CLEAVER-BROOKS

MODEL CEW

ProFire™ PACKAGED BOILER

Operation, Service, and Parts Manual

125 through 800 HP
Ohio Special 100 through 225 HP
Fuel: Light Oil, Gas or Combination

Manual Part No. 750-179 R1
1/99

CleaverBrooks

SAFETY PRECAUTIONS AND ABBREVIATIONS

Safety Precautions

It is essential to read and understand the following safety precautions before attempting to operate the equipment. Failure to follow these precautions may result in damage to equipment, serious personal injury, or death. A complete understanding of this manual is required before attempting to start-up, operate or maintain the equipment. The equipment should be operated only by personnel who have a working knowledge and understanding of the equipment.

The following symbols are used throughout this manual:

⚠ WARNING

This symbol indicates a potentially hazardous situation which, if not avoided, could result in serious personal injury, or death.

⚠ CAUTION

This symbol indicates a potentially hazardous situation which, if not avoided, could result in damage to the equipment.

Note: This symbol indicates information that is vital to the operation of this equipment.

Abbreviations

Following is an explanation of the abbreviations, acronyms, and symbols used in this manual.

AC	Alternating Current
AR	Automatic Reset
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHP	Boiler Horsepower
BTU	British Thermal Unit
°C	Degrees Celsius
CFH	Cubic Feet per Hour
Cu Ft	Cubic Feet
DC	Direct Current
°F	Degrees Fahrenheit
FM	Factory Mutual
FS	Flame Safeguard
ft	Feet
GPM	Gallons per Minute
Hd	Head
HT	Height
HTB	High Turndown Burner
HZ	Hertz
In W.C.	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LWCO	Low-Water cutoff
M	Million
MFD	Micro-Farad
MR	Manual Reset
NEC	National Electric Code
No.	Number
pH	Measure of the degree of acid or base of a solution
P/N	Part Number
PPM	Parts Per Million
PR	Program Relay
psi	Pounds Per Square Inch
SAE	Society of Automotive Engineers
scfh	Standard Cubic Feet per Hour
T	Temperature
TC	Temperature Control
TI	Temperature Gauge

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Please direct purchase orders for replacement manuals to your local Cleaver-Brooks authorized representative

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Printed in U.S.A.

⚠ WARNING

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

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

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

TO: Owners, Operators and/or Maintenance Personnel

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

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

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

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

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

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

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

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

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check 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.

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

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

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CHAPTER 1

Basics of Firetube Operation

A. GENERAL

Firetube boilers are available for low or high pressure steam, or for hot water applications. Firetube boilers are typically used for applications ranging from 15 to 800 horsepower. A firetube boiler is a cylindrical vessel, with horizontal tubes passing through and connected to the front and rear tube sheets. The vessel contains the water and absorbs the energy generated from the flame. The front door and rear door provide the seal to contain the hot combustion gasses. Baffles designed into the doors serve to redirect the combustion gasses through the various firetube passages. The flame originates in the furnace. As the combustion gasses travel down the furnace and through the various firetube channels, heat from the flame and combustion gasses 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 process, laundry, kitchen, etc. The nature of the facility's operation will dictate whether a steam or hot water boiler should be used.

The general information in this manual applies directly to Cleaver-Brooks Model CEW Boilers in sizes ranging from 125 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 Only

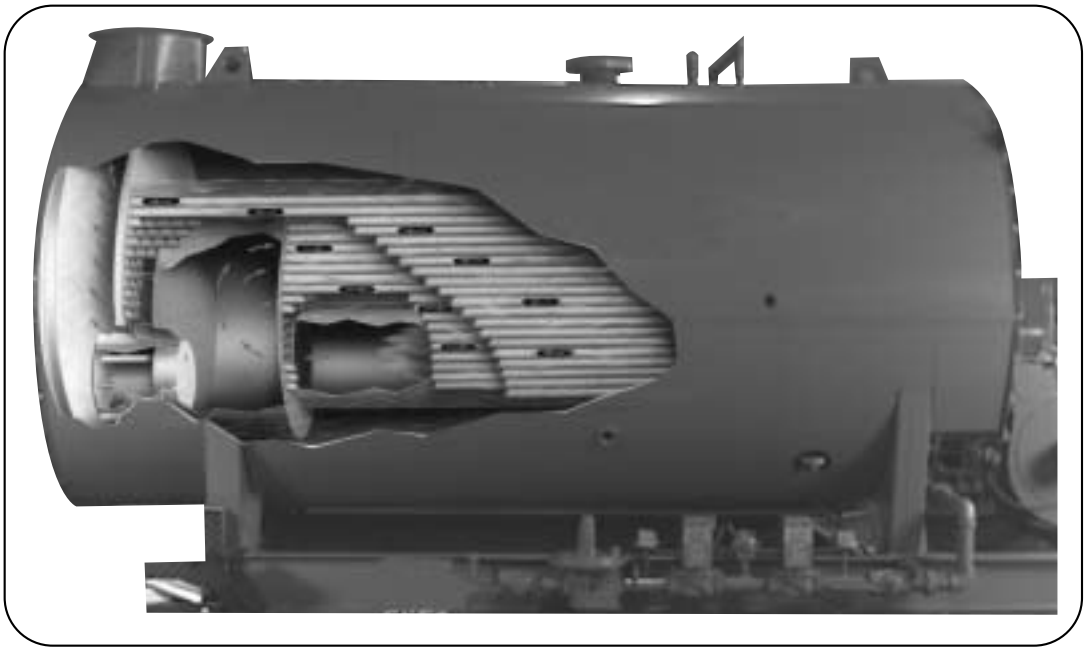


Figure 1-1: CEW Firetube Cut Away

Rated Capacity	125 through 800 hp
Operating Pressure	Steam 15-225 psig Hot Water 30-125 psig
Fuel	Light Oil or Gas or Combination
Ignition	Automatic
Firing 125-800 hp	Full Modulation
Burner (Oil)	No. 2 oil, 125-200 hp: Pressure atomization No. 2 oil, 250-800 hp: Air atomization
Burner (Gas)	Non-premix, Orificed Type
Air Shutter	Louver Type (Electrically Modulated)
Steam Trim	ASME Code
Water Trim	ASME Code

Note: For Ohio Special Rated Capacity information see Appendix A.

Always order genuine Cleaver-Brooks parts from your local Cleaver-Brooks authorized representative.

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

B. THE BOILER

The Model CEW boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, burner accessories, refractory, and appropriate boiler trim.

The horsepower rating of the boiler is indicated by the numbers following the fuel series. Thus, CEW700-250 indicates a gas-fired 250 hp boiler.

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

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

Hot water is commonly used in heating applications with the boiler supplying 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.

Steam boilers are designed for low pressure or high pressure applications. Low pressure boilers are limited to 15 psig design, and are typically used for heating applications. High pressure boilers are typically used for process loads and can have a design pressure of 75 to 250 psig.

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

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

⚠ CAUTION

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

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

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. Constant attention to water requirements will pay dividends in the form of longer life, less down-time, and prevention of costly repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove accumulations is described in Chapter 3.

The operator should be familiar with Chapter 3 before attempting to place the unit into operation.

C. CONSTRUCTION

Steam boilers designed for operating at 15 psig and hot water boilers designed for 250°F at 125 psi or less are constructed in accordance with Section IV, Power 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.

D. STEAM CONTROLS (ALL FUELS)

1. Operating Limit Pressure Control (Figure 1-4): Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
2. High Limit Pressure Control (Figure 1-4): 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.
3. Modulating Pressure Control (Figure 1-4): Senses changing boiler pressures and transmits the information

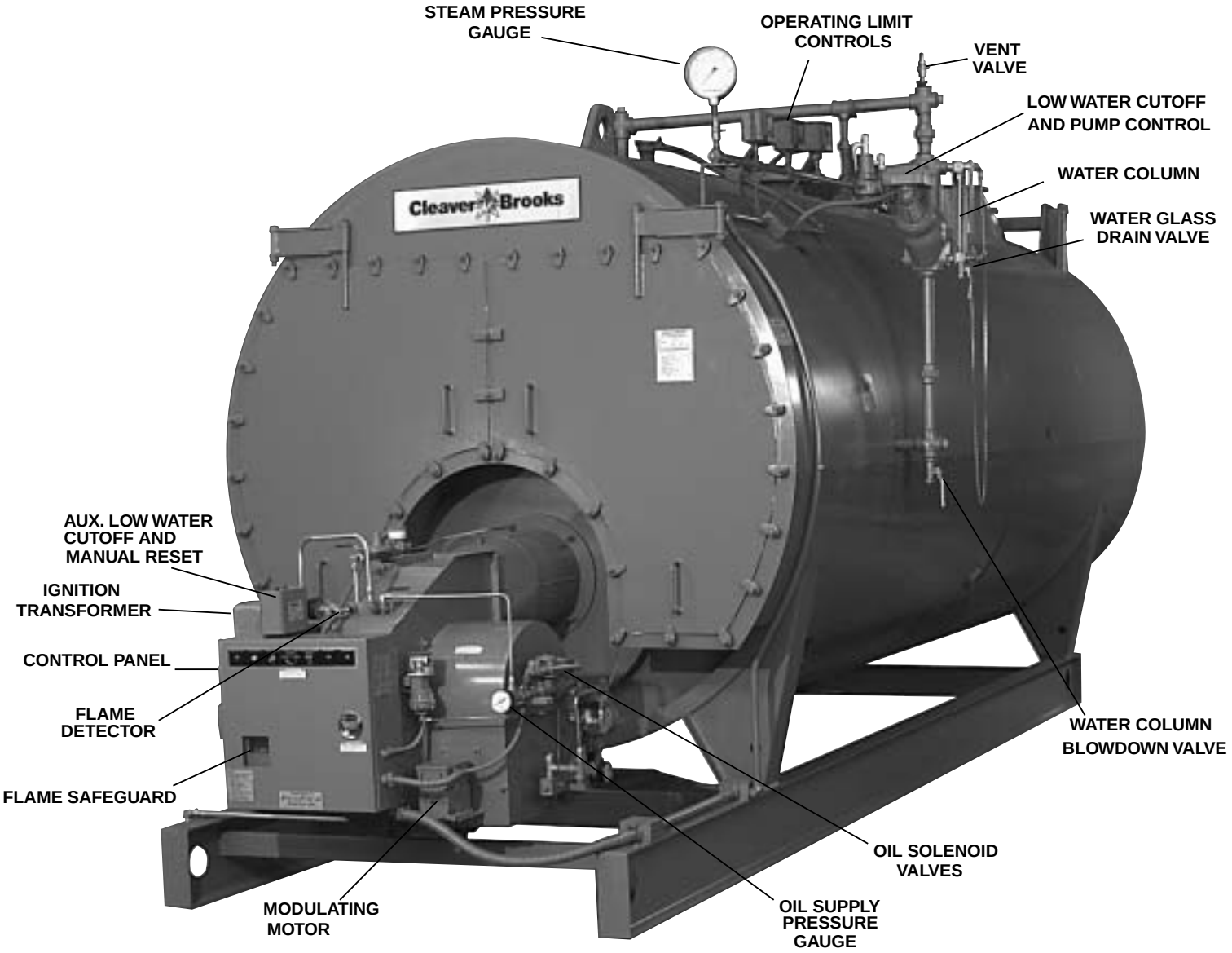


Figure 1-2: CEW 125-350 HP Steam Boiler - Light Oil or Gas Fired

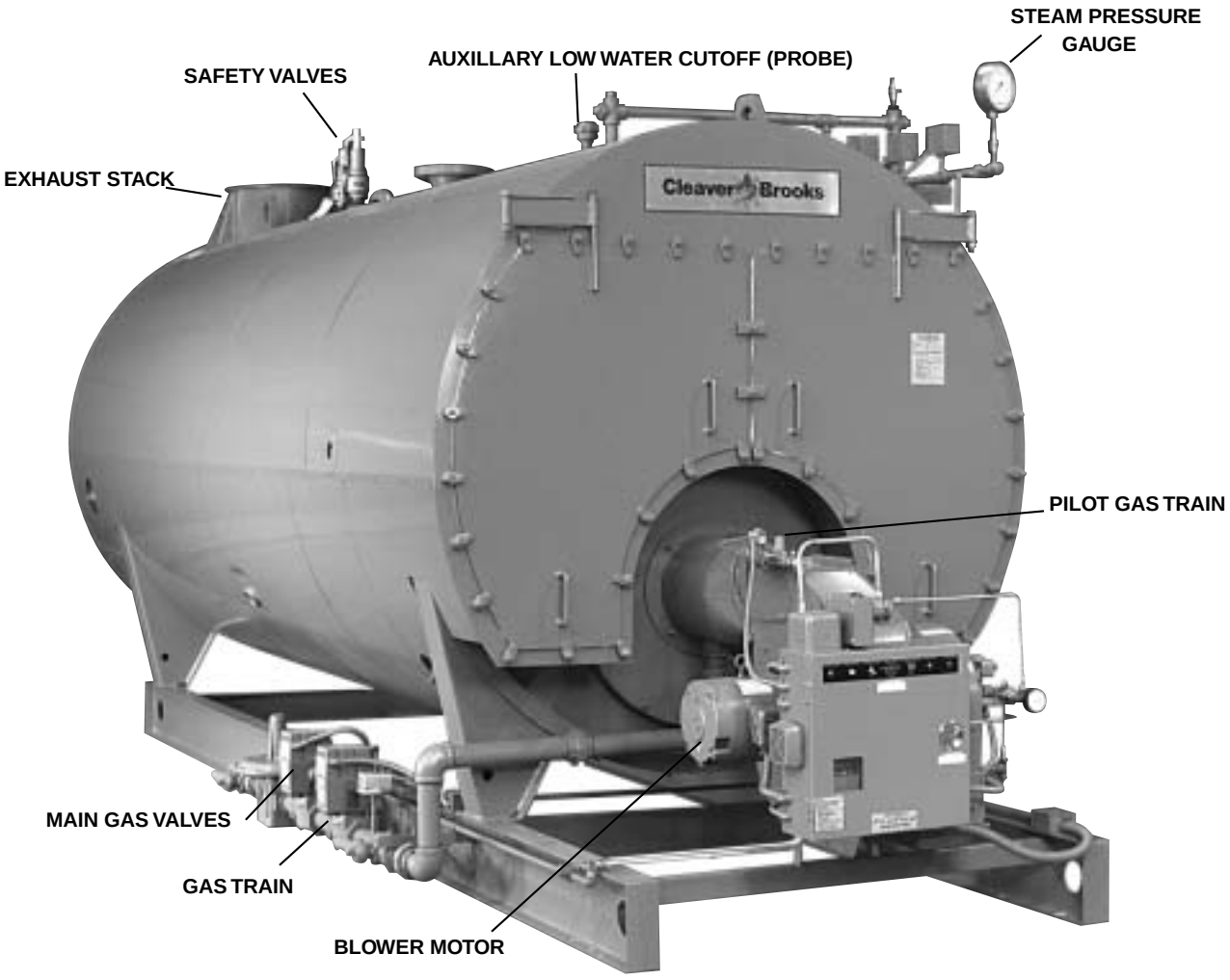


Figure 1-3: CEW 125-350 HP Steam Boiler - Light Oil or Gas Fired

to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."

