



CBEX Premium

Packaged Boiler

100-800 HP

Operation and Maintenance



Manual Part No. 750-343

02/2013



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

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

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

TO: Owners, Operators and/or Maintenance Personnel

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

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

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

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely alleviate certain repetitive chores, allowing more time for proper upkeep of the equipment.

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

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

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

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

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

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

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

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1.1 — Overview

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

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

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

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

This manual applies to CBEX Premium boilers ranging from 100 through 800 boiler horsepower for the following fuels:

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

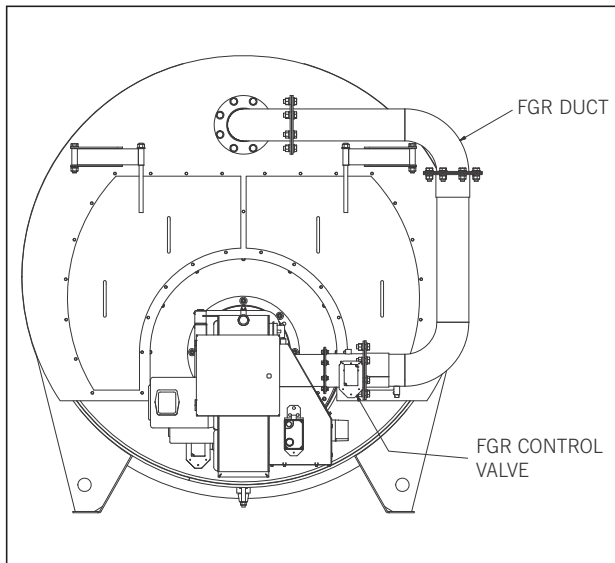


FIGURE 1-1. Induced Flue Gas Recirculation (IFGR)

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

The low emission option for the CBEX Premium line of Firetube Boilers reduces Nitrogen Oxide (NO_x) 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.

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

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

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

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

1.2 — The Boiler

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

The horsepower rating of the boiler is indicated by the numbers following the fuel series. For example, CBEX700-600 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.

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

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

Operating pressure is the pressure 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.

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

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

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

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

Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease, or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 3.

1.3 — Construction

Steam boilers designed for 15 psig and hot water boilers designed for 250° 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 250° F or 125 psi are likewise built to Section I of the ASME Code.

1.4 — Steam Controls (all fuels)

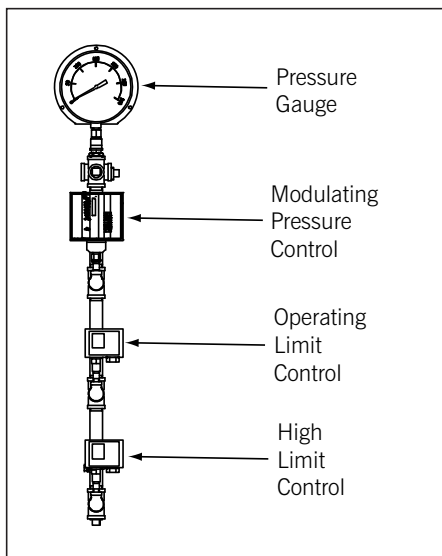


FIGURE 1-2. Steam Controls

1.4.1 — Pressure Controls

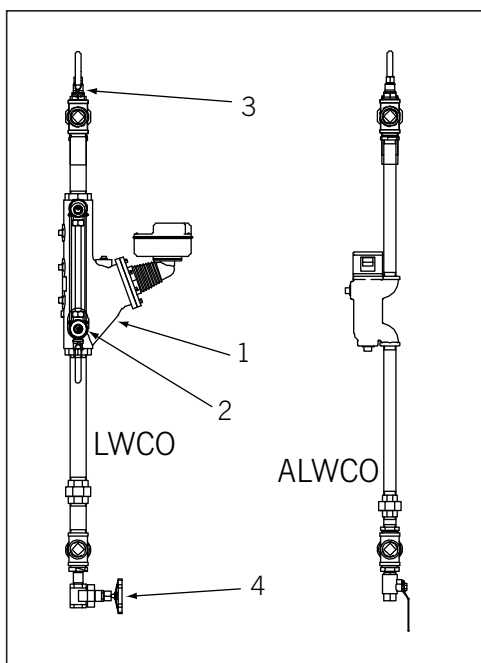
1. Pressure Gauge: Indicates boiler internal pressure.

2. Operating Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.

3. High Limit Pressure Control: Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. The high limit pressure control is normally equipped with a manual reset.

4. Modulating Pressure Control: Senses changing boiler pressure and transmits a signal to change the boiler firing rate (overridden when boiler is operating in 'manual' mode).

1.4.2 — Low Water Cutoff



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

1. Low Water Cutoff and Pump Control: Float-operated control responds to the water level in the boiler. It performs two distinct functions:

- Stops firing of the burner if water level lowers below the safe operating point. Energizes the low-water light in the control panel; also causes low-water alarm bell (optional equipment) to ring. Code requirements of some models require a manual reset type of low water cutoff.
- Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.

2. 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 the auxiliary low water cutoff.

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

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

1.4.3 — Safety Valve(s)

Safety Valves: Prevent pressure in excess of the design pressure of the vessel. The size, rating, and number of valves on a boiler are determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME Code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat. Apply only a moderate amount of pipe compound to male threads and avoid over-tightening, which can distort the seats. Use only flat-jawed wrenches on the flats provided. When installing a flange connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

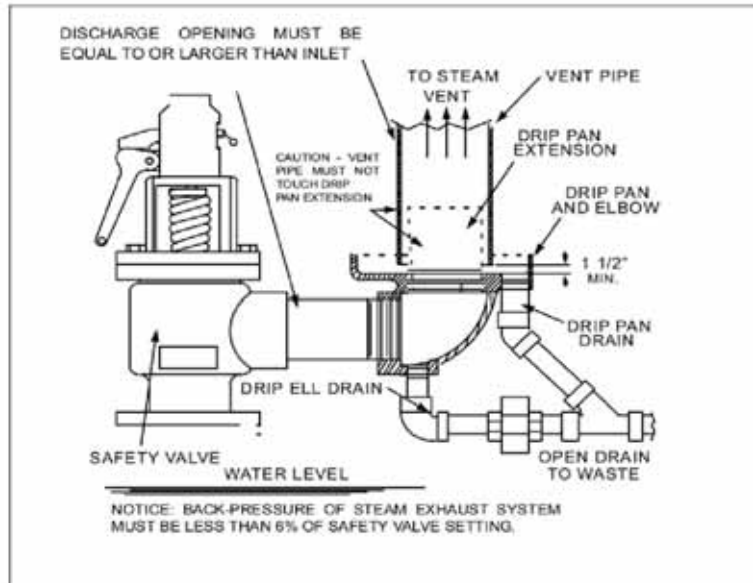


FIGURE 1-4. Safety Valve Piping and Safety Valves

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 — Temperature 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 “auto-matic.”
2. **High Limit Temperature Control:** Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop the burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
3. **Operating Limit Temperature Control:** Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.



FIGURE 1-5. Temperature Gauge and Hot Water Controls

1.5.3 — Low Water Cutoff and ALWCO

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

1.5.4 — Safety Valve(s)

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

2.1 — 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. Instructions for adjusting major components are given in Chapter 8, 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 7.

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

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

Refer to Chapter 5 for water requirements.

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

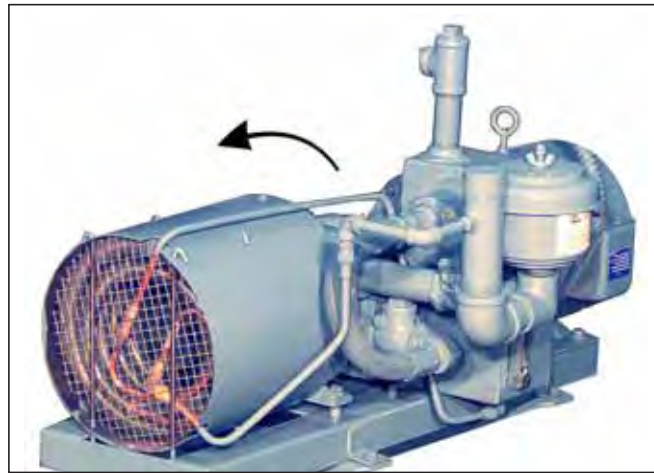


FIGURE 2-1. Air Compressor Motor Rotation

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

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

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.

2.2 — Control Settings: Steam and Hot Water

Operating control:

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

High limit control:

1. On a high pressure steam boiler, the high limit control should be set approximately 10 psig above the operating limit pressure control setting, if feasible, or midway between the operating limit pressure and the safety valve setting.
2. On a hot water boiler, the high limit temperature control should be 5° F to 10° F above the operating limit temperature control setting but within the limits of the design pressure of the pressure vessel.

Modulating control:

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.

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

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

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

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

2.3 — Induced Flue Gas Recirculation (IFGR) Setup

NOTE: Initial IFGR linkage settings and adjustments must be established by a Cleaver-Brooks authorized representative. Setup of the low emission (LE) option requires simultaneous consideration of air-to-fuel ratios and NO_x levels. This can only be accomplished with proper combustion emissions monitoring equipment with NO_x, O₂, 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 shut-down periods in which maintenance and/or adjustments have been performed on the fuel cams, fuel and air linkages, or IFGR control linkages, the recommended approach to startup is:

1. Set all boiler components to their initial settings as discussed in the appropriate chapters of this manual.

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

2.4 — Startup, Operating, and Shutdown: All Fuels

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

2.5 — Control Operational Test and Checks

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

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

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.

3.1 — Overview

ProFire V Series burners are assembled, wired, and tested at the factory. They are listed by the Underwriters Laboratory for the U.S. and Canada, and bears the UL and cUL markings when ordered as such by the customer. Compliance with other regulatory agencies such as CSD-1, I.R./GE GAP, F.M., etc., is available at time of order.

Optional controls and control systems are also available. The operator of this equipment must be familiar with the individual functioning of all controls to understand the operations and procedures described in this manual, and supplementary instructions provided with optional controls.



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

3.2 — Description

The ProFire V Series burners are designed to operate with gas and light oil. The burners are designed for automatic, unattended operation except for periodic inspection and maintenance. The control panel components require little attention except for occasional cleaning.

3.3 — Operating Controls - Panel

The burner control panel contains a flame safeguard programming control, motor relays (starters), and terminal strips mounted internally on a panel subbase. Lights, switches, and a control circuit breaker are mounted externally on the panel.

Control	Description
On-Off Burner Switch	To manually turn the burner on or off.
Fuel Selector Switch	Gas-Off-Oil Gas position: Selects gas as the firing fuel. Off position: Burner is off. Oil position: Selects oil as the firing fuel.
Control Circuit Breaker	Supplementary low overcurrent protection only. No larger than 15 amps.
Auto-Manual Modulation Selector Switch	Auto position: Selects boiler modulation control. In this position, the burner will operate automatically in response to load demand. Manual position: Selects 135 ohm potentiometer for manual modulating control.
Manual Modulating Control	135 ohm - increases or decreases the burner firing rate manually.
Signal Lamps	a) POWER ON (white): illuminates when the control circuit is energized (powered). b) IGNITION (amber): illuminates when the ignition transformer is powered, and the pilot valve is energized (opened). c) MAIN FUEL (green): illuminates when the main fuel valve or valves are energized (open). d) FLAME FAILURE (red): illuminates when the flame safeguard system fails to detect pilot or main flame.
Modulating Motor	Operates the air damper and fuel rate valves through a linkage system to adjust air-fuel ratios under all load conditions.
Ignition Transformer	Provides high voltage spark for ignition of gas pilot or main flame direct spark models.

3.4 — Flame Safeguard Controls

The flame safeguard controls the operating sequence of the combustion system (pre-purge, pilot, firing, and shutdown). The flame safeguard programmer incorporates a flame sensing cell (scanner) to shut down the burner in the event of pilot flame or main flame failure. Other safety controls shut down the burner based on sequence of operation as shown in the manufacturer's flame safeguard manual.

When a parallel positioning system is furnished, the flame safeguard may be incorporated as an integral component to the parallel positioning control. Consult controls documentation.

3.5 — Combustion Air Handling System

Component	Description
Motor and Blower	The impeller is directly driven by the motor at 3450 rpm. A heavy-duty forward curved multi-blade centrifugal impeller supplies combustion air.
Air Volume Regulator	Air dampers are located in the air inlet housing. The dampers are mechanically linked to the modulating motor.
Combustion Air Proving Switch	A pressure sensitive, differential switch actuated by air pressure created by the blower fan. Contacts close to prove combustion air flow.
Diffuser	An air flow diffuser stabilizes the flame front.

3.5.1 — Operation

Air from the impeller flows through the blast tube and diffuser to mix with fuel in the ignition zone. Combustion air flow rate is determined by the position of the air regulating blades at the inlet of the impeller. Linking the air flow with fuel flow provides efficient combustion at all firing rates.

3.6 — Oil System

Models VL - VLG are high pressure atomizing burners using fuel pressure for atomization. Atomized fuel is discharged from the nozzle as a fine conical spray.

Component	Description
Fuel Unit	Sizes 1 & 2: Direct driven from the blower motor with a flexible coupling at 3450 rpm, and set for 300 psi operation. The fuel unit is two stage (two sets of gears) and must be installed for a two pipe installation, one suction and one return line. Separately driven oil pumps are available as an option to the standard arrangement. Sizes 3 & 4: A separately driven oil pump is standard.
Nozzle	The nozzle meters oil flow delivering a specified amount at a specific pressure. Fuel pressure (mechanical) atomizes oil in a fine conical spray pattern from the nozzle orifice. The burner is supplied with nozzle(s) to fire to its maximum rate unless a different firing rate was specified. VL & VLG models 13-34 are supplied with simplex nozzles, models 35-168 are supplied with return flow nozzles.
Nozzle Adaptor	The nozzle adaptor provides the means for connecting fuel lines with the nozzle.
Oil Solenoid Valves	Two normally closed (N.C.) and one normally open (N.O.) solenoid valves are part of the oil system on Low-High-Off and Low-High-Low burners. The two N.C. valves provide positive shutoff of fuel oil while the one N.O. valve cycles the burner to High Fire when closed.
Oil Metering Valve	The firing rate is controlled by an adjustable metering valve in the return line. At Low Fire, the metering valve is open, and is closed at High Fire.
Oil Filter	Prevents foreign matter from entering the burner oil system. This item is provided as an option and shipped loose with the burner.

3.6.1 — Operation

Fuel oil is delivered to the fuel unit, either by gravity, fuel unit suction, or by a circulating pump, through a fuel oil filter. Pressurized fuel returns to the storage tank until the two solenoid valves open. On direct spark ignited burners (VL 13-55), ignition occurs when the oil valves open. Where gas pilots are provided (models VG and VLG), the oil valves open after the pilot is proven. Oil input rate is controlled by the oil metering valve, which varies the flow to meet load demands. The Low Fire positions bypass oil back to the storage tank. At High Fire, the metering valve is in the closed position. The modulating motor positions the metering valve and the air damper simultaneously.

3.7 — Ignition System

Oil only models VL 13-55 are supplied with direct spark ignition. Models VL 60-168 are supplied with a gas pilot system. Gas and combination gas-oil models are supplied with a gas ignition system. The standard pilot gas train consists of a manual shutoff cock, a gas pressure regulator, and a solenoid operated gas shutoff valve.

3.8 — Gas Handling System

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

Main Gas Train Component	Description
Gas Volume Valve	The butterfly type valve is positioned by linkage from the modulating motor and controls the rate of flow of gas.
Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner Standard U.L. burners include: <ul style="list-style-type: none"> Models 13-25: diaphragm gas valve & solenoid valve Models 30-50: one motorized gas valve w/proof of closure or two safety shutoff valves Models 55-120: one motorized gas valve w/proof of closure and one safety shutoff valve Models 126-168: two motorized gas valves (two motorized gas valves can be optionally provided on all models)
Main Gas Regulator	Regulates gas train pressure to specified pressure required at the burner manifold. Input is set by main gas pressure regulator adjustment.
Main Gas Cocks	Used for manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).
High Gas Pressure Switch (Models 30-168)	A pressure actuated switch that remains closed when gas pressure is below a selected setting. Should the pressure rise above the setting, the switch contacts will open causing the main gas valve(s) to close. This switch requires manual reset after being tripped.
Low Gas Pressure Switch (Models 30-168)	A pressure actuated switch that remains closed when gas pressure is above a selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.

3.8.1 — Operation

Metered gas flows through the main gas shutoff cock, through the pressure regulator to the automatic gas valves and butterfly valve to the gas manifold. The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor. The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

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

NOTE: Gas Train components upstream of the butterfly valve are shipped loose to be mounted by the installer.

NOTE: The pilot gas supply connection must be upstream of the main gas pressure regulator.

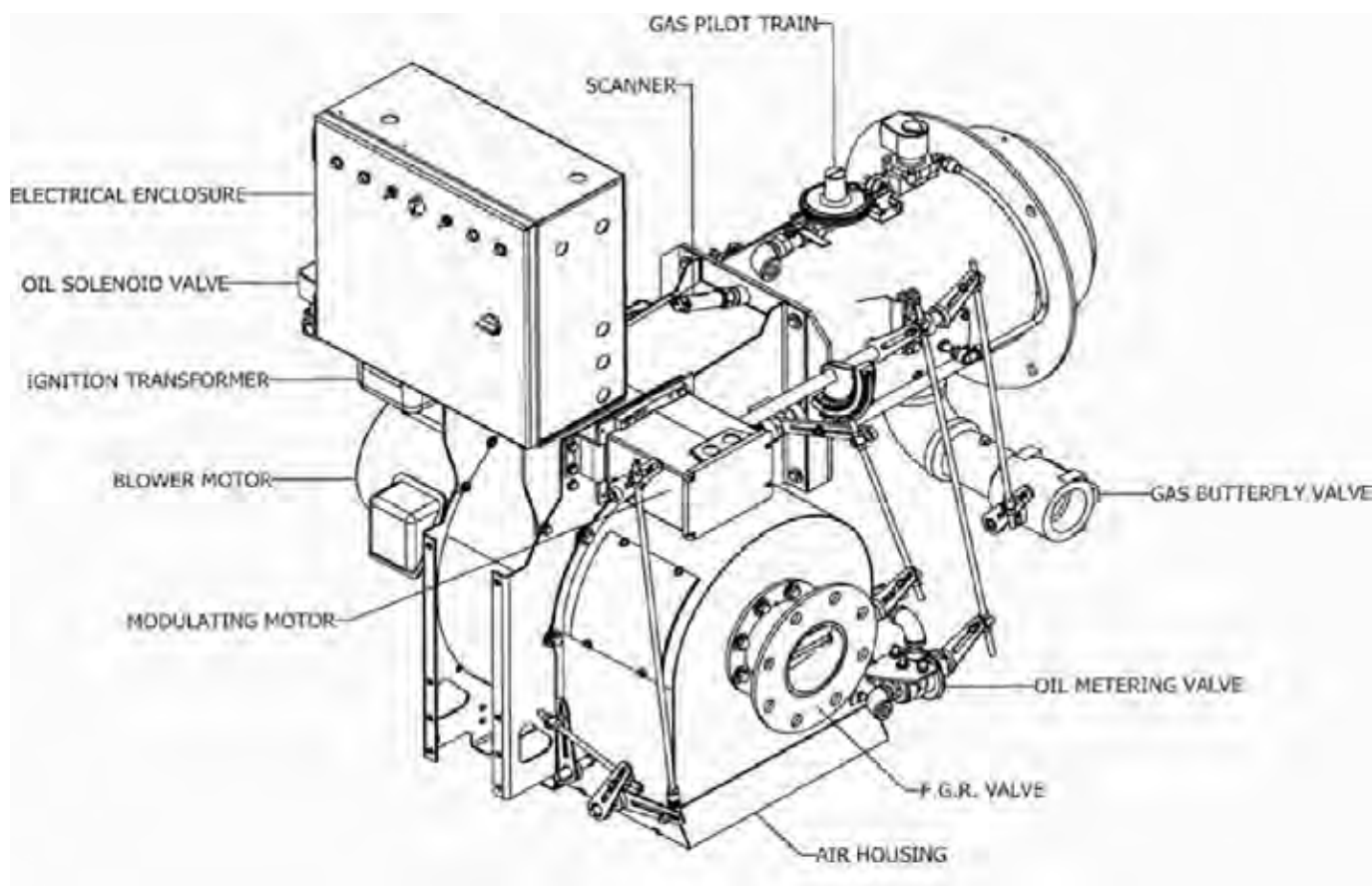


FIGURE 3-1. Burner Components

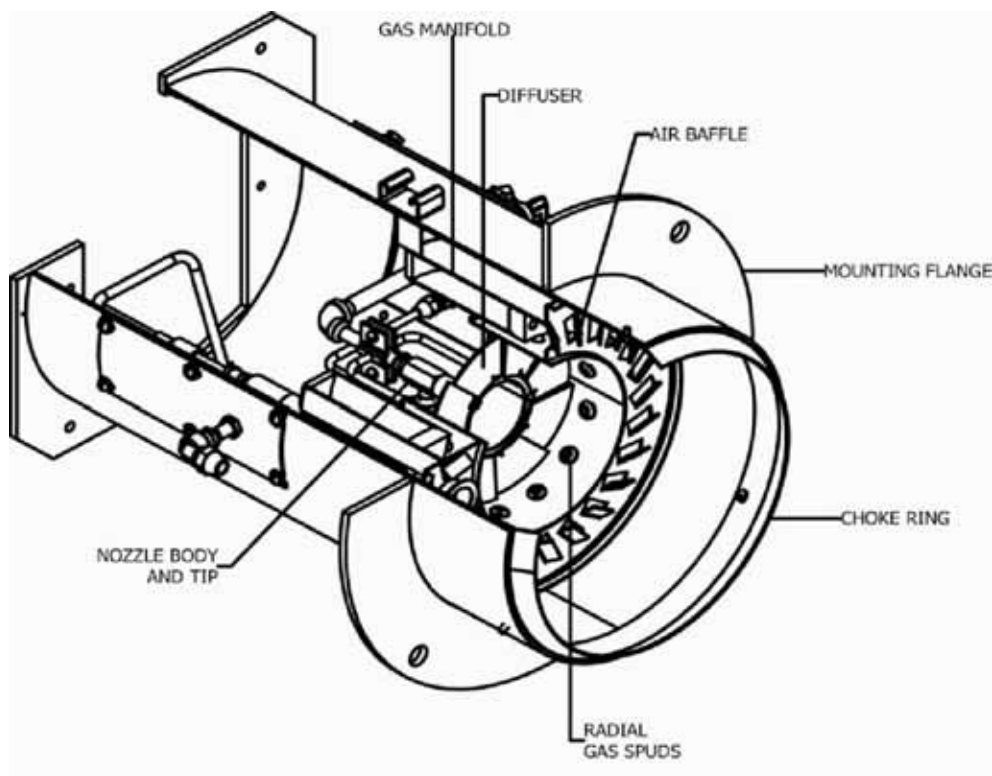


FIGURE 3-2. Burner Unit

3.9 — Draft Conditions

A boiler or other heating vessel fired with a V Series burner does not depend on chimney draft for proper combustion air. Combustion air is supplied by the burner forced draft blower providing adequate air for any normal combustion condition.

Since draft control is essential to maximum efficiency, a draft regulator may be required when the vessel is connected to a tall stack or where wind conditions may cause erratic draft. Excessive furnace draft contributes to inefficient burner operation.

Sealed boilers may be operated under positive firebox pressure within the capability of the burner.

3.10 — Combustion Air Supply

The space in which a burner operates must be supplied with adequate fresh air for combustion and ventilation purposes. Fresh air supply must meet or exceed all code requirements. Consult with insurance carrier and/or local authorities for specific regulations.

 **Warning**

The boiler room pressure must be at least equal to the outdoor atmospheric pressure. Where fan ventilation is used, air must be forced into the boiler room. Never exhaust air from the boiler room. Adjoining areas having exhaust fans must be positively isolated from the boiler room.

3.11 — Burner Installation

Prepare the boiler front plate as follows:

1. Determine burner mounting height. Locate and scribe a level horizontal centerline across the mounting face.
2. Locate and scribe a vertical centerline. Be sure stud locations line up where studs will have full support. If they don't, or if the opening is too large, a steel adapter plate, 3/8" minimum, may be welded or bolted in place. Suitable anchors should be provided to hold the refractory in place. The adapter plate must be properly sealed (use insulating rope gasket) to prevent leakage of combustion gases.
3. Using insulating rope gasket, wrap the rope on the inside of the bolt circle, looping the rope around the four mounting studs.
4. Set the burner into position for mounting and tighten into place. All burners are equipped with a four-hole mounting flange.
5. Permanently support the burner using the pipe support connections.
6. The space between the boiler refractory, water leg, or fire tube and outside diameter of the blast tube must be packed with plastic refractory, Kaiser Refractory Mono T-Air Set or equal. Ram plastic refractory from front to rear, parallel to the outside surface of the blast tube.

3.12 — Gas Piping

Gas service and house piping must supply the quantity of gas demanded by the unit at the pressure required at the burner gas train inlet.

All piping must be in strict accordance with applicable codes, ordinances, and regulations of the supplying utility. In the absence of other codes, piping should be in accordance with the following standards: "National Fuel Gas Code" NFPA No. 54, ANSI No. Z223-1.

Gas train components upstream of the butterfly valve are shipped loose. These components should be mounted by the installer as close to the butterfly valve as practical.

Normally, the control train is ordered to suit a particular code or insurance regulation, such as Underwriters Laboratories/Canadian Underwriters laboratories (UL/cUL), Factory Mutual, or Industrial Risk Insurance.

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

The pilot gas train is supplied with the burner, and is factory installed. The gas pilot supply line must be connected upstream of the main gas regulator. If a reducing bushing is required between the house piping and the burner piping, it should be close to the burner shutoff valve.

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

3.13 — Fuel Oil Piping

3.13.1 — Pressure Atomization Oil Piping

The VL and VLG model burners use pressure atomization. Fuel oil is provided by a burner mounted fuel unit directly coupled to the blower motor via a flexible coupling on Size 1 & 2 burners, Remote Pump on Size 3 & 4 burners. The suction and return line sizes (two-pipe system) are based on the suction rate of the fuel unit and not the burner firing rate. Pipe size must be selected so that suction vacuum is within suitable limits.

3.13.2 — Two Pipe - Single Burner Operation

A two-pipe system is essential. The suction and return between the storage tank or supply source and the burner must be sized to supply the required quantity of oil circulated, including excess oil returned to the storage tank.

3.13.3 — Suction Line Sizing

The suction load is determined by:

1. The vertical lift from the oil level in the tank to the pump.
2. Pressure drop through valves, fittings, strainers, etc.
3. The friction loss due to oil flow. This loss varies with:
 - a. Quantity of oil pumped (gph).
 - b. Length of suction line (feet).
 - c. Diameter of the suction line.
 - d. Number of fittings.

Although the gear type pumps used on the V series burners are capable of developing higher suction, it is not desirable to operate above 15 inches of mercury vacuum. If the vacuum is greater, flow may be erratic.

NOTE: Refer to the manufacturer's table for line sizing.

1. Check suction capacity.
2. Measure total pipe length (horizontal and vertical).
3. Read up from the line "total feet of copper tube" to the intersection line of the specific "suction capacity" in gph.
4. Read left to the column "inches of vacuum at fuel unit." This is vacuum required to draw oil through pipe listed at given length.
5. Add 1" of vacuum for every foot of lift.

6. Total inches of vacuum (frictional tube loss plus lift).
7. If total exceeds 15", check next larger pipe size.

3.13.4 — Return Line Sizing

Generally, the return line should be sized the same as the suction line.

3.13.5 — Two Pipe - Multiple Burner System

Several options exist for a multiple burner installation. Figure 3-8 is a typical installation showing separate suction lines for each burner with a common return line.

Figure 3-9 shows multiple burners with oil supplied by a transfer pump. The circulating pump is sized, in this case for the total suction capacity of all burners. Note that a special pressure regulating valve is required if the fuel unit inlet pressure is above 3 psi.

Figure 3-10 shows an installation using a day tank. A pump supplies oil to the day tank.

Figure 3-11 shows a flooded loop system. The circulating pump is sized according to the maximum burner firing rate for all burner plus a 30% service factor. The burner return lines feed into the common supply line.

NOTE: ProFire recommends that all oil firing burners be equipped with an oil strainer (if not included with the burner) to prevent particles from clogging the nozzle. It is essential to follow the strainer manufacturer's maintenance schedule to ensure proper filtration.

