER 1/4"	-
19	1	928-44			ONE-HOLE CLAMP	-
20	1	868-136			CAPSCREW HEX. HD. 1/4-20 x 3/4"	-
21	1	847-428	847-470		BUSHING 1-1/4" x 1/4"	ALL ST
22	1	847-432	847-472	————	BUSHING 1-1/4" x 1"	MAGNETROL
23	1	847-431	847-471		BUSHING 1-1/4" x 3/4"	ALL ST
	2	847-431	847-471		BUSHING 1-1/4" x 3/4"	MAGNETROL
24	1	————		847-612	BUSHING 1/2" X 1/4"	MAGNETROL
25	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	-
26	1	941-401			VALVE, GLOBE 3/4"	15-300#
27	2	847-432			BUSHING 1-1/4" x 1"	15-150#
	2	847-472			BUSHING 1-1/4" x 1"	200-300#
28	1	847-431			BUSHING 1-1/4" x 3/4"	15-150#
	1	847-471			BUSHING 1-1/4" x 3/4"	200-300#

* - 9FT. ON 78", 12FT. ON 96"

OPTIONAL REPLACEMENT FOR ITEM 2

LWCO W/ MODULATING SWITCH 193-7 & 194-7

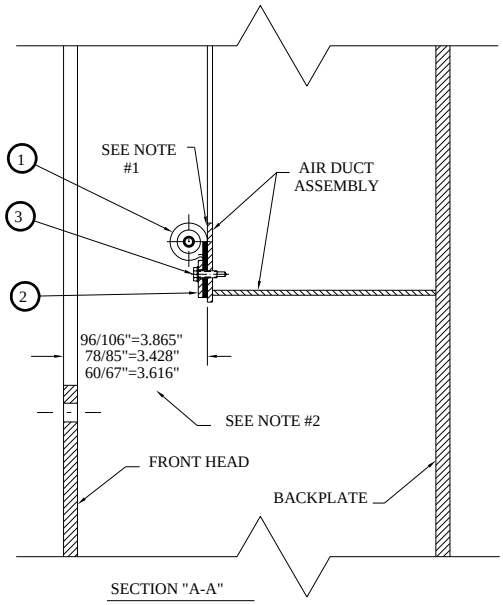
15-150# ST	817-1307
200-250# ST	817-1211

LWCO W/ SWITCH FOR MOTORIZED FEED VALVE 158, 193, & 194

15# ST	817-1161
150# ST	817-1155
200-250# ST	817-304

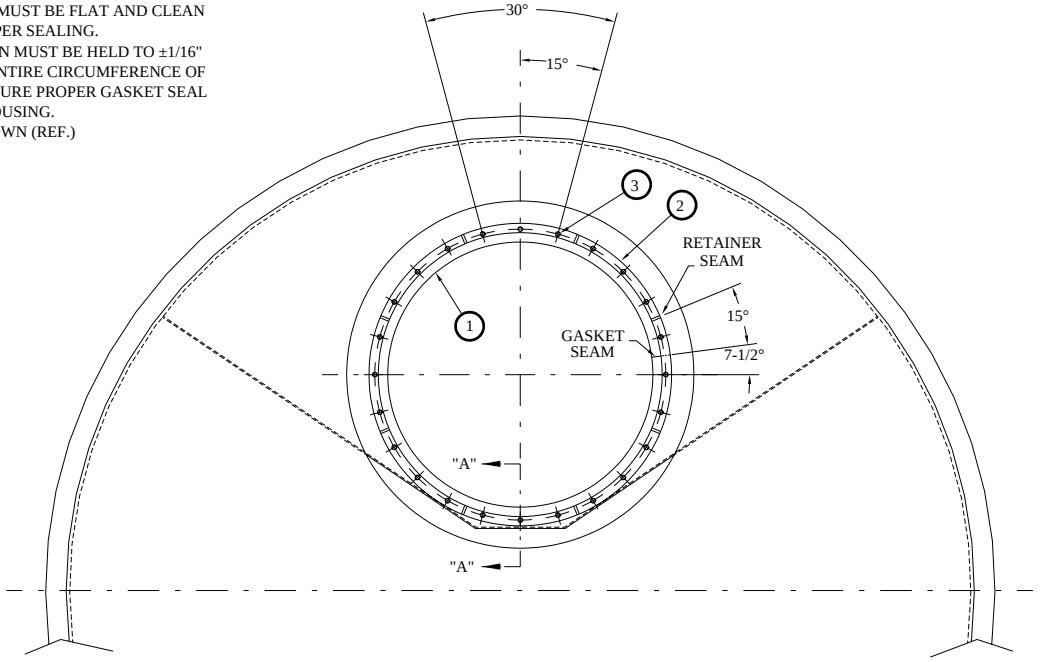
9.2.44 — Front Door 60”-106” Air Duct Gasket

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	032-02542	GASKET, AIR DUCT	60" & 67"
	1	032-02543	GASKET, AIR DUCT	78",-85"-96" & 106"
2	8	065-00810	RETAINER, AIR DUCT	60" & 67"
	8	065-00811	RETAINER, AIR DUCT	78",-85"-96" & 106"
3	24	841-01545	SCREW, SELF DRILLING, HEX WASHER HD	ALL



NOTES:

1.) THIS SURFACE MUST BE FLAT AND CLEAN TO ASSURE PROPER SEALING.
2.) THIS DIMENSION MUST BE HELD TO ±1/16" THROUGHOUT ENTIRE CIRCUMFERENCE OF OPENING TO ASSURE PROPER GASKET SEAL TO IMPELLER HOUSING.
3.) 96" BOILER SHOWN (REF.)



9.2.45 — Pressure Vessel Manway Components

QTY	DESCRIPTION	15#-150# D.P. PART NO.	200#-300# D.P. PART NO.
1	MANWAY COVER	821-00207	821-00207
2	MANWAY YOKE	953-00050	953-00050
1	MANWAY GASKET	853-00939	853-01044
2	BOLT	868-00751	868-00751
2	NUT	869-00065	869-00065
2	WASHER	952-00124	952-00124

9.2.46 — Pressure Vessel Handhole Components

QTY	DESCRIPTION	15#-150# D.P. PART NO.	200# & 250# D.P. PART NO.
6	HANDHOLE COVER	258-00011	258-00011
6	HANDHOLE YOKE	104-00449	104-00449
6	HANDHOLE GASKET	853-00935	853-01042
6	NUT	869-00017	869-00017
6	WASHER	952-00101	952-00101

9.2.47 — Pressure Vessel Handhole Components

QTY	DESCRIPTION	15#-150# D.P. PART NO.	200# & 250# D.P. PART NO.
6	HANDHOLE COVER	258-00011	258-00011
6	HANDHOLE YOKE	104-00449	104-00449
6	HANDHOLE GASKET	853-00935	853-01042
6	NUT	869-00017	869-00017
6	WASHER	952-00101	952-00101