4. Low Water Cutoff and Pump Control (Figure 1-6): 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.

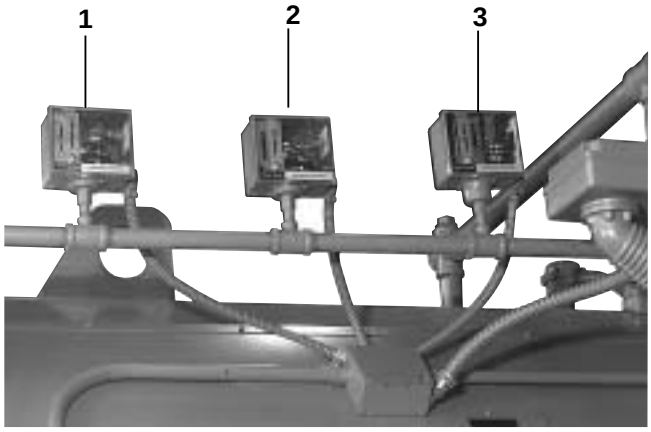
   •Starts and stops the feedwater pump (if used) to maintain water at the proper operating level (Figure 1-6).

⚠ CAUTION

Determine that the main and auxiliary low water cutoffs and pump control are level after installation and throughout the equipment's operating life. Failure to follow these instructions could result in equipment damage.

5. Water Column Assembly (Figure 1-5): Houses the low-water cutoff and pump control and includes the gauge glass and gauge glass shutoff cocks.

6. Water Column Drain Valve (Figure 1-5): Provided so that the water column and its piping can be flushed regularly



1. OPERATING LIMIT PRESSURE CONTROL
2. HIGH LIMIT PRESSURE CONTROL
3. MODULATING PRESSURE CONTROL

Figure 1-4: Steam Controls

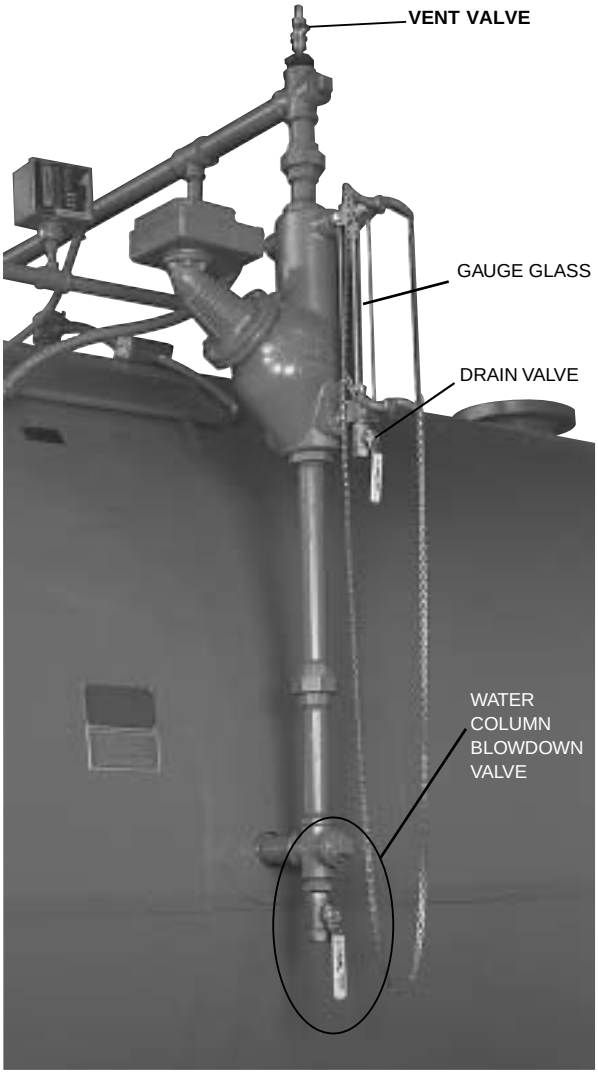


Figure 1-5: Water Column Assembly

to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low-water cutoff for the same purpose.

7. Gauge Glass Drain Valve (Figure 1-5): Provided to flush the gauge glass.

8. Vent Valve (Figure 1-2 & 1-5): Allows the boiler to be vented during filling, and facilitates routine boiler inspection as required by ASME Code.

9. Auxiliary Low Water Cutoff (Figure 1-7): Breaks the circuit to stop burner operation in the event boiler water drops below the master low-water cutoff point. Manual reset type requires manual resetting in order to start the burner after a low-water condition.

10. Safety Valve(s) (Figure 1-8): Prevent buildup over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The safety valves and the discharge piping are to be installed to conform to the ASME code requirements. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and code-required drains can be properly piped to prevent buildup of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening, 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 1-6: Low Water Cutoff Pump Control (Cutaway)

⚠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 personal injury or death

E. HOT WATER CONTROLS (ALL FUELS)

1. Water Temperature Gauge (Figure 1-10): Indicates the boiler internal water pressure.
2. Operating Limit Temperature Control (Figure 1-11): 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.
3. High Limit Temperature Control (Figure 1-11): Breaks a circuit to stop burner operation on a rise of temperature at a selected setting. It is adjusted to stop burner at a preselected temperature above the operating control setting. The high limit temperature control normally is equipped with a manual reset.
4. Modulating Temperature Control (Figure 1-11): Senses changing boiler water temperature and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on "automatic."
5. Low Water Cutoff (Figure 1-7): Breaks the circuit to stop burner operation if the water level in the boiler drops below safe operating point, activating low-water light and optional alarm bell if burner is so equipped.
6. Auxiliary Low Water Cutoff (Not Shown) (Optional): Breaks the circuit to stop burner operation if the water

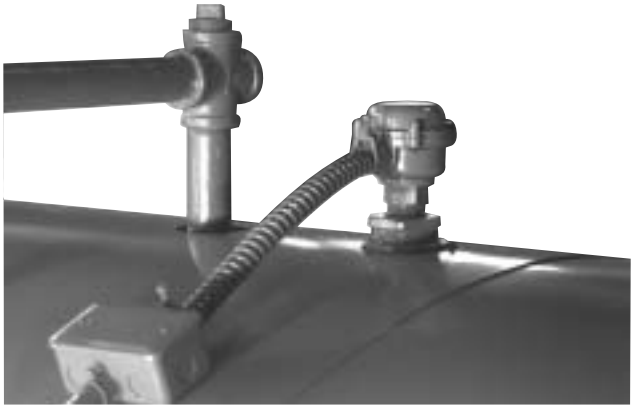


Figure 1-7: Low Water Cutoff

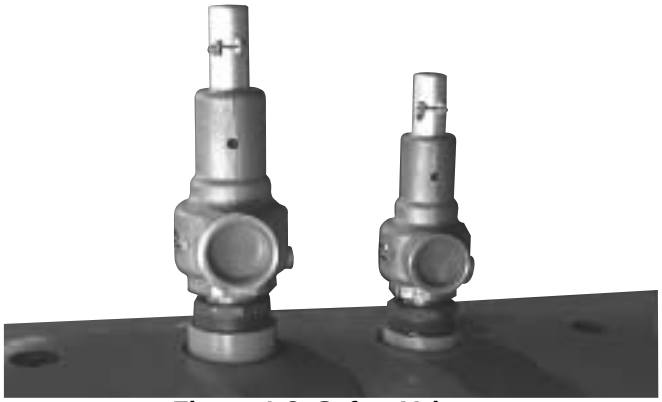


Figure 1-8: Safety Valves

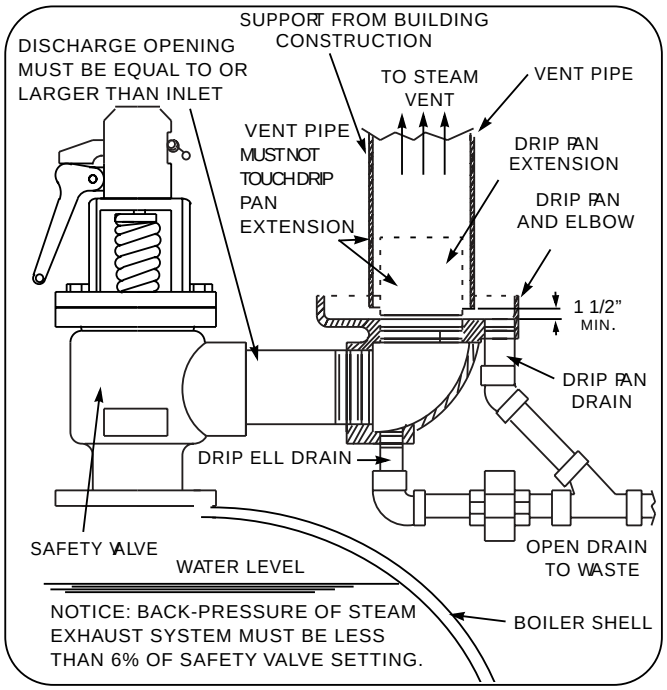


Figure 1-9: Recommended Piping For Steam Relief Valve (Not Furnished By Cleaver Brooks)

level in the boiler drops below the master low-water cutoff point.

7. Safety Valve(s) (Figure 1-8): 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.

⚠WARNING

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

Figure 1-10: Water Temperature Gauge

Figure 1-11: Water Temperature Controls

Notes

CHAPTER 2

ProFire™ Burner Operation and Control 125-350 HP (Ohio Special 100-225)

Note: Burner information for the CEW 400 to 800 hp. range, refer to manual #750-182.

A. GENERAL

The burner and all boiler related equipment must be installed in accordance with applicable local, state or provincial installation requirements including the National Electrical Code (NEC) and associated insurance underwriters. Where applicable, the Canadian Gas Association (CGA) B149 and Canadian Standards Association (CSA) B140 codes shall prevail.

Note: The main power disconnect for this equipment must be conspicuously labeled and placed within sight of the operating system, and/or equipped with lockout provisions.

Note: This manual must be readily available to all operators, and maintained in legible condition.

The information provided in this manual covers ProFire burners installed on CEW boilers.

The information in this chapter provides guidance for startup, testing, and adjustment of the Cleaver-Brooks ProFire burner. Personnel working on or operating the burner or related equipment must become familiar with all the procedures and information contained in this manual prior to initial startup, operation and/or adjustment of the burner.

This chapter applies exclusively to the Cleaver-Brooks ProFire burner, and focuses specifically on tasks related to adjustment of linkages and controls for efficient combustion and safe operation, pre-startup checkout and initial burner startup.

B. BURNER

The ProFire burner is designed to operate with natural gas or light oil at input rates from 2.5 to 14.6 MMBtu/hr. The burner can be configured to burn natural gas only, oil only, or as a natural gas or oil burner.

The burner includes all components and controls required for automatic modulating burner operation, and is also capable of operation over the full range under manual control.

The model number completely identifies its configuration. This information is located on the unit parts list, shipped with the burner. The model number components are as follows:

FP - W - X - Y - Z

Where:

FP designates the burner is designed for Firetube applications.

W designates the fuel; gas, oil, or combination (700, 100, or 200, respectively).

X designates the frame size of the burner (1, 2, 3, 4).

Y designates burner capacity (MMBtu/hr).

Z designates the insurance underwriter.

For Example:

FP - 700 - 2 - 3.5 - IRI

indicates a Firetube application that burns only natural gas; it is made of size-two components, and is rated for 3.5 MMBtu/hr fuel input at high fire and is configured to meet IRI (Industrial Risk Insurers) standards.

C. RECOMMENDED FUELS AND VENTILATION

ProFire burners are designed to burn either natural gas or distillate oil, as defined by ASTM D396 - 1978 specification.

⚠WARNING

This burner is designed to burn only those fuels shown on the burner data plate. Burning fuels not specified on the data plate could cause damage to the equipment, or can result in serious personal injury or death.

D. CONTROLS AND COMPONENTS

The burner can be equipped with special operating controls, various types of flame safeguard systems. The wiring and dimension diagrams and construction reference list (available with the burner) confirm the specific features and equipment included. Refer to Figures 2-1 through 2-5 for component locations. The following list describes components and basic functions of the burner.

1. Electrical Control Cabinet (Figure 2-1). The control cabinet houses many of the electrical control components and the flame safeguard. The operator control switches and indicator lights are located on the face of the control cabinet door (Figure 2-1). The following controls and indicators are provided:

   • Flame Failure Light: Illuminates (red) 20 seconds after the flame is extinguished. When this happens, the system automatically shuts down; manual reset of the flame safeguard is required.

   • Load Demand Light: Illuminates (white) when the boiler operating controls indicate a demand for hot water or steam.

   • Burner Switch: Activates or deactivates the operating cycle of the flame safeguard control.

   • Manual Flame Control: When in Manual Mode, it provides manual adjustment of the burner firing rate between low-fire and high-fire operation.

   • Manual-Auto Switch: Allows the operator to override the automatic boiler controls for manual firing rate adjustment.

   • Fuel Valve Light: Illuminates (green) when the selected fuel valve is energized.