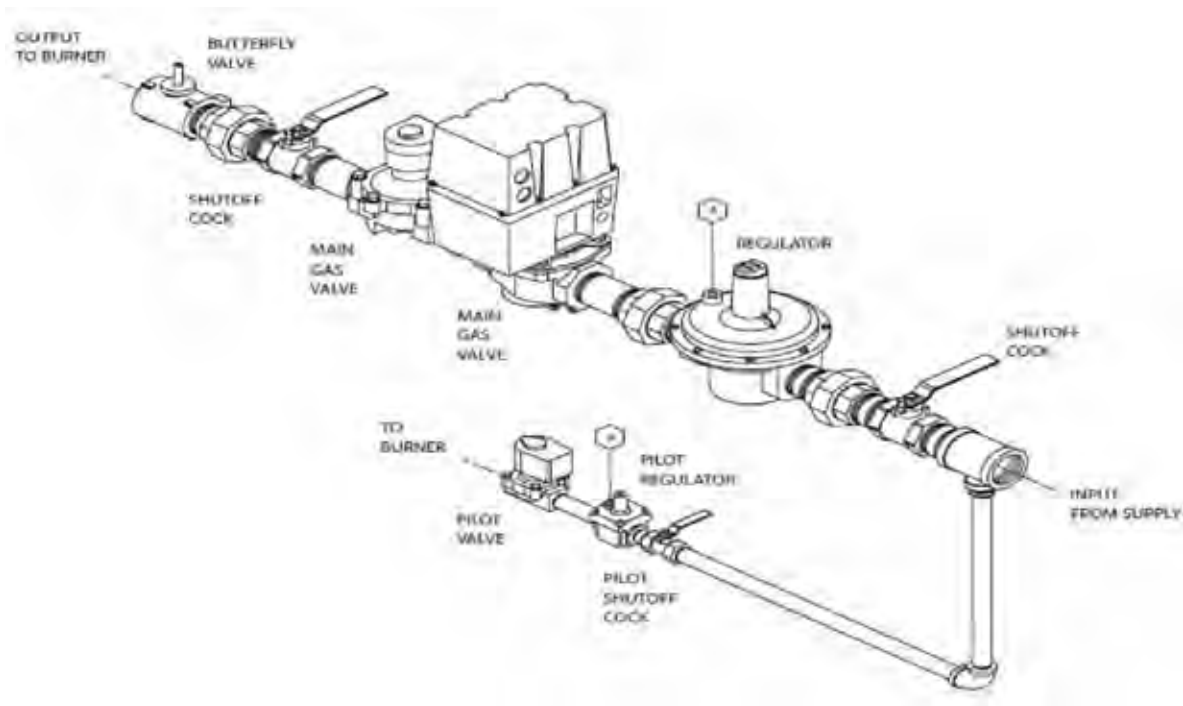


FIGURE 3-3. Typical U.L. Gas Train, Full Modulation System, Size 1 V13 to V34

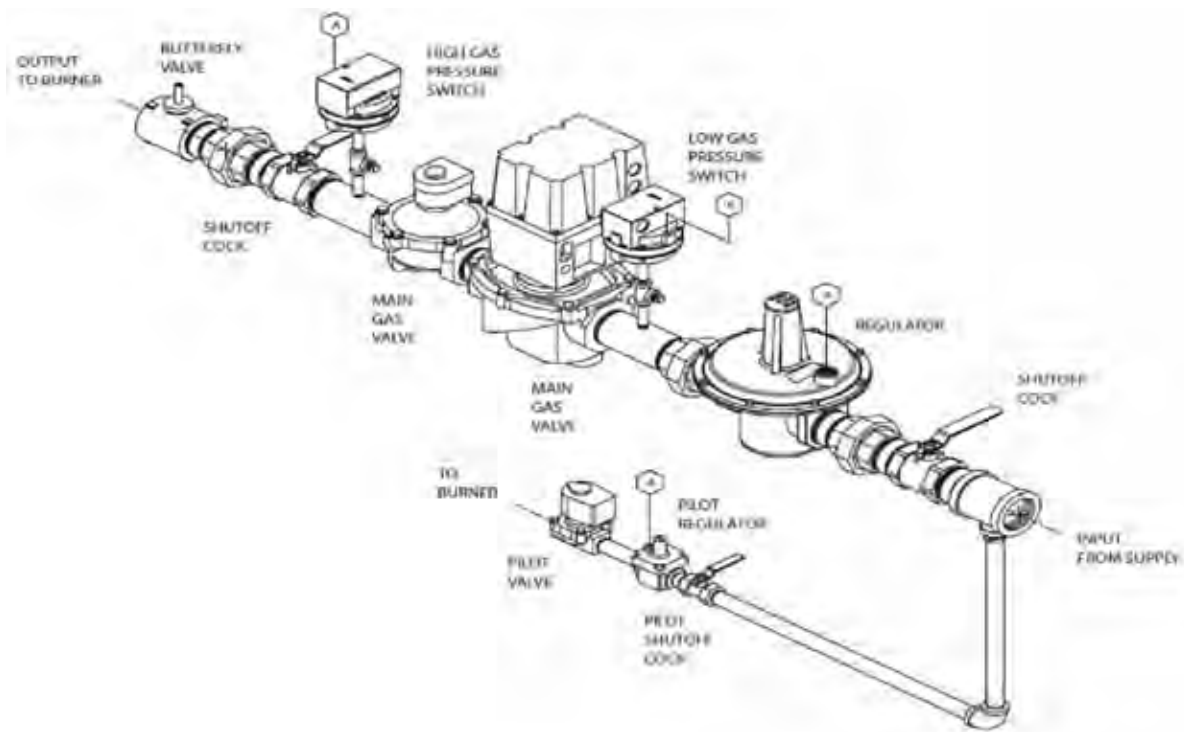


FIGURE 3-4. Typical U.L. Gas Train, Low-High-Off, Low-High-Low, Size 2 V35 to V63, Full Modulation System, Size 2-3-4, V35 to V168

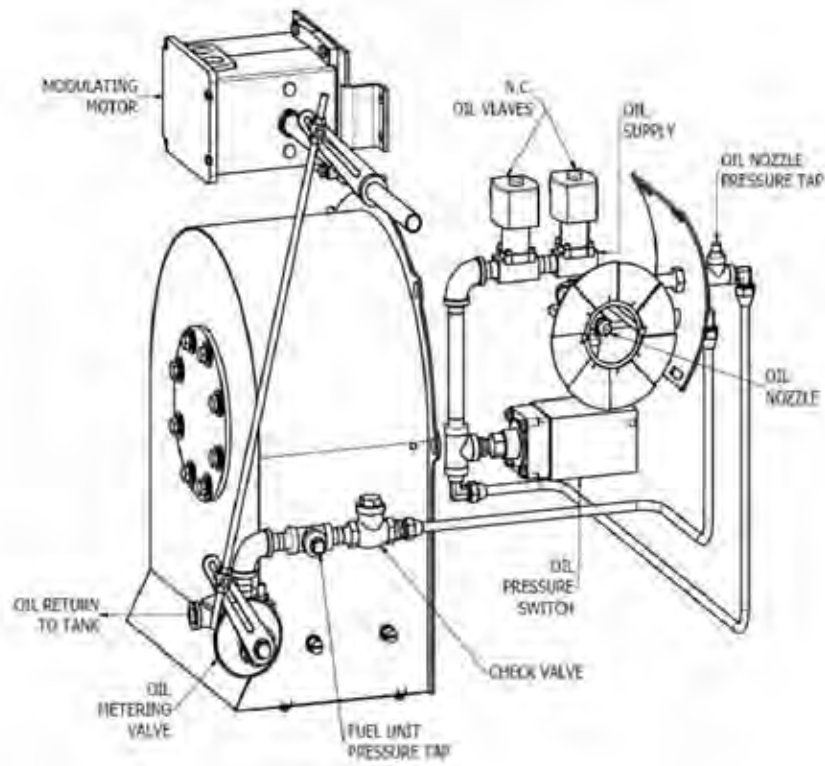


FIGURE 3-5. Remote Pump System

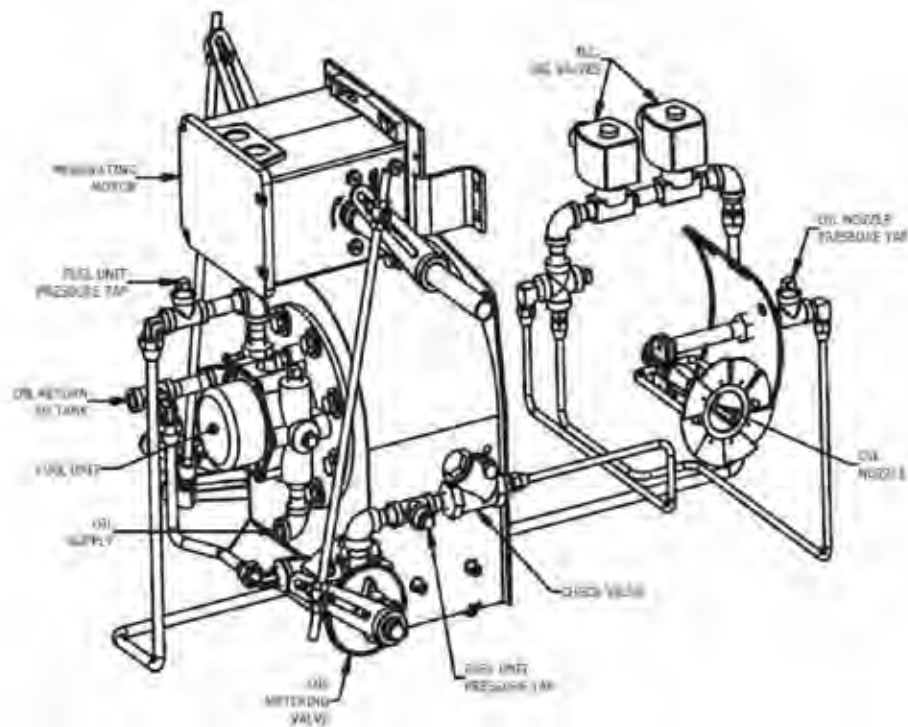


FIGURE 3-6. Full Modulation Oil System, Size 1 V13 to V34, Simplex Nozzle

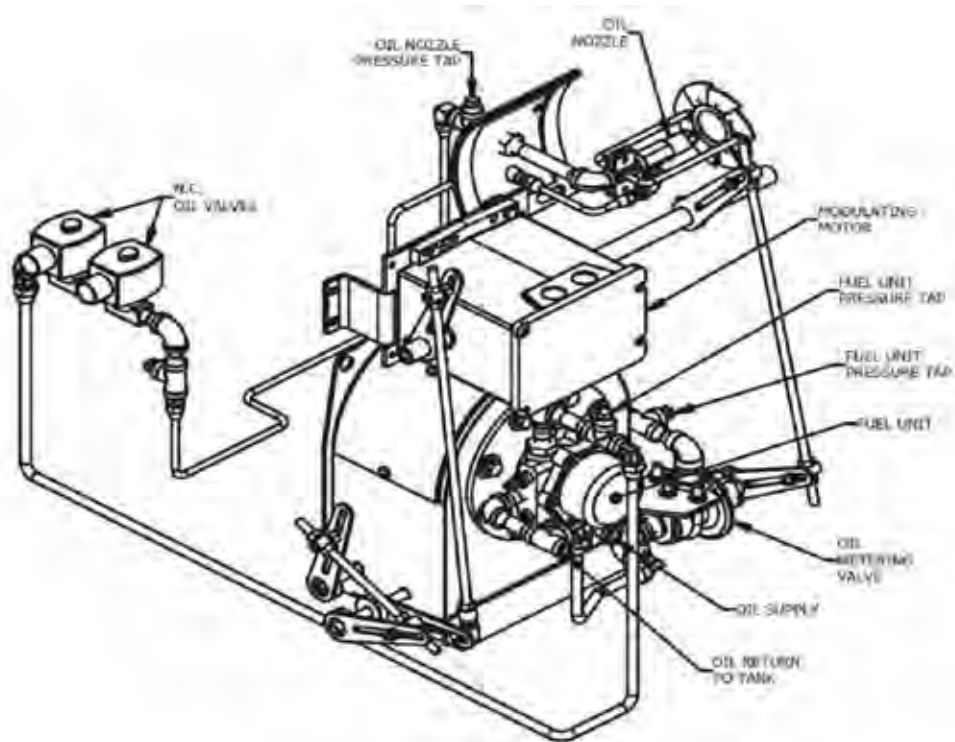


FIGURE 3-7. Full Modulation Oil System, Size 2 V35 to V55, Return Flow Nozzle

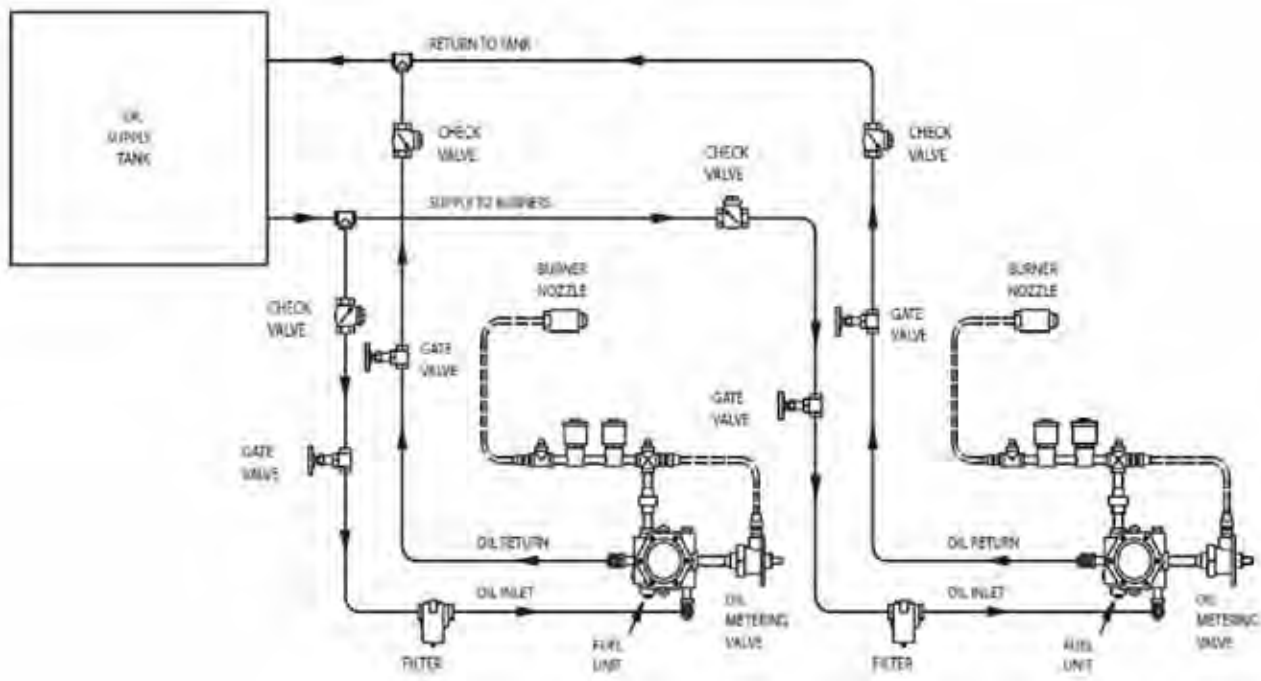


FIGURE 3-8. Multiple Burners with Separate Suction Lines

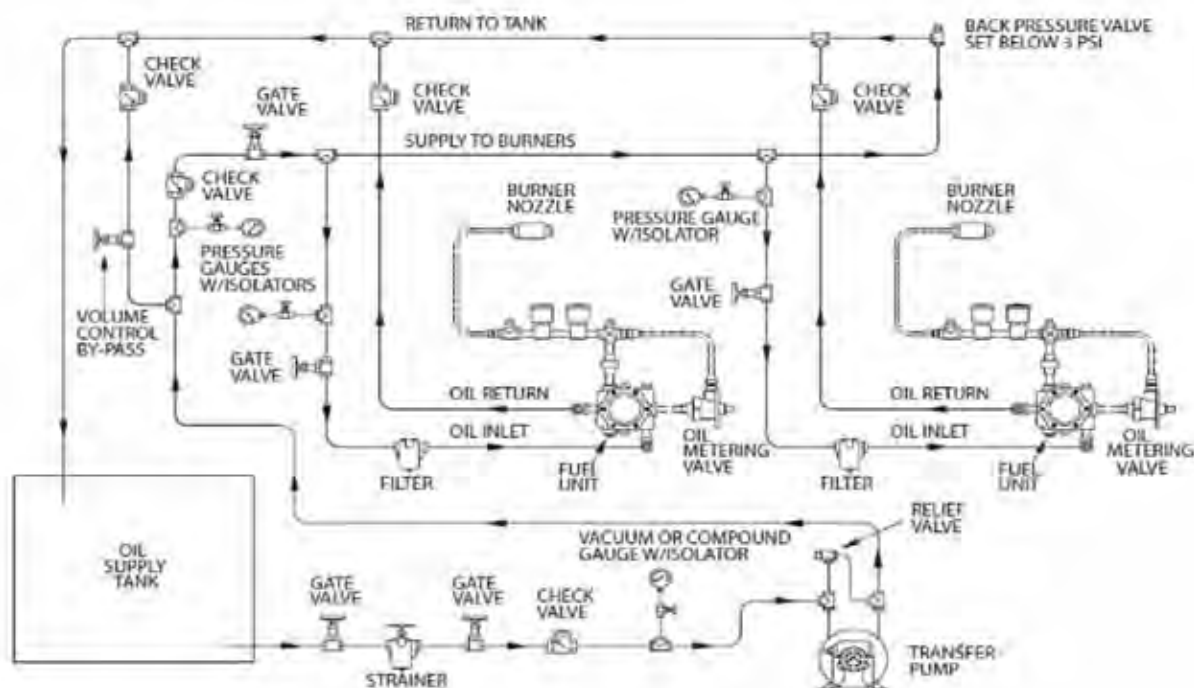


FIGURE 3-9. Typical Oil Loop for Multiple Burners with Transfer Pump

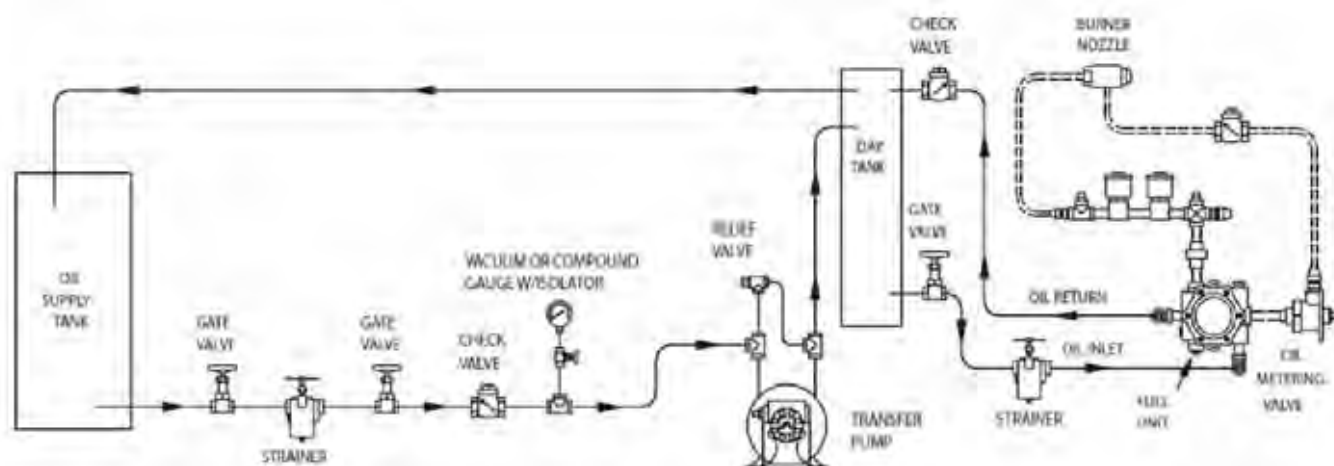


FIGURE 3-10. Typical Installation Using Day Tank

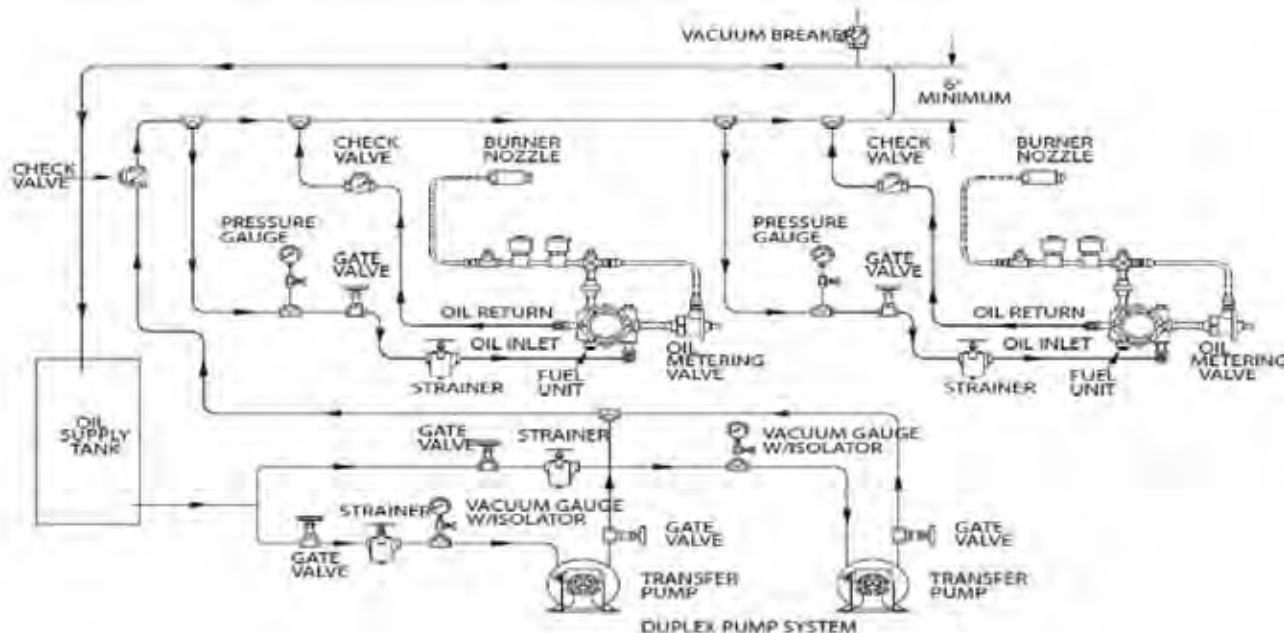


FIGURE 3-11. Typical Flooded Loop System

3.14 — Installation Checklist

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

Check:

- Electrical terminals in the control panel and on all electrical components.
 - Pipe fittings and unions.
 - Tubing connections.
 - Nuts, bolts, screws.
2. Open all necessary oil shutoff valves. Do not run pumps or fuel unit without oil.
 3. Before connecting electrical current to any component, be sure the voltage is the same as that specified on component nameplates.
 4. Before burner operation, be sure all motors are rotating in the proper direction.
 5. Before firing, make sure the burner firing head and dry areas of the boiler are protected with refractory. The burner mounting flange must be properly sealed against the vessel front plate.
 6. Make certain that the operator in charge is properly instructed in operation and maintenance procedures.

⚠ Caution

Before opening the manual gas shutoff valves, read the Regulator instructions carefully. The instructions are in the Regulator Box. Follow the manufacturer's recommendations. Open the shutoff valve on the inlet side of the regulator slowly and carefully to allow inlet pressure to buildup slowly in the Regulator until it is fully pressurized. Opening the shutoff valve quickly will damage the Regulator. Do not exceed the Regulator pressure ratings.

3.15 — Preparation for Initial Startup

When the installation is complete and all electrical, fuel, water, and vent stack connections are made, make certain these connections are tight. The operator should become familiar with the burner, boiler controls and components. Adjustment procedures should be reviewed prior to firing. The wiring diagram should also be studied along with the operating sequence of the burner programmer. Check the electrical power supply for accordance with the nameplate specifications for all motors and controls.

Read and understand starting instructions before attempting to operate the burner. The following checks must be made:

Component	Check
Boiler	<ul style="list-style-type: none"> Check boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the operating control. Set the operating control at the desired temperature or pressure.
Burner	<ul style="list-style-type: none"> Check fuses in the main panel and in the burner control cabinet. Check wiring to the burner control cabinet for compliance with the wiring diagram and local codes. The control cabinet components are 120 volt. If a control transformer is supplied, ensure that the supply voltage matches its primary voltage. Check motor rotation by momentarily closing the starter or relay. Blower rotation is clockwise when viewed from the drive end. Check the pilot electrode setting Check the control linkage for proper movement of the air volume damper and fuel metering components. This can be done by loosening the linkage at the actuator lever and manipulating by hand. Check the air shutter and adjust low fire setting.

3.16 — Firing Preparations

Check to make certain that all plugs, connections, linkages, etc., are tight. Prior to initial firing, oil flow and pressure should be verified.

3.16.1 — Gas Burners

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

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

On burners equipped with high and low gas pressure switches, set the switch pressure actuating levels and record the settings for future service reference.

See the burner specification nameplate inside the control panel door for minimum and maximum input rate and required manifold pressure.

When the conditions covered above are assured, the burner is ready for firing. Refer to Section 2.20 for starting and operating information.

3.16.2 — Oil Burners

Prior to initial firing, oil flow and pressure should be verified. If the burner is a dual fuel model, make certain that the main gas shutoff cock is closed and the fuel selector switch set to "OIL."

3.16.3 — Oil Flow

If the oil supply tank is below the level of the fuel oil unit, it is recommended that the suction line be primed with oil prior to starting the pump to avoid the possibility of damage to the pump through operation without lubrication.

To check for proper pump rotation, momentarily energize the starter. With rotation verified, operate the pump to determine that oil circulation is present. Observe the oil burner pressure gauge. If no pressure shows 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. Until oil flow is established, avoid prolonged operation of the pump. If oil flow is not established after a second priming, investigation is required.

A vacuum (or compound pressure-vacuum) gauge should be installed at the suction port of the pump. It is advisable that the reading be less than 15" Hg vacuum. Vacuum in excess of this may cause unstable firing.

3.16.4 — Oil Pressure and Vacuum

If the vacuum gauge reads higher than calculated, look for restriction in the suction line, a closed valve, kinked copper tubing, plugged filter, sticking check valve, frozen oil line, undersized oil line, or excessive lift.

When there is a positive head of oil at the fuel unit, either from a gravity or by pump circulation, the pressure must not exceed 3 psi at the fuel unit suction inlet. Special pressure regulating valves are available for suction pressure above 3 psi. The fuel unit discharge pressure should be set at 300 psi.

3.16.5 — Burner Settings

To ensure reliable and safe burner performance, the location and gap setting of the electrode for direct-spark igniters, and the relative positions of the burner nozzle, diffuser, and air baffle components must be correctly set. The air damper blades must be adjusted, relative to the established flow rates, to provide the correct amount of air for complete efficient combustion.

These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their position.

3.16.6 — Combustion Settings

Fuel and air flow rates are individually adjusted at low fire and at high fire to achieve rated heat input, firing rate turndown, optimum efficiency, safe operation, and the ability to cope with environmental changes (including air temperature, humidity, barometric pressure), and fuel property changes. Refer to the nameplate inside the control panel for minimum and maximum fuel input ratings.

3.16.7 — Test Equipment

The following tests should be conducted on site:

1. Combustion analyzer with O₂ indication.
2. U-Tube manometer, or pressure gauge, to measure gas pressures (Main and Pilot), pressure and vacuum gauge for the oil burners.
3. Inclined manometer to measure draft pressures.
4. Smoke spot tester for oil burners and CO analyzer for gas fired units.
5. Voltmeter/Ammeter.
6. Stack thermometer and thermocouples.

 **Warning**

Read the flame safeguard manual and fully understand its content before attempting to operate this equipment. If this instruction is ignored, serious injury or death may result.

 **Warning**

Should a starting failure occur for any reason, combustible fumes may fill the combustion chamber. Never attempt to re-light the burner under these conditions without first purging the chamber.

3.17 — Sequence of Operation

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

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

Refer to the manufacturer's literature on the programming control and to burner wiring diagrams for detailed information.

3.18 — Electrical Interference Test

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

3.18.1 — Gas Fired

1. Close the pilot and main line manual gas valves.
2. Start the burner and at time of pilot trial with just the electrical ignition system energized. The flame relay should not pull in (should not be energized).

Upon completion of a successful test, proceed with startup procedures.

3.18.2 — Oil Fired

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

3.19 — Startup and Operating

3.19.1 — Gas Burners

Performing a Gas Valve Leak Test (Bubble Test)

A gas valve leak test must also be performed on the automatic safety shutoff valves located in the main gas train prior to any initial commissioning or subsequent maintenance of the burner and gas train systems - where automatic valve proving systems interlocked with the main burner safety control are not provided. This test should be performed periodically to ensure no leakage of valves in their closed or de-energized position.

The unit should be taken out of service if the unit fails any of the following tests. Any defective part must be replaced prior to putting the equipment back into service.

Warning

Failure to follow this procedure may result in explosion, fire, property damage, and personal injury. This procedure must be performed only by authorized and qualified personnel.

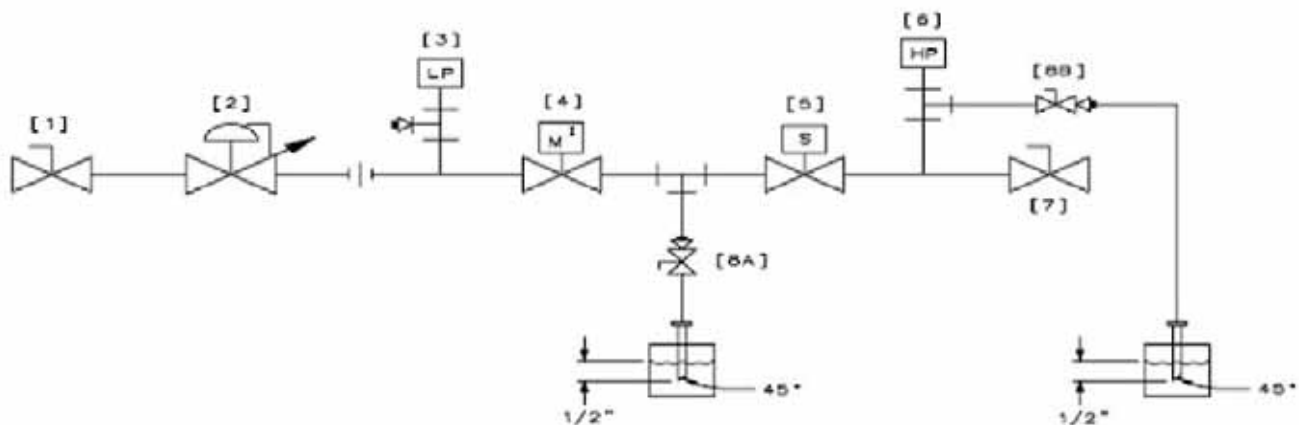


FIGURE 3-12. Gas Valve Leak Test Diagram

1. Close (or shut off) the manual valve [7] downstream of the automatic safety shutoff valves, trapping gas pressure between the safety shutoff valves and manual valve and causing a flame failure. This should close the auxiliary safety shutoff valve [4] and main gas safety shutoff valve [5]. If both or either valve fails to close, DO NOT proceed further until the problem is corrected.
2. Release gas pressure at the leak test cock [8B] between the manual valve [7] and main gas safety shutoff valve [5], then conduct a bubble test for leak through the blocking valve [5]. If no leak, close the test cock.
3. Release gas pressure at the test cock [8A] and bubble test for leak through the auxiliary safety shutoff valve [4]. If no leak is observed, close the test cock and go to the next step. If either valve leaks, correct the problem and retest 10 times before proceeding.
4. When there are no valve leaks, open the manual valve [7] and relight the burners. Then close the manual valve [1]. The safety shutoff and blocking valve should close due to low gas pressure.
5. Relight the burners. Reduce the high gas pressure switch [6] setpoint setting until it reaches the operating gas pressure, which should cause the auxiliary and main gas safety shutoff valves to close from high gas pressure. RETURN THE SETPOINT TO ITS ORIGINAL POSITION BEFORE PROCEEDING.
6. Shut off the combustion air blower. This should cause a failure due to low air pressure and cause the safety valves to close.
7. Reset all manual valves to their normal setting for operation. Make sure all electric valves are operating normally. Make sure all test cocks are closed before resuming normal operation.
8. Close the downstream main and pilot gas cocks. Make sure the "ON-OFF" switch is in the "OFF" position. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.

9. For “LOW-HIGH-OFF” or “LOW-HIGH-LOW” and “FULL MODULATION” models, set the “MANUAL-AUTO” switch to the “MANUAL” position.
10. Set the manual potentiometer to low fire position.
11. Open the gas pilot cock and check the pressure. Normal setting is 4” to 6” WC when the pilot is burning.
12. Set the “ON-OFF” switch to “ON.” The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized.
13. On initial startup it is recommended that the main gas shutoff cock remain closed until the programmer has cycled through pre-purge and pilot sequence. Then determine that the main gas valve opens. When this is confirmed, turn the burner switch “OFF” and let the programmer finish its cycle. Check to see that the gas valve has closed tightly.
14. If ignition does not occur, turn the burner switch “OFF” and allow the programmer to recycle for a new ignition trial.
15. Turn the burner “ON” and after pilot ignition when the flame relay pulls in, the slow opening, motorized, main gas valve is energized. Slowly open the downstream manual shutoff gas cock. Main flame should ignite at this time. The gas valve and air damper continue advancing until high fire is reached.

Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the gas low fire rate by adjusting the butterfly valve and air linkage. Refer to the adjustment section of this manual. Using the combustion analysis instrument, adjust the low fire. Typical combustion analysis for low fire is 5% to 6% O₂ on standard turndown systems, and between 6.5% and 9% for higher turndown systems. Verify the minimum input rate by measuring the gas meter.

When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.

After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. Check high fire at this point using combustion instruments. High fire combustion analysis typically is 3% to 4% O₂. Verify maximum input rate by measuring the gas meter.

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate setting. CO levels should be less than 400 ppm on an air-free basis at all firing rates, with <50 ppm as the target value.

When conditions covered above are assured, refer to Sections 3.20 and 3.21.

3.19.2 — Oil Burners

1. The fuel selector switch should be set to “OIL” and the “ON-OFF” switch is in the “OFF” position. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
2. Set the “ON-OFF” switch to “ON.” The burner will start and pre-purge. After pre-purge, the ignition transformer will direct spark. If the flame detector proves the presence of a satisfactory pilot, the programmer will proceed to main flame ignition.
3. Make initial air shutter settings for smooth ignition. Return line oil pressure should be set according to guidelines in Chapter 4. Do not repeat unsuccessful light off attempts without rechecking burner and pilot adjustment. Vent fuel vapors from the combustion chamber after each unsuccessful light off attempt. Set the oil low

fire rate by adjusting the oil return pressure and air linkage. Using the combustion analysis instrument, adjust the low fire. Typical combustion analysis for low fire is 5% to 6% O₂.

4. When low fire is adjusted, shut down the burner. Restart several times to be sure the low fire setting is suitable. Readjust if necessary. Never start the burner with fuel vapor in the furnace. In case of emergency, open the main power switches and close all fuel valves. After combustion adjustments are satisfactorily set, allow the heating vessel to slowly reach normal operating pressure or temperature.
5. After the boiler has reached operating temperature or pressure, turn the potentiometer switch in small increments to the high fire position. This will cause the metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. In high fire the oil metering valve should be in the fully closed position and the fuel oil pressure should be about 300 psi. Check high fire at this point using combustion instruments. High fire combustion analysis typically is 3.5% to 4% O₂. Verify maximum input rate by measuring the oil meter if available or by weighing the oil.

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

Do not disturb established low fire adjustment. Allow the burner to return to low fire position before adjusting high or intermediate settings.

When conditions covered above are assured, refer to Sections 3.20 and 3.21.

3.19.3 — Combination Gas-Oil Burners

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas.

Refer to the gas burner or oil burner adjustment procedures and Chapter 4.

Once the adjustments are set for oil, shutdown the burner and restart and adjust the natural gas fuel. Do not readjust the air dampers. The adjustment is made by balancing the fuel input rate against the existing flow of combustion air.

When conditions covered above are assured, refer to Sections 3.20 and 3.21.

NOTE: Size 1 & 2 combination gas/oil units use a direct coupling from the blower motor to the oil pump. When firing gas for an extended period of time, the coupling should be manually removed and replaced only when firing oil. If the coupling is left connected to the blower motor, ensure that there is proper oil circulation at all times to avoid damage to and seizure of the pump.