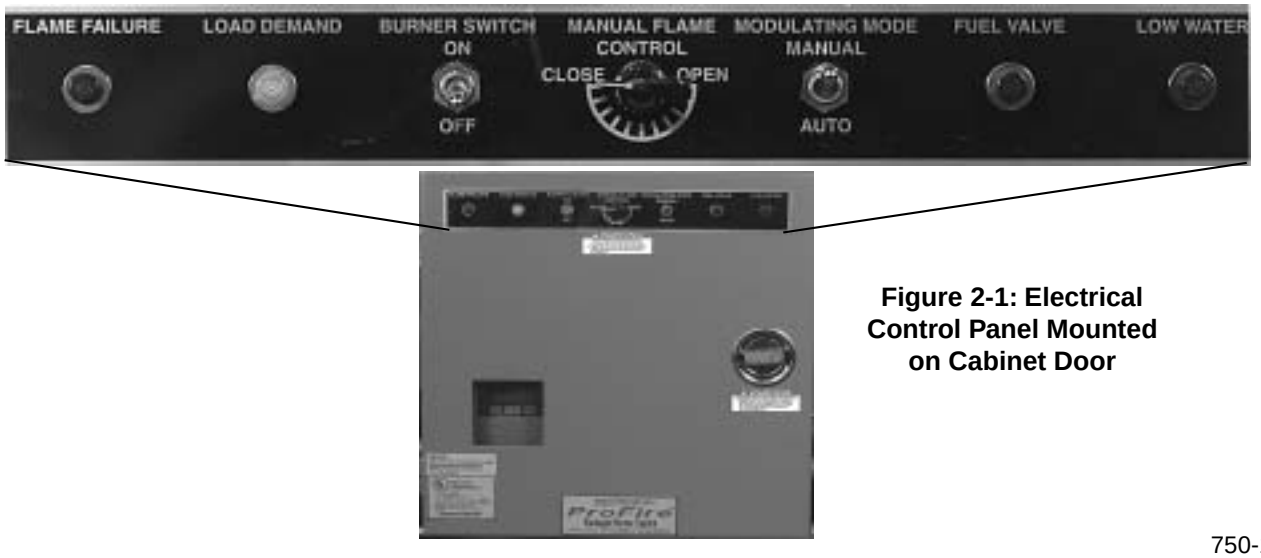
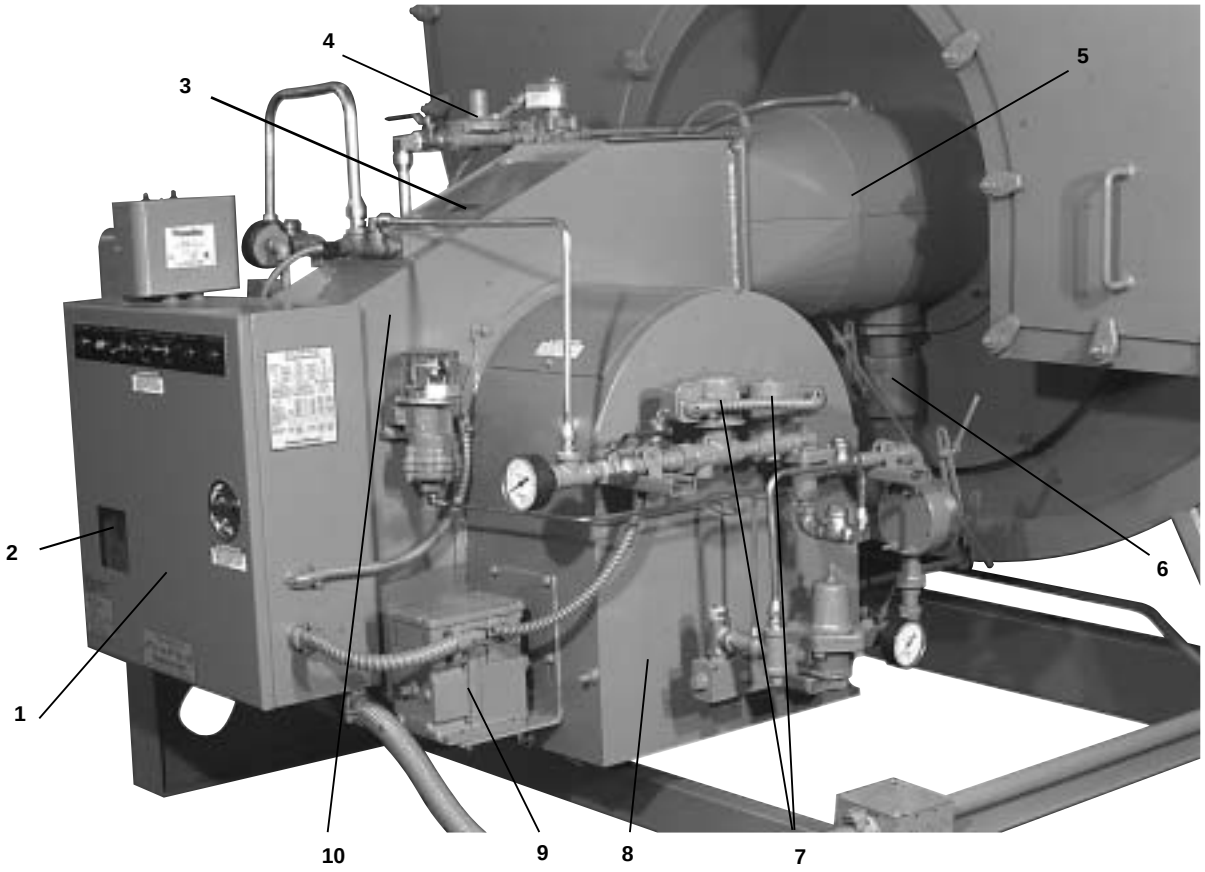


Figure 2-1: Electrical Control Panel Mounted on Cabinet Door



1. ELECTRICAL CONTROL CABINET
2. FLAME SAFEGUARD
3. REAR CAP (with viewing window)
4. PILOT GAS TRAIN
5. BLAST TUBE
6. GAS BUTTERFLY VALVE
7. OIL SOLENOID VALVES
8. AIRBOX
9. MODULATING MOTOR
10. BLOWER HOUSING

Figure 2-2: ProFire Burner Combustion System

• Low Water Light: Illuminates (red) when the boiler low water cutoff control is activated.

• Fuel Selection Switch: Allows the operator to select either gas or oil as the active fuel on combination burners. (The switch is located inside the control cabinet.)

2. Flame Safeguard (Figure 2-2). The flame safeguard controls the operating sequences of the combustion system (prepurge, pilot, firing, and shutdown). The control also monitors the flame, using a scanner which is sensitive to specific flame wave lengths. The flame safeguard also automatically shuts down the burner when the flame signal becomes too weak. Different types of flame safeguard devices can be installed in the combustion systems. Check the wiring diagram for your burner for information on the specific unit installed on your burner.

3. Rear Cap (Figure 2-2). The rear cap contains the locking setscrew for adjustment of the oil nozzle relative to diffuser, and also the flame scanner for the flame safeguard. The rear cap must be removed to enable removal of the oil gun assembly.

4. Pilot Gas Train (Figure 2-2). The standard pilot gas train consists of a manual stopcock, a gas pressure regulator, and a solenoid-operated gas shut-off valve. The gas pilot valve assembly controls a relatively small flow rate of natural gas to operate the gas-electric pilot.

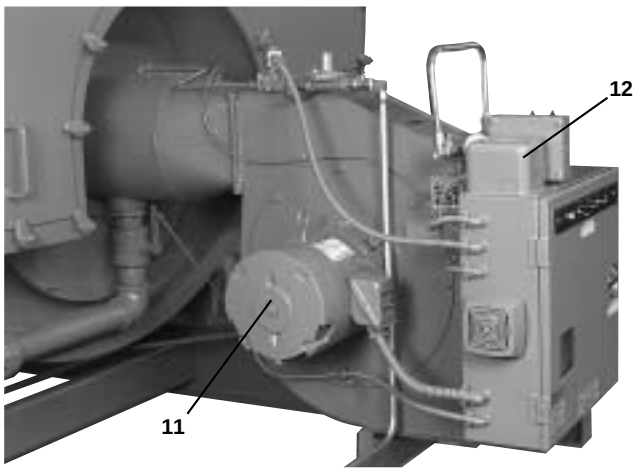
5. Blast Tube (Figure 2-2). The blast tube functions as a duct for combustion air, and houses the fuel nozzle(s), gas pilot assembly, and air diffuser assemblies.

6. Gas Butterfly Valve (Figure 2-2). The gas butterfly valve regulates the flow rate of natural gas into the burner. The gas butterfly valve is connected, by linkage and a jack shaft, to the modulating motor, which provides the rotary motion to open and close the valve.

7. Oil Solenoid Valves (Figure 2-2). The oil solenoid valves are in series and downstream of the oil metering valve in the supply line to the oil burner assembly. Two valves are provided. These valves are simultaneously energized to

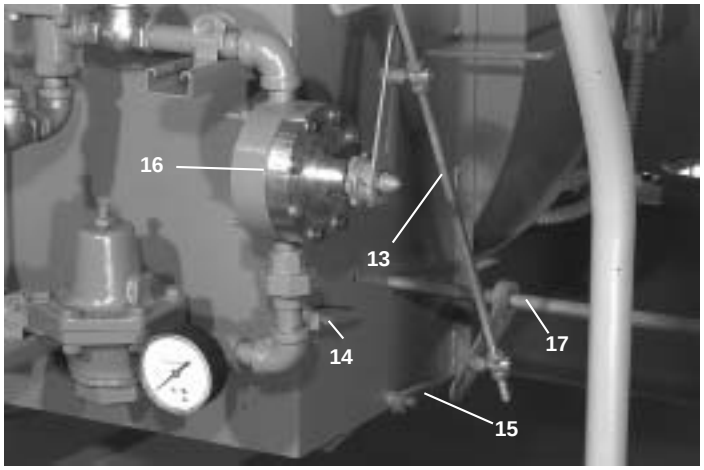
open and release fuel oil to the burner. The valves close to stop combustion when oil is the fuel.

8. Airbox (Figure 2-2). The airbox is attached to the inlet side of the fan housing. It serves as the inlet and flow regulating valve for combustion air, and houses the combustion air control shutters.
9. Modulating Motor (Figure 2-2). The modulating motor is coupled to the jack shaft that operates the main air shutter and the fuel valve linkages. The modulating motor produces the torque and rotary positioning required for firing rate control.
10. Blower Housing (Figure 2-2). The blower housing encloses the impeller. The fan drive motor is mounted directly to the blower housing.
11. Combustion Air Fan Motor (Figure 2-3). The electric motor drives the combustion air fan and the oil pump (if so equipped up to 200 hp).
12. Ignition Transformer (Figure 2-3). The ignition transformer produces the high voltage required for spark generation by the pilot electrode(s).
13. Oil Valve Linkage (Figure 2-4). The valve linkage transfers the modulating motion from the main air shutter shaft to the fuel metering valve shafts. The linkage provides a means of adjustment to maintain the correct fuel-to-air ratio over the entire burner operating range, high fire to low fire.
14. Low-Fire Shutter (Figure 2-4). The low-fire shutter provides a means to set the correct combustion air flow rate for low-fire operation. The handle indicates relative shutter position.
15. High-Fire Shutter (Figure 2-4). The high-fire shutter provides a means to set the correct combustion air flow rate for high-fire operation. The handle indicates relative shutter position.
16. Oil Metering Valve (Figure 2-4). The oil metering valve regulates the flow rate of oil into the burner. The oil metering valve is connected by linkage and a jack shaft to the modulating motor, which provides the rotary motion to open and close the valve.
17. Main Air Shutter Shaft (Figure 2-4). The main air shutter modulates the combustion air between low fire and high fire conditions. The shaft connects the modulating motor to the main air shutter and to the fuel valve linkage assemblies.
18. Combustion Air Proving Switch (Figure 2-5). The combustion air proving switch provides confirmation to the flame safeguard that the combustion air fan is



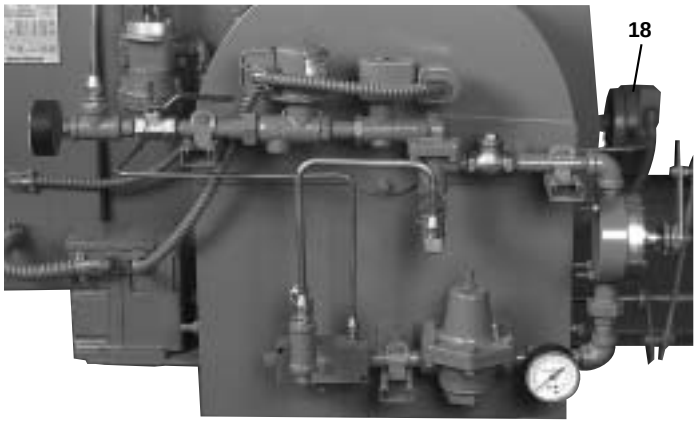
11. COMBUSTION AIR FAN MOTOR
12. IGNITION TRANSFORMER

Figure 2-3: ProFire Burner Combustion Air Motor



13. VALVE LINKAGE
14. LOW-FIRE SHUTTER ADJUSTMENT HANDLE
15. HIGH-FIRE SHUTTER ADJUSTMENT HANDLE
16. OIL METERING VALVE
17. MAIN AIR SHUTTER SHAFT

Figure 2-4: Air Shutter and Valve Linkage



18. COMBUSTION AIR PROVING SWITCH

Figure 2-5: Combustion Air Proving Switch

providing air flow. The fuel supply valves will not open if this switch does not sense adequate air pressure.

19. Air Pump (Figure 2-6). A remote mounted air pump is used on CEW boilers above 200 horse power. The air pump provides the primary air for atomization of the oil in the oil gun.
20. Oil Pump (Figure 2-7). The oil pump provided for oil burning is coupled to an extension of the combustion air fan shaft, up to 200 hp.
21. Impeller (Figure 2-8). The impeller is designed with backwards-inclined vanes. It is located inside the blower housing, and is driven by the combustion air fan motor. The impeller provides combustion air to the burner assembly.

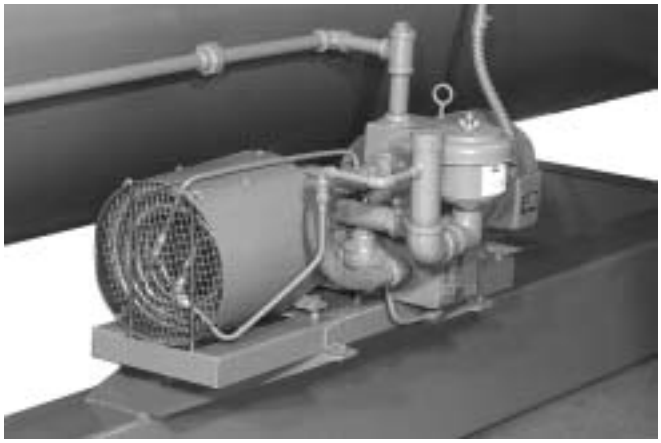


Figure 2-6: Air Pump Module

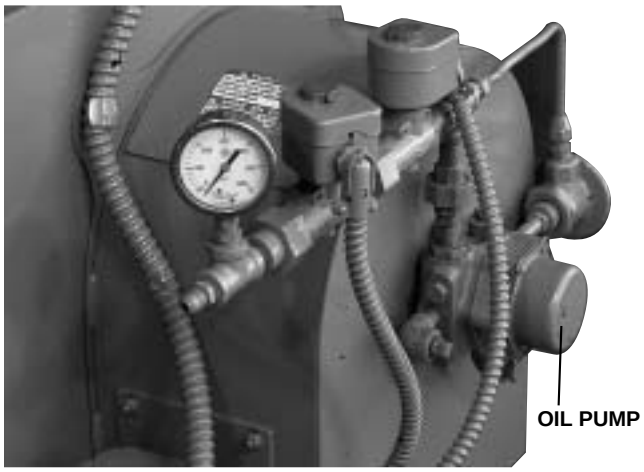


Figure 2-7: Mounted Oil Pump

Special Tools

The impeller puller (Figure 2-9), part number 943-388 should be used to remove the impeller from the fan motor shaft.

To order special tools, contact your authorized Cleaver-Brooks representative.

Figure 2-9: Impeller Puller Part Number 943-388

Figure 2-8: Air Box and Impeller

ITEM	ACCOMPLISHED BY	REMARKS
Daily		
Gauges, Monitors, and 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 Alarm	Operator	Refer to instructions.
Weekly		
Low Water Fuel Cutoff and Alarm	Operator	Refer to instructions.
Firing Rate Control	Operator	Verify factory settings.
Igniter	Operator	Make visual inspection. Check flame signal strength if meter-fitted.
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, (2) main fuel cock and/or valve(s). Check safety shutdown timing. Record in log.
Flame Signal Strength Controls	Operator	If flame signal meter installed, read and log for both pilot and main flames. Notify service if readings are very high, very low, or fluctuating. Refer to instructions.
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.
High & Low Oil Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.

Table 2-2. Recommended Test Schedule

ITEM	ACCOMPLISHED BY	REMARKS
Semi-Annually		
Low Water Fuel Cutoff and Alarm	Operator	Perform a slow drain test in accordance with ASME Boiler and Pressure Vessel Code Section VI.
Firing Rate Control	Service Technician	Verify factory settings.
Inspect Burner Components	Service Technician	Refer to instructions.
Annually		
High Limit Safety Control	Service Technician	Manually adjust until switch opens.
Firing Rate Control	Service Technician	Check with combustion test.
Pilot and Main Gas or Main Oil Fuel Valves	Service Technician	Perform leakage tests. Refer to instructions
Operating Control	Service Technician	Manually adjust until switch opens.
Fuel Valve Interlock Switch (POC)	Service Technician	Refer to instructions. Disconnect POC wire at valve.
Burner Position Interlock	Service Technician	Refer to instructions. Disconnect wire at valve.
Low Fire Start Interlock	Service Technician	Refer to instructions.
Automatic ChangeOver Control (Dual Fuel)	Service Technician	Under supervision of gas utility.
Pilot Turndown Tests	Service Technician	Required after any adjustments to flame scanner mount or pilot burner. Verify annually. Refer to instructions.
Refractory Hold-In Controls	Service Technician	See “Pilot Turndown Tests.”
As Required		
High & Low Oil Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Pilot Turndown Tests	Service Technician	Required after any adjustments to flame scanner mount or pilot burner. Verify annually. Refer to instructions.

Table 2-2. Recommended Test Schedule (Continued)

Notes

CHAPTER 3

Waterside Care And Requirements

A. GENERAL

The operator should be familiar with Chapter 3 before attempting to place the unit into operation.

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

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

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. It is vital 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 Chapter 3.

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 only covers boilers using water. Glycol solutions have different operating requirements, circulation rates and temperatures, etc.

B. WATER REQUIREMENTS

1. HOT WATER BOILER

Air Removal

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

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, causing corrosion in the boiler and possible breeching.

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 start-up.

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.

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 by-pass 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 eliminates the possibility of stratification within the unit 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 a flow of water exists through the boiler before initial firing or refiring after boiler has been drained.

Water Circulation

Table 3-1 shows the maximum gpm circulation rate of boiler water in relation to full boiler output and system temperature drop.

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. In order to put the boiler and the expansion tank on the suction side of the pump. The suction side is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

It is common practice to install a standby system circulating pump. The main circulating pumps are usually located adjacent to the boilers in the boiler room.

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 Figure 3-2.

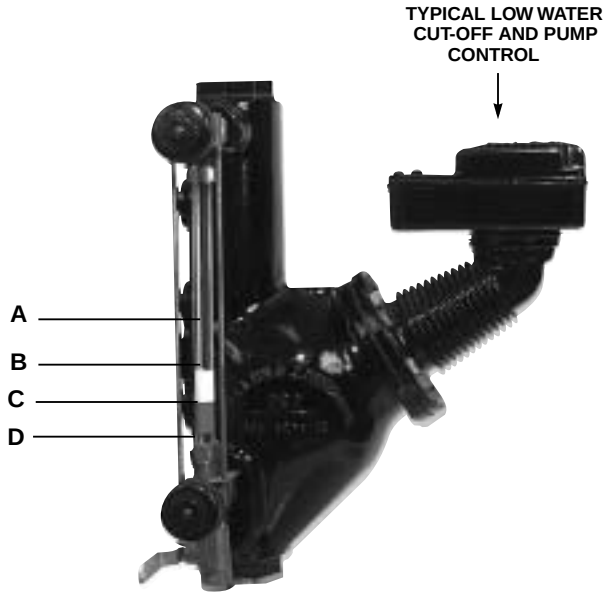
When initially firing a newly installed boiler, or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to opening the header valves.

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.

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									
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

Table: 3-1 Maximum Circulating Rate in Gallons Per Hour For Hot Water Boilers



A. NORMAL LEVEL OF WATER: FEED PUMP TURNS OFF AT THIS POINT. FILL PRESSURE VESSEL INITIALLY TO THIS HEIGHT.

B. PUMP TURNS ON WHEN WATER LEVEL REACHES B. DISTANCE A-B IS APPROXIMATELY3/4 INCH.

C. LOW WATER CUT-OFF POINT BURNER WILL SHUT OFF IF WATER LEVEL LOWERS TO THIS POINT.

D. FIRST VISIBLE POINT IN THE GAUGE GLASS.

Figure 3-1: Low Water Cutoff Sight Gauge

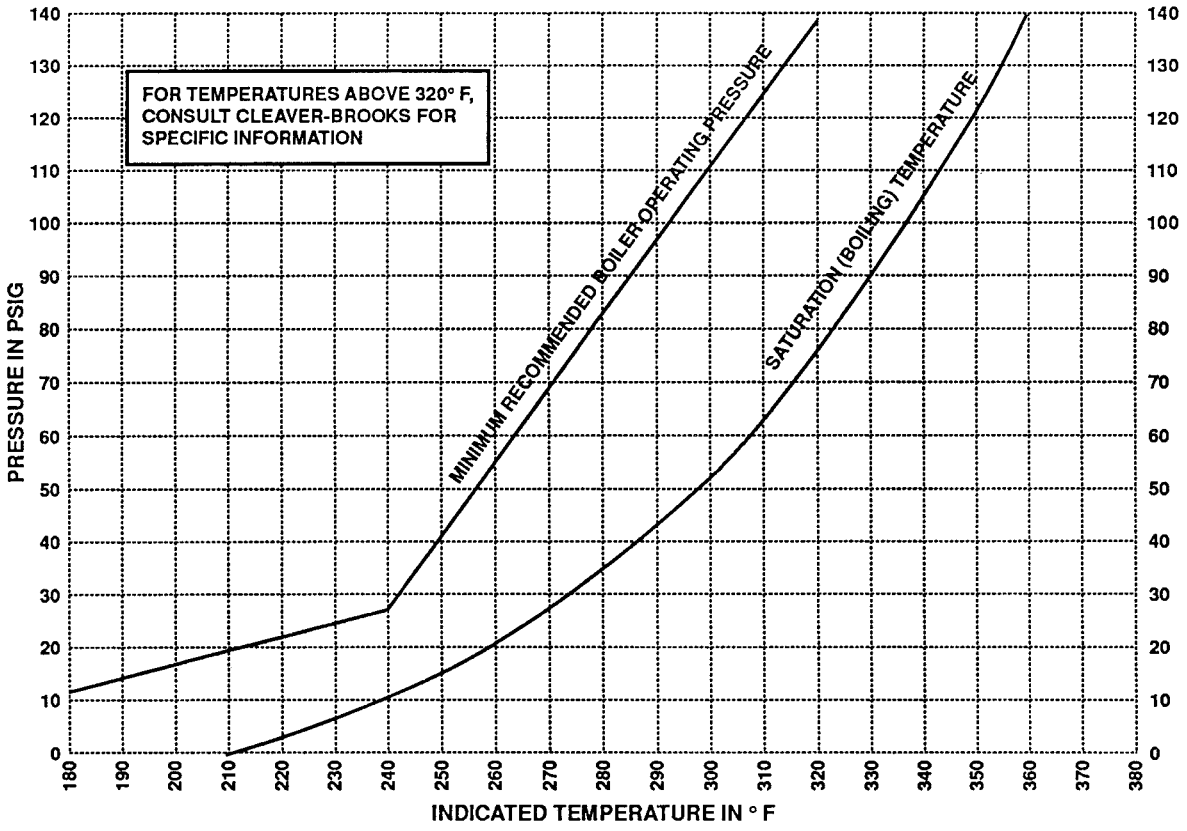


Figure 3-2: Internal Boiler Pressure

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 shown in Figure 3-1.

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.

Water Feeder (optional) Operation

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

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

⚠WARNING

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

C. 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, at the lowest operating cost. 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 in general 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 intercrystalline 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.

D. CLEANING

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.

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 of safety devices, and quite possibly cause unnecessary and expensive re-work, repairs, and down-time.

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 the 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 with an alkaline detergent solution.

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.

E. BOIL-OUT OF 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 over-heating 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.

⚠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 personal injury or death

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 added as a wetting agent.

The suggested general procedure for cleaning a boiler is as follows:

(1) Have sufficient cleaning material on hand to complete the job.

(2) When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water, stirring it at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.

(3) An over-flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.

(4) Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate the valves. Use care in removing and reinstalling the valves.

Refer to Chapter 1, Section D for valve installation instructions.

(5) All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.

(6) Fill the pressure vessel with clean water until the top of the tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in the initial fill should be at ambient temperature.

(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.

⚠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 personal injury or death

(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 boil out.

(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.

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.

F. WASHING OUT

1. HOT WATER BOILER

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and water treated), and 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 waterside.

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.

2. STEAM BOILER

No later than three months after initially placing the boiler into operation and starting service, 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.

Flushing of Pressure Vessel Interior

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.

G. 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 the concentration of solids in the boiler water occurs.

Solids are brought in by the feedwater even though the water is 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 high efficiency, some solids will be present in the boiler feedwater.

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 more importantly, can cause overheating of boiler metal. Over heating of boiler metal can result in tube failures or other pressure vessel metal damage and lead to boiler down-time 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, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of the concentration requires the use of boiler water blowdown.

1. TYPES OF BLOWDOWN

There are two principal types of blowdown: intermittent manual blowdown, and continuous blowdown.

Intermittent Manual Blowdown

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

The blowdown tappings are located at the bottom or lowest part of the boiler in order to lower the dissolved solids in the pressure vessel water, and to remove a portion of the sludge that accumulates in the lower part of the vessel.

Equipment generally consists of a quick opening valve and a shut-off valve. The valves and necessary piping are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping and is the continuous removal of concentrated water.

The surface blow-off 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 surface sediment, oil or other impurities from the surface of the pressure vessel water.

A controlled-orifice valve is used to allow a continual, yet controlled, flow of concentrated water.

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with the test analysis.

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

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.

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

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

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

A hot water boiler does not normally include openings for surface blowdown and bottom blowdown since blowdowns are seldom 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.

Manual Blowdown Procedure

Blowdown is most effective at a point in time when the generation of steam is at the lowest rate and feedwater input is also low, thus providing a minimum dilution of the boiler water with low concentration feedwater.

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

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Valves will vary depending upon pressure involved and make or manufacturer. If seatless valves are installed, follow the manufacturer's recommendations.

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 or downstream valve, crack it slightly to allow the lines to warm, then continue opening slowly.

⚠ 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.

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.

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

H. 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.

⚠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 personal injury or death

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 - again 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.

If the internal inspection is being made at the request of an authorized inspector, it is well to ask the inspector 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, blow-off valves, all fuel valves, valves to expansion tank, 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.

I. PREPARATION FOR EXTENDED LAY-UP

Many boilers used for heating or seasonal loads or for stand-by 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.

Too many conditions exist to lay down definite rules. 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.

Whichever method is used, common sense dictates a periodic recheck of fireside and waterside conditions during lay-up to allow variations from the above methods for special area or job-site conditions.

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

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 town. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during cooling. 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 lay-up, 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.

To prevent condensation from forming in the control cabinet, keep the control circuit energized. For extended lay-up periods, especially where high humidity or large swings in ambient temperature occur, the program relay 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, or grease or tar paint. Refractories should be brushed clean and wash-coated. All openings to the pressure vessel, such as manhole and handholes, should be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in stand-by 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 of time. 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. Fireside surfaces must be thoroughly cleaned and refractory should be wash-coated.

CHAPTER 4

Sequence Of Operation

A. GENERAL

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

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

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

Abbreviations for the various electrical components are listed in Figure 4-1. The sequences outlined in Chapter 4 employ specific nomenclature to aid in applying the text to the wiring diagram.

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

- Boiler water is up to the correct level, closing the low-water cutoff switch.
- The low-water light (panel) is off.
- The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cutoff setting.
- All applicable limits are correct for burner operation.
- The load demand light glows (fuel pressure, temperature).
- Reset manual reset (water, fuel pressure, operating limits).

All entrance switches are closed and power is present at the line terminals of:

- Blower motor starter
- Air compressor motor starter (if provided)
- Oil pump motor starter (if provided).

The sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the program relay. Chapters 5 and 6 contain operating instructions and specific information on setting and adjusting the controls.

B. CIRCUIT AND INTERLOCK CONTROLS

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

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

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

Limit Circuit:

- Burner switch (BS)
- Operating limit control (OLC) - pressure or temperature
- High limit control (HLC) - pressure or temperature
- Low-water cutoff (LWCO)
- Gas-oil selector switch (GOS) - (Combination burner only)
- Low gas pressures switch (LGPS)
- High gas pressure switch (HGPS)
- Fuel valve over travel interlock circuit
- Main gas valve auxiliary switch (MGVAS)

Blower Motor Starter Circuit

- Blower motor starter (BMS)
- Air compressor motor starter (ACMS) (if provided)

Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)
- Atomizing air proving switch (AAPS) (if provided)

Low Fire Proving Circuit

- Low fire switch (LFS)

Pilot Ignition Circuit

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

Flame Detector Circuit

- Flame detector (FD)

Main fuel valve circuit

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

Firing Rate Circuit

- Modulating damper motor (MDM)
- Manual-automatic switch (MAS)
- Manual flame control (MFC)
- Modulating control (MC)

High Fire Proving Circuit

- High fire switch (HFS)

Running Interlock and Limit Circuit

- Low oil pressure switch (LOPS)
- High oil temperature switch (HOTS)
- Auxiliary low-water cutoff (ALWCO)

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

C. SEQUENCE OF OPERATION - OIL OR GAS

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

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

Pre-Purge Cycle - When the burner switch (BS) is turned "on," and controls wired in the "limit" and "fuel valve interlock" circuits are closed and no flame signal is present, the "blower motor start circuit" is powered energizing the blower motor starter (BMS). The load demand light (LDL) turns on. When firing oil, the air compressor motor starter (ACMS) (if provided) is also powered.

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

On all boilers the circuitry will include a high fire switch (HFS). The purpose of the switch is to prove that the modulating damper motor (MDM) has driven the damper to the open position during the pre-purge cycle.

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

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

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

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

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

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

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

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

⚠WARNING

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

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

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

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

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

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

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

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

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

D. FLAME LOSS SEQUENCE

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

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

⚠ CAUTION

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

1. No pilot flame.

The pilot flame must be ignited and proven within a 10-second period after the ignition cycle begins. If not proven within this period, the main fuel valve circuit will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately deenergized and the pilot valve closes, the reset switch lights and lockout occurs immediately.

The blower motor will continue to operate. The flame failure light and the alarm bell (optional) are energized 10 seconds later.

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

2. Pilot but no main flame.

When the pilot flame is proven, the main fuel valve circuit is energized. The pilot flame will be extinguished 10 seconds later. The flame detecting circuit will respond to deenergize the main fuel valve circuit within 2 to 4 seconds to stop the flow of fuel. The reset switch lights and lockout occurs immediately. The blower motor will continue to operate.

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

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

3. Loss of flame.

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

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

If the burner will not start, or upon a safety lockout, the troubleshooting section in Chapter 7 and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent.