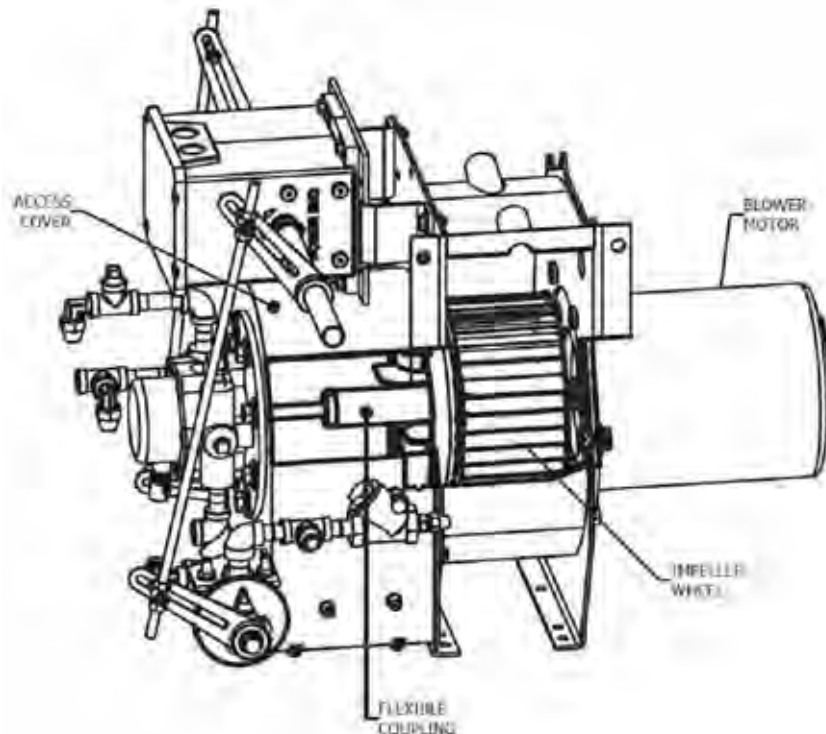


FIGURE 3-13. Blower Motor and Flexible Coupling

3.20 — Normal Operation

Normal operation must be with the “MANUAL-AUTO” switch selector on “AUTO.”

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

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

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

3.21 — Shutdown

When the operating limit control setting is reached or the burner switch is turned “OFF,” the following sequence occurs:



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

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

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

4.1 — Overview

ProFire E Series burners are assembled, wired, and tested at the factory. They are listed by the Underwriters Laboratory, CSD-1, NFPA-85, F.M., including the national Electrical Code (NEC), and associated insurance underwriters. Where applicable, the Canadian Gas Association (CGA) B149 and the Canadian Standards Association (CSA) B140 codes shall prevail. Other regulatory agency control options are available.



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

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

The ProFire E Series oil burners are of the low pressure, air atomizing (nozzle) type. Gas burners are of the peripheral mix type. All burners feature ignition by spark-ignited gas pilot flame. With either fuel, the burner operates with full modulation. A switch permits changeover from automatic fully modulated firing to manually set firing at any desired rate between minimum and maximum. Additional safeguards assure that the burner always returns to the minimum firing position for ignition.

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

4.2 — Operating Controls

4.2.1 — Control Panel

The control panel contains a flame safeguard programming control, motor starters, relays, time delays, and terminal strips mounted internally on a panel sub-base. Lights, switches, potentiometers, a control circuit breaker, and flame safeguard displays are mounted externally on the panel.

Component	Details
On-Off Burner Switch	For gas or oil only.
Fuel Selector Switch	Gas-Off-Oil For combination gas-oil burners only. a) Gas Position: Selects gas as the firing fuel. b) Off Position: Burner off. c) Oil Position: Selects oil as the firing fuel. NOTE: When changing from oil to gas fuel, allow the programmer to complete post-purge and shutdown before moving the selector switch to the gas position. This will allow the interlock circuit to de-energize at either the oil-air pump or the compressor.
Control Circuit Breaker	Supplementary low overcurrent protection only. No larger than 15 amps.
Auto-Manual Modulation Selector Switch	a) Auto Position: Selects boiler modulation control. b) Manual Position: Selects 135 ohm potentiometer for manual modulating control.
Manual Modulating Control 135 ohm	Increases or decreases the burner firing rate manually.
Signal Lamps	a) Power On (white): Illuminates when the control circuit is energized (powered). b) Ignition (amber): Illuminates when the ignition transformer is powered, and gas pilot valve is energized (open). c) Main Fuel (green): Illuminates when the main fuel valve or valves (gas or oil) are energized (open). d) Flame Failure (red): Illuminates when the flame safeguard system fails to detect pilot or main flame.

4.2.2 — Flame Safeguard Controls

The flame safeguard programmer incorporates a flame sensing cell (scanner) to shut down the burner in the event of pilot flame or main flame failure. Other safety controls shut down the burner based on sequence of operation as shown in the manufacturer's flame safeguard manual.



Read the flame safeguard manual and fully understand its contents before attempting to operate this equipment. Failure to do so may result in serious personal injury or death.

4.2.3 — Firing Rate Controls

Regardless of the fuel used, burner input is fully modulated between low fire and high fire on boiler demand. The firing rate is controlled by the potentiometer-regulated modulating motor. The combustion air control damper, oil metering pump, and/or gas volume butterfly valve are controlled through variable rate rod and lever linkages. The modulating motor rotates 90° from low to high position. Flow rate through each component is adjusted by positioning the control rods on the levers and the angular position of levers on shafts. The lever on the modulating motor shaft actuates the high fire position proving switch.

4.3 — Combustion Air Handling System

The combustion air handling system consists of two major components:

Component	Details
Damper Assembly	A rotary damper regulates the combustion air volume and is positioned by a modulating motor. The damper is normally almost closed in the low fire position and opens as the burner drives toward a high fire position.
Motor Driven Impeller	The diameter of the impeller determines available air pressure and the width determines air capacity in cubic feet per minute. Alternate motor-impeller combinations are available for 50 cycle or 60 cycle power and for firing against either moderate or high furnace pressure. All standard impellers are sized for up to 2,000 ft. altitudes and up to 4" W.C. furnace pressures. Alternate impeller wheels are available. For higher altitudes and higher furnace pressures, motor and impeller combinations are determined at the factory.

4.4 — Firing Head

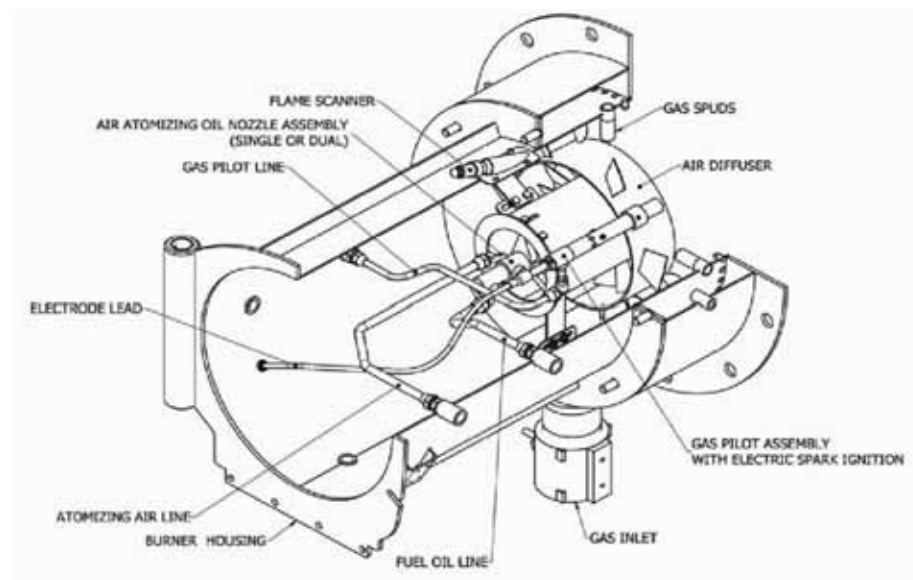


FIGURE 4-1. Burner Housing

Access to the firing head is provided by swinging open the impeller housing. First, disconnect the damper linkage, release the housing latch, and swing the housing to the open position. An internal gas pilot is standard on all burners. Pilot gas pressure is adjusted at the pilot pressure regulator.

4.5 — Oil System Air Atomizing

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

4.5.1 — 3-Way Solenoid Valve

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

4.5.2 — Nozzle Assembly

The nozzle assembly consists of four main parts: body, compression spring, swirler, and tip. The swirler is held against the nozzle tip by the compression spring. The nozzle body has inlet ports for air and oil lines. Metered fuel oil enters the nozzle body and flows through a tube to the swirler. Oil is forced from the core of the swirler to the side ports where it meets with the atomizing air. Atomizing air enters and passes through the nozzle body to grooves in the swirler, where it mixes with fuel oil. Air/oil passes through grooves and out of the nozzle orifice in a cone of atomized oil. Proper velocity and angle of the fine spray ensures good mixing with the combustion air, providing quiet starts and excellent combustion efficiency. During pre- and post-purge, the nozzle tip is purged with air. This prevents afterdrip or baked-on residue.

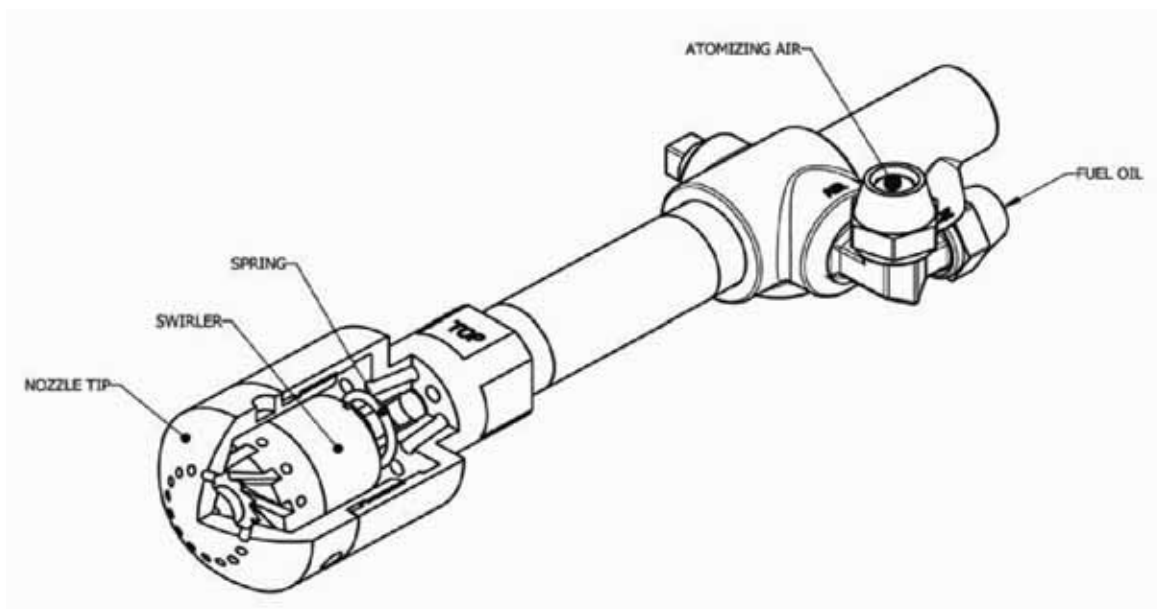


FIGURE 4-2. Nozzle Assembly

4.5.3 — Oil Strainer

Prevents foreign matter from entering the burner oil system.

4.5.4 — Atomizing Air Proving Switch

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

4.5.5 — Oil Metering

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

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

4.5.6 — Separate Compressor Module

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

Air is supplied by a positive displacement rotary vane compressor. This provides a constant volume of atomizing air regardless of pressure. The compressor module includes motor, air-oil reservoir tank, air filter, and lube oil cooling coil. Air enters the compressor through the filter. The air flows from the compressor into the air-oil separating and reservoir tank. Filtering material and baffles separate the lube oil from the compressed air. The tank air pressure forces lubricating oil from the tank to the compressor to lubricate bearings and vanes. A sight glass indicates the level of lubricating oil in the air/oil reservoir. Lubricating oil must be visible in the gauge glass at all times. Air compression heat is absorbed in part by the flow of lube oil, creating a hot oil mist. The air/oil mist is cooled by a coil assembly. Lube oil is also cooled before entering the compressor.

Fuel is delivered to the positive displacement metering pump at 10 to 15 psi. Metered oil is delivered to the common port of a 3-way solenoid valve for transfer to the burner nozzle through the normally closed port or back to the storage tank through the normally open port. During pre- and post-purge, metered oil is returned to the tank. During normal firing, all metered oil is delivered to the nozzle. For the description of typical fuel oil piping installations, see Chapter 2. Air enters a rotary vane compressor through an air cleaner where it is compressed to atomizing pressure. Air flows from the compressor to an air/oil tank which serves the multiple purpose of dampening air pulsation, lube oil mist recovery, lube oil and atomizing air storage. The compressor rotor is cooled and lubricated continuously by oil under pressure from the air/oil tank. Oil vapor is extracted by a mist eliminator in the upper section of the tank. Atomizing air from the upper tank section is delivered to the nozzle at a constant volume. Air pressure increases as the burner firing rate increases. Atomizing pressure may be adjusted by the needle valve located on the air-oil pump. The valve allows air to be bled from the tank to the compressor inlet. Delivery rate of the fuel oil metering pump is controlled by the modulating motor through adjustable linkage.

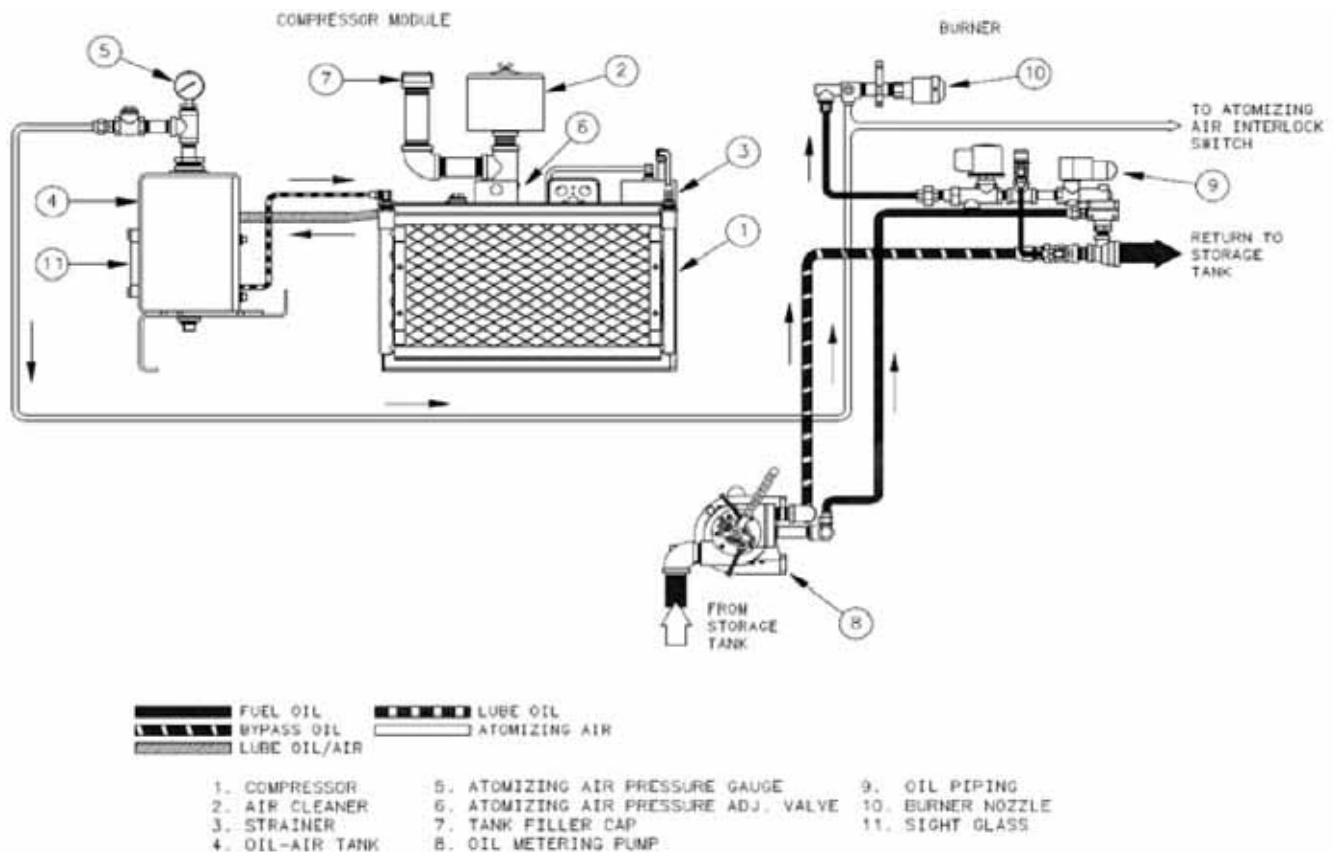


FIGURE 4-3. Compressor Module and Burner

4.6 — Gas System

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

4.6.1 — Main Gas Train Components

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

Component	Description
Gas Volume Valve	The butterfly-type valve is positioned by linkage from the modulating motor and controls the rate of flow of the gas.
Main Gas Valves	Electrically operated safety shutoff valve(s) that open to admit gas to the burner. Standard U.L. burners include: <ul style="list-style-type: none"> Models E84-105: One motorized gas valve w/closure interlock and one solenoid valve. Models E126-630: Two motorized gas valves, one w/closure interlock.
Main Gas Regulator	Regulates gas train pressure to specified pressure required at inlet to the gas train. Input is set by the main gas pressure regulator adjustment.
Main Gas Cocks	For manual shutoff of the gas supply upstream of the pressure regulator. A second shutoff cock downstream of the main gas valve(s) provides a means of testing for leakage through the gas valve(s).
High Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is below a pre-selected setting. Should the pressure rise above the setting, the switch contacts will open causing main gas valve(s) to close. This switch requires manual reset after being tripped.
Low Gas Pressure Switch	A pressure actuated switch that remains closed when gas pressure is above a pre-selected setting. Should the pressure drop below this setting, the switch contacts will open, causing main gas valve(s) to close. This switch requires manual reset after being tripped.

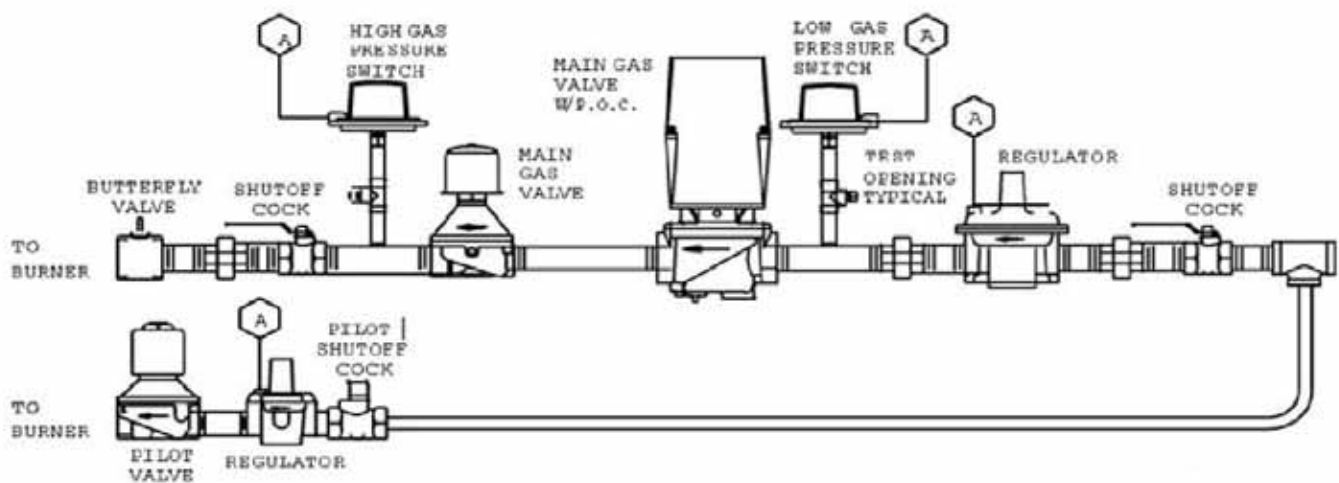


FIGURE 4-4. Main Gas Train

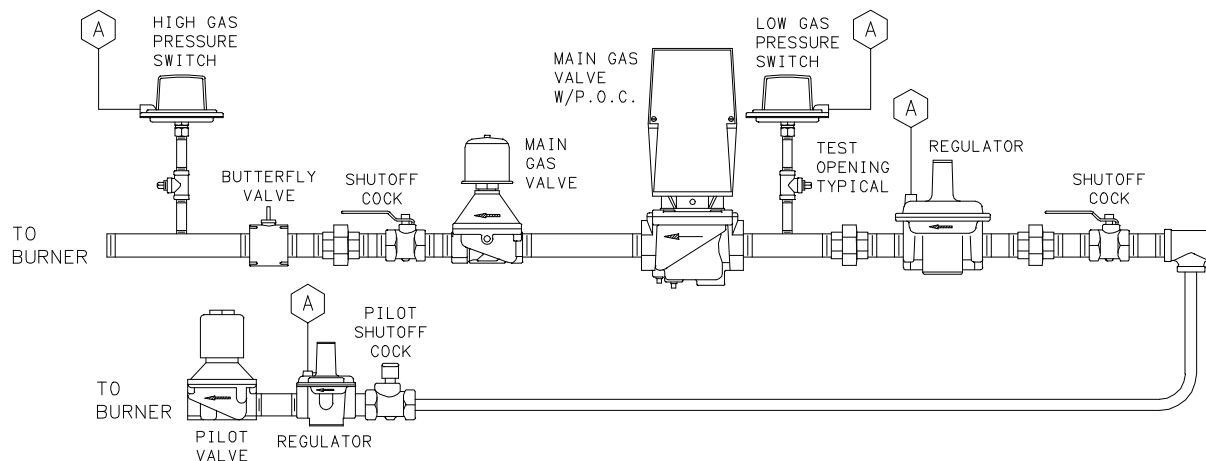


FIGURE 4-5. Main Gas Train (BTU Specific)

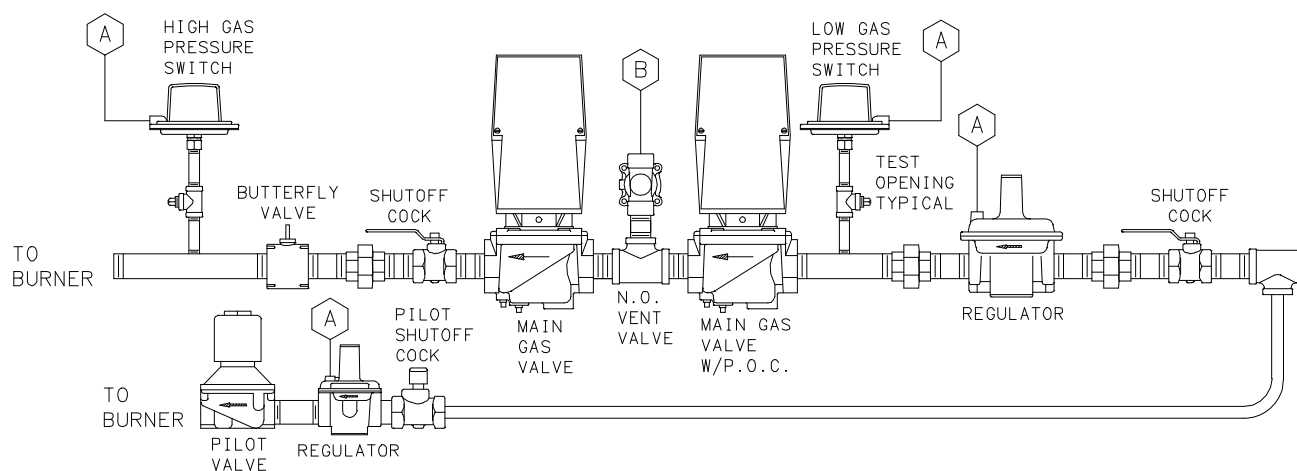


FIGURE 4-6. Main Gas Train (BTU Specific)

NOTE: These piping layouts are for reference only and are subject to change without notice. Optional equipment may change a layout.

4.6.2 — Pilot Gas Train Components

Component	Description
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.
Gas Pressure Regulator	Reduces gas pressure to that required by the pilot.
Gas Pilot Shutoff Cock	For manually closing the pilot gas supply.

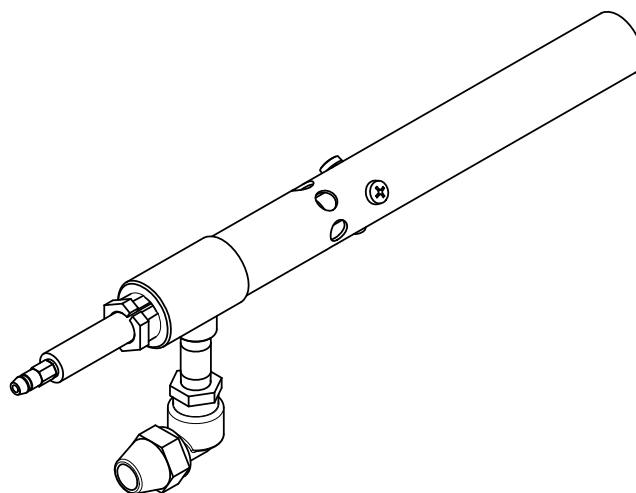


FIGURE 4-7. Gas Pilot

4.6.3 — Operation

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

The butterfly gas valve modulates flow to burner input demand. The butterfly valve is positioned through mechanical linkage by the modulating motor. The air control damper is positioned simultaneously by the modulating motor.

The automatic gas valve(s) cannot be energized unless the combustion air proving switch is closed. The low and high gas pressure switches must be closed to prove proper gas pressure.

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

4.7 — Electrical Power

Electrical power available is usually 208 volt, 3-phase, 60 cycle, 230/460 volt, 3-phase, 60 cycle or 380 volt, 3-phase, 50 cycle. Control circuit is 115 volt, single phase, 60 cycle or 115 volt, single phase, 50 cycle. Refer to the electrical schematic diagram shipped with the burner. Power connections are made at the control panel. Wiring from the panel to burner mounted components is installed at the factory. Wiring from the burner panel to boiler controls, low water controls, remote compressor motor, and remotely located fuel valves is furnished by the installer.

4.8 — Draft Control

Automatic over-fire draft control or barometric draft regulators are not usually required except where the system has a tall chimney. The exact height of a chimney requiring draft control is indeterminate, but draft regulation is seldom needed for chimneys less than fifty feet high, especially with Scotch Marine or sealed firebox boilers. Fuel oil piping and gas piping instructions are described in this Chapter.

4.9 — Installation

Locate the burner properly. The burner is designed for operation with the blast tube level. Do not tilt the burner up or excessively downward. Installation of the refractory oven or combustion cone, shipped with the burner. Securely support the burner pedestal on the floor or foundation. Allow enough clearance at the rear of the burner to allow the housing to swing open for service and maintenance. Many boilers, including some Scotch Marine types, do not have sufficiently rigid front plates and require additional support under the burner base. Bases under the support leg must be long enough to support the burner when being inserted or withdrawn from the boiler. Boilers operating with the combustion pressure above atmospheric pressure must be sealed to prevent escape of combustion products into the boiler room. The burner mounting flange is designed to provide for a seal. The face of the boiler and burner flange must be sealed with a rope gasket (not supplied with the burner). Make sure the dry oven and burner blast tube are concentric. For maximum safety, it is recommended that boilers not operating under pressure should also be sealed.

E-SERIES REFRACTORY DIMENSIONS

DIMENSION	SIZE-1	SIZE-2	SIZE-3	SIZE-4
"A"	13.4	16	19	22
"B"	4	4	4	4
"C"	19.25	24	28.25	31.25
"D"	2	4	4	4
"E"	8	12	8	12
"F"	0°	15°	0°	0°

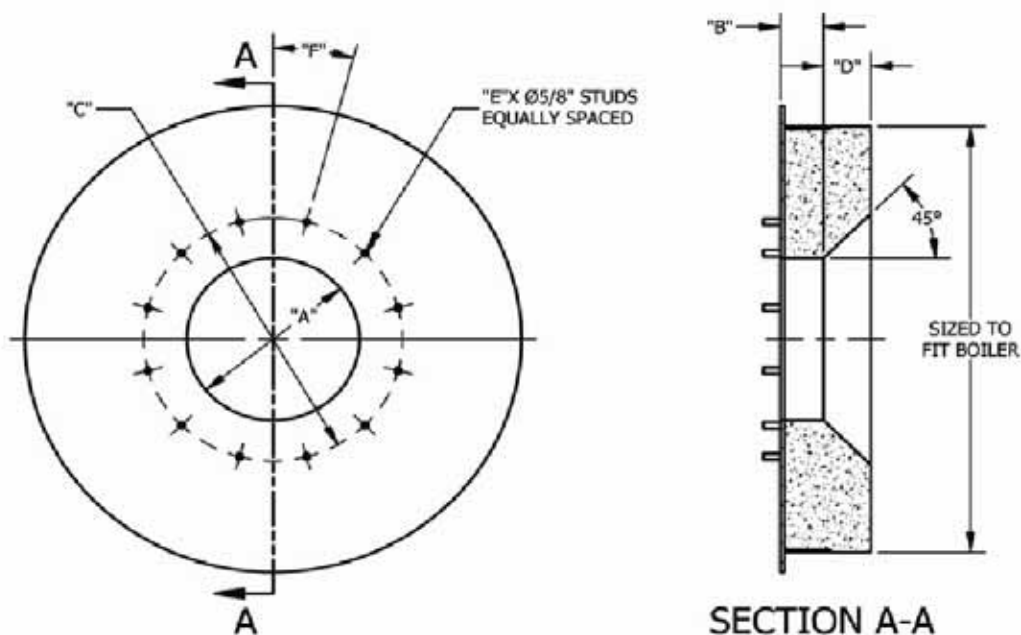


FIGURE 4-8. E-Series Refractory Dimensions

4.10 — Packing Plastic Refractory Around Oven (If Dry Oven is Supplied)

⚠ Caution

It is important that you provide support for the housing when in the open position to prevent damage to the hinges and subsequent components.

The area between the outside circumference of the dry oven and existing refractory should be packed with Kaiser Refractory Mono T-9 Airset or equal within two hours after coating the dry oven with Trowleze. From inside the furnace, ram the plastic refractory from the front to the rear, parallel to the outside surface of the dry oven.