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

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

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

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

MNEMONIC	DESCRIPTION
	A
A	Amber (Color Of Pilot Light)
AAFL	Atomizing Air Failure Light
AAFR	Atomizing Air Failure Relay
AAPL	Atomizing Air Proven Light
AAPS	Atomizing Air Proving Switch
AAPS-B	Atomizing Air Proving Switch- Burner
AAPS-C	Atomizing Air Proving Switch- Compressor
AASS	Atomizing Air Selector Switch
AB	Alarm Bell
ACCR	Air Compressor Control Relay
ACM	Air Compressor Motor
ACMCB	Air Compressor Motor Circuit Breaker
ACMF	Air Compressor Motor Fuses
ACMS	Air Compressor Motor Starter
ACMSI	Air Compressor Motor Starter Interlock
AH	Alarm Horn
ALFR	Assured Low Fire Relay
ALWCO	Auxiliary Low Water Cutoff
AM	Ammeter
AMS	Atomizing Media Switch
AOV	Auxiliary Oil Valve
APR	Air Purge Relay
APV	Air Purge Valve
AR	Alarm Relay
AS	Auxiliary Switch (Suffix)
ASR	Alarm Silencing Relay
ASS	Alarm Silencing Switch
ASV	Atomizing Steam Valve
AT	Annunciator Transformer
AWCBDS	Auxiliary Water Column Blowdown Switch
	B
B	Blue (Color of Pilot Light)
BC	Bias Control
BDCS	Breeching Damper Closed Switch
BDOS	Breeching Damper Open Switch
BDRS	Blowdown/Reset Switch
BFPL	Boiler Feed Pump Light
BFPM	Boiler Feed Pump Motor
BFPMCB	Boiler Feed Pump Motor Circuit Breaker
BFPMF	Boiler Feed Pump Motor Fuses
BFPMS	Boiler Feed Pump Motor Starter
BFPS	Boiler Feed Pump Switch
BFTS	Back Flow Temperature Switch
BHS	Boiler - Header Switch
BIOL	Boiler in Operation Light
BIOR	Boiler In Operation Relay
BM	Blower Motor
BMCB	Blower Motor Circuit Breaker
BMCR	Blower Motor Control Relay
BMF	Blower Motor Fuses
BMPR	Blower Motor Power Relay
BMPS	Blower Motor Purge Switch
BMR	Blower Motor Relay
BMS	Blower Motor Starter
BMSI	Blower Motor Starter Interlock
BMSS	Boiler Master Selector Switch

MNEMONIC	DESCRIPTION
BS	Burner Switch
BSS	Boiler Selector Switch
BWPM	Booster Water Pump Motor
BWT	Booster Water Thermostat
	C
CAFL	Combustion Air Failure Light
CAFR	Combustion Air Failure Relay
CAP	Capacitor
CAPS	Combustion Air Proving Switch
CCCB	Control Circuit - Circuit Breaker
CCF	Control Circuit Fuse
CCRS	Control Circuit Reset Switch
CCT	Control Circuit Transformer
CIPL	Changeover In Progress Light
CL	Canopy Light
CLS	Canopy Light Switch
COPS	Changeover Pressure Switch
COR	Changeover Relay
COTD	Changeover Time Delay
CPOL	Control Power on Light
CR	Control Relay
CSSS	Control System Selector Switch
CWPM	Circulating Water Pump Motor
CWPMCB	Circulating Water Pump Motor Circuit Breaker
CWPMF	Circulating Water Pump Motor Fuses
CWPMS	Circulating Water Pump Motor Starter
CWPMSI	Circulating Water Pump Motor Starter Interlock
CWPR	Circulating Water Pump Relay
CWPS	Circulating Water Pump Switch
CWSV	Cooling Water Solenoid Valve
	D
D	Denotes Digester Gas Equipment (Prefix)
DCVM	Direct Current Voltmeter
DG	Draft Gauge
DGHPV	Digester Gas Housing Purge Valve
DHWC	Deaerator High Water Control
DHWL	Deaerator High Water Light
DHWR	Deaerator High Water Relay
DISC	Disconnect (Entrance Switch)
DLWC	Deaerator Low Water Control
DLWL	Deaerator Low Water Light
DLWR	Deaerator Low Water Relay
DM	Damper Motor
DMT	Damper Motor Transformer
DNS	Day-Night Switch
DODE	Delay On Deenergization (Timer)
DOE	Delay On Energization (Timer)
DPS	Damper Positioning Switch
DS	Door Switch
	E
EDS	Emergency Door Switch
ESS	Emergency Stop Switch
ETM	Elapsed Time Meter
	F
FADM	Fresh Air Damper Motor
FADR	Fresh Air Damper Relay
FD	Flame Detector

Figure 4-1: Electrical Nomenclature

MNEMONIC	DESCRIPTION
FDJB	Flame Detector Junction Box
FDPS	Flow Differential Pressure Switch
FFA	Flame Failure Alarm
FFL	Flame Failure Light
FFR	Flame Failure Relay
FGR	Flue Gas Recirculation
FGRCDTD	Flue Gas Recirculation Cool Down Time Delay
FGRCPS	Flue Gas Recirculation Cam Position Switch
FGRFM	Flue Gas Recirculation Fan Motor
FGRFMS	Flue Gas Recirculation Fan Motor Starter
FGRFMSI	Flue Gas Recirculation Fan Motor Starter Interlock
FGRMVLS	Flue Gas Recirculation Manual Valve Limit Switch
FGRTD	Flue Gas Recirculation Time Delay
FORS	First Out Reset Switch
FPM	Feed Pump Motor
FPMS	Feed Pump Motor Starter
FPR	Feed Pump Relay
FPS	Feed Pump Switch
FRI	Firing Rate Interface
FRP	Firing Rate Potentiometer (O2 Trim)
FS	Flow Switch
FSS	Fuel Selector Switch
FSSM	Flame Signal Strength Meter
FVEL	Fuel Valve Energized Light
FVL	Fuel Valve Light
FVR	Fuel Valve Relay
FWC	Feed Water Control
FWVT	Feed Water Valve Transformer
	G
G	Green (Color Of Pilot Light)
GGL	Gauge Glass Light
GOL	Gas Operation Light
GOR	Gas-Oil Relay
GOS	Gas-Oil Switch
GOR	Gas-Oil Relay
GPS	Gas Pressure Sensor
GPV	Gas Pilot Valve
GPVV	Gas Pilot Vent Valve
GR	Gas Relay
GSSV	Gas Sensor Solenoid Valve
GVEL	Gas Valve Energized Light
GVTS	Gas Valve Test Switch
	H
HATC	High Ambient Temperature Control
HBWTC	High Boiler Water Temperature Control
HBWTL	High Boiler Water Temperature Light
HFAV	High Fire Air Valve
HFGV	High Fire Gas Valve
HFL	High Fire Light
HFOV	High Fire Oil Valve
HFPS	High Furnace Pressure Switch
HFS	High Fire Switch
HFS-A	High Fire Switch - Air
HGPL	High Gas Pressure Light
HGPR	High Gas Pressure Relay
HGPS	High Gas Pressure Switch
HHFL	Header High Fire Light

MNEMONIC	DESCRIPTION
H/LWA	High Low Water Alarm
HLC	High Limit Control
HLFC	High-Low Fire Control
HLPC	High Limit Pressure Control
HLTC	High Limit Temperature Control
HMC	Header Modulating Control
HOPL	High Oil Pressure Light
HOPR	High Oil Pressure Relay
HOPS	High Oil Pressure Switch
HOLC	Header Operating Limit Control
HOTL	High Oil Temperature Light
HOTR	High Oil Temperature Relay
HOTS	High Oil Temperature Switch
HPCO	High Pressure Cutoff
HSPC	High Steam Pressure Control
HSPL	High Steam Pressure Light
HSPR	High Steam Pressure Relay
HSTC	High Stack Temperature Control
HSTL	High Stack Temperature Light
HSTS	High Stack Temperature Switch
HWAR	High Water Alarm Relay
HWC	High Water Control
HWCO	High Water Cutoff
HWL	High Water Light
	I
(I.C.)	Instantaneously Closed
(I.O.)	Instantaneously Open
IL	Ignition Light
INT	Interval (Timer)
IR	Ignition Relay
IT	Ignition Transformer
	J
JPP	Jackshaft Position Potentiometer
	L
LAMPS	Low Atomizing Media Pressure Switch
LASPS	Low Atomizing Steam Pressure Switch
LDL	Load Demand Light
LDPS	Low Differential Pressure Switch
LDS	Low Draft Switch
LFAV	Low Fire Air Valve
LFGV	Low Fire Gas Valve
LFHTD	Low Fire Hold Time Delay
LFL	Low Fire Light
LFOV	Low Fire Oil Valve
LFPS	Low Fire Pressure Switch
LFR	Low Fire Relay
LFS	Low Fire Switch
LFS-A	Low Fire Switch - Air
LFS-F	Low Fire Switch - Fuel
LFS-G	Low Fire Switch - Gas
LFS-O	Low Fire Switch - Oil
LFTC	Low Fire Temperature Control
LGPL	Low Gas Pressure Light
LGPR	Low Gas Pressure Relay
LGPS	Low Gas Pressure Switch
LIAPS	Low Instrument Air Pressure Switch
LLPC	Low Limit Pressure Control

Figure 4-1: Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
LLPR	Low Limit Pressure Relay
LLR	Lead Lag Relay
LLTC	Low Limit Temperature Control
LLTR	Low Limit Temperature Relay
LOPL	Low Oil Pressure Light
LOPR	Low Oil Pressure Relay
LOPS	Low Oil Pressure Switch
LOTL	Low Oil Temperature Light
LOTR	Low Oil Temperature Relay
LOTS	Low Oil Temperature Switch
LPAPS	Low Plant Air Pressure Switch
LPCO	Low Pressure Cutoff
LPS	Low Pressure Switch
LSPAR	Low Steam Pressure Alarm Relay
LSPC	Low Steam Pressure Control
LSPL	Low Steam Pressure Light
LSPR	Low Steam Pressure Relay
LSPS	Low Steam Pressure Switch
LTS	Lamp Test Switch
LWA	Low Water Alarm
LWAR	Low Water Alarm Relay
LWCO	Low Water Cutoff
LWFL	Low Water Flow Light
LWL	Low Water Light
LWR	Low Water Relay
LWRR	Low Water Reset Relay
	M
MA	Milli-amp
MAS	Manual - Automatic Switch
MAM	Micrometer
MC	Modulating Control
MCS	Manual Control Switch
MDM	Modulating Damper Motor
MDMAS	Modulating Damper Motor Auxiliary Switch
MFC	Manual Flame Control (Potentiometer)
MFGRTS	Minimum Flue Gas Recirculation Temperature Switch
MFVL	Main Fuel Valve Light
MFWV	Motorized Feed Water Valve
MGV	Main Gas Valve
MGVAS	Main Gas Valve Auxiliary Switch
MGVEL	Main Gas Valve Energized Light
MGVV	Main Gas Vent Valve
MLC	Modulating Level Control
(MOM)	Momentary
MOV	Main Oil Valve
MOVAS	Main Oil Valve Auxiliary Switch
MOVEL	Main Oil Valve Energized Light
MPC	Modulating Pressure Control
MPCB	Main Power Circuit Breaker
MPP	Manual Positioning Potentiometer
(MR)	Manual Reset
MTC	Modulating Temperature Control
MVA	Make-Up Valve Actuator
	N
N	Denotes Natural Gas Equipment (Prefix)
(N.C.)	Normally Closed
(N.O.)	Normally Open
NFL	No Flow Light
NFR	No Flow Relay
NGHPV	Natural Gas Housing Purge Valve
	O
ODA	Outlet Damper Actuator
ODM	Outlet Damper Motor
ODMAS	Outlet Damper Motor Auxiliary Switch
ODMT	Outlet Damper Motor Transformer
ODS	Oil Drawer Switch
OH	Oil Heater
OHCB	Oil Heater Circuit Breaker
OHF	Oil Heater Fuses
OHR	Oil Heater Relay
OHS	Oil Heater Switch
OHT	Oil Heater Thermostat
OLC	Operating Limit Control
OLPC	Operating Limit Pressure Control
OL'S	Thermal Overloads
OLTC	Operating Limit Temperature Control
OMPM	Oil Metering Pump Motor
OMPMF	Oil Metering Pump Motor Fuse
OOL	Oil Operation Light
OPM	Oil Pump Motor
OPMCB	Oil Pump Motor Circuit Breaker
OPMF	Oil Pump Motor Fuses
OPMS	Oil Pump Motor Starter
OPPM	Oil Purge Pump Motor
OPR	OIl Purge Relay
OPRL	Oil Pump Running Light
OPRS	Oil Pressure Sensor
OPS	Oil Pump Switch
OPSPM	Oil Pump Supply Pump Motor
OPV	Oil Purge Valve
OR	Oil Relay
ORV	Oil Return Valve
OSOV	Oil Shutoff Valve
OSPS	O2 Set Point Switch
OSS	Oil Selector Switch
OT	Outdoor Thermostat
OTS	Oil Temperature Sensor
OV	Oil Valve
OVAS	Oil Valve Auxiliary Switch
OVEL	Oil Valve Energized Light
	P
P	Denotes Propane Gas Equipment (Prefix)
PAASV	Plant Air Atomizing Solenoid Valve
PAPS	Purge Air Proving Switch
PC	Pump Control
PCL	Purge Complete Light
PCR	Pump Control Relay
PFCC	Power Factor Correction Capacitor
PFFL	Pilot Flame Failure Light
PFFR	Pilot Flame Failure Relay
PFPS	Positive Furnace Pressure Switch
PHGPS	Pilot High Gas Pressure Switch
PIPL	Purge in Progress Light
PIS	Pilot Ignition Switch
PLC	Programmable Logic Controller
PLGPS	Pilot Low Gas Pressure Switch

Figure 4-1: Electrical Nomenclature (Continued)

MNEMONIC	DESCRIPTION
POL	Power On Light
POV	Pilot Oil Valve
PPL	Pre-Purging Light
PPR	Post Purge Relay
PPTD	Post Purge Time Delay
PR	Program Relay
PRL	Purge Ready Light
PRPTD	Pre-Purge Time Delay
PR	Program Relay
PRPTD	Per-Purge Time Delay
PS	Power Supply
PSF	Power Supply Fuse
PSS	Pump Selector Switch
PSV	Purge Solenoid Valve
PT	Purge Timer
PTS	Pump Transfer Switch
PUCR	Purge Complete Relay
PUR	Purge Relay
	R
R	Red (Color of Pilot Light)
RAR	Remote Alarm Relay
RATD	Remote Alarm Time Delay
RES	Resistor
RML	Run Mode Light
RMR	Release To Modulate Relay
RS	Range Switch
RSR	Remote Start Relay
RTD	Resistance Temperature Detector
	S
SBFPL	Stand By Feed Pump Light
SBFPM	Stand By Feed Pump Motor
SBFPMCB	Stand By Feed Pump Motor Circuit Breaker
SBFPMF	Stand By Feed Pump Motor Fuses
SBFPMS	Stand By Feed Pump Motor Starter
SBOV	Surface Blow Off Valve
SBPS	Sootblower Pressure Switch
SBR	Sootblower Relay
SC	Scanner
SCTS	Supervisory Cock Test Switch
SDL	Steam Demand Light
SHT	Steam Heater Thermostat
SHV	Steam Heater Valve
SLCL	Safety Limits Complete Light
SPIR	System Pump Interlock Relay
SPS	Steam Pressure Sensor
SS	Selector Switch
SSC	Sequencing Step Controller
SSL	Safety Shutdown Light
SSR	Solid State Relay
SSV	SpanSolenoid Relay
STHWC	Surge Tank High Water Control
STHWL	Surge Tank High Water Light
STHWR	Surge Tank High Water Relay
STLWC	Surge Tank Low Water Control
STLWL	Surge Tank Low Water Light

MNEMONIC	DESCRIPTION
STLWR	Surge Tank Low Water Relay
	T
(T.C.)	Timed Closed
(T.O.)	Timed Open
TB	Terminal Block
T/C	Thermocouple
TC	Time Clock
TCR	Time Clock Relay
TD	Time Delay
TDAS	Time Delay Auxiliary Switch
TFWR	Transistorized Feedwater Relay
TPL	Transfer Pump Light
TPM	Transfer Pump Motor
TPMCB	Transfer Pump Motor Circuit Breaker
TPMF	Transfer Pump Motor Fuses
TPMS	Transfer Pump Motor Starter
TPS	Transfer Pump Switch
	U
UVFD	Ultra-Violet Flame Detector
	V
V	Voltmeter
VDR	Voltage Differential Relay
	W
W	White (Color of Pilot Light)
WC	Water Column
WCBDS	Water Column Blow Down Switch
WF	Water Feeder
WFNL	Water Flow Normal Light
WLC	Water Level Control
WO	Denotes Waste Oil Equipment (Prefix)
WTS	Water Temperature Sensor
	Y
Y	Yellow (Color of Pilot Light)

Figure 4-1: Electrical Nomenclature (Continued)

CHAPTER 5

Starting And Operating Instructions 125-350 hp (Ohio Special 100-225 hp)

A. GENERAL

Instructions in Chapter 5 are all based upon installation being complete and all electrical, fuel, water and vent stack connections are made.