4.11 — Typical Oil Supply Loop

Continuous oil circulation must be supplied to the burner at a rate of 50 percent greater than the high fire burning rate. The oil circulating pump should be located as close as possible to the storage tank to keep suction lines

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

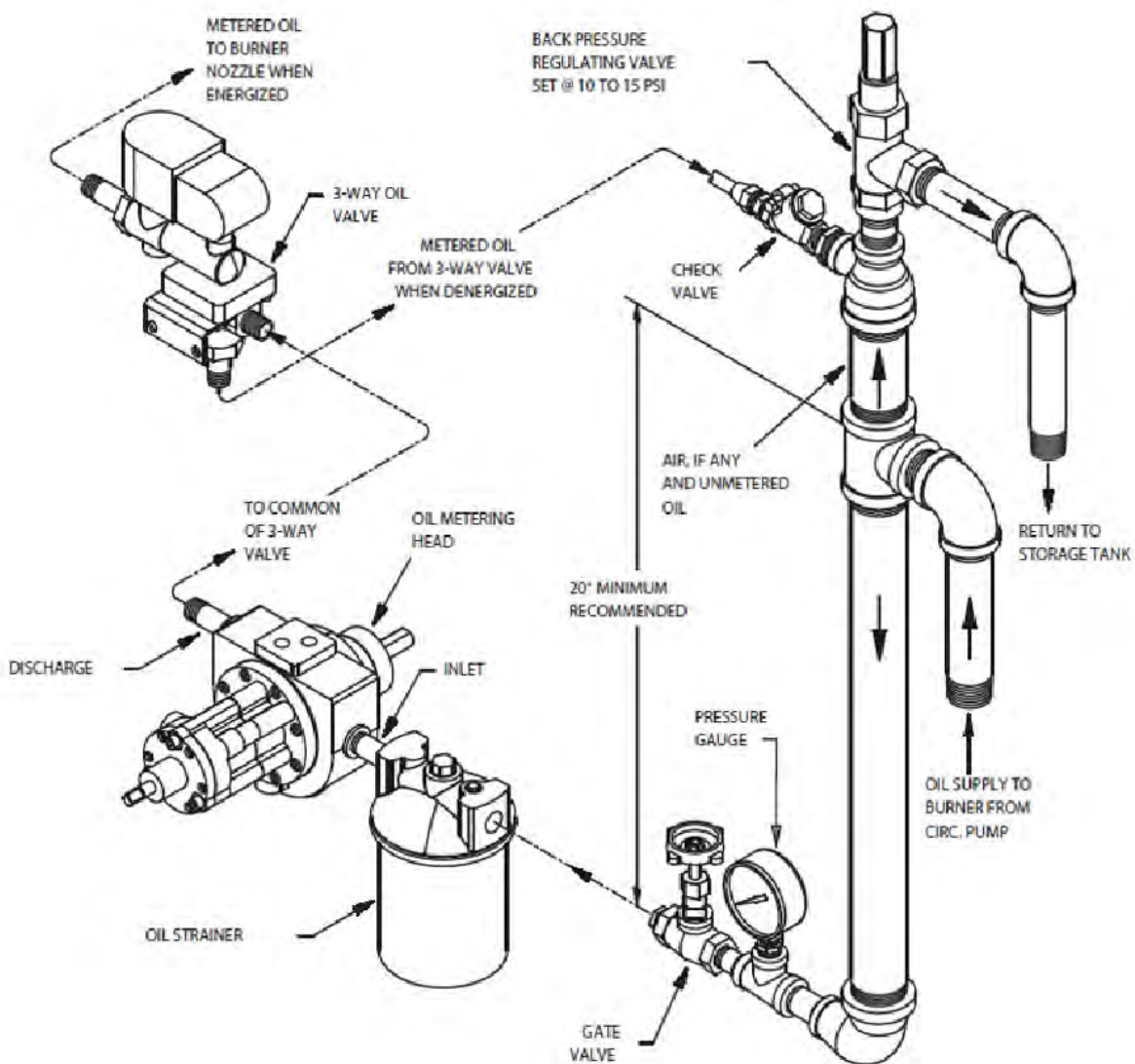
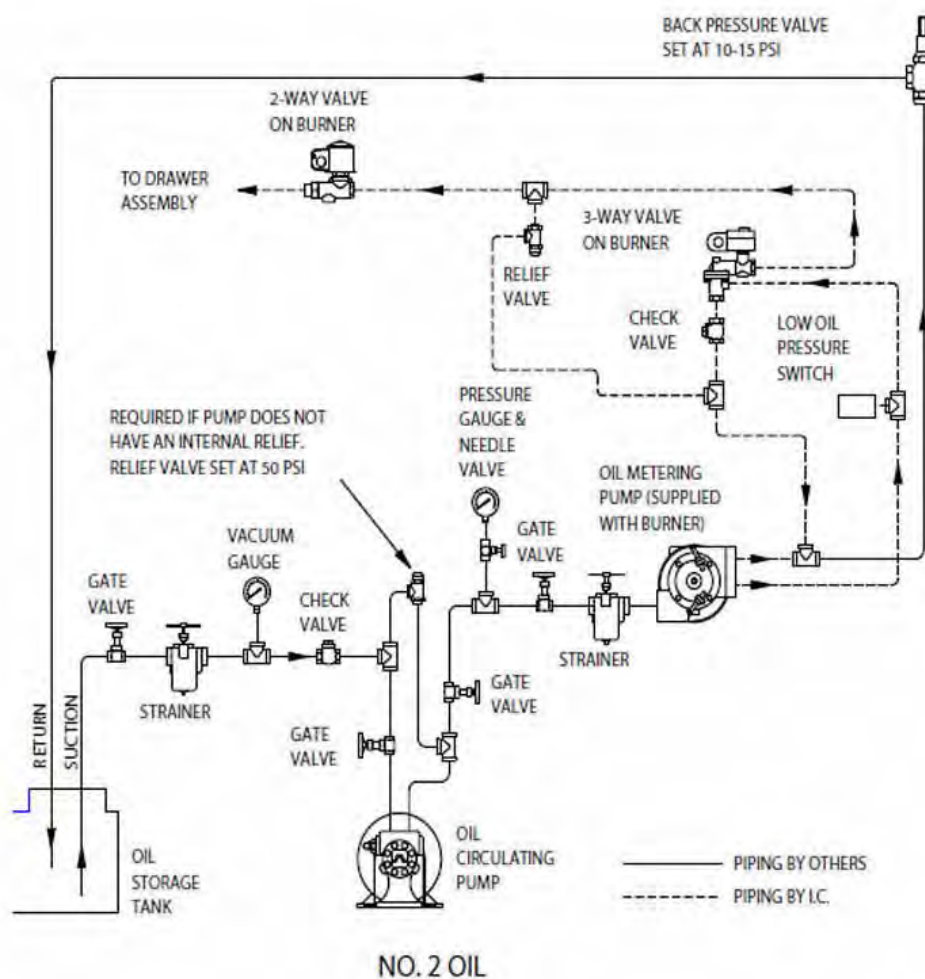


FIGURE 4-9. Typical Oil Supply Loop

4.12 — Oil Circulating Loop Operation

An oil circulating pump provides continuous oil circulation to the circulation loop. A back pressure valve holds 10 to 15 psi on the loop system. With the oil supply line connected only to the oil metering pump inlet, all oil must pass through the pump. During pre-purge, unmetered oil flows through a bypass section of the oil metering pump. Metered oil passes through the metering section to a de-energized 3-way oil valve (common port). Both unmetered and metered oil must pass through the back pressure valve and return to an oil storage tank. The oil metering pump will only meter oil. It will not serve as a circulating pump. At trial for main flame (main fuel), the 3-way oil valve is energized admitting metered oil to the nozzle for atomization and fast smooth ignition. Unmetered oil continues to flow through the bypass section of the oil metering pump and returns to an oil storage tank. For No. 2 oil, refer to Figure 4-10 and Figure 4-11.

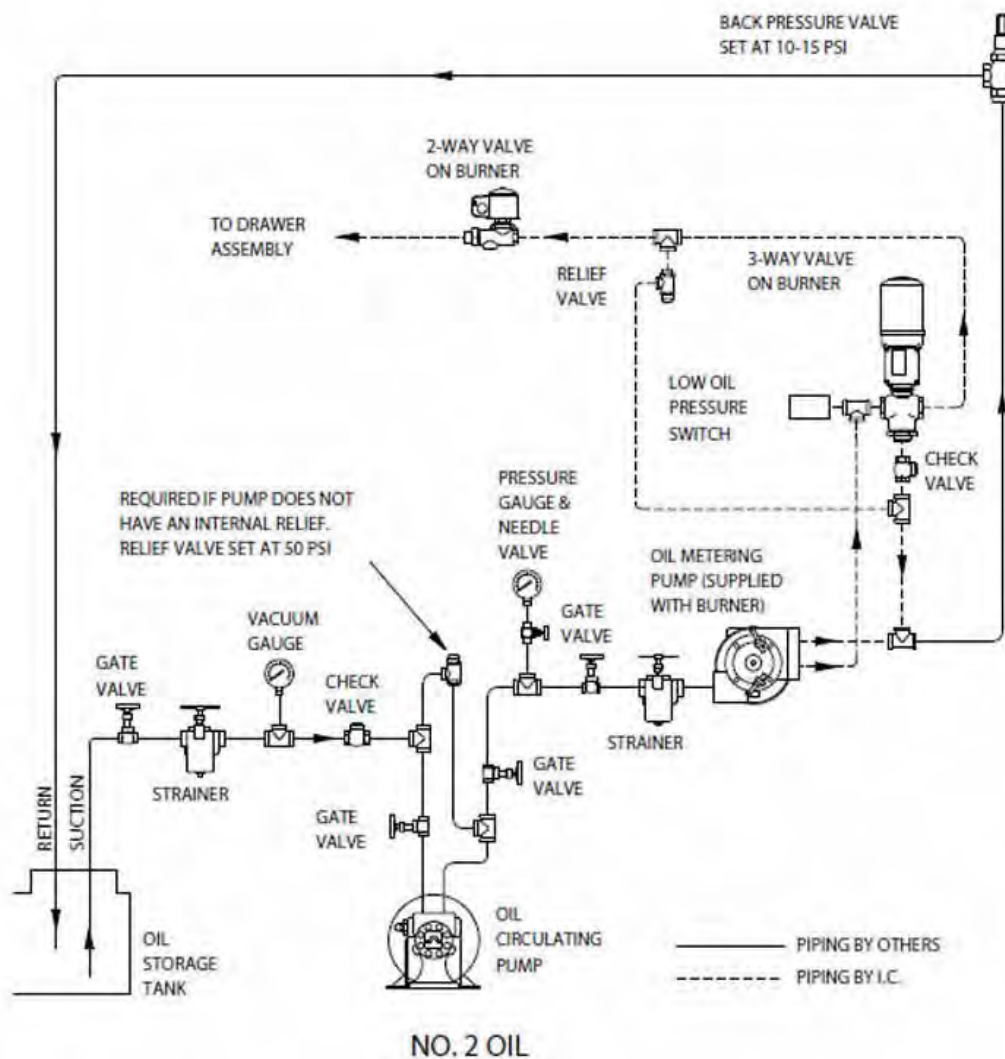


RECOMMENDED PIPE SIZE

TANK TO CIRCULATING PUMP		CIRC. OIL PUMP TO BURNER & RETURN	
2"	EL, LNEL 84, 105, 147, 168, 210	1 1/2"	EL, LNEL 84, 105, 147, 168, 210

THIS PIPING LAYOUT IS FOR REFERENCE ONLY
AND IS SUBJECT TO CHANGE WITHOUT NOTICE.
OPTIONAL EQUIPMENT MAY CHANGE THIS LAYOUT

FIGURE 4-10. No. 2 Oil Loop



RECOMMENDED PIPE SIZE

TANK TO CIRCULATING PUMP		CIRC. OIL PUMP TO BURNER & RETURN	
2"	EL, LNEL 252, 294, 336, 378, 420	1 1/2"	EL, LNEL 252, 294, 336, 378, 420

THIS PIPING LAYOUT IS FOR REFERENCE ONLY
AND IS SUBJECT TO CHANGE WITHOUT NOTICE.
OPTIONAL EQUIPMENT MAY CHANGE THIS LAYOUT

FIGURE 4-11. No. 2 Oil Loop, with Check Valve

4.13 — Circulating Oil Pump

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

4.14 — Back Pressure Valve

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

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

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

4.15 — Gas Piping

Gas service and house piping must supply the quantity of gas demanded by the unit at the pressure required at the burner gas train inlet. All piping must be in strict accordance with applicable codes, ordinances, and regulations of the supplying utility. In the absence of other codes, piping should be in accordance with the following standards: "National Fuel Gas Code" NFPA No. 54, ANSI No. Z 223.1 (for Canada, the Canadian Gas Association (CGA) B149 and Canadian Standards Association (CSA) B140 codes shall prevail).

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

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

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

The gas piping must be internally clean and free of foreign material. Before the gas system is placed into service, a leak test must be performed.

4.16 — Installation Checklist

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

Check:

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

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

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

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

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

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

Caution

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

Do not exceed the regulator pressure ratings.

Caution

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

4.17 — Preparations for Starting

When the installation is complete and all electrical, fuel, water, and vent stack connections are made, make certain said connections are tight. The operator should become familiar with the burner, boiler controls, and components. To identify controls and components, refer to contents of Chapter 1. Adjustment procedures given in Chapter 4 should be reviewed prior to firing. The wiring diagram should also be studied along with the operating

sequence of burner programmer. Read and understand starting instructions before attempting to operate the burner. Before attempting to start the burner, the following checks must be made:

Item	Check
Boiler	Check the boiler water level. Be sure all boiler valves are installed correctly and positioned properly. Set the high limit control slightly above the desired temperature. Set modulating controls at the desired temperature or pressure.
Burner	<p>Check the electrical power supply to the burner in accordance with the name-plate voltage on all motors and the control circuit. Check the direction or rotation of the motors. Open the housing to check the electrode setting. Check the gas pilot pressure at the pilot gas regulator. The normal setting is 3" to 6" W.C.</p> <p>For protection in shipment, the flame safeguard control chassis is shipped unmounted. Check all screw connections before attaching the flame safeguard chassis to the base. The screw must be secure to assure low resistance connections. The relay chassis is mounted on the sub-base with a screw which, when tightened, completes the connection between the sub-base and chassis contacts. Press the manual reset button to be sure safety switch contacts are closed.</p> <p>Check the control linkage for proper movement of the air volume damper and fuel metering components. This can be done by loosening the linkage at the actuator level and manipulating by hand.</p> <p>Check the air shutter and adjust low fire setting.</p>
Oil-Air Tank (Lube Oil)	<p>Check the lube oil level in the air-oil tank. Inspect oil level regularly. Loss of oil will damage the compressor. Fill the tank with non detergent SAE30 oil to a level midway up the sight glass. Do not overfill the tank.</p> <p>For a normal environment use SAE10 oil. Change oil every 2000 hours of operations.</p>

4.17.1 — Oil Flow

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

4.17.2 — Oil Pressure

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

4.17.3 — Firing Preparations for Oil Burners

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

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

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

To verify air flow and pressure, momentarily flip the switch "ON" and immediately turn "OFF." The programmer will continue through its cycle, however, without ignition or energizing the fuel valves. Observe the air pressure gauge.

With the compressor running and no oil flow, the pressure should be approximately 10 psi. The schematic flow diagrams in Chapter 1 indicate the flow of fuel and atomizing air.

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

4.17.4 — Firing Preparations for Gas Burners

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

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

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

4.18 — Electrical Interference Test

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

4.18.1 — Gas Fired

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

4.18.2 — Oil Fired

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

4.19 — Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 3" to 6" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

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

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

4.20 — Startup Sequence

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

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

Refer to the manufacturer's literature on programming controls and to burner wiring diagrams for detailed information.

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

4.21 — Automatic Shutdown

Limit or operating controls open:

1. Fuel valves close. Main fuel lamp goes off. Flame safeguard timer starts.
2. Flame safeguard timer and burner motor stop. Burner is ready for startup on the next call for heat.

4.22 — Manual Shutdown

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

4.23 — Safety Shutdown

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

 **Warning**

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

 **Warning**

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

 **Warning**

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

- **The lockout switch on the flame safeguard control must be manually reset before the burner will fire again.**
- 2. If a low water condition occurs, the burner shuts down as in Automatic Shutdown.
- 3. If a high or low gas pressure condition occurs while firing on gas, the burner shuts down as in Automatic Shutdown.
- **Condition must be corrected and the respective gas pressure switch manually reset before the burner will fire again on gas.**

4.24 — Startup and Operating

4.24.1 — Gas Burners

1. Close the main and pilot gas cocks.
2. Make sure the ON-OFF switch is in the “OFF” position and the fuel selector switch is turned to “GAS.”
3. Actuate the manual reset button of the flame safeguard control to close the safety switch contacts.
4. Set the MANUAL-AUTO switch in the “MANUAL” position.
5. Set the manual potentiometer in the low fire position.
6. Open the gas pilot cock.
7. Set the ON-OFF switch to “ON.” The burner will start and pre-purge. After pre-purge, the ignition transformer and the gas pilot solenoid are energized. Before proceeding, conduct electrical interference and pilot turndown tests if not previously done.

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

High fire combustion analysis typically is 9% to 10.5% CO₂. When conditions covered above are assured, refer to Sections 4.25 and 4.26.

4.24.2 — Oil Burners

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

11. Allow the burner to return to the low fire position before adjusting high or intermediate settings. The primary atomizing air pressure will increase automatically with the oil flow rate. Typically, for No. 2 oil, CO₂ is 10% to 13% at high fire.

When conditions covered above are assured, refer to Sections 4.25 and 4.26.

4.25 — Normal Operation

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

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

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

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

4.26 — Shutdown

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

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

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

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

 **Warning**

The warning symbol consists of a black triangle with a white exclamation mark inside.

An ultraviolet flame sensor electrical spark interference test must be performed after final adjustment.

5.1 — Overview

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

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

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

The strict observance of water requirements for both steam and hot water boilers is essential to boiler life and length of service. It is vital that care be taken in placing the pressure vessel into initial service. The waterside of new boilers and new or remodeled steam 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 have different operating requirements, circulation rates, temperatures, etc.

5.2 — Water Requirements

5.2.1 — Hot Water Boilers

Air Removal

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

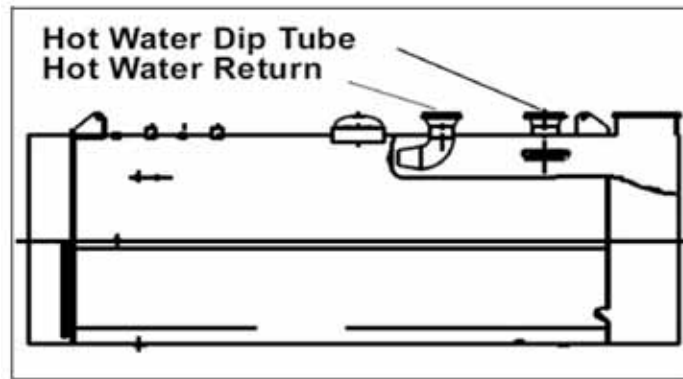


FIGURE 5-1. Dip Tube

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

Minimum Water Temperature

The minimum recommended boiler water temperature is 170° F. When water temperatures lower than 170° 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 170° F.

Rapid Replacement of Boiler Water

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

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

Continuous Flow Through the Boiler

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

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

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

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

Water Circulation

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

BOILER SIZE (BHP)	BOILER OUT- PUT (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	538

FIGURE 5-2. Maximum Circulating Rate Chart

Multiple Boiler Installations

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

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

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

Pump Location

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

Pump Operation

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

Pressure

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

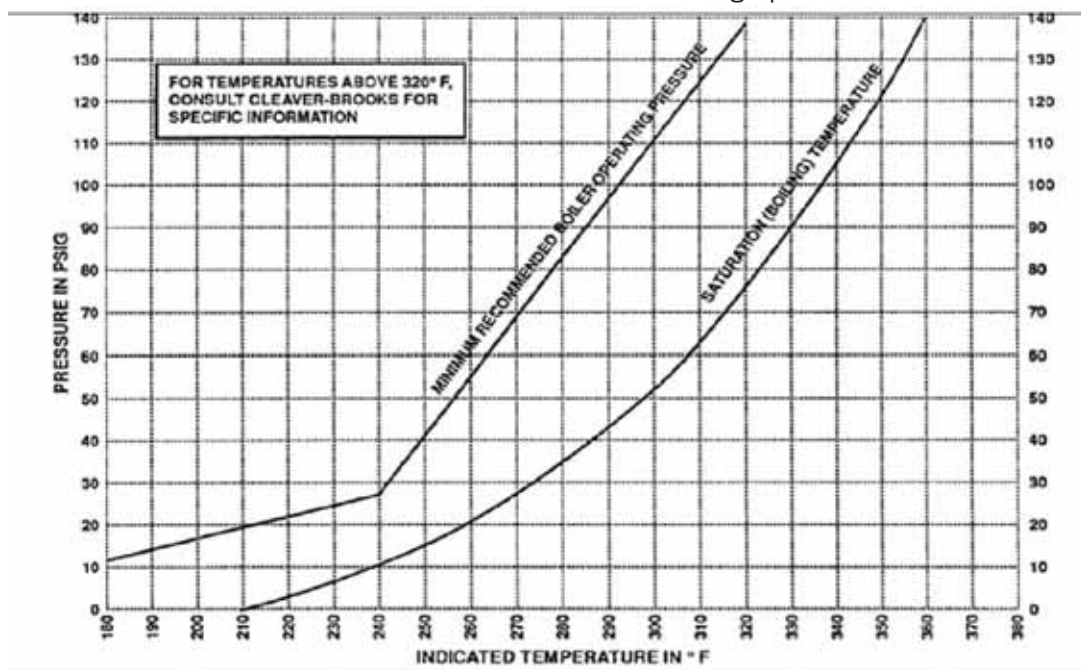


FIGURE 5-3. Internal Boiler Pressure

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.

5.2.2 — Steam Boiler

Feed Pump Operation

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

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

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

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

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.

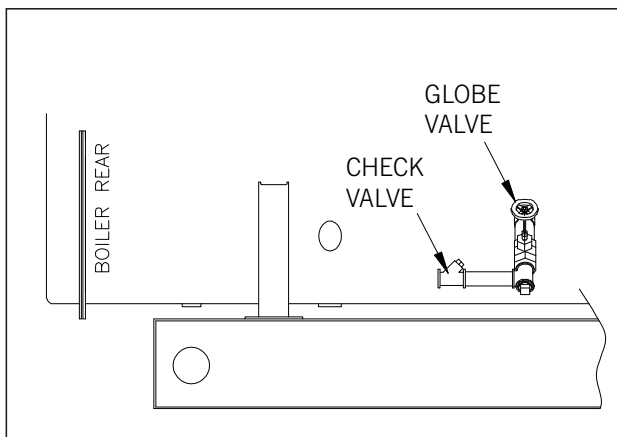


FIGURE 5-4. Feedwater Piping

5.3 — Water Treatment

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

Objectives of water treatment are:

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

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

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

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

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

5.4 — Cleaning

5.4.1 — 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.

5.4.2 — 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.

5.5 — Boil-Out of a New Unit

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

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

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

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

 **Warning**

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

The suggested general procedure for cleaning a boiler is:

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

Water Capacity and Weights

CBEX Premium Water Capacity				
	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.
5. An overflow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. The safety valve tapping is usually used.

6. Fill the pressure vessel with clean water at ambient temperature until the top of the tubes are covered. Add the cleaning solution, slowly and in small amounts, and then fill to the top with water.
7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. Do not produce steam pressure.
8. Allow a small amount of fresh water to enter the boiler to create a slight overflow that will carry off surface impurities.
9. Continue the boil and overflow process until the water clears. Shut the burner down.
10. Let the boiler cool to 120° F or less.
11. Remove handhole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect the surfaces. If they are not clean, repeat the boilout.
13. After closing the handholes and reinstalling the safety or relief valves, fill the boiler and fire it until the water is heated to at least 180° F to drive off any dissolved gases, which might otherwise corrode the metal.

 **Warning**

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

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

5.6 Washing Out

5.6.1 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.

5.6.2 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.

5.7 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 on in the following ways.

5.7.1 — Types of Blowdown

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

Intermittent Manual Bottom Blowdown

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

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

Equipment generally consists of two quick opening valves and one slow opening valve. 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 free to expand.

Continuous Blowdown (Controlling TDS)

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

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

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

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

5.7.2 — Frequency of Manual Blowdown

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

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

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

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

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

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

5.7.3 — 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 blowdown valve be left open. The operator should never leave until the blow-down operation is completed and the valves are closed.

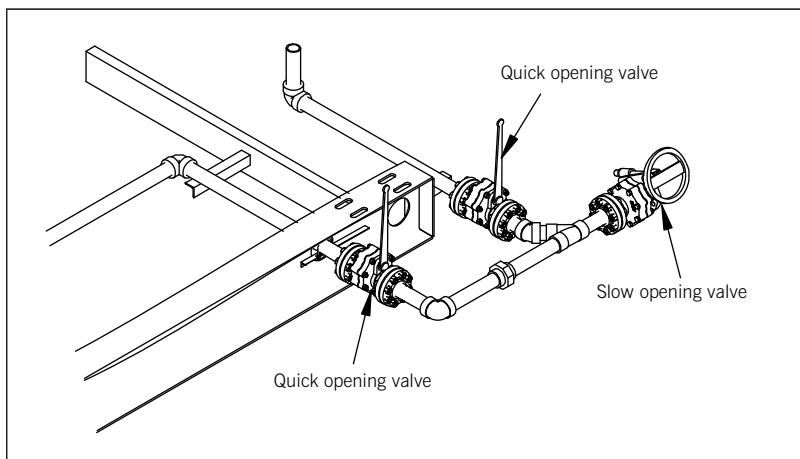


FIGURE 5-5. Bottom Blowdown Piping

5.8 — 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.

5.9 — Preparation for Extended Layup

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

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

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

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

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

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

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

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

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 this chapter apply to standard components furnished on steam or hot water boilers fired with gas and/or the various grades of oil.

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

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

NOTE: Observe that proper air damper linkage and fuel metering adjustment procedures are followed for standard CBEX (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: CBEX (model), 700 (fuel), 250 (HP), 150 (pressure)

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

The modulating motor contains either one or two internal switches depending upon application. The micro-switches 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 8° 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 60° 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.

6.4 — ProFire V Burner Adjustments

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

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

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

6.4.1 — Combustion Adjustment on Oil and Gas

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

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

Stack Temperature

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

Smoke Measurement

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

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

Test Equipment

The following test equipment should be used to set up and adjust the burner correctly:

1. Combustion analyzer with O_2 indication.



2. U-Tube manometer, or pressure gauge, to measure gas pressures (Main and Pilot), vacuum and pressure gauges for oil.
3. Inclined manometer to measure draft pressures.
4. Smoke spot tester for oil burners and CO analyzer for gas fired units.
5. Voltmeter/Ammeter.
6. Stack thermometer and thermocouples.

Air Flow Adjustments

The V Series burners have a two-blade air shutter design. Both blades are coupled together, and attached to the modulation motor. Changing the positions of the linkage rods on the linkage control arms will change the way the damper blades open and close.

Combustion Settings

Fuel and air flow rates are individually adjusted at low fire and at high fire to achieve rated input, firing rate turn-down, optimum efficiency, safe operation, and the ability to cope with environmental changes (including air temperature, humidity, barometric pressure), and fuel property changes.

Turndown capability for oil is less than that for gas due to the excess air requirement of oil for clean combustion. Therefore, on combination fueled burners, gas turndown performance may be restricted (or determined) by the excess air levels set initially for oil combustion. For burners equipped with the optional Siemens modulating motor, gas turndown will not be limited to the oil setting. Each fuel will have a separate modulation range, independent of each other.

Two key components residing in flue gas are used to optimize combustion efficiency: excess air and unburned fuel. The system should be adjusted to the minimum excess air quantity that provides low levels of unburned fuel with sufficient remaining oxygen to cope with normal atmospheric and fuel related changes. Unburned fuel is measured as carbon monoxide (CO) when burning natural gas, and smoke spots when burning oil.

Gas Adjustments

Low fire combustion analysis typically is 6% to 9% O₂ and less than .04% CO (400 ppm). A high fire reading typically is 3% to 5% O₂ and less than .04% CO. The V Series burners are capable of operating at low excess air and less than 50 ppm CO levels at all firing rates.

Fuel Oil Adjustments

Adjust for a "clean fire." Typically for No. 2 oil, O₂ is 5% to 6% at low fire and 3.5% to 4.5% at high fire. The burner should be set up and maintained to yield smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot buildup in the boiler.

6.5.2 — Gas Pilot Flame Adjustment

Burner models VG-VLG and VL-60 to 168 are equipped with a gas pilot system. The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 4" to 6" WC when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame. Although it is possible to visibly adjust the size of the pilot flame, obtain a proper DC volt or microamp reading of the flame signal.

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

 **Warning**

An ultra violet flame sensor electrical spark interference test must be performed after final adjustment. See Chapter 3 for additional information.

Check the pilot electrode setting. The pilot is accessible by loosening the four screws on the side of the blast tube and disconnecting the gas line.

6.5.3 — Direct Spark Oil Pilot Adjustment

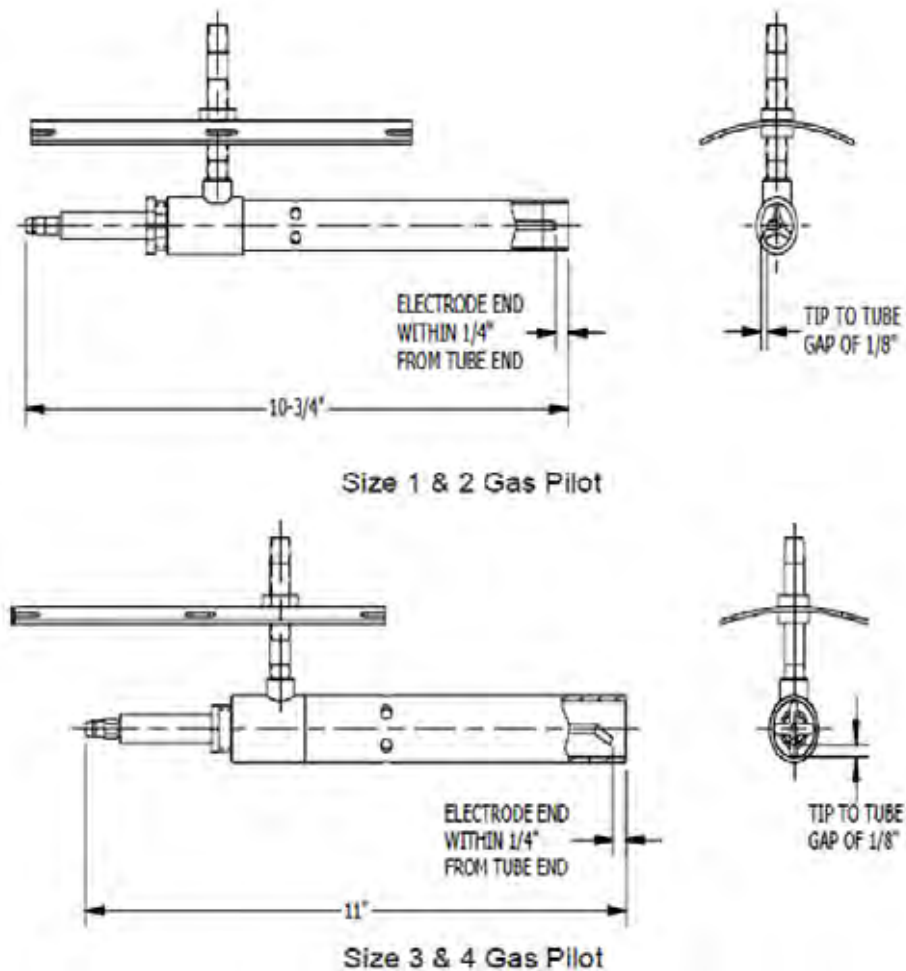
Burner models VL-13 to 55 are equipped with a direct spark ignition. Remove the oil drawer assembly and check electrode settings and nozzle size.

6.5.4 — Burner Settings

To ensure reliable and safe burner performance, the location and gap setting of the electrodes, and the relative positions of the burner nozzle, diffuser, and air baffle components must be set correctly. These items are preset at the factory, but must be checked prior to placing the burner into initial service, or after conducting any service work that may have altered their position.

The nozzle/diffuser assembly must be removed from inside the burner to enable measurement and adjustment. To remove:

1. Lockout and tag the electrical power supply to the burner to prevent inadvertent operation during checking or maintenance activities.
2. Disconnect the high voltage power supply from the oil-spark-ignition electrodes (if installed).
3. Disconnect the oil piping from the side of the blast tube.
4. Remove the fasteners that secure the drawer to the side of the burner housing, and remove the complete assembly.
5. For burners with a gas pilot:
 - a. Disconnect the pilot line and loosen the locking screws on the pilot access cover located on the side of the blast tube.
 - b. Disconnect the high voltage ignition cable by pulling it straight back, away from the pilot assembly. The pilot assembly will slide back and away from the diffuser.
 - c. Turn the assembly and retract it through the access hole.
 - d. Check the electrode position as shown in Figure 4-1.
 - e. Re-assemble in reverse order.

**FIGURE 6-1. Gas Pilots**

Measure the position of the tip of the nozzle to the diffuser and compare it with the following drawer assembly drawings. To adjust:

1. Loosen the locking screws on the diffuser clamp.
2. Slide the diffuser clamp along the length of the burner pipe until the correct dimension is obtained.
3. Tighten the diffuser clamp securely to the burner pipe. Apply a lock-tight type compound to the screws before tightening.
4. Carefully install the drawer assembly into the burner. Reconnect the oil line and high voltage power cable to the assembly.

Measure the position of the diffuser to the air baffle and compare it to the following drawer assembly drawings. To adjust:

1. Measure the distance between the leading edge of the diffuser and the front face of the inner ring on the air baffle assembly.

2. If adjustment is required, loosen the burner pipe locking setscrew located on the rear cap at the top of the fan housing, and slide the burner pipe until the correct dimension is obtained.
3. Tighten the burner pipe locking setscrew securely.