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

⚠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 personal injury or death

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

The boiler should be filled with water to the proper operating level using water of ambient temperature. Be sure that treated feedwater is available and used. In hot water applications, the entire system should be filled and vented. Refer to Chapter 3 for water requirements. On a steam boiler, open the vent valve (Figure 1-2) to vent air displaced during filling. Leave the vent valve open until the escape of steam is noted after the burner is operating.

⚠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 personal injury or death

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

Check for rotation of all motors by momentarily closing the motor starter or relay. The blower impeller rotation is counter-clockwise for the CEW, when viewed from the motor side of the burner (see Figure 5-1). The air pump rotation is clockwise when viewed from its drive end (see Figure 5-2).

B. Preparation for Initial Startup

NOTE: All work on the burner should be performed by qualified persons knowledgeable in applicable codes. Wiring should be in accordance with the National Electrical Code (NEC).

1. FUEL SUPPLY

Before initial startup, verify that all fuel connections are tight. Fuel supply lines should be securely connected, correctly supported, and leak tested.

The gas train for gas-fired, or combination gas/oil, burners is provided with the overall boiler package. Configuration of the appropriate gas train is based on minimum requirements established by Underwriter's Laboratories / CGA and the responsible insurance carrier if applicable (Figure 5-11 shows the configuration of the gas train for various insurance requirements).Table 1-1 shows minimum and maximum gas pressure limits for the various burner configurations.

The pilot gas train is supplied with the burner, and is factory-installed.

Fuel oil piping for oil-fired systems is shown pictorially in Figure 5-3 and 5-4. In this circuit, an oil supply line from the oil tank is connected to the inlet port of the oil pump, and an oil return line from the pump circulates excess oil from the pump back to the oil supply tank.

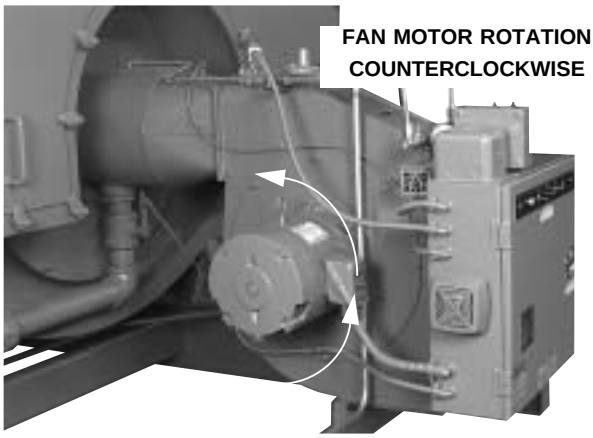


Figure 5-1: Fan Motor CBE

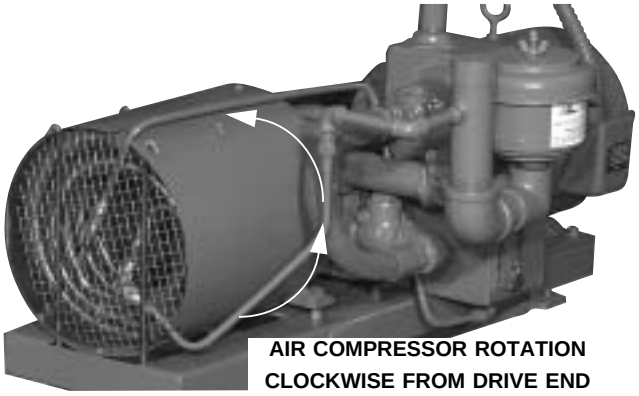


Figure 5-2: Air Compressor

Before burner startup, the two oil solenoid valves are in the closed (de-energized) position and the oil metering valve is in its most open position. Under this condition (with the pump operating), oil cannot flow to the oil burner nozzle, but circulates through the by-pass tubing, oil metering valve, and back to the inlet of the pump. When the flame safeguard control calls for the main flame, the two oil solenoid valves are electrically energized. After opening, oil flows through the nozzle at the low-fire flow rate.

When high-fire operation is required, the modulating motor, by way of the valve linkage, rotates the oil metering valve to its least-open position. This reduces the flow rate of oil through the by-pass circuit, which increases the oil flow to the burner nozzle.

⚠ CAUTION

When oil pumps are driven directly, oil circulation is required at all times. Do not start the burner with closed stop valves in the suction or return lines or serious damage will occur

It is a requirement 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.

Note: 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.

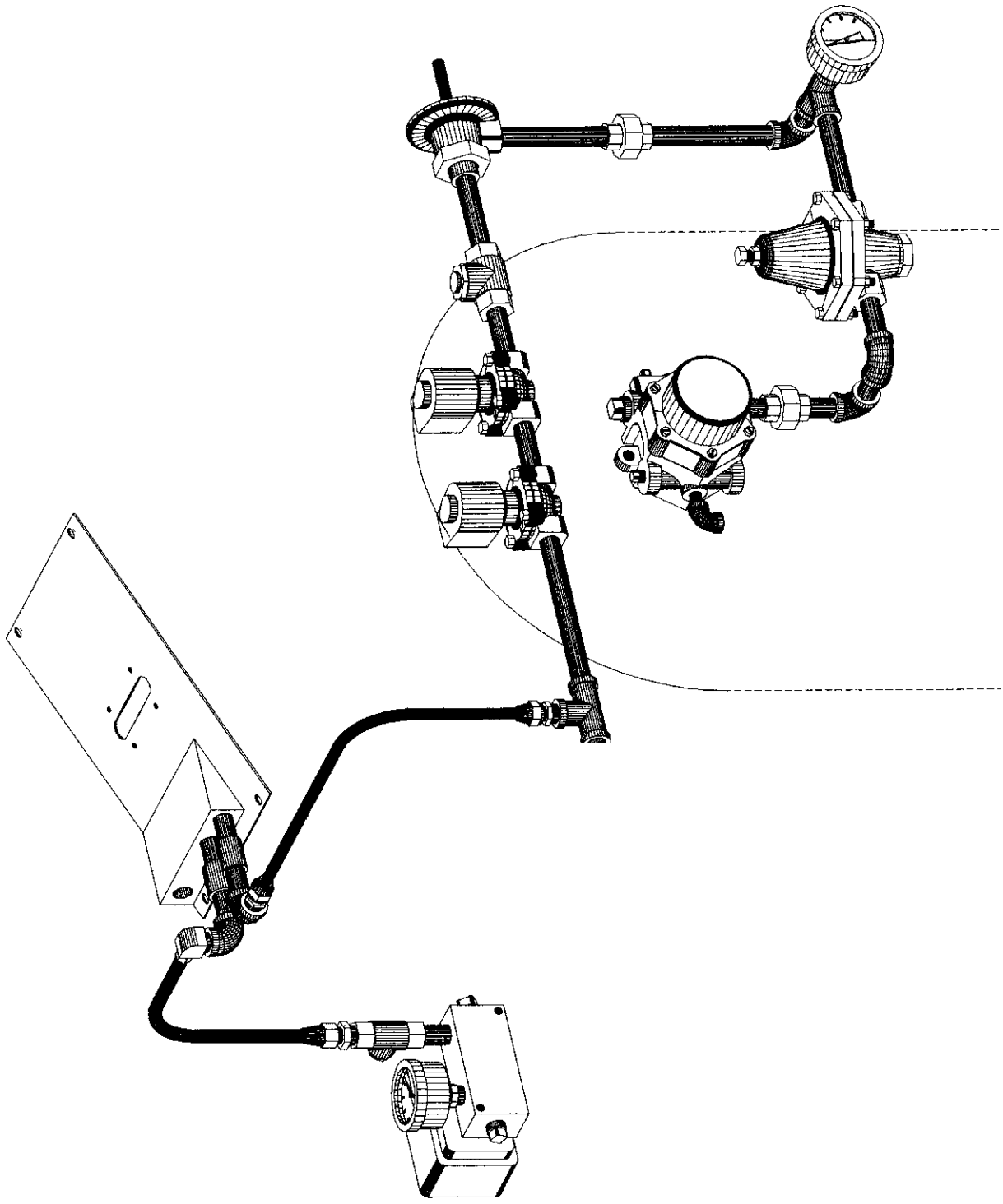


Figure 5-3: ProFire Burner Air Atomized, Direct Drive System (Light Oil)

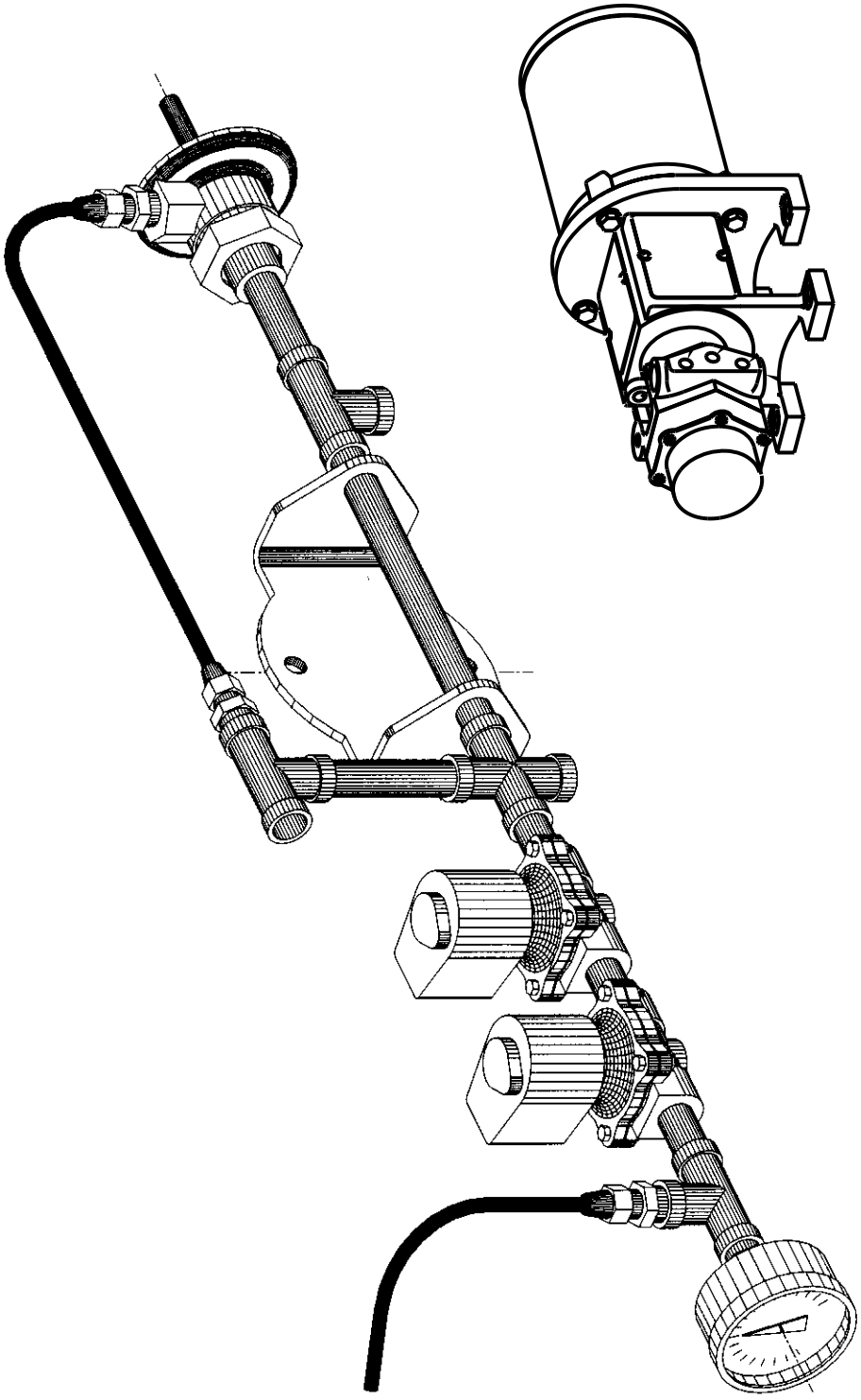


Figure 5-4: ProFire Burner Pressure Atomized with Remote Pump System

2. CONTROL SETTINGS - STEAM AND HOT WATER

See Chapter 6 for adjustment instructions for the following controls.

Inspect the operating limit control for proper setting.

1. The 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 control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the high limit control for proper setting.

3. ELECTRICAL REQUIREMENTS AND CONNECTIONS

⚠WARNING

Shut off and lock out all electrical power to the burner before performing any service or maintenance that requires removal of electrical equipment covers or component parts. Failure to follow these instructions could result in serious personal injury or death.

Verify that all electrical power supplies and branch circuit wiring are sized in accordance with the electrical loads shown on the specification plate on the side of the burner control cabinet (Figure 5-10). Check system interlocks, control interfaces, and any additional remote controls against the system schematic and wiring diagram. Refer to the Cleaver-Brooks wiring diagram supplied with the burner for specific requirements. Verify that all supply wiring terminations are tight.

4. LINKAGE CONNECTIONS

Inspect all linkages for damage and/or loosening during shipment. All fasteners must be secure for safe operation. All connections must be correctly positioned and tightened. Apply a lock-tight type compound to any fasteners after adjustment.

5. BURNER SETTINGS

To ensure reliable and safe burner performance, the location and gap setting of the electrodes for the direct-spark igniters, and the relative positions of the burner nozzle and diffuser components must be correctly set (Figures 5-5, 5-6, 5-7, and 5-8). 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 positions.

The nozzle assembly must be removed from inside the burner to enable measurement and adjustment of the oil-spark-ignition electrodes (furnished only on oil burners) and the nozzle relative to the diffuser.

1. Remove the nozzle assembly as follows:

⚠WARNING

Inadvertent burner operation can cause serious injury, or death. Do not perform maintenance on a burner without first disabling the electrical power supply. Lock out and tag the electrical power supply to prevent inadvertent burner startup during checkout or maintenance activities. Failure to follow these instructions could result in serious personal injury or death.