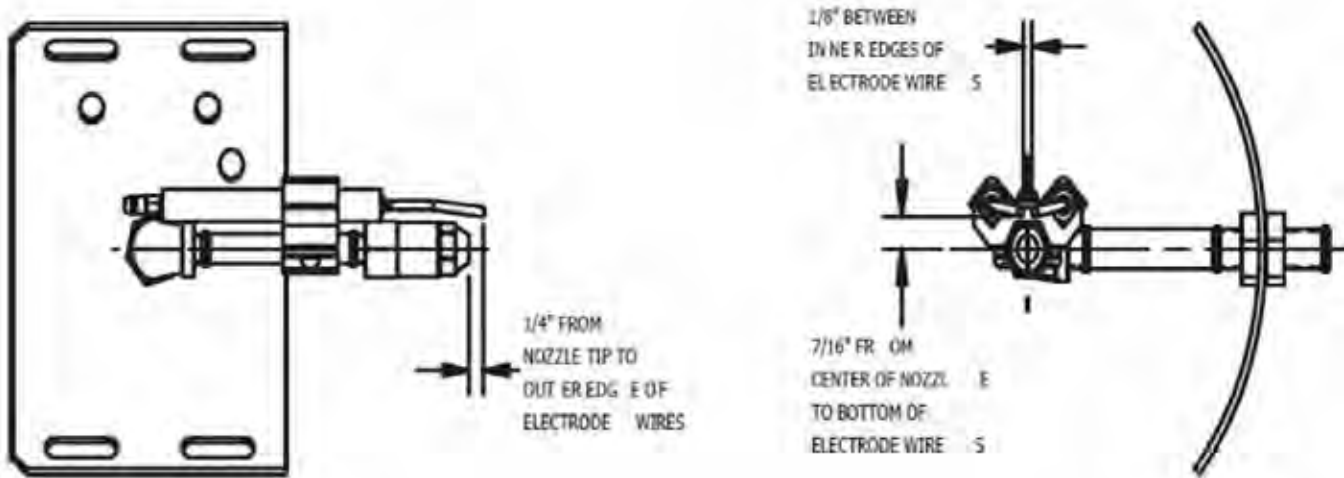


FIGURE 6-2. Direct Spark Ignition

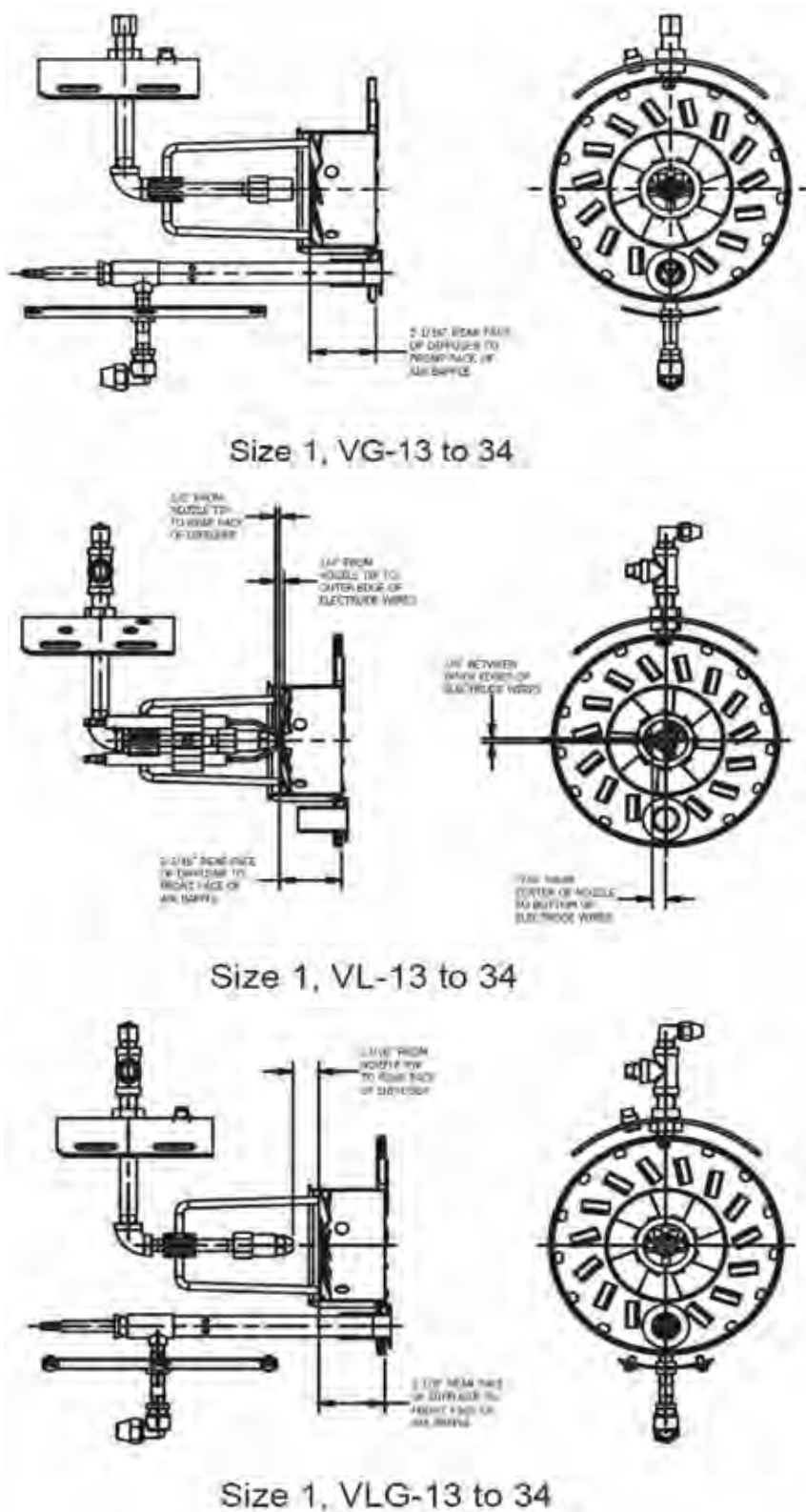


FIGURE 6-3. Drawer Assemblies

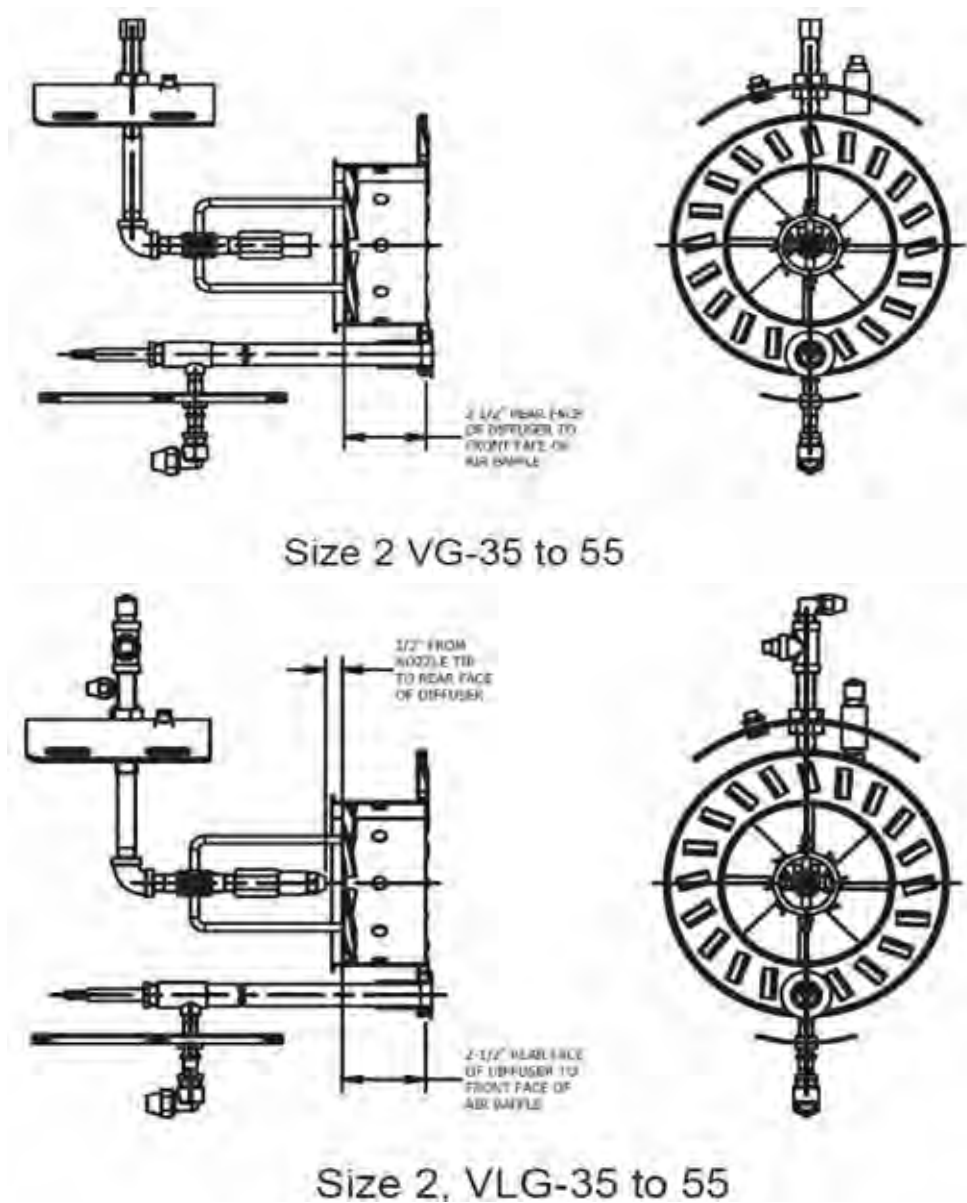


FIGURE 6-4. Drawer Assemblies

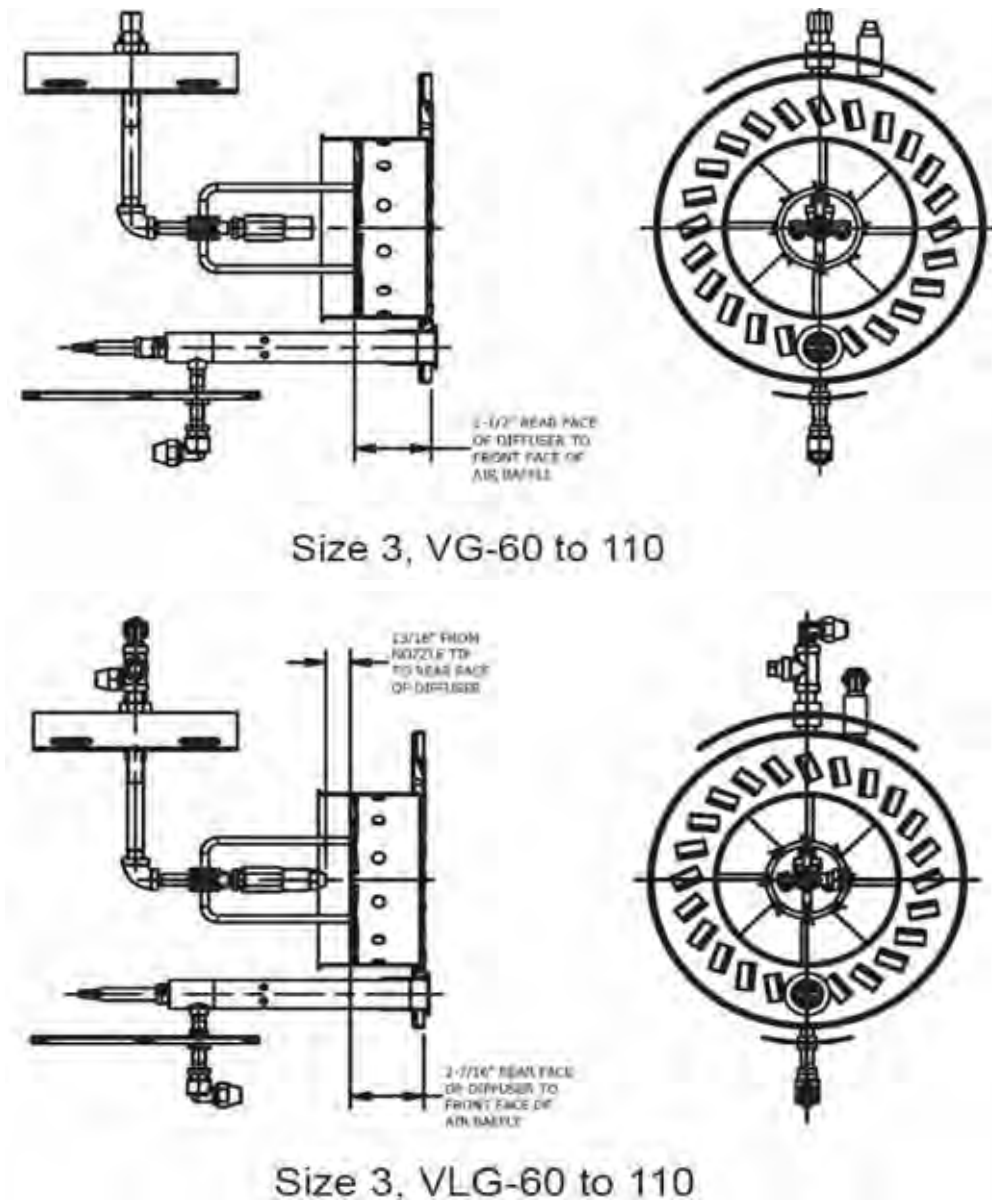


FIGURE 6-5. Drawer Assemblies

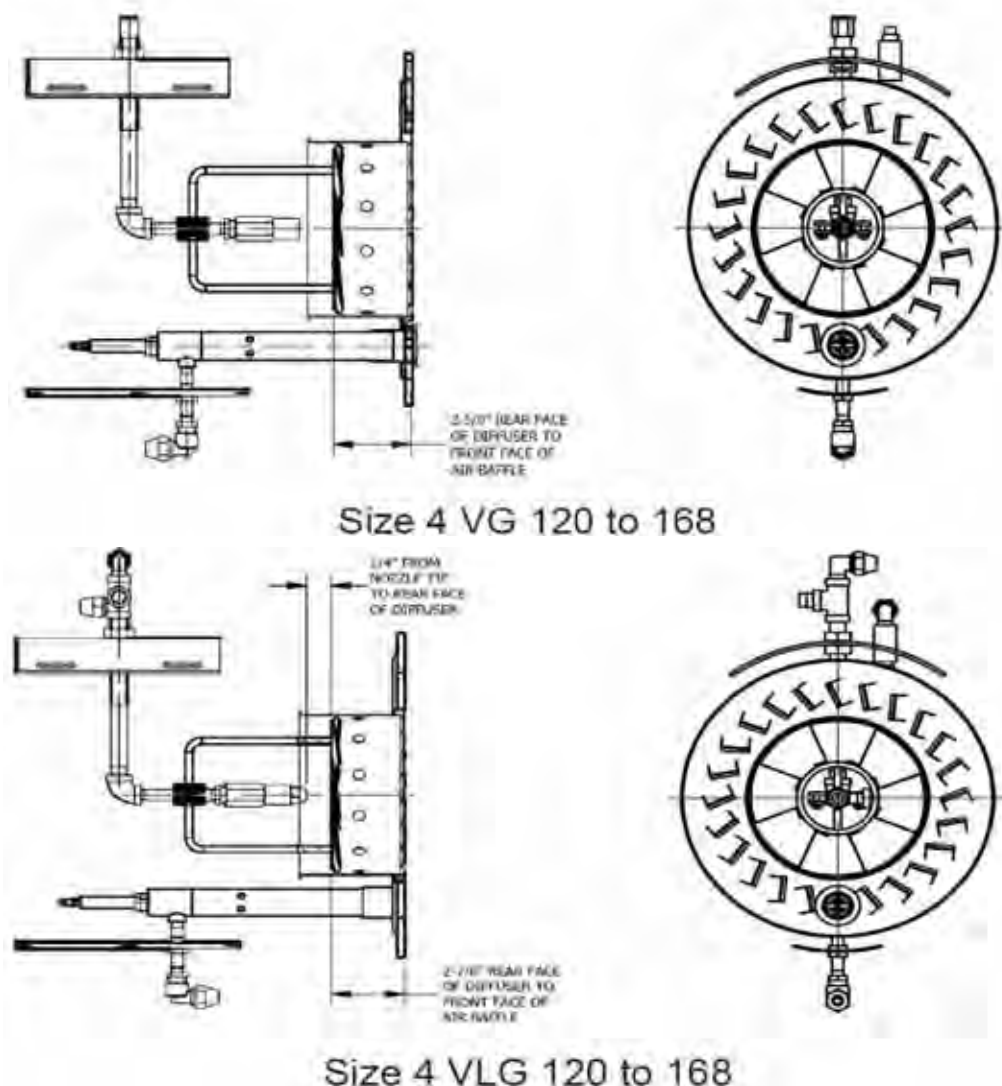


FIGURE 6-6. Drawer Assemblies

6.5.5 — Pilot Turndown Test

For burners equipped with a gas pilot, conduct the following test:

1. Turn the burner switch "ON." This will start the blower motor and initiate the pre-purge sequence. Make sure a pressure gauge 0" to 10" W.C. or a manometer is installed in the pilot line to monitor the pilot gas pressure.
2. When the pilot comes on, put the programmer timer on pilot hold by placing the "RUN-TEST" switch of the flame safeguard to the "TEST" position.

NOTE: Refer to the flame safeguard control manual instructions.

3. Check the flame signal strength. Adjust the flame signal by increasing or decreasing pilot gas pressure with the regulator spring. Normal setting is 4" to 6" W.C.



4. Perform a pilot turndown test by reducing the pilot pressure very slowly until the scanner loses sight of the flame and gives a flame lockout, then reset the adjustment to normal level. Note the minimum pressure level.
5. After adjusting the pressure back to normal level, set the programmer to the “RUN” position. Main flame will come on and the burner is in the low fire position.
6. Start and stop the burner several times to ensure proper pilot setting.

6.5.6 — Full Modulation Burner Adjustments

Refer to the burner data plate located inside the control panel door. The nameplate will list the burner information:

- burner and control voltage
- phase
- cycle
- motor amperage
- maximum and minimum fuel input settings
- manifold pressure (at zero furnace pressure - add the furnace pressure to get the correct manifold pressure at maximum firing rate)

These procedures assume that the pre-startup tasks, check list, electrical interference test, and pilot turndown tests have been performed in accordance with the instructions in this manual.

For most efficient combustion, allow the boiler to fully warm up before making adjustments. Refer to the boiler instruction manual for the boiler controls settings.

Gas Burners

The gas burner adjustments on a full modulation burner consist of the gas pressure regulator, butterfly gas valve, low and high gas pressure switches (Model V30-168), and air dampers.

1. Open the manual gas shutoff cocks.
2. Check the gas pressure at the inlet of the regulator and the pressure downstream of the regulator. Make sure they are in accordance with the regulator specifications. The gas pressure required at the manifold is the pressure that is required to fire the burner at its rated capacity. To adjust the regulator, unscrew the cap located on top and turn the adjustment screw clockwise to increase pressure, or counterclockwise to decrease pressure.
3. Set the “MANUAL-AUTO” switch to the “MANUAL” position.
4. Position the manual flame control potentiometer in the “CLOSED” (low fire) position.
5. Turn the burner switch to the “ON” position. The burner will start and be in the low fire position.
6. After a few seconds, the O₂ analyzer should have an accurate reading of the O₂ present in the flue gas. Normally, O₂ levels are set between 4% and 6% at low fire on standard turndown systems and between 6% and 9% on high turndown systems, with less than 50 ppm CO as a target value. To obtain the proper readings, adjust the gas butterfly opening and air shutters. Record the readings and pressures at the burner manifold and gas train.
7. Operate the boiler at low fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards “OPEN” in small increments. This will cause the butterfly valve to open, allowing more gas into the burner.
8. At each point allow the burner to operate for a few minutes before recording the O₂, CO, and pressure readings. Observe that the O₂ and CO levels remain within an acceptable limit. Adjust the pressure regulator as

necessary, to correct this situation. Continue to do this until the burner reaches high fire (the potentiometer is at the "OPEN" position).

9. Adjust the high fire gas input to match maximum rating. At high fire, the butterfly valve should be near the full open position. Adjust the gas regulator so the manifold pressure matches the rating on the burner data plate. Verify and record the readings and pressures. High fire is typically 3% to 4% O₂ with less than 50 ppm CO as a target value.
10. Modulate the burner to low fire. Verify the readings.

The burner should be adjusted to provide correct fuel flow at a constant rate, at the low fire and high fire position as indicated on the burner data plate. This is achieved by clocking the gas flow at the gas meter. The gas utility or gas meter calibration data should be consulted to determine the correction factors to be applied to the meter.

Natural Gas Input Calculation Using a Meter

$$Input(Btu/hr) = HHV \cdot \frac{cf}{t} \cdot 3600 \cdot \left(\frac{P_m + P_b}{P_{ref}} \right) \cdot \left(\frac{T_{ref} + 460}{T_g + 460} \right)$$

HHV = Higher Heating Value of gas, Btu/ft³ (if no data is available, use 1000)

CF = Cubic Feet of gas clocked

t = Gas Meter Clock Time, seconds

P_m = Meter Upstream Pressure (see P_{ref} for units)

P_b = Barometric Pressure (see P_{ref} for units)

P_{ref} = 14.696 psi, or 29.92 "HG, or 406.77" W.C.

T_{ref} = Gas Reference Temperature, °F (use 77 if data unavailable)

T_g = Gas Temperature at meter, °F

11. Adjust the low and high gas pressure switches by turning the adjusting screw until the indicator moves to a pressure slightly lower than normal operating pressure for the low gas pressure switch, and slightly higher for the high gas pressure switch (usually 50% below and 50% higher than normal pressure, respectively).
12. Tighten all linkages and marked settings. Complete the Startup Report.
13. Turn the "MANUAL-AUTO" switch to "AUTO." The burner will now modulate according to the load demand to the boiler.

Burners Equipped with Optional FGR Valve for Low NOx Applications

LVN burners are equipped with an FGR (flue gas recirculation) valve to lower the NOx emissions. An adjustable cam is provided to adjust the FGR valve position throughout the firing range on gas. Follow the steps for gas above, with the following additions:

1. Make sure the FGR valve is in the nearly closed position.
2. Start the burner and hold at low fire until the boiler is at the proper operating pressure or temperature.
3. With an analyzer in the stack, adjust the FGR valve cam screw to obtain sub 30 ppm NOx levels.

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

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



adjust the air damper blades to raise the O_2 to proper low fire values. If the proper NO_x values can not be reached by adjusting the cam screw, the FGR linkage will have to be adjusted as well.

5. Once the low fire setting is complete, continue with the instructions above, adjusting the cam at each screw, to obtain the proper NO_x values. Verify the values modulating back to low fire, and adjust accordingly.

Oil Burners

The oil burner adjustments consist of the oil metering valve and air shutters. The firing rate is regulated by a metering valve in the nozzle return line. At low fire, the arrow on the valve points to approximately number 7, and at high fire it is in the closed position (no return flow), approximately at number 2. The oil metering valve position will vary the oil pressure to the nozzle. An oil pressure gauge should be installed in the return line to monitor the oil pressure. Oil pressure at low fire is approximately 80 to 100 psi and 300 psi at high fire. Size 1 V13 to 25 uses a simplex nozzle, sizes 2 and 3 use a return flow nozzle.

1. Set the “MANUAL-AUTO” switch on the “MANUAL” position.
2. Position the manual flame control potentiometer in the “CLOSED” (low fire) position.
3. Turn the burner switch to the “ON” position. The burner will start and be in the low fire position.
4. Adjust low fire with the metering valve position to have approximately 80 to 90 psi, and adjust the low fire air shutter for a clean fire. Record the combustion reading from the flue gas analyzer, normally 4.5% to 6.5% O_2 and less than No. 1 Smoke (Bacharach).
5. Operate the boiler at low fire until it is up to operating pressure (steam) or temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards “OPEN” in small increments. This will cause the metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle.
6. At each point, allow the burner to operate for a few minutes before recording the O_2 , CO, Smoke, and pressure readings. Observe that your O_2 and CO levels remain within an acceptable limit. Adjust the oil pressure as necessary, to correct this situation. For burners with the cam trim option, adjust the cam screws throughout the range to obtain correct O_2 and CO levels. Continue to do this until the burner reaches high fire (the potentiometer is at the “OPEN” position).
7. Adjust the high fire fuel input to match maximum oil pressure. At high fire, the metering valve should be in the fully closed position and the pressure should be 300 psi. Verify and record the readings and pressures. High fire is typically 3.5% to 4.5% O_2 with less than No. 1 Smoke. Adjust the high fire excess air rate using the high fire shutter adjustment.
8. Modulate the burner to low fire. Verify the readings once again. The burner should be adjusted to provide correct fuel flow at a constant rate, at the low fire and high fire position as indicated on the burner data plate.
9. Tighten all linkages and marked settings. Complete the Startup Report.
10. Turn the “MANUAL-AUTO” switch to “AUTO.” The burner will now modulate according to the load demand to the boiler.

Combination Gas-Oil Burners

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas. After being completely adjusted for oil combustion, the burner is restarted and adjusted using natural gas as fuel. Combustion adjustment of the combination burner for natural gas involves balancing the input rate only against the existing flow of combustion air, as established initially for oil.

NOTE: Do not readjust the air shutter when turning the combination burner for combustion of natural gas.

1. Set the “MANUAL-AUTO” switch to the “MANUAL” position.
2. Position the manual flame control potentiometer in the “CLOSED” (low fire) position.
3. Turn the fuel selector switch to the “OIL” position.
4. Turn the burner switch to the “ON” position.
5. Proceed with startup and adjustments using the procedures explained in Section 4.9.3.
6. After the system has been completely adjusted for oil firing, place the burner switch “OFF,” and position the fuel selector switch to “GAS.”
7. Proceed with startup and adjustments using the same procedures explained in Section 4.9.1. Do not alter the air settings set for oil. Correct the O₂ levels by adjusting the butterfly valve.

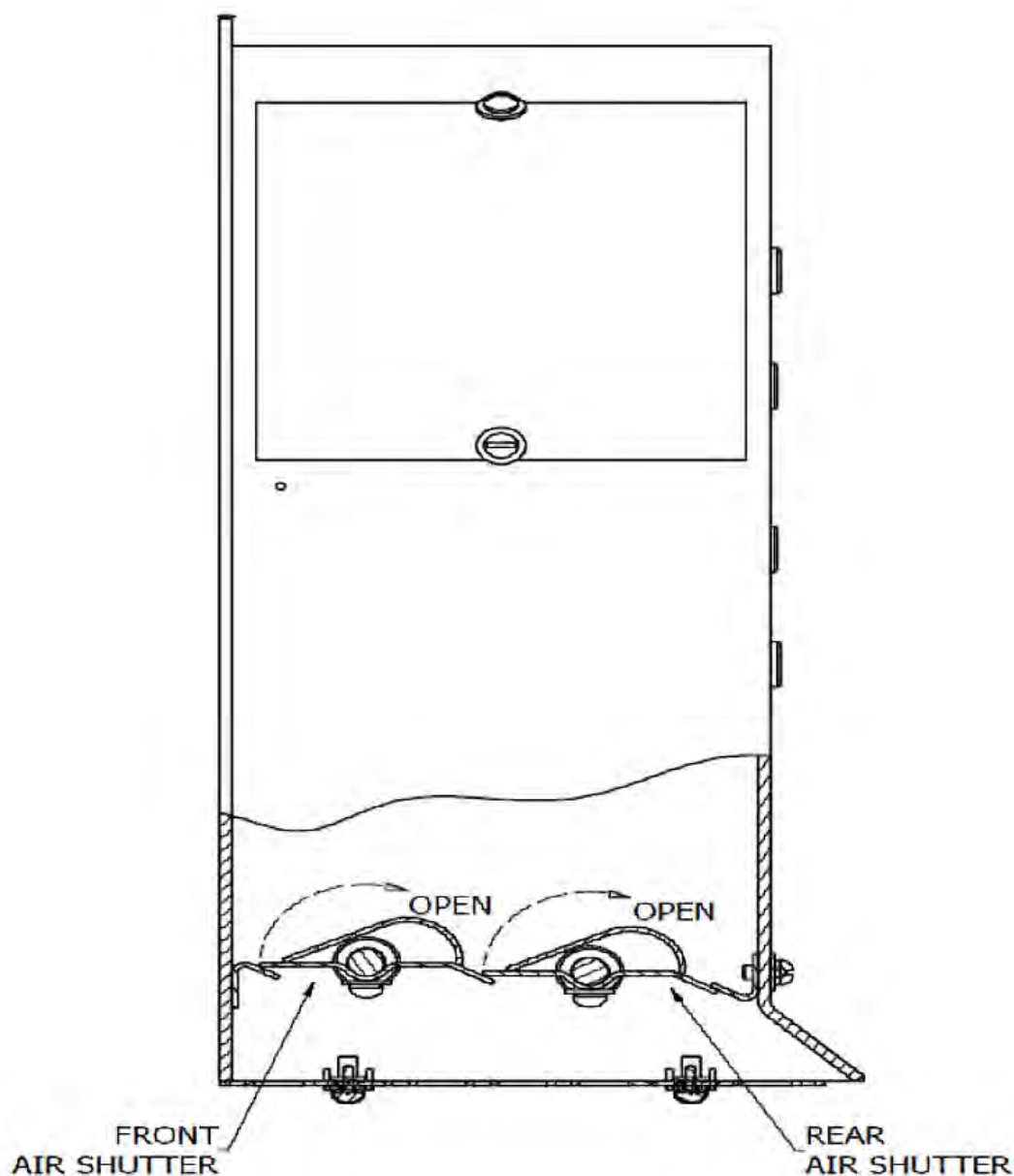


FIGURE 6-7. Front and Rear Shutters

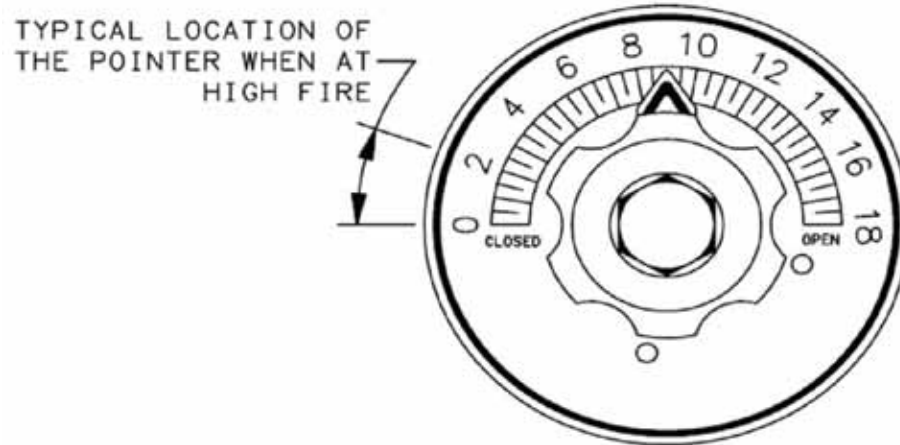


FIGURE 6-8. Oil Metering Adjustment Knob

6.5 — ProFire E Burner Adjustments

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

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

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

6.5.1 — Combustion Adjustment on Gas and Oil

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

The proper settings of air-fuel ratios must be determined by flue gas analysis. Combustion gas analysis indicates the air to fuel ratio and the degree of complete combustion. Instruments are available to measure carbon dioxide (CO₂), oxygen (O₂), and carbon monoxide (CO).

Stack Temperature

Net stack temperature is obtained by subtracting the ambient temperature from the flue gas temperature. A high net stack temperature indicates wasted heat. Stack temperature should be as low as possible without causing flue gas condensation.

Stack heat loss can be reduced by decreasing either the temperature or the volume of the flue gas, or both. Flue gas temperature is reduced by improving heat transfer or by reducing excess combustion air. A certain amount of excess air is necessary to complete combustion. More efficient burners require minimum excess air.

Smoke Measurement

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

Smoky combustion can result from:

- Improper air delivery
- Insufficient draft
- Improper fuel viscosity
- Improper fuel-air ratio
- Excessive air leaks in the combustion chamber
- Improper fuel oil temperature

Gas Adjustments

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

Fuel Oil Adjustments

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

6.5.2 — Electrical Interference Test

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

Gas Fired

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

Oil Fired

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



6.5.3 — Gas System

Gas Pressure

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

Gas Flow

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

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

Gas Pilot Flame Adjustment

The gas pilot flame is regulated by adjusting the pressure setting of the pilot regulator. Normal setting is 3" to 6" W.C. when the pilot is burning. The flame must be sufficient to be proven by the flame detector and ignite the main flame.

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

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



Warning

An ultra-violet flame sensor electrical spark interference test must be performed after final adjustment. See Section 4.3 of this chapter for additional information.

Main Gas Pressure Regulator

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

Low Gas Pressure Switch

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

High Gas Pressure Switch

Turn the adjusting screw until the indicator moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure, but not at a pressure so close to normal operating pressure that

unnecessary shutdowns occur. This switch must be manually reset after tripping. To reset, allow gas pressure to drop and press the manual reset button.

Gas Combustion Adjustment

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

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

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

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

Recheck low fire and adjust if necessary.

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

NOTE: Check for CO through the entire firing range.
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6.5.4 — Oil System

Oil Metering System

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

1. Oil tanks are not empty.
2. All oil valves between the burner and the tank are open.
3. The suction line is not airbound.
4. The low fire setting has not been disturbed.
5. There is pressure at the separate metering unit, but not exceeding 20 psi.
6. The pump turns freely.
7. The strainer at the suction side of the circulating pump is not clogged.
8. The burner strainer is not dirty.
9. The nozzle is not plugged or carboned. This will show up as excessive primary air pressure.
10. The oil bypass valve is not bypassing the metered fuel oil.

Internal wear of the pump may take place due to the presence of dirt in the oil and in time this will result in excessive clearances which reduce the pump capacity. If the oil metering pump fails to deliver capacity or meters erratically, replace the oil and air pump as a unit and return the old pump for repair or exchange (where allowed).



Atomizing Air Pressure

Atomizing air in the air/oil tank is regulated by adjusting valve in the return air line on integral metering units or in the air inlet on air compressor module burners. The air pressure is indicated by the pressure gauge at the air/oil tank.

A minimum of 10 psi air pressure in low fire is suggested. As the firing rate increases, the air pressure also increases. Air pressure will be less with light oils. If any change in atomizing air pressure is made, check ignition several times for reliable light off. Adjustments should be set to obtain reliable ignition with best low and high fire combustion results.

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

Atomizing Air Proving Switch

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

Low Oil Pressure Switch

The low oil pressure switch is adjusted at the minimum setting of 4 psi. Turning the knob clockwise will increase pressure, counterclockwise will decrease pressure.

6.5.5 — Parallel Positioning Adjustment

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

6.5.6 — Firing Rate Controls

Firing rate adjustments are made at the modulating motor linkages to the combustion air inlet damper, air-oil metering pump, and main gas butterfly valve. Settings are determined by the operating length of the levers and the angular position on the shafts. Increasing the lever lengths on damper, pump or valve decreases the flow rate. Driving and driven levers are approximately parallel, but the angles can be adjusted to vary the rate of change. The most rapid rod travel occurs when the lever is perpendicular to the rod. The closer the rod comes to being parallel with the lever, the slower the rod moves. ALWAYS allow the burner to return to low fire position before adjusting high or intermediate settings. DO NOT alter low fire settings.

Normally, the air control damper will be approximately 1" open in low fire position. Excessive opening in low fire can cause pilot ignition problems. Air to the pilot is supplied under pressure to compensate for variations in furnace pressure, but the damper must be in low fire position for reliable ignition.



Warning

Keep fingers away from the air intake below the damper. The damper is actuated with sufficient force to cause severe injury.

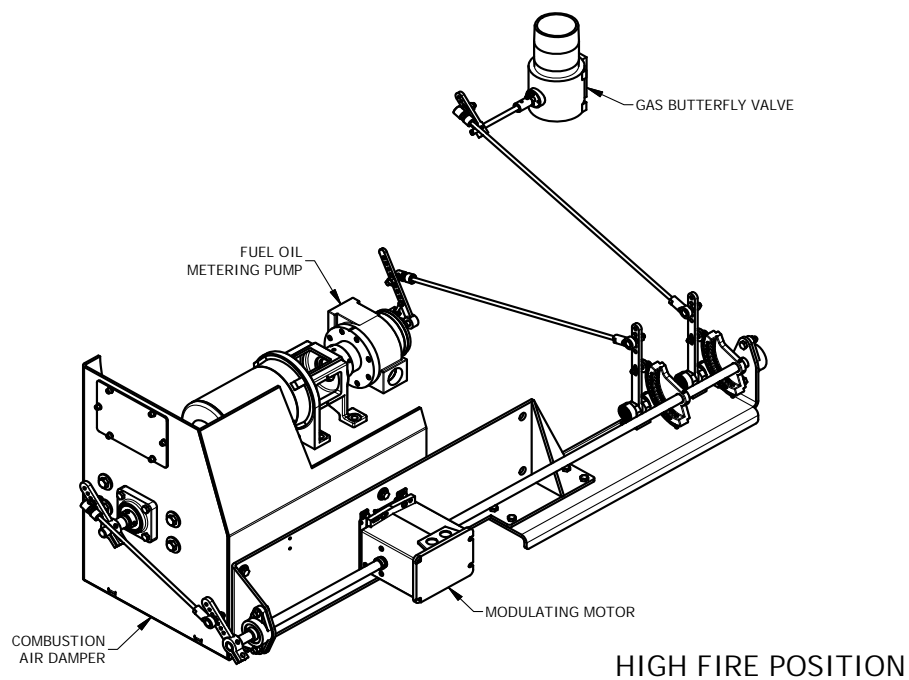
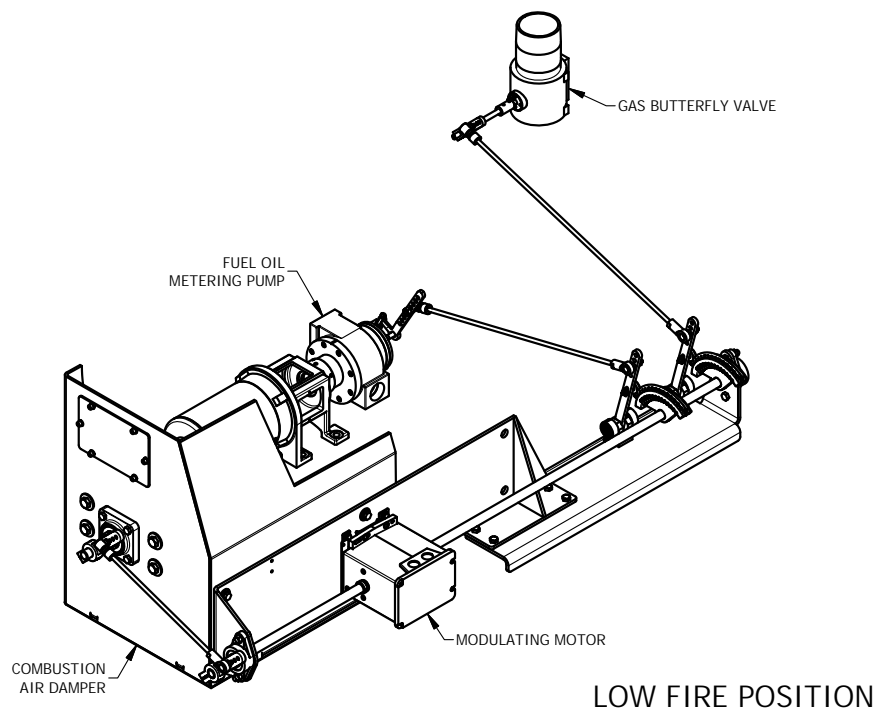


FIGURE 6-9. Firing Rate Control Positions

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.

 **Caution**

Never attempt to circumvent any of the safety features.

 **Warning**

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

 **Warning**

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

 **Warning**

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

The 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.

7.2 — Emergency Shutdown

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

7.3 — 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.
	4. Fuel valve interlock circuit not completed. A. Fuel valve auxiliary switch not closed.
NO IGNITION	1. Lack of spark. A. Electrode grounded or porcelain cracked. B. Improper electrode setting. C. Loose terminal on ignition cable - or cable shorted. D. Inoperative ignition transformer. E. Insufficient or no voltage at pilot ignition circuit terminal.
	2. Spark but no flame. A. Lack of fuel - no gas pressure, closed valve, empty tank, broken line, etc. B. Inoperative pilot solenoid. C. Insufficient or no voltage at pilot ignition circuit terminal. D. Too much air.
	3. Low-fire switch open in low-fire proving circuit. A. Damper motor not closed, slipped cam, defective switch. B. Damper jammed.
	4. Running interlock circuit not completed. A. Combustion or atomizing air proving switches defective or not properly set. B. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

Problem	Possible Cause(s)
PILOT FLAME, BUT NO MAIN FLAME	1. Insufficient pilot flame.
	2. Gas fired unit: A. Manual gas cock closed. B. Main gas valve inoperative. C. Gas pressure regulator inoperative.
	3. Oil fired unit: A. Oil supply cut off by obstruction, closed valve, or loss of suction. B. Supply pump inoperative. C. No fuel. D. Main oil valve inoperative. E. Check oil nozzle, gun, and lines.
	4. Flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.
BURNER STAYS IN LOW-FIRE	1. 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.
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.

8.1 — Overview

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

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

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

 **Caution**

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

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction and permit prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks — fuel, water, steam, exhaust gas — should be repaired promptly and under conditions that observe necessary safety precautions. Preventive maintenance measures, such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc., should be included in regular maintenance activities.

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 pre-heater	
Record flue gas temperature	Check indicating lights and alarms	Check air pump coupling alignment	
Record oil pressure and temperatures	Check operating and limit controls	Inspect/repair burner housing to refractory seal	
Record gas pressure	Check safety and interlock controls		
Treat water according to the established program	Check for leaks, noise, vibration, unusual conditions, etc.		
Record atomizing air pressure	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. Inspections are usually, though not necessarily, scheduled for periods of normal boiler down time, such as an off season. This major inspection can often be used to accomplish maintenance, replacement or repairs that cannot easily be done at other times. Inspection also serves as a good basis for establishing a schedule for annual, monthly, or other periodic maintenance programs.

While the inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the operator an excellent opportunity for detailed inspection and check of all components of the boiler including piping, valves, pumps, gaskets, refractory, etc. Comprehensive cleaning, spot painting or repainting, and the replacement of expendable items should be planned for and taken care of during this time. Any major repairs or replacements that may be required should also, if possible, be coordinated with the period of boiler shutdown.

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

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

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

8.2 — Fireside Cleaning



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.

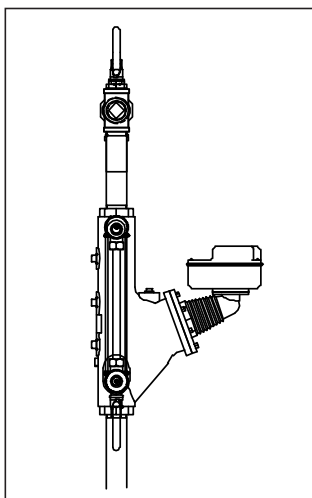
Clean-out should be performed at regular and frequent intervals, depending upon load, type, and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer can be used as a guide to clean-out intervals since an accumulation of soot deposits will raise the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

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.

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.

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 8-2. Low Water Cutoff

8.3.1 — Steam Boiler

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



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

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

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

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

8.3.2 — Hot Water Boiler

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

8.4 — Water Gauge Glass

A broken or discolored glass should be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use loose packing which could be forced below the glass and possibly plug the valve opening.

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



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

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

**Warning**

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

FIGURE 8-3. Water Column Gauge Glass Replacement

8.5 — Electrical Controls

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

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

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

**Caution**

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

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

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

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 bent out of position.

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

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

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

Warning

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

8.6.1 — Checking Pilot Flame Failure

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

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

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



8.6.2 — Checking Failure to Light Main Flame

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

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

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

8.6.3 — Checking Loss of Flame

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

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

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

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

8.9 — IFGR Inspection and Adjustment

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

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

8.10 — Safety Valves



FIGURE 8-4. Safety Valves

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

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



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

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

FIGURE 8-5. Operating Safety Valves

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

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

8.11 — Air Pump and Lubricating System

8.11.1 — 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.

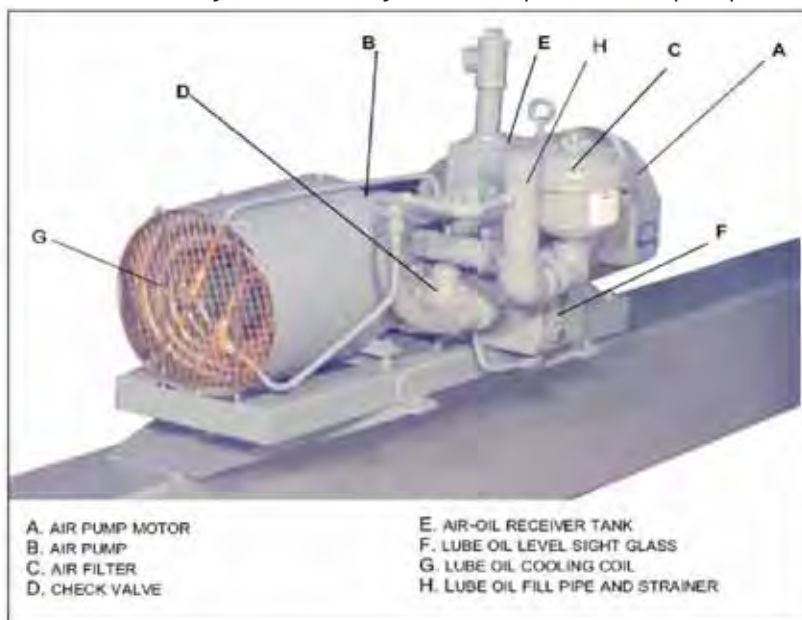


FIGURE 8-6. Air Pump

8.11.2 — 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.

8.11.3 — 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.

8.11.4 — Air-Oil Tank

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

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

Follow previous instructions for oil replacement.

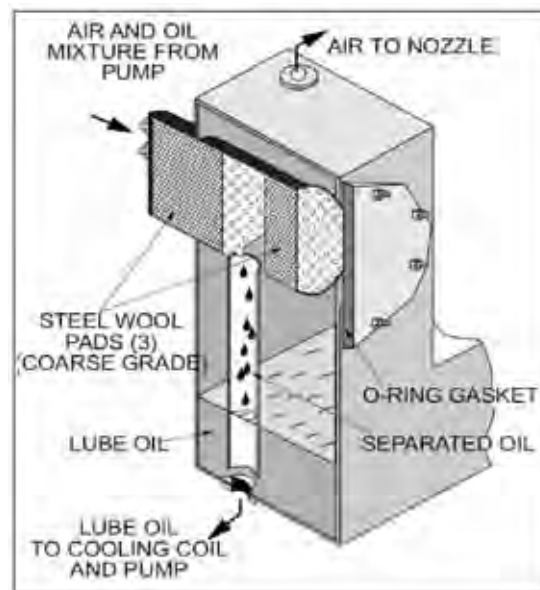


FIGURE 8-7. Air-Oil Receiver Tank

8.11.5 — 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.

8.11.6 — Flexible Coupling Alignment

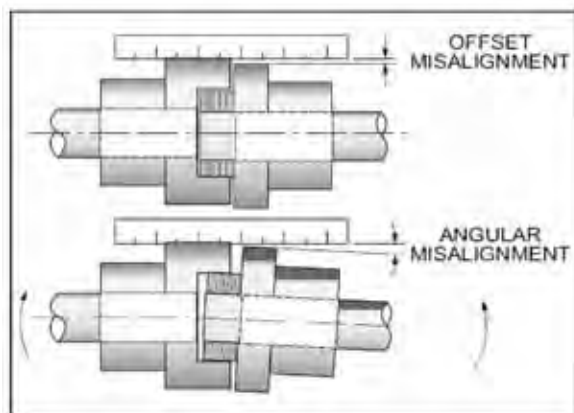


FIGURE 8-8. Flexible Coupling Alignment

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

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

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

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

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

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

Set the spacing between the halves at one point by using a thickness gauge and then rotate the coupling slowly to be sure that clearance at that point remains the same through 360 degrees of rotation. Adjust to obtain proper gap by loosening the hold-down bolts and shifting either the pump or the motor as required. Generally, a slight tapping on either the front or rear legs is all that is needed to obtain lateral adjustment. Rear legs may require shimming for vertical correction.

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

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

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

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

8.11.8 — Air Compressor Replacement

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

Dismantling

1. Lift out the two front cylinder pins that hold the screen, and remove the screen.
2. Disconnect the flared nut on tubing "A" (behind screen) (see Figure 8-31) and lift tubing "A" high enough to prevent drainage of lubricating oil from the tank.
3. Disconnect the flared nut at the orifice fitting.
4. Remove the two sheet metal screws that hold the cylinder in place. One screw is located at the top rear of the cylinder, the other is at the bottom front.
5. Remove the entire heat exchange assembly, consisting of the cylinder, the finned tubing, and the oil line "B".
6. Remove the fan from the air pump.
7. disconnect the flexible air line from the lube tank.
8. Remove the coupling guard by pushing in on both sides until it clears the clamp.
9. Loosen the clamp at the rear of the tank and remove the tank with copper tubing "B" attached.
10. Leave the rear pump bracket (coupling end) in place to aid in realignment of the replacement pump. Do this by removing the two capscrews that extend through the bracket into the pump housing. Temporarily leave the front bracket attached to the pump.
11. Remove screws holding the front bracket to the base and lift off the pump with its attachments. Note the location of the pipe fittings and brackets prior to removing for installation on the replacement pump. If piping is dismantled, be sure that the check valve is re-installed so that the gate swings toward the pump.

Reassembly

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

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

Refer to the previous section on coupling alignment instructions.

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

When re-installing the fan, slide the hub on the pump shaft so that it is bottomed. Tighten the setscrew and cap-screws. 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.

8.12 — Front and Rear Access

8.12.1 - Front Smoke Box

Opening Doors

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

Insulating the Smoke Box

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

Preparing to Close Doors

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

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

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

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

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

Closing and Sealing Doors

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

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

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

8.12.2 — Rear Access Plug

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

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

8.13 — Lubrication

8.13.1 — 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 8-9. Electric Motors

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

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

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

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

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

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

8.13.2 — Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

8.14 — Combustion Adjustments

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

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

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

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

8.15 — ProFire V Burner Maintenance

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

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

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



Warning

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

 **Caution**

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

8.15.1 — Control System

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

 **Warning**

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

Programming Control

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

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

Motors

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

8.15.2 — Gas System

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

Solenoid Valves

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



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

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

 **Caution**

All power must be disconnected before servicing valves.

Motorized Main Gas Valves

Should the valve fail to operate, check for voltage at the valve. Make certain that the main shutoff cock is closed prior to testing. The actuator is not field repairable nor should it be disassembled. Replace the actuator if the valve fails to operate.

After replacement, cycle the valve with the fuel shutoff to determine that it opens and closes. If the valve has a visual indicator, observe its position for correct operations.

8.15.3 — Oil System

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

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

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

8.15.4 — Drawer Assembly

The drawer assembly may be removed for inspection and service.

1. Shut off the burner, position the switch to "OFF."
2. Shut off all electric power to the burner.
3. Disconnect the fuel lines from the drawer assembly access cover.
4. After making note of where the bolts are located in relationship to the access cover slots, remove the drawer assembly access cover bolts. Pull the drawer partially out of the housing. Reach inside to disconnect the ignition cables from the electrodes for direct spark applications. Pull the drawer assembly completely out of the housing.

5. To reinstall the drawer assembly, insert it part way into the housing, connect the ignition cables, if applicable, and seat the assembly fully. Install the access cover bolts loosely. Slide the cover into the original location and tighten the bolts. Reconnect the fuel lines.

8.15.5 — Ignition Electrode, Cable and Pilot

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

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

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

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

8.15.6 — Flame Scanner

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

8.15.7 — Burner Mounting Inspection

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

8.15.8 — Extended Shutdown

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

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



8.15.9 — Maintenance Flow Chart Recommended Test Schedule

Item	Service By	Remarks
DAILY		
Gauges, Monitors, Indicators	Operator	Make Visual Inspection and record readings in log.
Instrument and Equipment Settings	Operator	Make visual check against recommended specifications.
Low Water, Fuel Cutoff and Alarms	Operator	Refer to instructions.
WEEKLY		
Firing Rate Control	Operator	Verify factory settings.
Igniter	Operator	Make visual inspection. Check flame signal strength.
Pilot and Main Fuel Valves	Operator	Open limit switch. Make audible and visual check. Check valve position indicators, and check fuel meters.
Flame Failure Controls	Operator	Close manual fuel supply for (1) pilot and (2) main fuel cock and/or valve(s). check safety shutdown timing. Record in log.
Flame Signal Strength Controls	Operator	Read and log the flame signal for both pilot and main flame. Notify service if readings are very high, very low, or fluctuating.
Linkages	Operator	Check all burner linkages for tightness. Tighten if required.
MONTHLY		
Low Fan Pressure Interlock	Operator	Manually adjust until switch opens.
High and Low Gas Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Scanner and Diffuser	Operator	Check, inspect and clean for soot buildup.
Pilot Assembly	Operator	Check for loosening of components, erosion or carbon buildup.
ANNUALLY		
Strainer (Oil Units)	Operator	Replace or clean the oil strainer element.
Impeller	Operator	Inspect and clean the combustion impeller.
Combustion Test	Service Tech	Perform a complete combustion test. Adjust burner if necessary. Read and log data.
Pilot Turndown Test	Service Tech	Required after any adjustment to flame, scanner, or pilot adjustment.
Operating Controls	Service Tech	Refer to instructions.

8.16 — ProFire E Burner Maintenance

Warning

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

Caution

It is important that you provide support for the housing when in the open position to prevent damage to the hinges and other components.

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

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

Unusual noise, improper gauge reading, leak, sign of overheating, etc., can indicate a developing malfunction, requiring corrective action.

8.16.1 — Control System

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

Programming Control

This control requires no adjustment, nor should any attempt be made to alter contact settings or timing logic. Those programmers with contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Never use abrasive materials. The manufacturer's bulletin also contains troubleshooting information. The flame detector lens should be cleaned as often as conditions demand. A periodic safety check procedure should be established to test the complete safeguard system. Tests should verify safety shutdown with a safety lock out upon failure to ignite the pilot or the main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. The safety check procedures are contained in the manufacturer's bulletin.

8.16.2 — Impeller and Inlet Cone

Proper clearance between the impeller and the inlet housing set at 3/8” nominal. Adjust the inlet cone so it is centered in the inlet of the impeller and tighten the bolts. There should be no contact between the inlet cone and the impeller. Inserting a bar through the impeller blade and using it as a lever will only damage the blade and also void the impeller warranty.

8.16.3 — Firing Head Inspection

Disconnect the damper linkage, release the impeller housing latches, and swing the housing open for access to the firing head. Inspect the flame scanner lens to be sure it is clean. Inspect the lead wire to the ignition electrode. It must be firmly attached and the insulation should be clean and free of cracks. The oil nozzle should be inspected periodically depending on the grade of oil burned and the cleanliness of the environment.

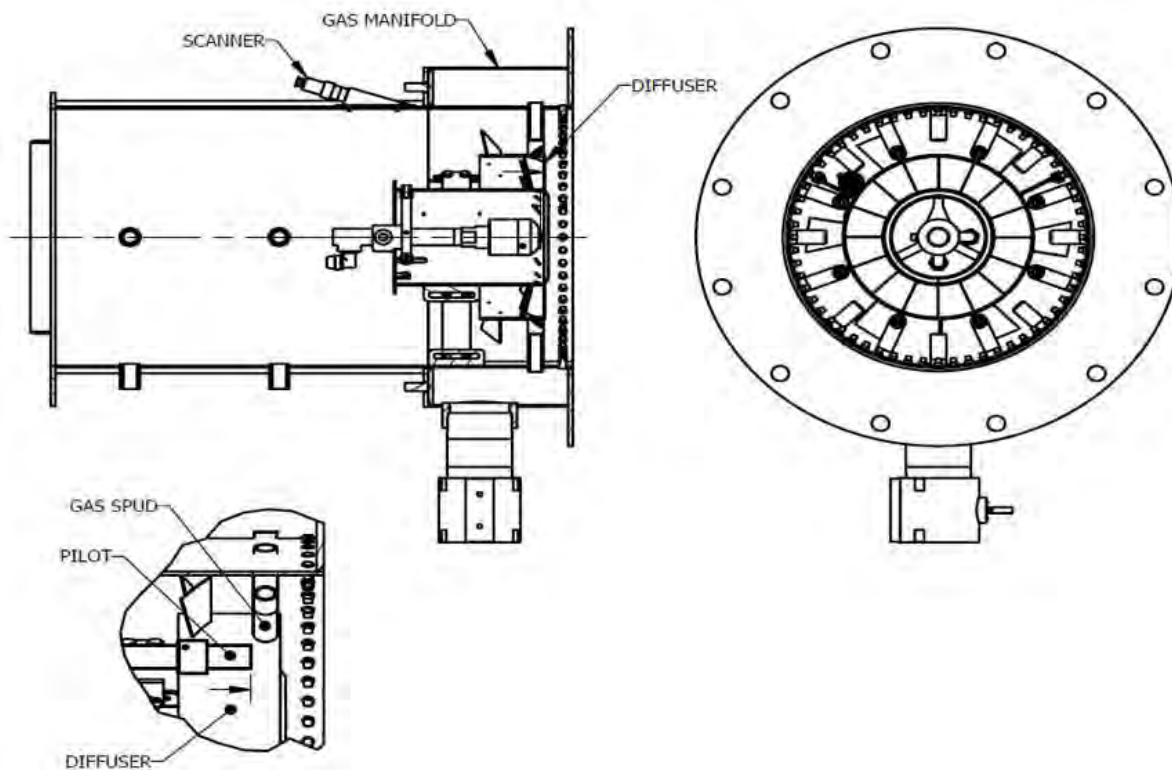
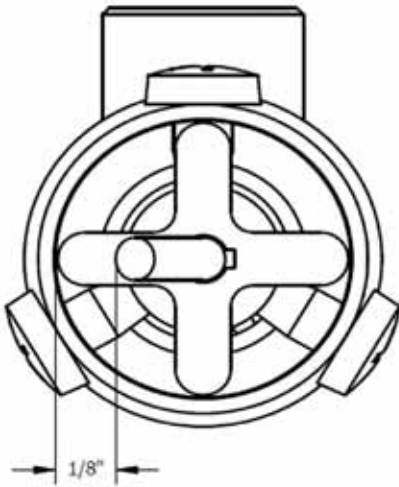


FIGURE 8-10. Firing Head Assembly

8.16.4 — Pilot and Ignition Electrode



The ignition transformer requires little attention other than making sure the ignition wire is firmly attached to the transformer and the electrode. Be sure the wire insulation is in good condition and not grounded. Failure to keep the ignition electrode clean and properly set can cause faulty operation. Refer to Figure 9-26 for electrode gap setting and position. The pilot assembly is supported by a socket in the diffuser and gas inlet tube. No adjustment is required except proper positioning of the electrode wire.

FIGURE 8-11. Pilot Electrode Gap

8.16.5 — Flame Scanner

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

8.16.6 — Oil Nozzle

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

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

To clean the nozzle tip and swirler:

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

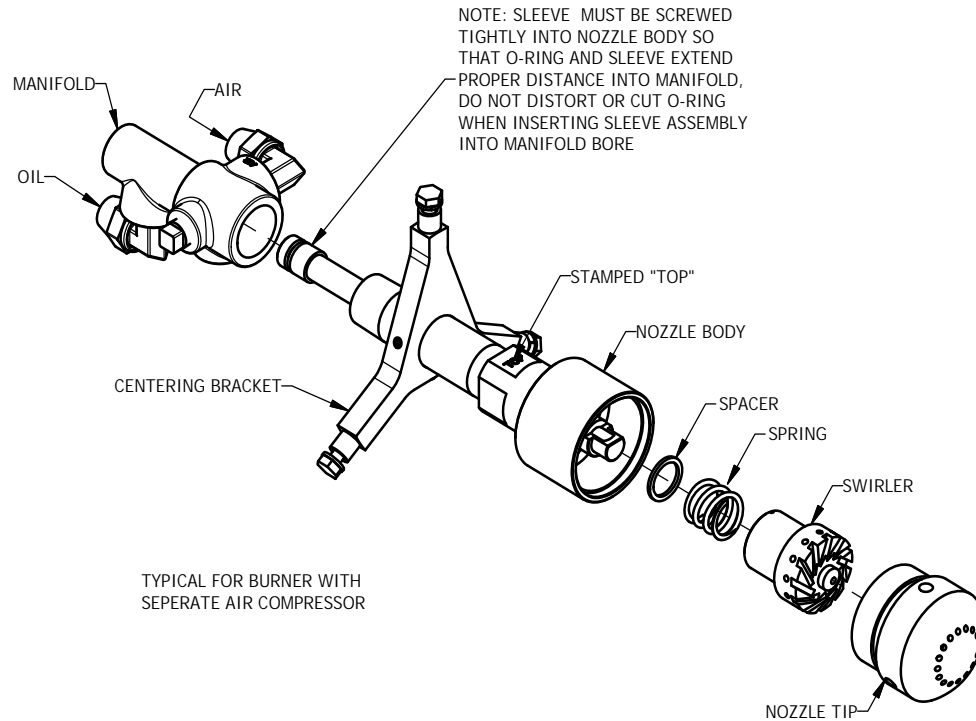


FIGURE 8-12. Oil Nozzle Assembly

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

⚠ Caution

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

8.16.7 — Diffuser

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

1. First remove the electrode leads, the gas pilot assembly, air and oil tubes before you attempt to remove the diffuser.
2. Mark the diffuser relative position to the blast tube, with a scribed or pencil line where the three mounting screws are located, to insure that the diffuser is placed back in the same position.
3. Remove the three screws holding the diffuser to the blast tube and slowly pull the diffuser along the blast tube towards the firing head.
4. Clean all carbon from the diffuser vanes and reinstall in reverse order of disassembly aligning the diffuser with the scribed marks.

5. When reinstalling, be sure the diffuser is centered with the proper distance.

8.16.8 — Firing Rate Controls

Check all rods and linkages, Make sure all connections are tight. Adjust if necessary. Perform a combustion test and readjust the burner if necessary.

8.16.9 — Burner Mounting Inspection

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

NOTE: It is essential that the cam spring, cam follower bearing wheel, and cam follower arm at the pivot point be greased sparingly every month to ensure smooth operation of the cam assembly. Regular automotive bearing grease should be used.

8.16.10 — Fuel Oil System

Fuel Oil Circulating Pump

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

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

NOTE: Heavy fuel oil sometimes will not leak out through a suction line joint when the burner is idle, but the same joint may allow air leakage inward when a vacuum is created in the line by pump action. The cause of a pulsating burner fire can often be traced directly to air leakage in the oil suction line. Always be sure the suction line joints are absolutely air tight.

Caution

Do not attempt field repair of the compressor. Installation of a new compressor is mandatory. Send the old compressor in for repair or exchange (where allowed).

Caution

Do not attempt to disassemble the oil metering pump in the field. Any attempt will void the warranty or the exchange policy.



Primary Air Pump or Compressor

The air compressor itself requires little maintenance, however, its life is dependent upon sufficient clean, cool lubricating oil. The oil level in the air-oil tank must be checked regularly. Lack of oil will damage the compressor. Disassembly or field repairs to the air compressor are not recommended. Check the air-oil tank sight glass for proper oil level. The level should be kept at midpoint up the glass. The compressor rotor must turn freely. All tube connections must be air tight.

Alignment of the compressor and motor sheaves and proper belt tension are important.

Belt tension is adjusted according to the displacement on the belt with thumb pressure. The displacement should be 3/8 to 1/2 inch.

To adjust, loosen the two bolts on the compressor mounting flange and the three setscrews which hold the compressor in place.

The mounting flange is slotted at the top, which permits belt tightening. If the slot in the mounting flange is insufficient for obtaining proper belt tension, the modular base has two extra holes for this purpose.

Move the top bolt to the next hole and adjust. Tighten bolts and setscrews. Replace belt guards. If belt becomes frayed or cracked, replace it.

Caution

The metering pump is lubricated by fuel oil and must not be operated longer than one minute if it's not pumping oil. Failure to comply will result in premature pump failure and void any warranty implied or otherwise.

Air Cleaner

Never operate the compressor without the air cleaner in place. The cleaner should be cleaned at regular intervals. The correct oil level must be maintained in the air cleaner. Use the same oil used for air compressor lubrication.

Air-Oil Tank

Check the lube oil level in the air-oil tank. Inspect oil level regularly as loss of oil will damage the compressor. Change oil every 2000 hours of operation. The air-oil tank should be drained once a year and thoroughly flushed. Remove the mist eliminator pads from the upper section of the tank, wash thoroughly in kerosene and dry. Refill with non detergent SAE30 oil to a level midway up the sight glass. For normal environment use SAE30 oil. For a 32 ° F and below environment use SAE10 oil.

Oil Level Sight Gauge

The oil level sight gauge can be cleaned by removing it from the air-oil tank and soaking it in a detergent solution. If cleaning the gauge proves unsatisfactory, replace it.

Compressor Oil Filter (Lube Oil Strainer)

The lube oil strainer prevents foreign materials from entering the compressor. The strainer screen must be cleaned at regular intervals.

The screen is easily removed for cleaning by unscrewing the bottom plug. Immerse in solvent and thoroughly clean.

Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel. The strainer screen must be removed and cleaned at regular intervals. The screen should be removed and cleaned thoroughly by immersing it in solvent and blowing it dry with compressed air. Light oil strainers should be cleaned each month. Heavy oil strainers should be checked and cleaned as often as the experience indicates the necessity.

8.16.11 — Gas System



All power must be disconnected before servicing the valves.

Motorized Main Gas Valves

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

Solenoid Valves

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

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

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

8.16.12 — Electrical System

Because of the many types of flame safeguard systems applicable to this equipment, complete descriptions of all E Series burner electrical systems are beyond the scope of this manual. An individual electrical schematic drawing is shipped with each burner and complete operation and troubleshooting instructions are available from the various flame safeguard system manufacturers.

Electric Motors

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

8.16.13 — Extended Shutdown

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



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

8.16.14 — Recommended Maintenance Schedule

Item	Service By	Remarks
DAILY		
Gauges, Monitors, Indicators	Operator	Make visual inspection and record readings in log.
Instrument & Equipment Settings	Operator	Make visual check against recommended specifications.
Low Water, Fuel Cutoff & Alarms	Operator	Refer to instructions.
WEEKLY		
Firing Rate Control	Operator	Verify factory settings.
Igniter	Operator	Make visual inspection. Check flame signal strength.
Pilot & Main Fuel Valves	Operator	Open limit switch. Make audible and visual check. Check valve position indicators, and check fuel meters.
Flame Failure Controls	Operator	Close manual fuel supply for (1) pilot and (2) main fuel cock and/or valve(s). Check safety shutdown timing. Record in log.
Flame Signal Strength Controls	Operator	Read and log the flame signal for both pilot and main flame. Notify Service if readings are very high, very low, or fluctuating.
Linkages	Operator	Check all burner linkage for tightness. Tighten if required.
MONTHLY		
Low Fan Pressure Interlock	Operator	Manually adjust until switch opens.
High & Low Gas Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Scanner & Diffuser	Operator	Check, inspect, and clean for soot buildup.
Pilot Assembly	Operator	Check for loosening of components, erosion, or carbon buildup.
ANNUALLY		
Strainer (Oil Units)	Operator	Replace or clean the oil strainer element.
Impeller	Operator	Inspect and clean the combustion impeller.
Combustion Test	Service Tech	Perform a complete combustion test. Adjust burner if necessary. Read and log data.
Pilot Turndown Test	Service Tech	Required after any adjustment to flame, scanner, or pilot adjustment.
Operating Controls	Service Tech	Refer to instructions.