   A. Lock out and tag the electrical power supply to the burner to prevent inadvertent operation during checkout or maintenance activities.
   B. Disconnect the high-voltage power supply from the oil-spark-ignition electrodes (if installed).
   C. Disconnect the oil piping from the end of the blast tube.
   D. Remove the fasteners that secure the nozzle/diffuser assembly to the top of the fan housing, and remove the nozzle assembly from the burner.
2. Measure the position and gap of the pilot electrodes, and compare these to the dimensions shown in Figure 5-5. If necessary, adjust the position of the electrodes relative to the nozzle as follows:
   A. Loosen the locking screws on the spark ignition clamp assembly (Figure 5-5).
   B. Rotate and slide each electrode in the clamp, as necessary, to achieve the correct position relative to the burner tip.
   C. Tighten the locking screws securely to lock the electrodes in position. Apply a lock-tight type compound to the screws before tightening.
3. Refer to Figure 5-6. 5-7 and 5-8 and measure the distance from the tip of the nozzle to the diffuser inside the blast tube. If necessary, adjust the position of the diffuser as follows:
   A. Loosen the locking screw on the back cap.

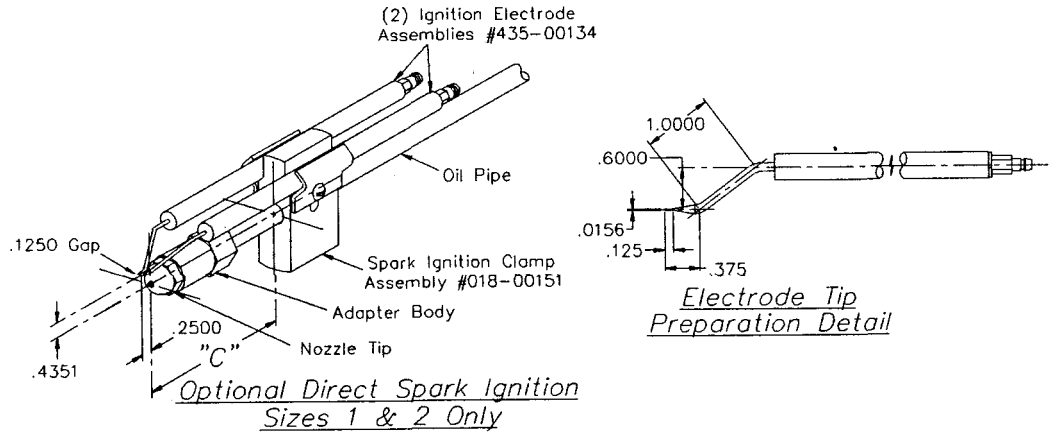


Figure 5-5: Direct Spark Electrode Setup

B. Slide the oil pipe fore or aft along the length of the burner pipe until the correct dimension is achieved.

C. Tighten the locking screw securely to the oil pipe. Apply a Lock-tight type compound to the screws before tightening.

4. Carefully install the adjusted nozzle assembly into the burner. Then re-connect the oil supply and high-voltage power cable to the assembly.

C. Startup Procedures

PRESTART TASKS AND CHECKLIST - ALL FUELS

Before proceeding with system startup and adjustment, be sure that overall installation is complete. Review the boiler operating and installation manual carefully to verify that the boiler is properly set up for operation. Check that all shipped-loose items (those items not installed when shipped) have been correctly installed. Verify the supply of fuel. Check to make sure the burner is wired as shown on the wiring diagram. Ensure that all control wiring terminals are tight.

Complete the following checklist in preparation for system startup:

• Confirm that the fuel and electrical connections have been completed in accordance with the applicable codes and insurance requirements (if necessary), and that connections comply with the piping schematic and wiring diagram.

• Check the combustion air fan motor for correct rotational direction.

• Check that the boiler is filled with water to the proper level, and that all circulating pumps (hot water units) are correctly installed and operational.

• Verify that there is proper gas pressure at the gas train, if this is a gas or combination burner. See the burner specification plate (Figure 5-10) for minimum and maximum natural gas pressure requirements.

• For oil burners confirm that the oil tank is adequately

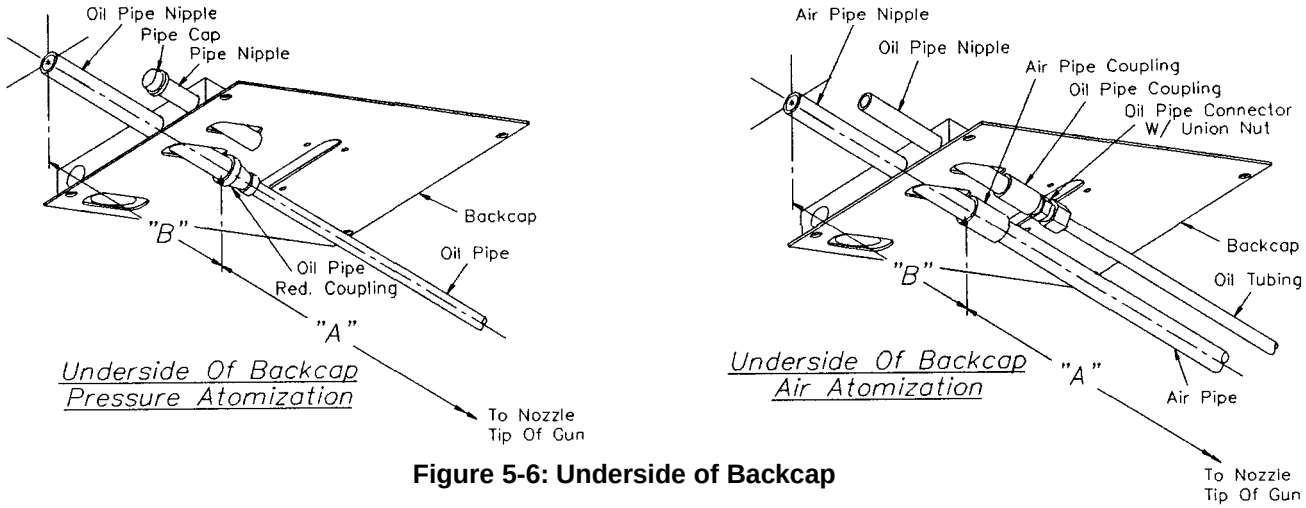
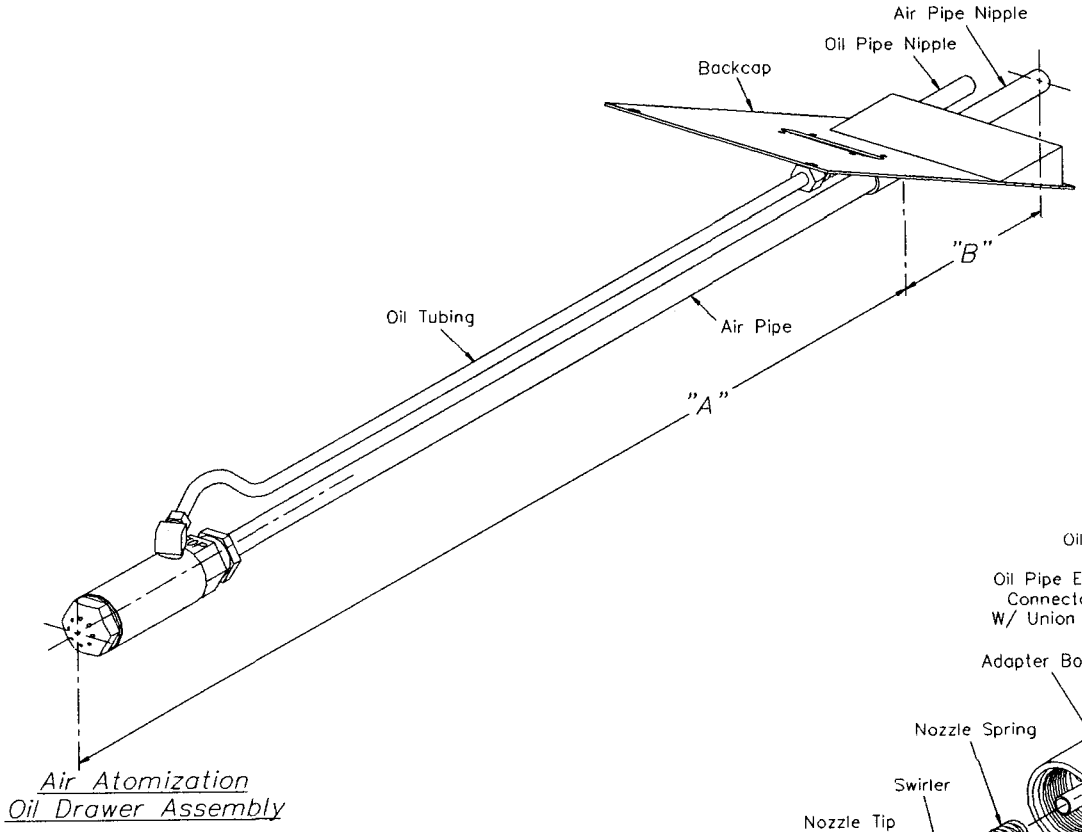
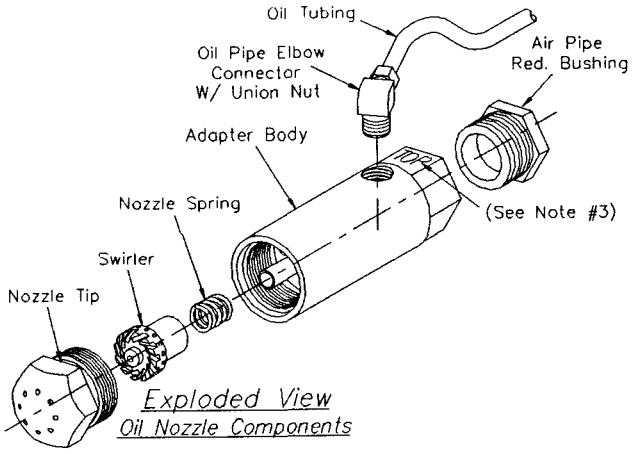


Figure 5-6: Underside of Backcap





Notes:

1) *Apply Loctite To All Fasteners.*
2) *Do NOT Use Teflon Tape On Pipe Joints.*
3) *Orient "Top" of Adapter Body On Top Vertical Centerline As Shown.*

Dimension Table

	Air Atomization		Pressure Atomization		
	"A"	"B"	"A"	"B"	"C"
Size 1	-----	-----	23.250	2.875	3.500
Size 2	-----	-----	23.6875	3.500	3.3125
Size 3	31.750	4.500	28.250	4.500	-----
Size 4	39.000	5.500	-----	-----	-----

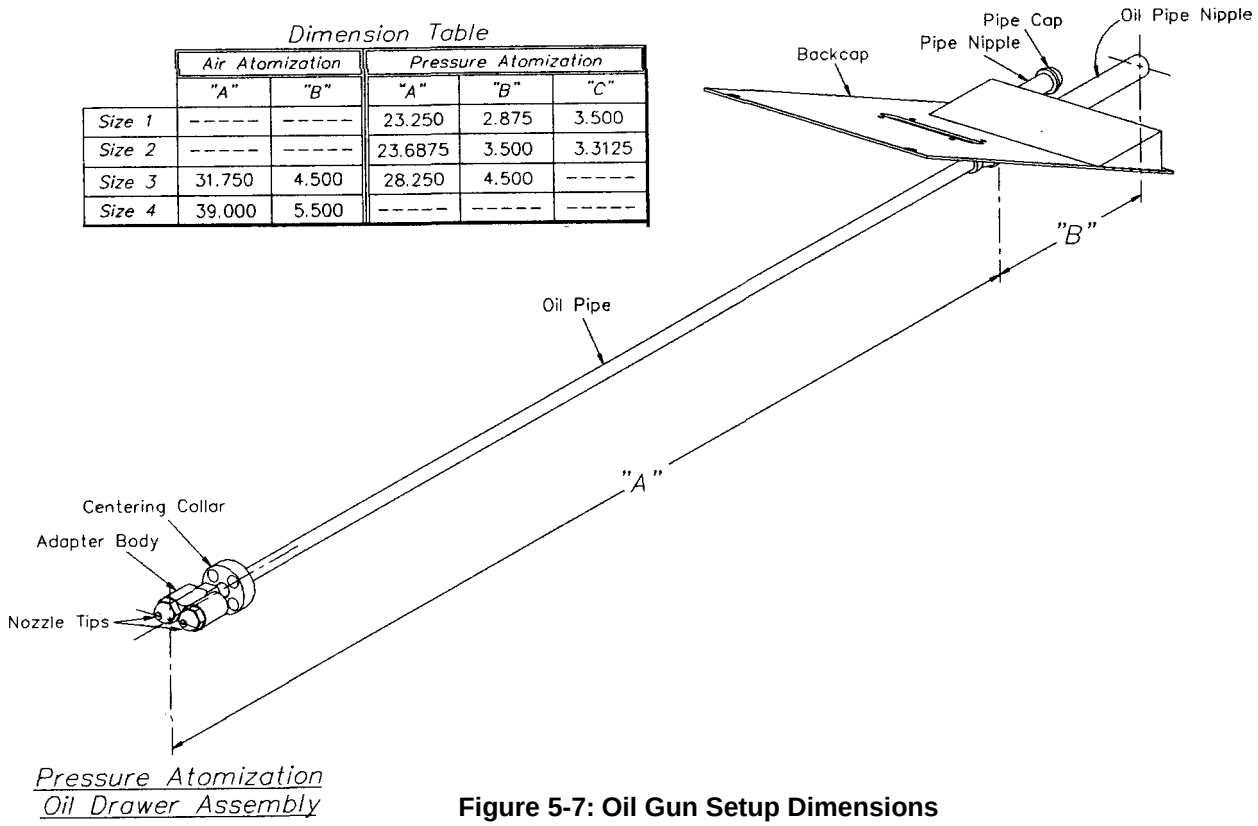


Figure 5-7: Oil Gun Setup Dimensions

filled with the correct grade of fuel oil, and that any isolation valves in the supply and return lines are open.

• Check that the flame safeguard has been properly installed inside the control panel.

• Verify that the prestart checklist for the boiler has been thoroughly completed.

• Provide the following test equipment on site:

1. Combustion analyzer for O_2.
2. U-tube manometer, or pressure gauge, to measure gas pressures (main and pilot).
3. Inclined manometer to measure draft pressures.
4. Smoke spot tester for oil fired units. (CO analyzer for gas fired burners).
5. Voltmeter.
6. Thermometers and thermocouples.

⚠ CAUTION

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner.

AIR AND FUEL CONTROLS (DESCRIPTION)

The combustion system air and fuel controls have been factory adjusted, and the unit has been test fired before it was shipped. Regardless of preliminary adjustment and operation, it is necessary to readjust the controls for local conditions:

• The fuel flow controls must be adjusted to establish the rated heat input over the full range of firing-rate modulation.

• The air controls need to be adjusted, relative to the established fuel flow rates, to provide the correct amount of air for complete, efficient combustion.

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

a. Air Flow Adjustments

ProFire burners have a unique air shutter design that enables precise, independent, air flow rate adjustment for both the high-fire and the low-fire operating points. This design incorporates a variable main air shutter (mounted on a shaft and direct-coupled to the modulating motor), plus two adjustable, but non-modulating, air shutters.

The modulating main air shutter regulates the flow of inlet air through the fan at flow rates between high-fire and low-fire conditions. One non-modulating air shutter (for high-fire combustion air control) is adjusted to provide the correct amount of air while the system is operating at the high-fire fuel input rate with the main air shutter fully open. The other non-modulating shutter (low-fire combustion air control) is adjusted to provide the correct amount of air with the system operating at the low-fire fuel input rate with the main shutter completely closed.