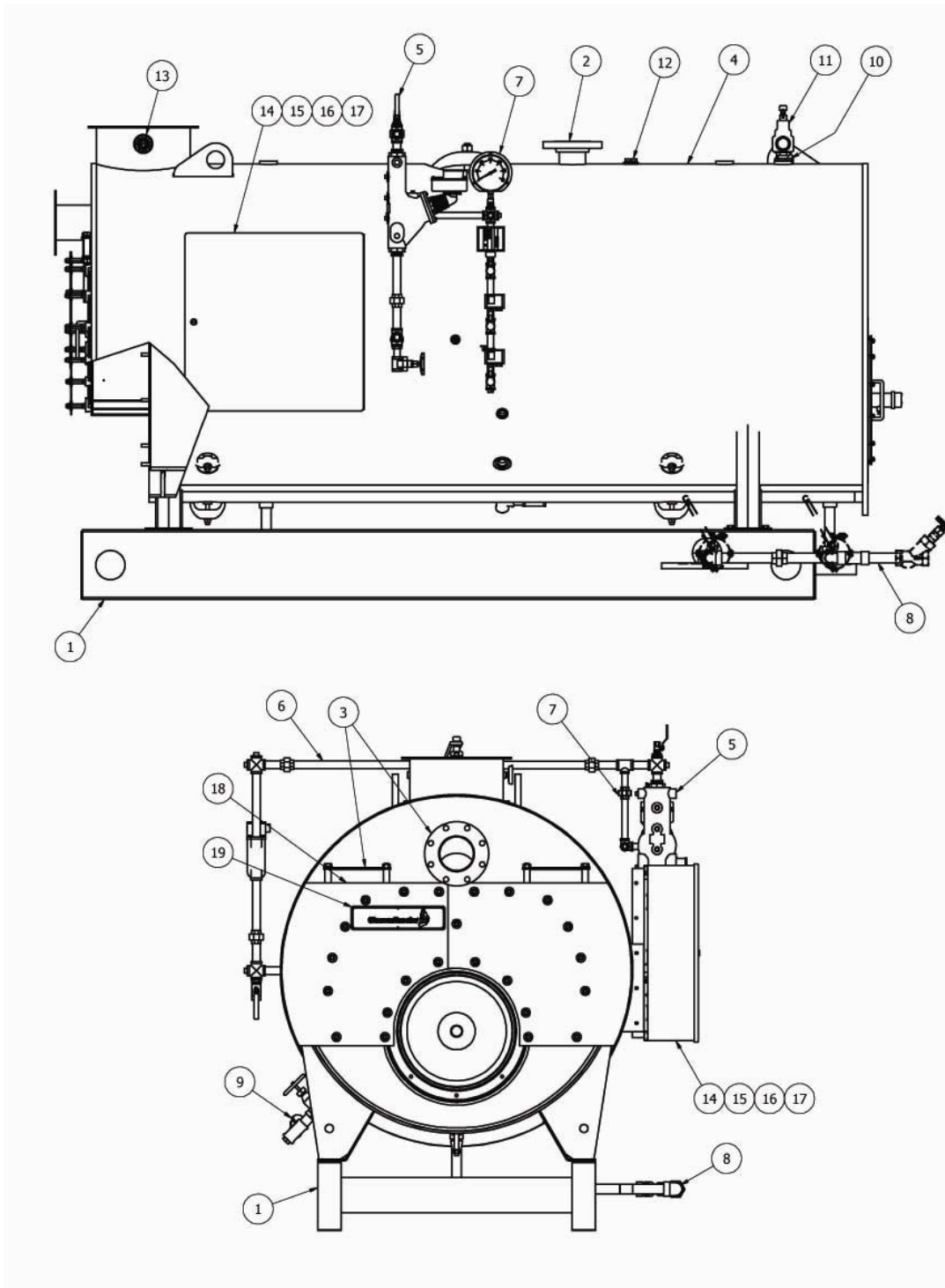
9.1— Ordering Parts

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

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

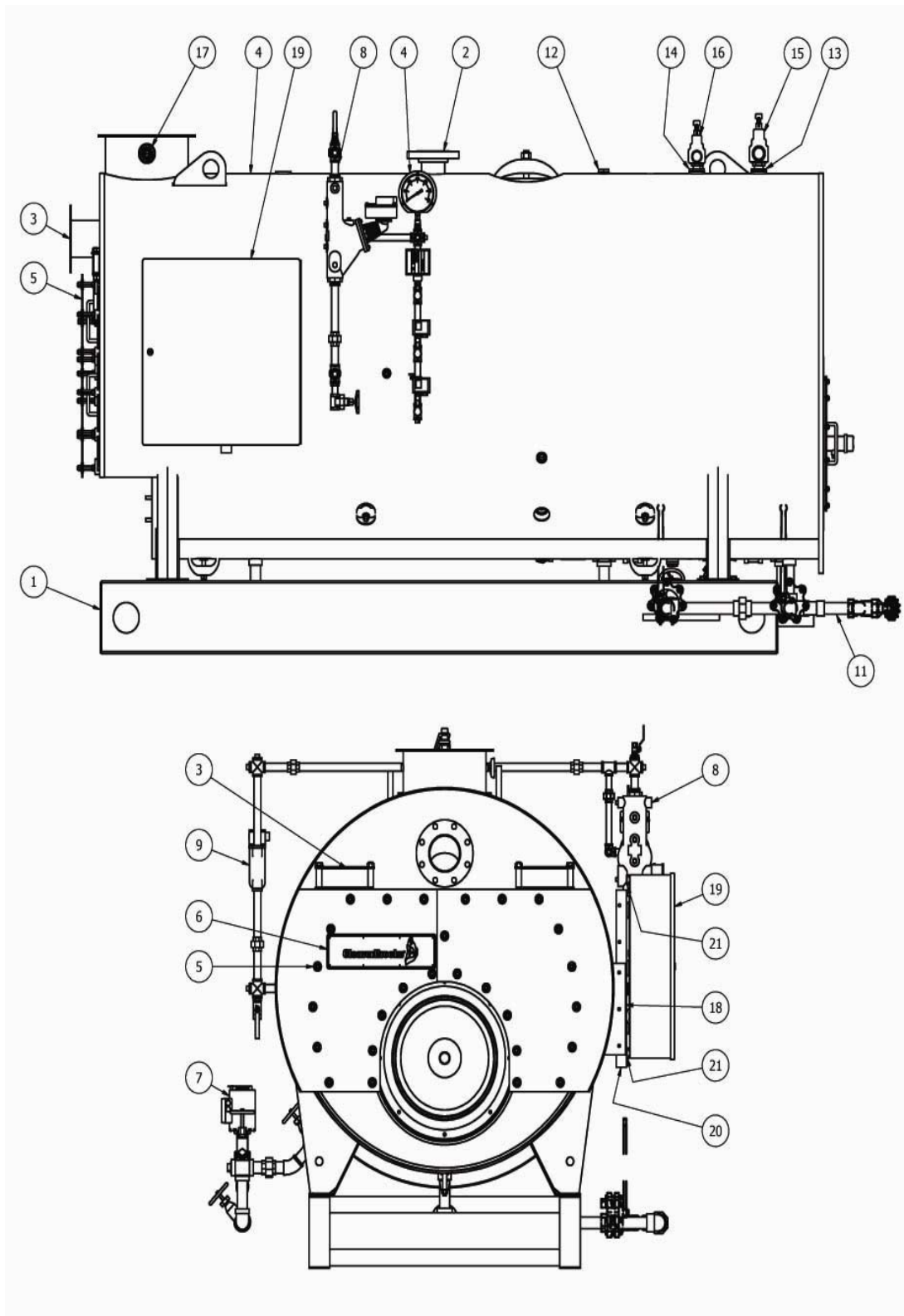
9.2— High Level Assembly

9.2.1— 55"



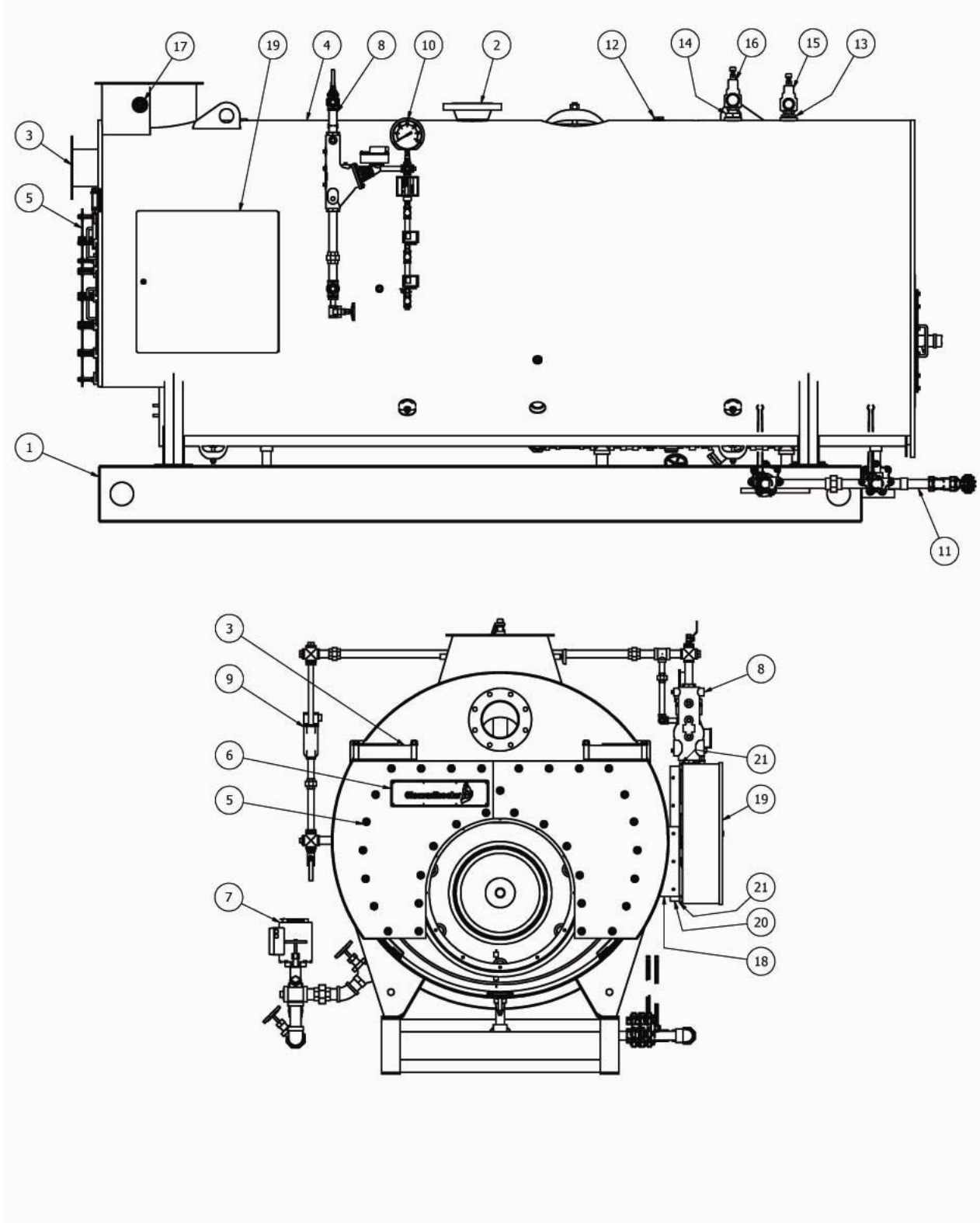
Item	QTY	Part Number	Description
1	1	003-02546-000	Skid Assembly, 100 HP CBEX-Premium
2	1	270-03816-000	Pressure Vessel, 100 HP CBEX-Premium, 150# Steam
3	1	168-00029-000	Smoke Box, Insulated, 55" CBEX-Premium, W/FGR
4	1	465-02738-000	Insulation & Lagging Installation, 100 HP CBEX Boilers
5	1	146-01158-000	Piping, Water Column, LWCO, 55" CBEX 150# MDM 1575-RL
6	1	146-01158-000	Piping, Water Column, ALWCO, 55" CBEX Boilers
7	1	146-01159-000	Piping, Pressure Controls
8	1	146-01162-000	Piping, Blowdown, 100 HP CBEX-Premium
9	1	146-01163-000	Piping, Feedwater, 1-1/4" 150#
10	1	847-00479-000	Bushing, HX HD, 2" X 1-1/4" NPT, 3000#, ASTM A105 Forged Steel
11	1	940-02138-000	Valve, Safety, 1-1/4" X 1-1/2" NPT, Kunkle #6010GFE
12	1	157-02468-000	Fitting, Surface Blowoff, 55" CBEX Boilers
13	1	937-00028-000	Thermometer, 3" Dial, 200-700 F
14	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
15	1	008-04013-000	Bracket, Vertical Support
16	2	976-00642-000	Unistrut 30" LG.
17	1	008-03186-000	Web Plate
18	1	656-09810-000	Heat Shield Installation
19	1	146-00236-000	Name Plates and Tags

9.2.2— 60"



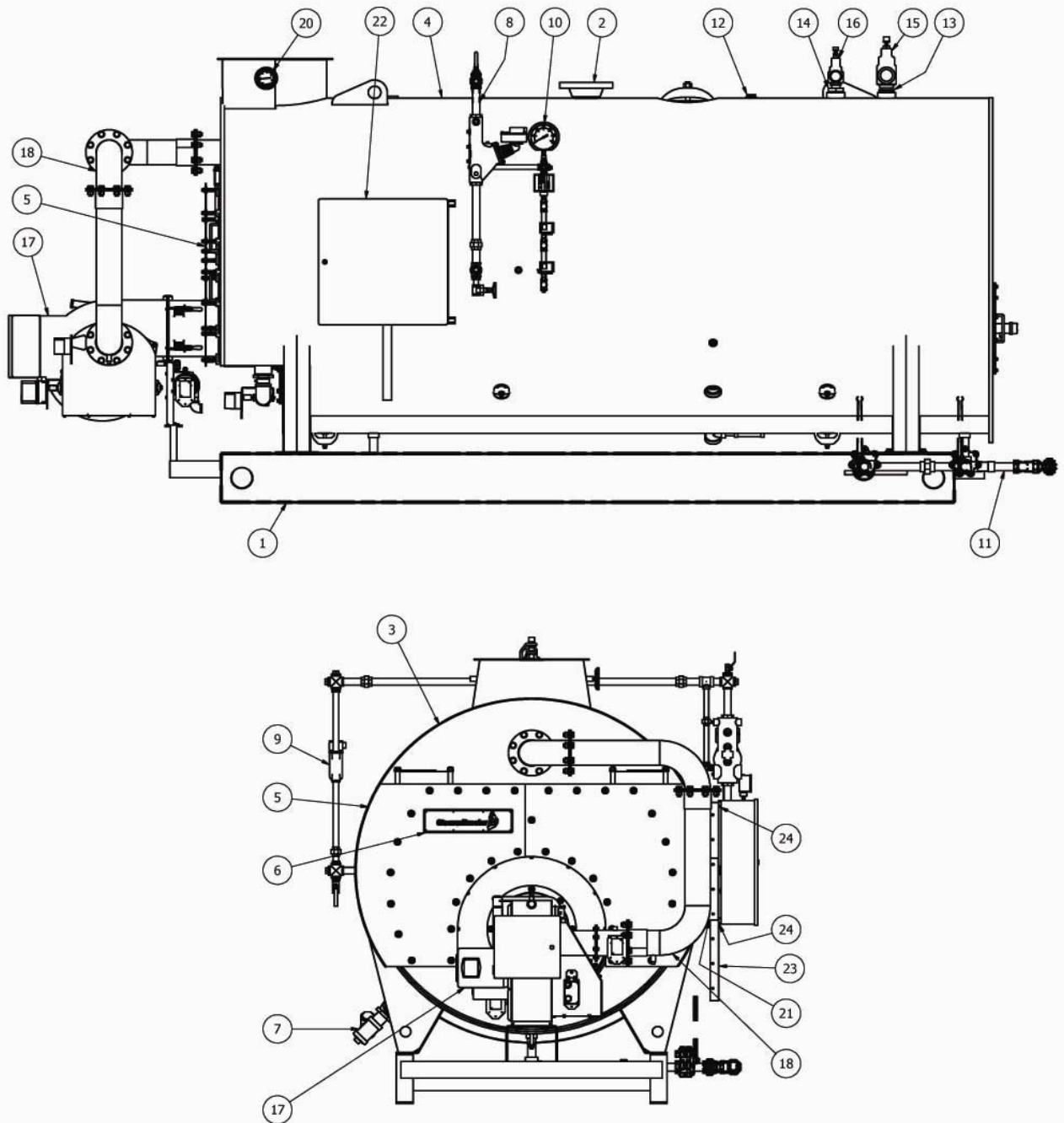
Item	QTY	Part Number	Description
1	1	003-02383-000	Skid Assembly, 150 HP CBEX-Premium
2	1	270-03690-000	Pressure Vessel 150#
3	1	168-00007-000	Smoke Box Assembly
4	1	465-02727-000	Insulation & Lagging Installation
5	1	656-09752-000	Heat Shield Installation, 60" CBEX
6	1	146-00236-000	Nameplates and Tags
7	1	146-01163-000	Piping, Feedwater and Bypass
8	1	146-01158-000	Piping, Water Column, LWCO
9	1	146-01158-000	Piping, Water Column, ALWCO
10	1	146-01159-000	Piping, Pressure Controls
11	1	146-01162-000	Piping, Blowdown, 150 HP CBEX
12	1	157-02150-000	Fitting, Surface Blowoff
13	1	847-00479-000	Bushing, HX HD, 2" X 1-1/4" NPT
14	1	847-00478-000	Bushing, HX HD, 2" X 1" NPT
15	1	940-02138-000	Valve, Safety, 1-1/4" X 1-1/2" NPT, Kunkle #6010GFE
16	1	940-02741-000	Valve, Safety, 1" X 1-1/4" NPT, Kunkle #6010FEE
17	1	937-00028-000	Thermometer, 3" Dial, 200-700 F
18	1	008-03186-000	Web Plate
19	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
20	1	008-04013-000	Bracket, Vertical Support
21	2	976-00642-000	Unistrut 30" LG.

9.2.3— 67"



Item	QTY	Part Number	Description
1	1	003-02409-000	Skid Assembly, 250 HP CBEX
2	1	270-03698-000	Pressure Vessel 150"
3	1	168-00009-000	Smoke Box Assembly
4	1	465-02728-000	Insulation & Lagging Installation
5	1	656-09756-000	Heat Shield Installation, 60" CBEX
6	1	146-00236-000	Nameplates and Tags
7	1	146-01163-000	Piping, Feedwater and Bypass
8	1	146-01158-000	Piping, Water Column, LWCO
9	1	146-01158-000	Piping, Water Column, ALWCO
10	1	146-01159-000	Piping, Water Column, Controls
11	1	146-01162-000	Piping, Blowdown, 250 HP CBEX
12	1	157-02435-000	Fitting, Surface Blowoff
13	1	847-00483-000	Bushing, Reducing, 2-1/2" X 1-1/4" NPT F.S. ANSI B16.11
14	1	847-00484-000	Bushing, HX HD, 2-1/2" X 1-1/2" 3000# FS
15	1	940-02138-000	Valve, Safety, 1-1/4" X 1-1/2" NPT, Kunkle #6010GFE
16	1	940-02109-000	Valve, Safety, 1-1/2" NPT, Kunkle #6010HGE
17	1	937-00028-000	Thermometer, 3" Dial, 200-700 F
18	1	008-03186-000	Web Plate
19	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
20	1	008-04013-000	Bracket, Vertical Support
21	2	976-00642-000	Unistrut 30" LG.

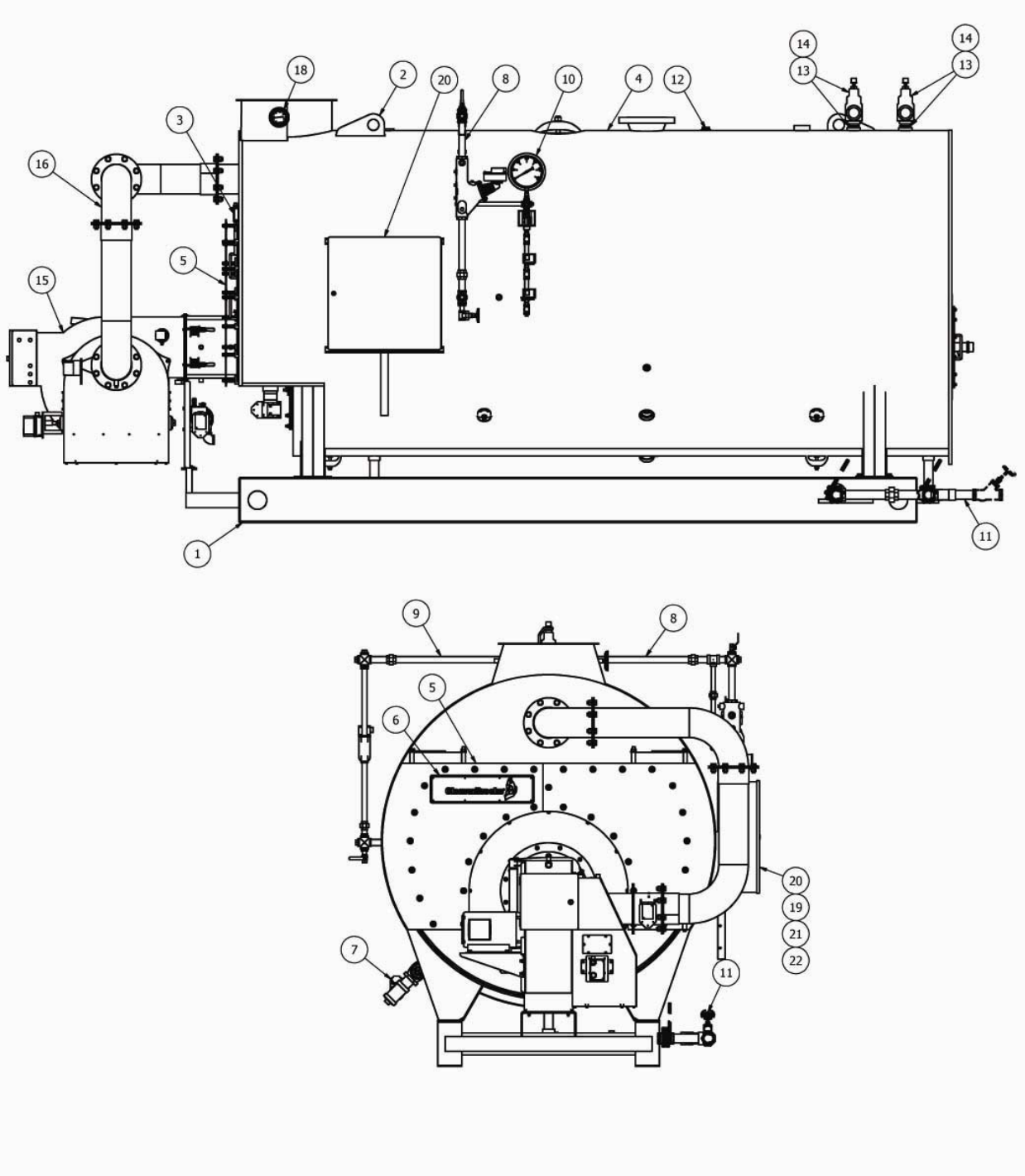
9.2.4— 78"



Item	QTY	Part Number	Description
1	1	003-02363-000	Skid Assembly
2	1	270-03682-000	Pressure Vessel 150#
3	1	SEE TABLE	Smoke Box Assembly
4	1	465-02719-000	Insulation & Lagging Installation
5	1	656-09711-000	Heat Shield Installation, 78" CBEX
6	1	146-00236-000	Nameplates & Tags
7	1	146-01163-000	Feedwater Piping
8	1	146-01158-000	Piping, Water Column, LWCO
9	1	146-01158-000	Piping, Water Column, ALWCO
10	1	146-01159-000	Piping, Water Column, Controls
11	1	146-01162-000	Piping, Blowdown
12	1	157-01886-000	Fitting, Surface Blowoff
13	1	847-00487-000	Bushing, Reducing, Hex HD., 3" NPT X 2" NPT
14	1	847-00486-000	Bushing, Hex HD., 3" X 1-1/2" 3000# FS
15	1	940-02108-000	Valve Safety, 2" NPT, Kunkle #6010JHE
16	1	940-02109-000	Valve Safety, 1-1/2" NPT, Kunkle #6010HGE
17	1	146-00578-000	Install, IC Burners
18	1	146-00579-000	Install, FGR Piping for IC Burners
19	1		N/A
20	1	937-00145-000	Thermometer, 5" Dial, 200-700 F
21	1	008-03186-000	Web Plate
22	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
23	1	008-00275-000	Vertical Support
24	2	976-00642-000	Unistrut 32" Lg.

HP	NOx	FGR Size	Item #3
350	STD	N/A	168-00016-000
	30	6"	168-00014-000
	9	10"	168-00015-000
400	STD	N/A	168-00016-000
	30	8"	168-00003-000
	9	10"	168-00015-000

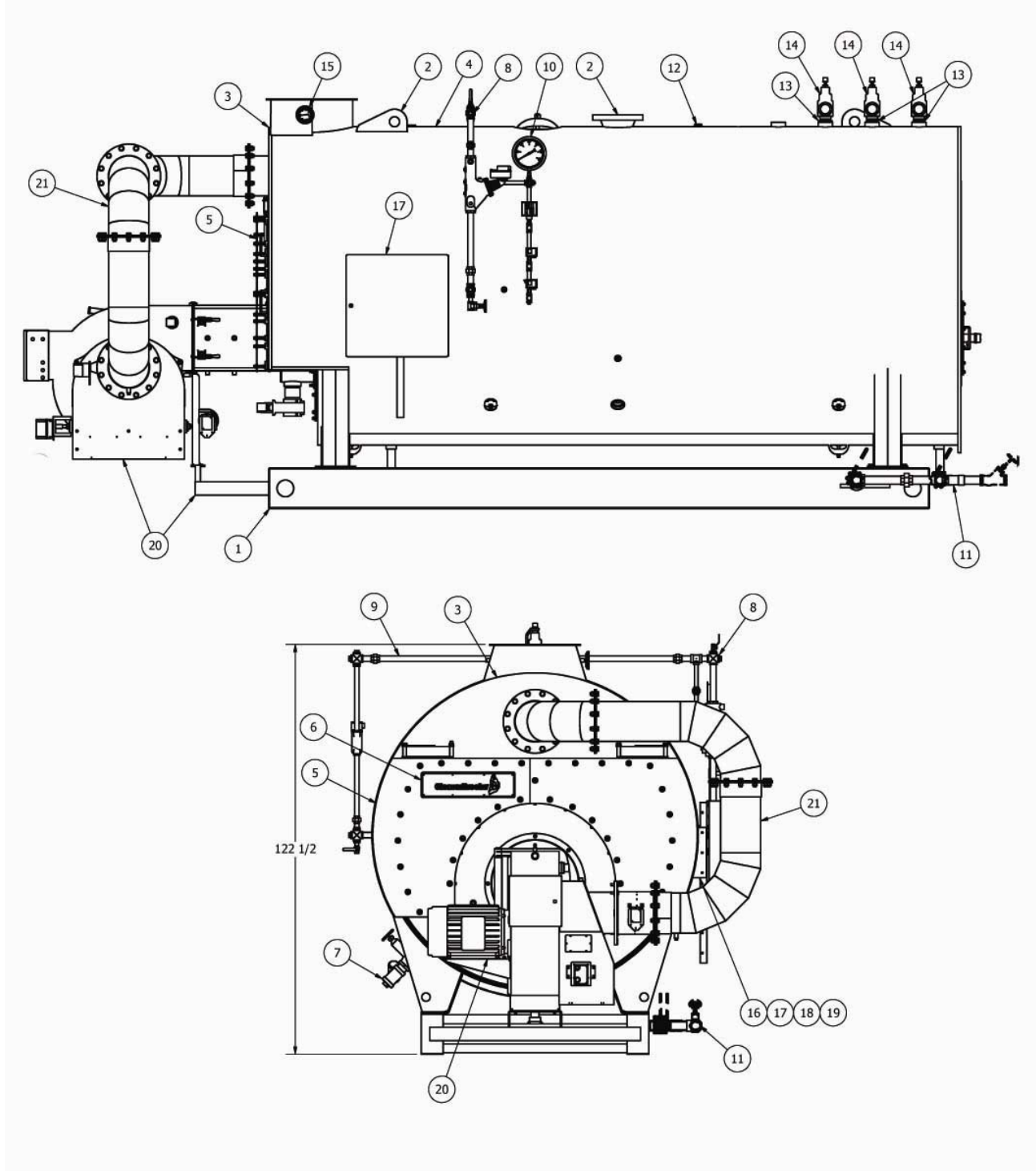
9.2.5— 85"



Item	QTY	Part Number	Description
1	1	003-02349-000	Skid Assembly
2	1	270-03658-000	Pressure Vessel 150#
3	1	SEE TABLE	Smoke Box Assembly
4	1	465-02713-000	Insulation & Lagging Installation
5	1	656-09707-000	Heat Shield Installation, 85" CBEX
6	1	146-00236-000	Nameplates & Tags
7	1	146-01163-000	Feedwater Piping 85"
8	1	146-01158-000	Piping, Water Column, LWCO
9	1	146-01158-000	Piping, Water Column, ALWCO
10	1	146-01159-000	Piping, Water Column, Controls
11	1	146-01162-000	Piping, Blowdown
12	1	157-02424-000	Fitting, Surface Blowoff
13	2	847-00485-000	Bushing, Reducing, Hex HD., 2-1/2" X 2" NPT, 3000#
14	2	940-02108-000	Valve Safety, 2" NPT, Kunkle #6010JHE
15	1	146-00578-000	Install, IC Burner
16	1	146-00579-000	Install, FGR Piping for IC Burner
17			N/A
18	1	937-00145-000	Thermometer, 5" Dial, 200-700 F
19	1	008-03186-000	Web Plate
20	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
21	1	008-00275-000	Vertical Support
22	2	976-00642-000	Unistrut 32" Lg.

HP	NOx	FGR Size	Item #3
500	STD	N/A	168-00019-000
	30	8"	168-00020-000
	9	10"	168-00001-000
600	STD	N/A	168-00019-000
	30	8"	168-00020-000
	9	10"	168-00001-000

9.2.6— 92"

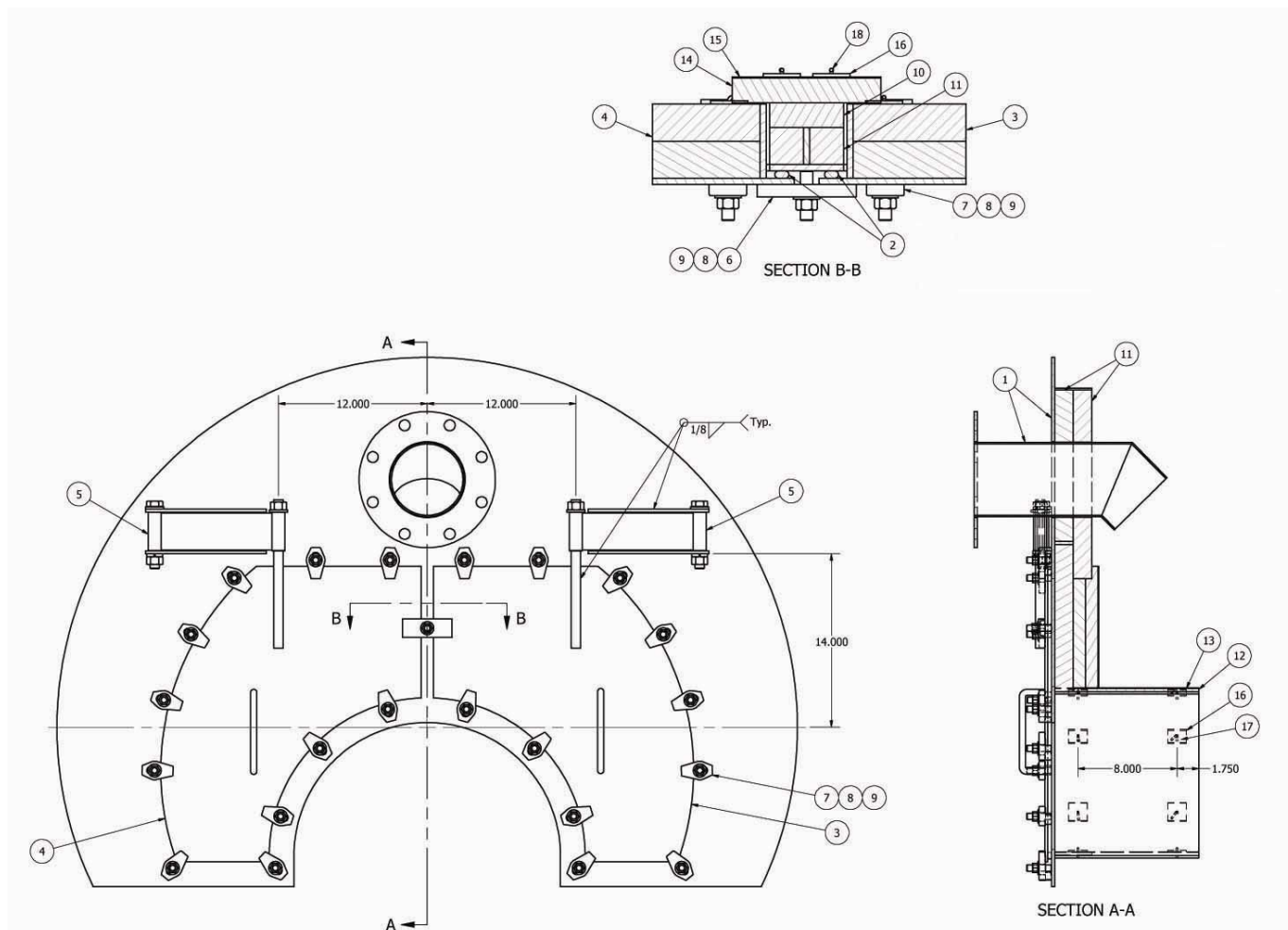


Item	QTY	Part Number	Description
1	1	003-02380-000	Skid Assembly, 700-800 HP
2	1	270-03665-000	Pressure Vessel 150#
3	1	SEE TABLE	Smoke Box Assembly
4	1	465-02726-000	Insulation & Lagging Installation
5	1	656-09734-000	Heat Shield Installation, 92" CBEX
6	1	146-00236-000	Nameplates & Tags
7	1	146-01163-000	Feedwater Piping, 2-1/2", 0-150#
8	1	146-01158-000	Piping, Water Column, LWCO
9	1	146-01158-000	Piping, Water Column, ALWCO
10	1	146-01159-000	Piping, Water Column, Controls
11	1	146-01162-000	Piping, Blowdown
12	1	157-01869-000	Fitting, Surface Blowoff
13	3	847-00487-000	Bushing, Reducing, Hex HD., 3" X 2" NPT
14	3	940-02108-000	Valve Safety, 2" NPT, Kunkle #6010JHE
15	1	937-00145-000	Thermometer, 5" Dial, 200-700 F
16	1	008-03186-000	Web Plate
17	1	848-01093-000	Panel, 30" X 30" X 8-5/8", NEMA 1
18	1	008-00275-000	Vertical Support
19	2	976-00642-000	Unistrut, 30" Lg.
20	1	146-00578-000	Install, IC Burner
21	1	146-00579-000	Install, FGR Piping for IC Burner

HP	NOx	FGR Size	Item #3
700	STD	N/A	168-00024-000
	30	12"	168-00025-000
	9	12"	168-00025-000
800	STD	N/A	168-00024-000
	30	12"	168-00025-000
	9	14"	168-00026-000

9.3— Front Smoke Box

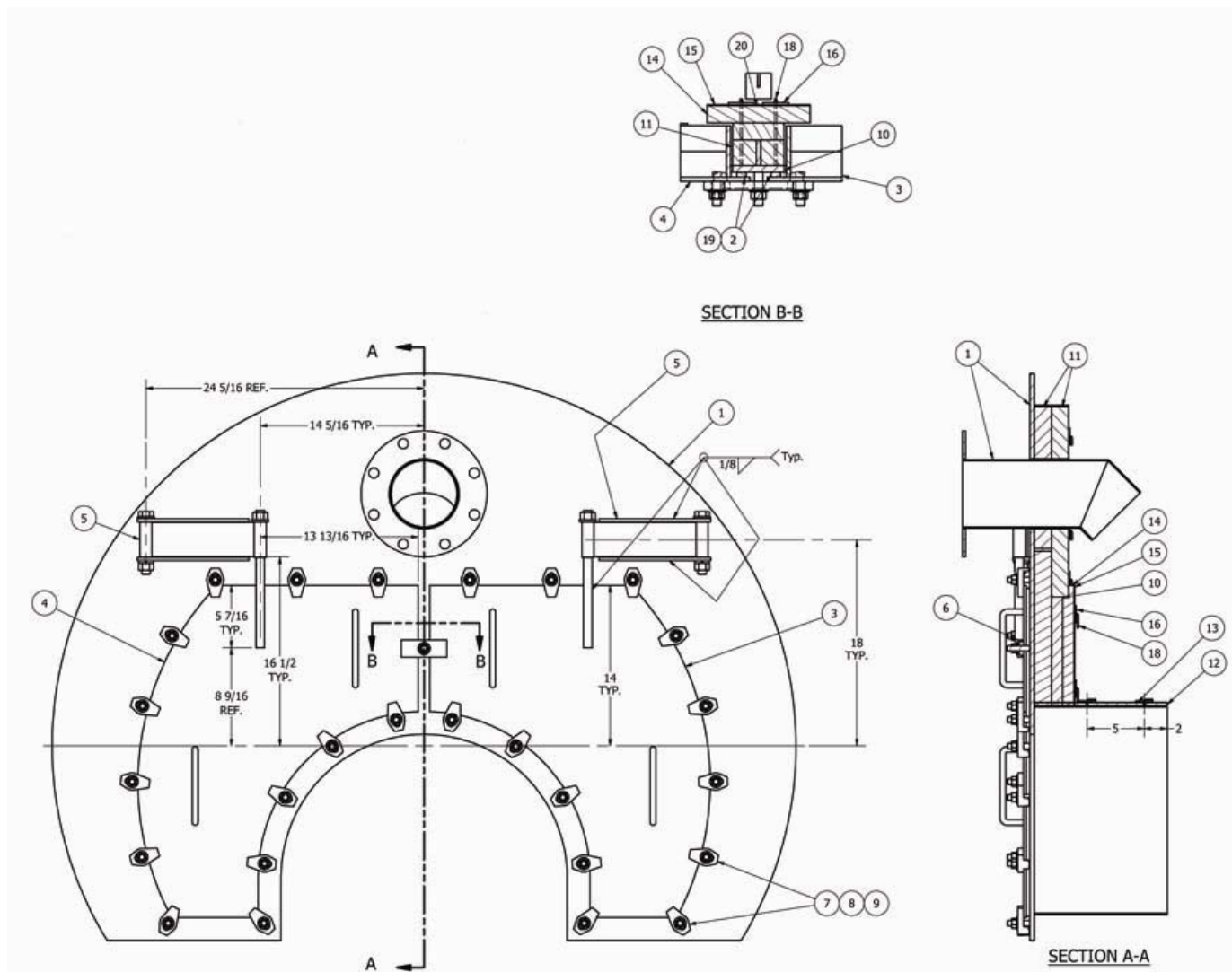
9.3.1— 55"



Item	QTY	Part Number	Description
1	1	168-00030-000	Smoke Box Weldment, 55" CBEX Premium with FGR
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 74" Lg.
3	1	132-02748-000	Door, Front Smoke Box, RH, 55" CBEX Premium
4	1	132-02749-000	Door, Front Smoke Box, LH, 55" CBEX Premium
5	2	462-00024-000	Davit, Front Door, 60"
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	22	103-00375-000	Locking Lug
8	23	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	23	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.18 Sq. Ft. Ea.)

Item	QTY	Part Number	Description
11	2	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (6.03 Sq. Ft. Ea.)
12	1	872-01081-000	Wet Felt, 1/4" X 11-5/8" X 66" Lg. Superwool 607 (5.3 Sq. Ft.)
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 11-5/8" X 66" Lg. 304 SS (765 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 9-7/8" Lg. Superwool 607 (.41 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 9-7/8" S.S. (60 Sq. In.)
16	38	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	34	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

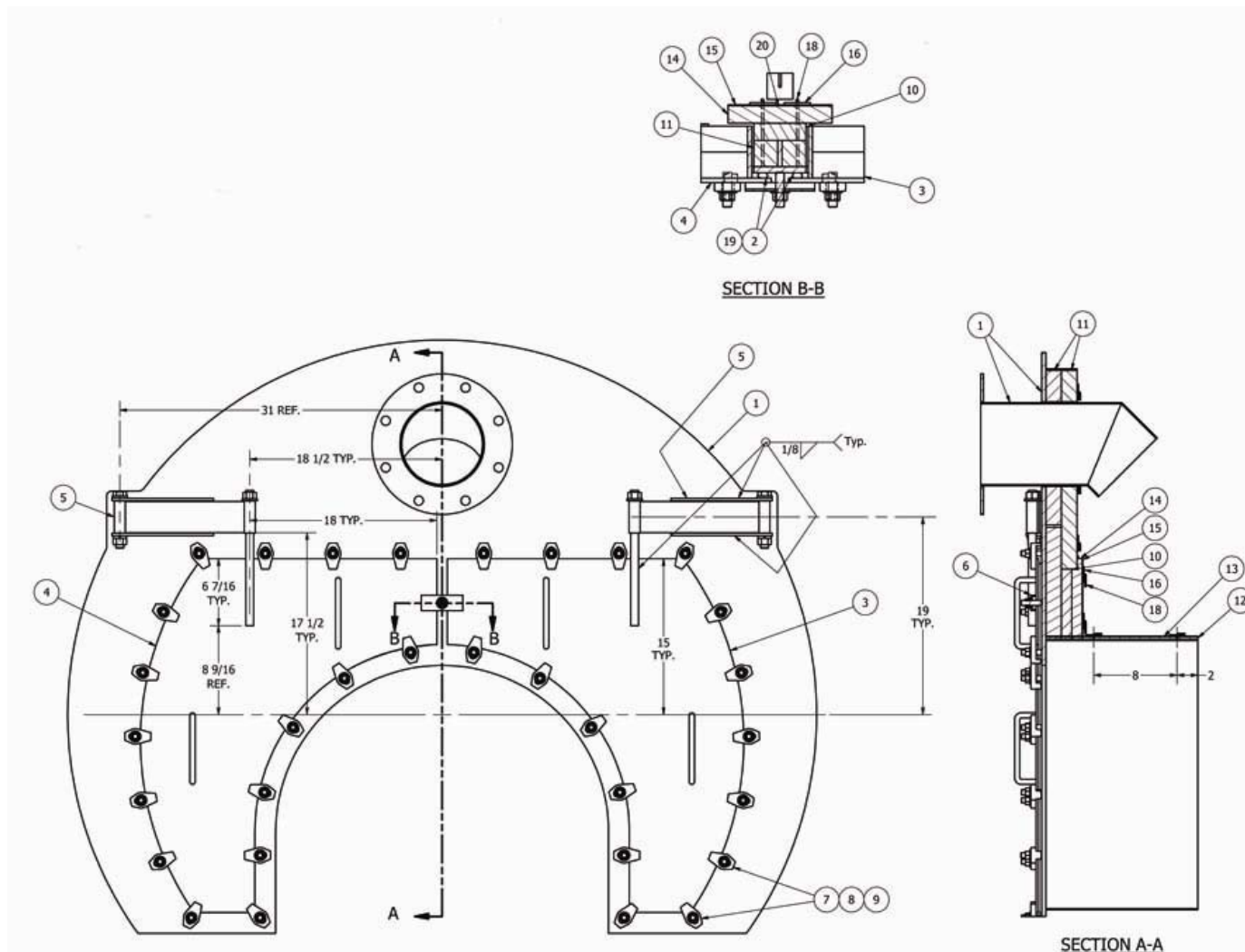
9.3.2— 60"



Item	QTY	Part Number	Description
1	1	168-00008-000	Smoke Box Weldment, 60"
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 89" Lg.
3	1	132-02708-000	Door, Front Smoke Box, RH.
4	1	132-02709-000	Door, Front Smoke Box, LH.
5	2	462-00024-000	Davit, Front Door, 60"
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	26	103-00375-000	Locking Lug
8	27	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	27	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.2 Sq. Ft.)

Item	QTY	Part Number	Description
11	2	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (7.5 Sq. Ft.)
12	1	872-01081-000	Wet Felt, 1/4" X 11-5/8" X 75" Lg. Superwool 607 (6.1 Sq. Ft.)
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 11-5/8" X 75" Lg. 304 SS (872 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 9-7/8" Lg. Superwool 607 (.41 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 10-1/2" S.S. (63 Sq. In.)
16	48	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	44	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

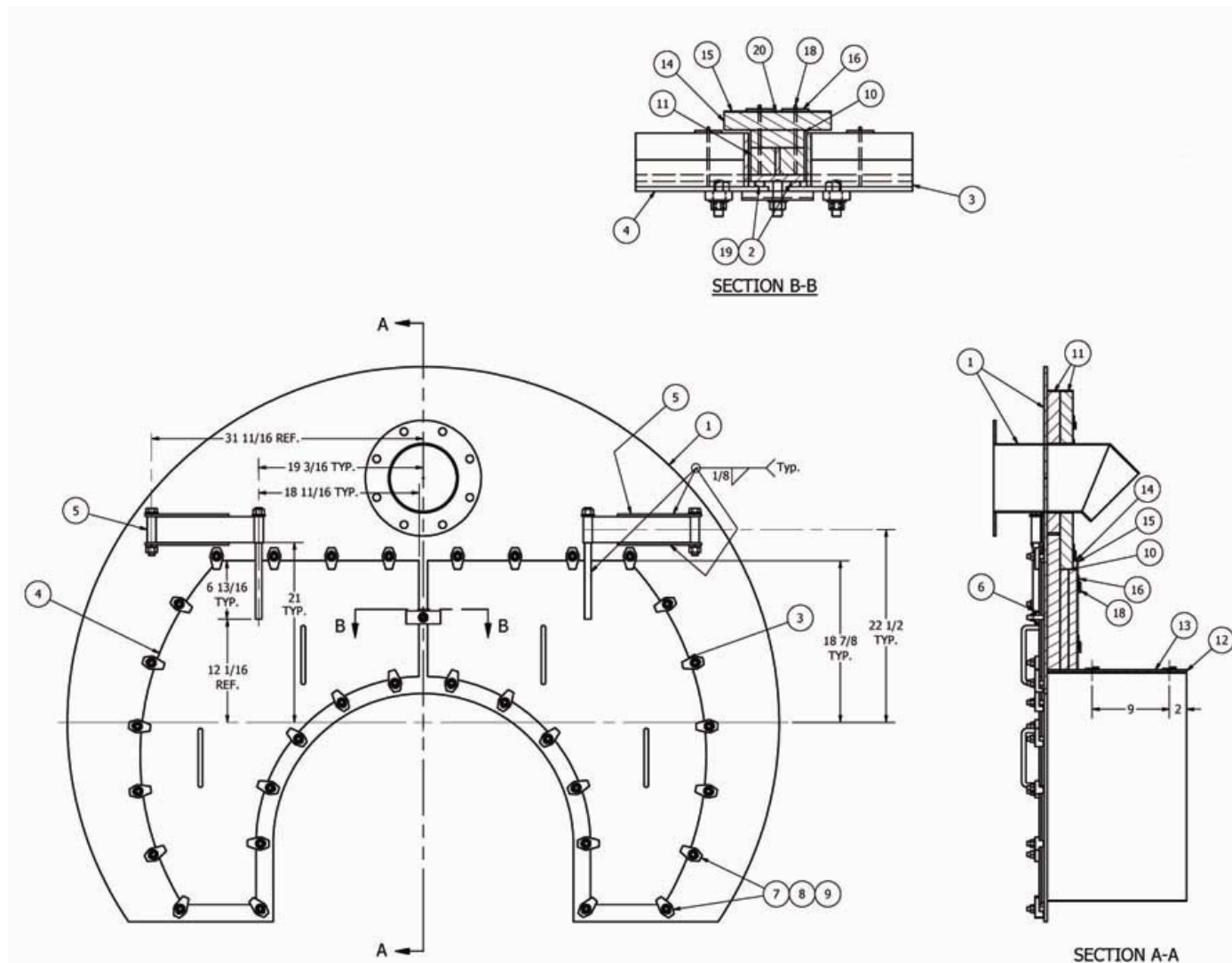
9.3.3— 67"



Item	QTY	Part Number	Description
1	1	168-00010-000	Smoke Box Weldment, 67"
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 105" Lg.
3	1	132-02716-000	Door, Front Smoke Box, RH.
4	1	132-02717-000	Door, Front Smoke Box, LH.
5	2	462-00025-000	Davit, Front Door, 78"
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	32	103-00375-000	Locking Lug
8	33	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	33	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.2 Sq. Ft.)
11	2	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (7.9 Sq. Ft.)

Item	QTY	Part Number	Description
12	1	872-01081-000	Wet Felt, 1/4" X 14-5/8" X 90-1/2" Lg. Superwool 607 (9.2 Sq. Ft.)
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 14-5/8" X 90-1/2" Lg. 304 SS (1324 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 7-3/4" Lg. Superwool 607 (.32 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 7-3/4" S.S. (46.5 Sq. In.)
16	50	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	46	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

9.3.4— 78"

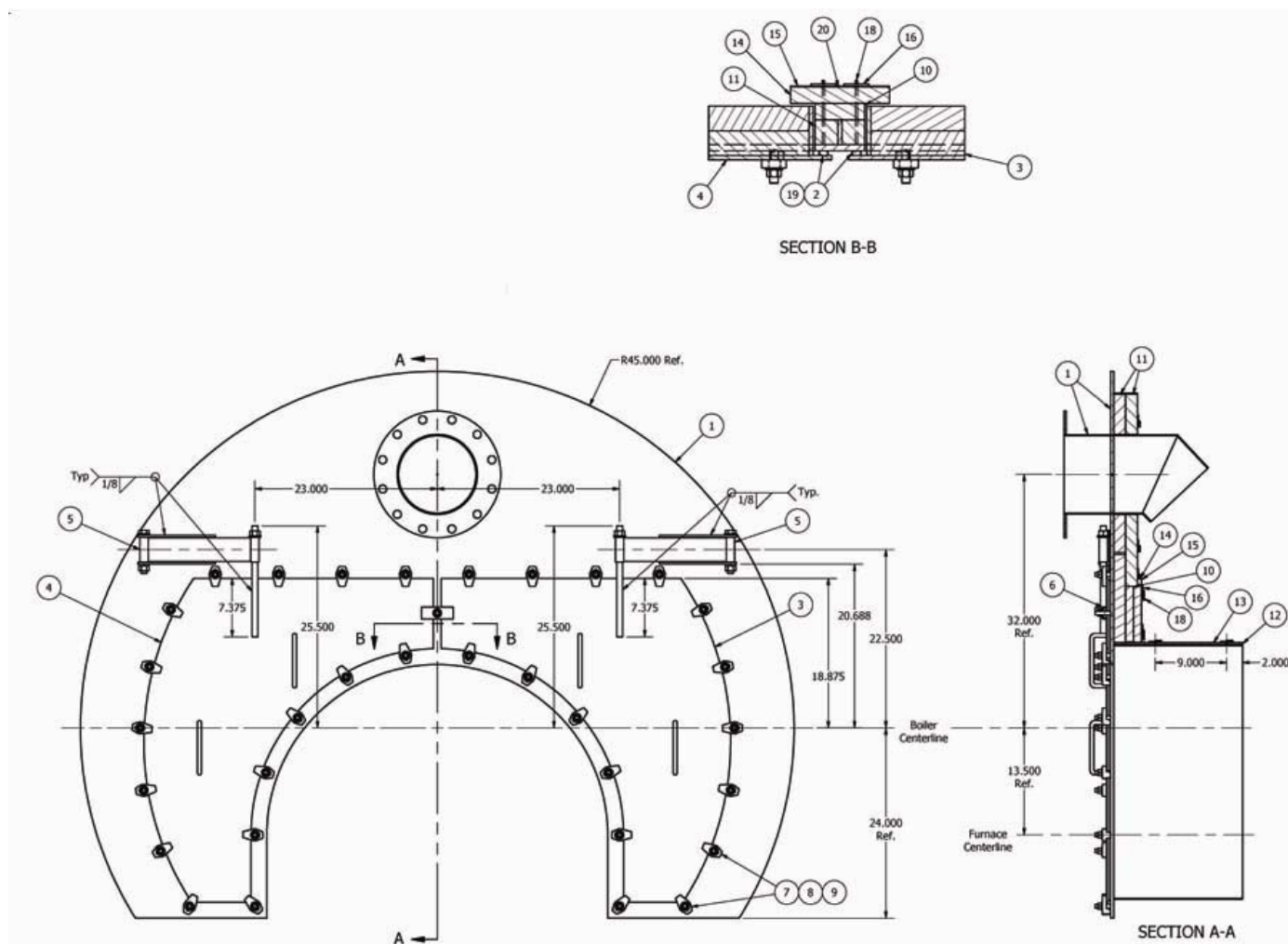


Item	QTY	Part Number	Description
1	1	SEE TABLE	Smoke Box Weldment, 78"
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 122" Lg.
3	1	132-02697-000	Door, Front Smoke Box, RH.
4	1	132-02698-000	Door, Front Smoke Box, LH.
5	2	462-00025-000	Davit, Front Door, 78"
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	32	103-00375-000	Locking Lug
8	33	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	33	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.24 Sq. Ft.)

Item	QTY	Part Number	Description
11	2	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (10.5 Sq. Ft.)
12	1	872-01081-000	Wet Felt, 1/4" X 16-1/4" X 101-1/4" Lg. Superwool 607 (13.2 Sq. Ft.)
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 16-1/4" X 101-1/4" Lg. 304 SS (1645 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 12-3/4" Lg. Superwool 607 (.53 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 12-3/4" S.S. (76.5 Sq. In.)
16	50	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	46	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

Assembly Part Number	Item 1 Part Number	FGR Size
168-00016-000	168-00013-000	N/A
168-00014-000	168-00011-000	6"
168-00003-000	168-00004-000	8"
168-00015-000	168-00012-000	10"

9.3.5— 85"

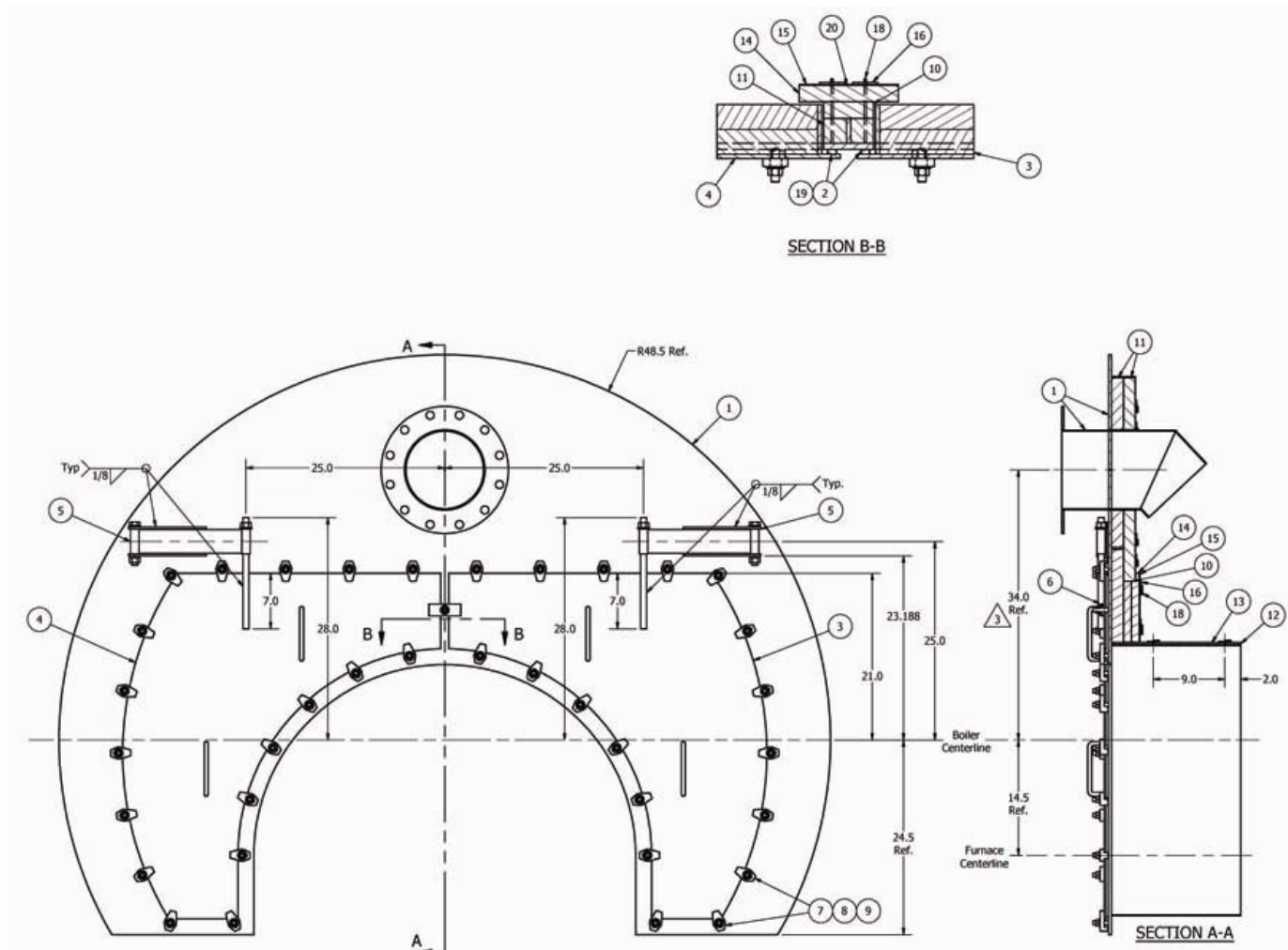


Item	QTY	Part Number	Description
1	1	SEE TABLE	Smoke Box Weldment, 85"
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 131" Lg.
3	1	132-02690-000	Door, Front Smoke Box, RH.
4	1	132-02691-000	Door, Front Smoke Box, LH.
5	2	462-00099-000	Davit, Front Door & Rear Door
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	32	103-00375-000	Locking Lug
8	33	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	33	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.15 Sq. Ft.)
11	1	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (13.2 Sq. Ft.)
12	1	872-01081-000	Wet Felt, 1/4" X 16-1/4" X 115-3/4" Lg. Superwool 607 (13.2 Sq. Ft.)

Item	QTY	Part Number	Description
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 16-1/4" X 116-1/2" Lg. 304 SS (1893 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 8" Lg. Superwool 607 (.33 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 8" S.S. (48 Sq. In.)
16	50	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	46	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

Assembly Part Number	Item 1 Part Number	FGR Size
168-00019-000	168-00017-000	N/A
168-00020-000	168-00018-000	8"
168-00001-000	168-00002-000	10"

9.3.6— 92"

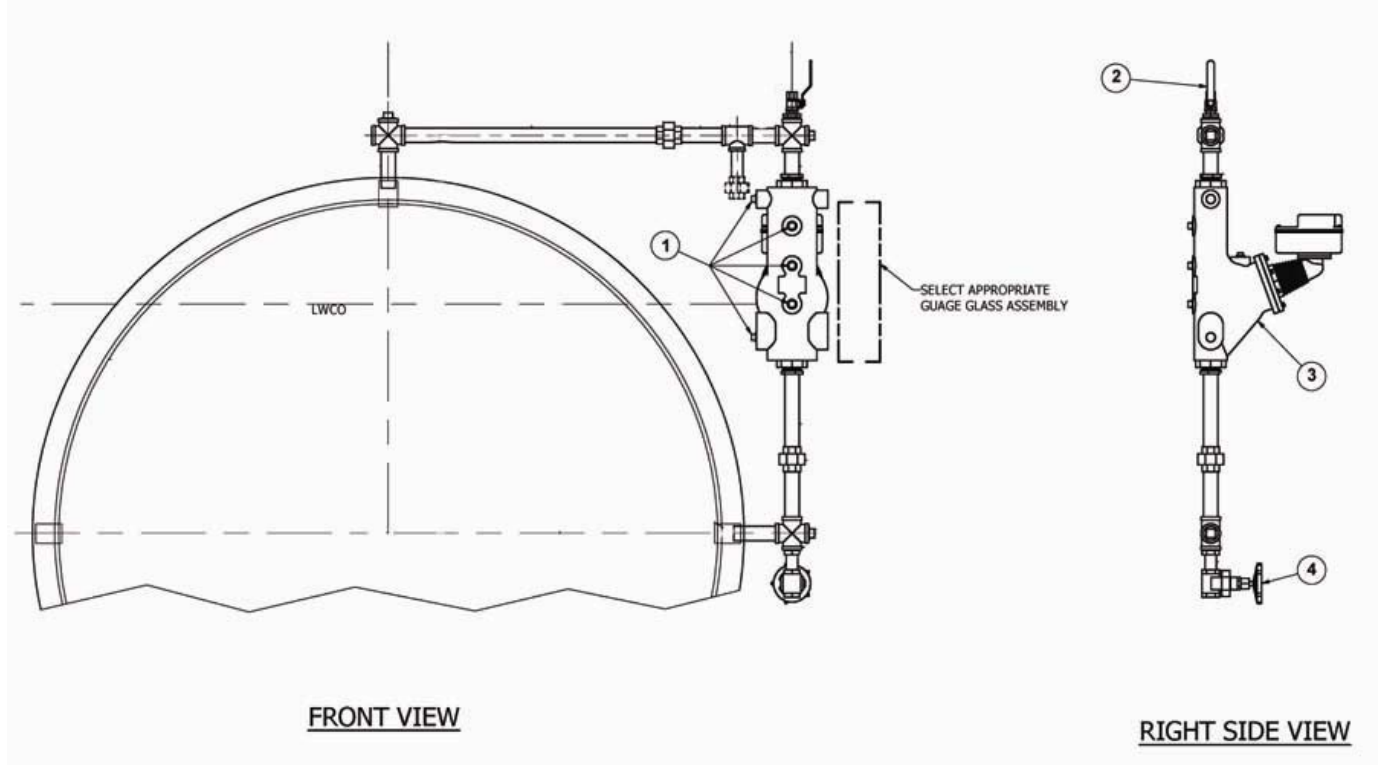


Item	QTY	Part Number	Description
1	1	SEE TABLE	Smoke Box Weldment, 92"
2	2	872-00622-000	Rope, Fiberfax, 2300 Deg. 1/2" Dia. X 142" Lg.
3	1	132-02705-000	Door, Front Smoke Box, RH.
4	1	132-02706-000	Door, Front Smoke Box, LH.
5	2	462-00099-000	Davit, Front Door & Rear Door
6	1	149-00917-000	Sized Channel, 1-1/2" X 1/2" X 1/8" X 4" Lg. A575 Gr. M1020 Steel
7	36	103-00375-000	Locking Lug
8	37	952-00108-000	Washer, Flat, 1/2" S.A.E. Plain Steel
9	37	869-00015-000	Nut, Hex Hd. 1/2-13 UNC ASTM A563 Gr. A
10	1	872-01007-000	Insulation Board, 1" 1900 Deg. Geminite 19 Series (.17 Sq. Ft.)
11	1	872-01008-000	Insulating Board, 1-1/2" 1900 Deg. Geminite 19 Series (14.2 Sq. Ft.)
12	1	872-01081-000	Wet Felt, 1/4" X 16-1/4" X 115-3/4" Lg. Superwool 607 (13.2 Sq. Ft.)

Item	QTY	Part Number	Description
13	1	930-00135-000	Wire Mesh, 18 Ga. X 1/2" Mesh X 16-1/4" X 116-1/2" Lg. 304 SS (1893 Sq. In.)
14	1	872-01082-000	Insulating Blanket, 1" Thk. X 6" X 8" Lg. Superwool 607 (.35 Sq. Ft.)
15	1	930-00135-000	Wire Mesh, 1/2" Mesh X 18 Ga. X 6" X 8-11/16" S.S. (52 Sq. In.)
16	52	828-00034-000	Clip, Insulation Retainer, 1-1/2" Sq. X 10 Ga. S.S.
17	48	903-00299-000	Pin, Welding, 10 Ga. X 4" Lg. S.S.
18	4	903-00298-000	Pin, Welding, 10 Ga. X 5" Lg. S.S.
19	1	797-01813-000	Super Tack Adhesive
20	6 oz.	872-00443-000	Rigidizer
21	1	872-00757-000	Insulation, Fibrefrax Caulk, Tube

Assembly Part Number	Item 1 Part Number	FGR Size
168-00024-000	168-00021-000	N/A
168-00005-000	168-00006-000	10"
168-00025-000	168-00022-000	12"
168-00026-000	168-00023-000	14"

9.4— Low Water Cutoff



Item	QTY	Part Number	Description
1	5	858-00266-000	Pipe Plug, Sq. Hd., 1/2" NPT, F.S., A-105
2	1	941-00055-000	Valve, Ball, 1/4" NPT
3	1	817-02405-000	Control, Pump & LWCO, MCDM 157S-RL
4	1	941-00170-000	Valve, Gate, BR, 3/4" TE, 300#



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