The three air shutters are mounted inside the airbox assembly. The high-fire and low-fire air shutters are mounted on independent shafts. A pointer, mounted on each shaft, indicates the set position of each non-modulating shutter. Adjustment of these shutters is accomplished by loosening a setscrew that holds the shutter shaft within a stationary collar mounted on the airbox.

b. 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. Adjustments may be required to meet certain environmental emissions criteria, such as NOx or CO. Combustion adjustments also vary with specific system applications.

Turndown capability for oil is less than that for natural gas. Therefore, on combination fueled burners, gas turndown performance may be restricted (or determined) by the excess air levels set initially for oil combustion.

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.

ProFire burners are capable of operating at CO levels of less than 50 ppm at all firing rates. The burner should be set-up

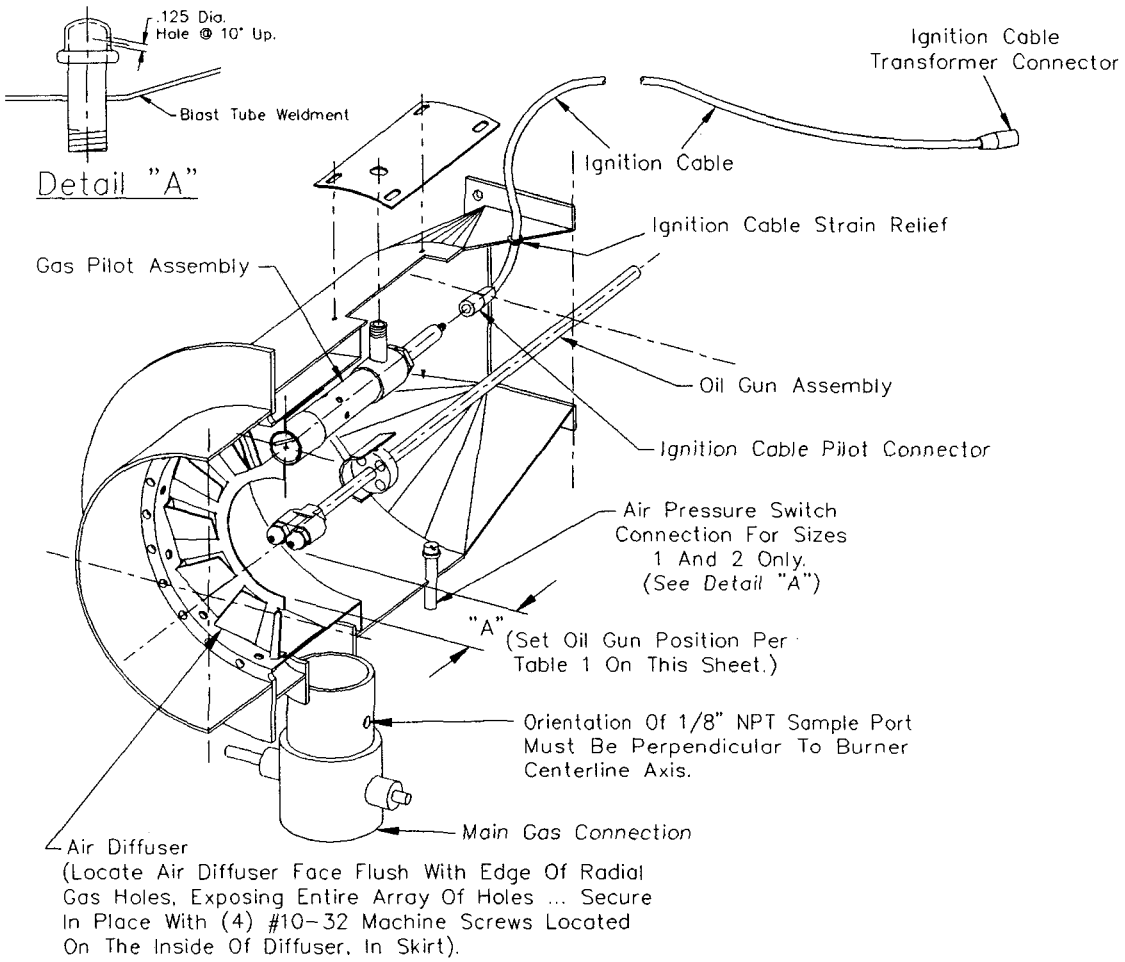


TABLE 1

Dim. "A"	Size 1	Size 2	Size 3	Size 4
Air Atomization	----	----	0.750	0.500
Pressure Atomization	1.375	4.000	4.000	----

Figure 5-8: Blast Tube and Diffuser Start Up Dimensions

and maintained to yield smoke spot levels less than a #1 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot build-up in the boiler.

D. Burner Adjustments, Single Fuel Natural Gas

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excess oxygen in the flue gas accordingly.

This section provides detailed procedures for setup and adjustment of a gas-fired combustion system. Similar discussions are also presented in this chapter for startup and adjustment of oil-fired and combination-fueled gas or oil systems.

These procedures assume that the pre-startup tasks, checklists, and adjustments covered in this manual have been completed, and that the boiler system is prepared for initial

CEW (Type "F") Burners

SYSTEM TYPE	DESCRIPTION See Detail "B"	LINKAGE ARM ANGULAR ORIENTATION (In Degrees) BOILER HORSEPOWER / INPUT (MMbh)						ROD CLAMP POSITION FROM CENTER POINT (In Inches) BOILER HORSEPOWER / INPUT (MMbh)					
		125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7	125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7
STRAIGHT GAS AND GAS / AIR ATOMIZED OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	+20	+20	+28	+15	+15	+15	2.50	2.50	2.50	3.00	3.00	3.00
	MAIN GAS VALVE ARM	+25	+15	+30	-15	-15	-10	3.50	4.00	3.00	3.75	3.75	3.75
	GAS VALVE SETTING (Deg. Open)	20	10	10	10	20	15	--	--	--	--	--	--
	MAIN SHAFT F.G.R. VALVE ARM												
GAS WITH PRESSURE ATOMIZATION OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	+20	+20	-10	--	--	--	2.50	2.50	2.25	--	--	--
	MAIN GAS VALVE ARM	+30	+20	+35	--	--	--	3.25	4.00	3.75	--	--	--
	GAS VALVE SETTING	28	15	20	--	--	--	--	--	--	--	--	--
	MAIN SHAFT F.G.R. VALVE ARM				--	--	--				--	--	--
PRESSURE ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM	+90	+80	+50	--	--	--	2.00	3.00	3.25	--	--	--
	OIL CONTROLLER ARM	+32	+40	+40	--	--	--	3.75	3.25	3.00	--	--	--
	OIL VALVE SETTING (Ref. No.)	5.5	11	9.5	--	--	--				--	--	--
	MAIN SHAFT F.G.R. VALVE ARM				--	--	--				--	--	--
AIR ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM				+115	+115	+115				2.50	3.00	3.25
	OIL CONTROLLER ARM				-20	-20	-15				3.00	3.75	3.25
	OIL VALVE SETTING (Ref. No.)				1.5	1.5	2						
	MAIN SHAFT F.G.R. VALVE ARM												

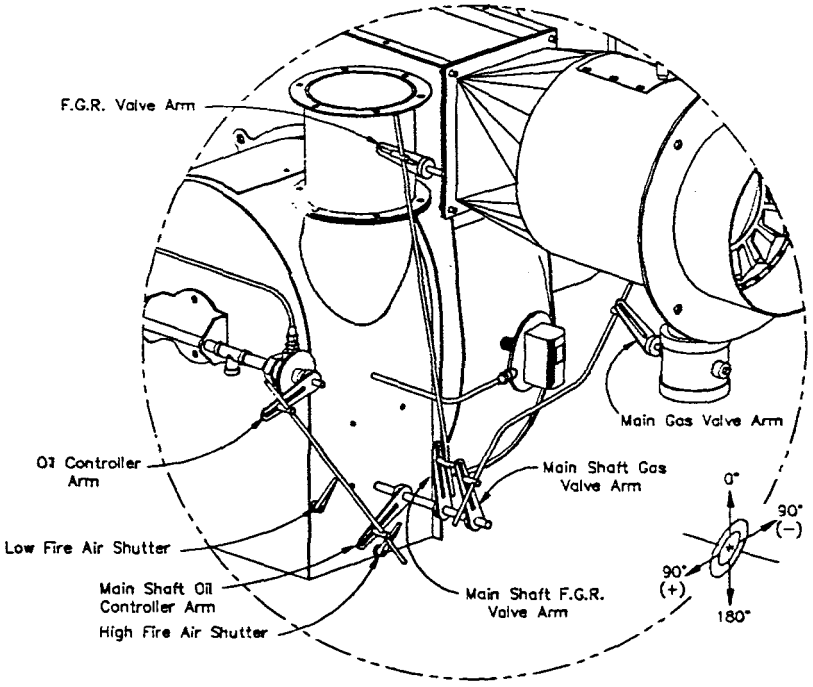


Figure 5-9: Burner Linkage Setup

startup. All necessary test equipment, specified in Section C, should be available on site and installed.

> **⚠ CAUTION**
>
> *Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner.*

CONTROLS SETUP. Complete the following burner system control setup steps before beginning the natural gas startup procedure:

1. Check the linkages to confirm they are securely fastened and ready for operation.

   NOTE: The linkages have been factory-set and tested, although they may require fine adjustment for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with Figure5-9.

2. Place the burner switch to the OFF position (see Figure 2-1).
3. Place the Manual/Auto mode switch to the MANUAL position (see Figure 2-1).
4. Place the manual flame control potentiometer in the CLOSED (low-fire) position (see Figure 2-1).

STARTUP. Proceed with startup of the natural gas-fired system as follows:

1. Close the manual shutoff valves on the burner gas train.
2. Turn on electrical power for the burner, boiler, and related components.
3. Place the upstream manual gas valve in the on position, allowing natural gas to enter the gas train. (furthest from the burner)
4. Verify that the gas metering valve is nearly closed.
5. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.
6. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
7. When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by observing the stem move from the CLOSED to the OPEN position.

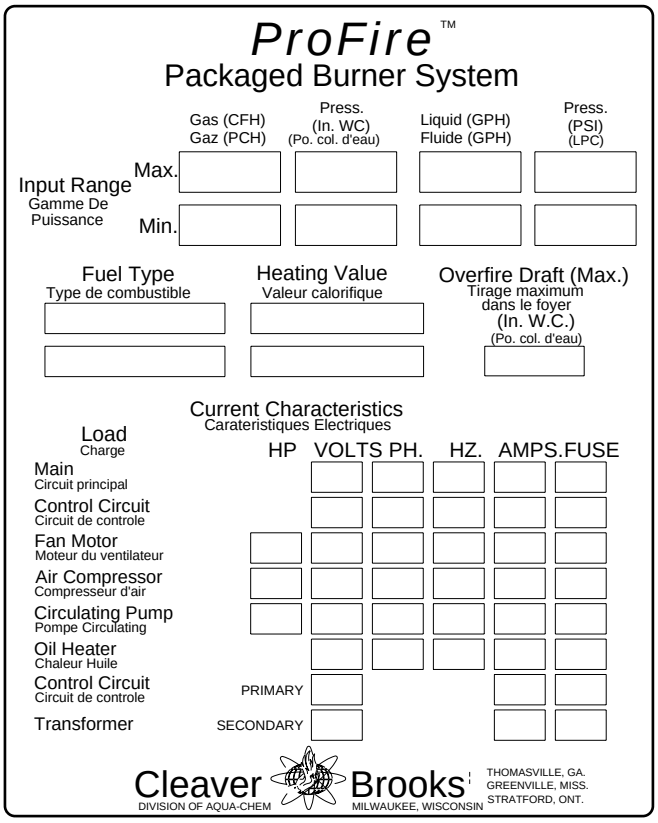
   NOTE: For initial boiler startup, the downstream manual gas shutoff valve should be in the closed position to ensure proper operation of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.

8. After the main flame has been established, the gas manifold pressure entering the burner should be read (using the pressure tap between the butterfly valve and the blast tube) to determine an initial estimate of the gas input rate and compare to Figure 5-10. This will provide an approximation of the burner input. Obtain a stable operating point by adjusting the butterfly valve to the pressure indicated in Figure 5-10, and select the temporary firing rate. This rate for startup is not critical, but merely an acceptable starting point to begin the high fire adjustment procedures.
9. After a few seconds, the O_2 analyzer should have an accurate reading of the O_2 present in the flue gas. Table 5-1 shows the acceptable O_2 range for the gas burner. Normally, O_2 levels are set between 4 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).
10. 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. While increasing the input, observe that the O_2 levels remain within the range listed in Table 5-1. Adjust the gas 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).
11. Adjust the high fire gas input to match the maximum rating. At high fire, the butterfly valve should be near the full open position. Adjust gas pressure to obtain the correct fuel input. (Maximum pressure is specified on the burner specification plate.)

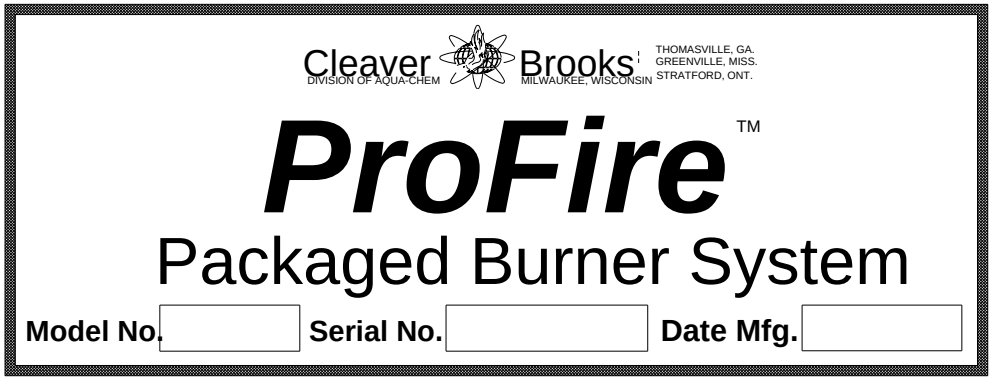
    If a dedicated gas meter is available, the following formula may be used to check fuel flow. Conduct this measurement while operating at a constant rate.

    NOTE: Some meters may require 6.0 IN. H_2O correction to Pgas. Consult meter calibration data.

$$\text{Gas Input} = (\text{HHV}) \times \left[\frac{\text{Patm} + \text{Pgas}}{29.92}\right] \times \left[\frac{520}{\text{Tgas} + 460}\right] \times \left[3600 \frac{\text{s}}{\text{hr}}\right] \times \left[\text{RATE} \frac{\text{ft}^3}{\text{s}}\right] = \left[\frac{\text{Btu}}{\text{hr}}\right]$$



SPECIFICATION PLATE



NAME PLATE

Figure 5-10: Specification Plate and Burner Name Plate

Burner Ratings	Gas Train Insurance Designations		
	Standard	FM	IRI
2.51 - 5.0 MMBtu/hr	M2	M2	M4
5.01 - 9.00 MMBtu/hr	M3	M3	M4
9.01 - 12.00 MMBtu/hr	M3	M3	M4
12.00 - 14.6 MMBtu/hr	M4	M4	M4

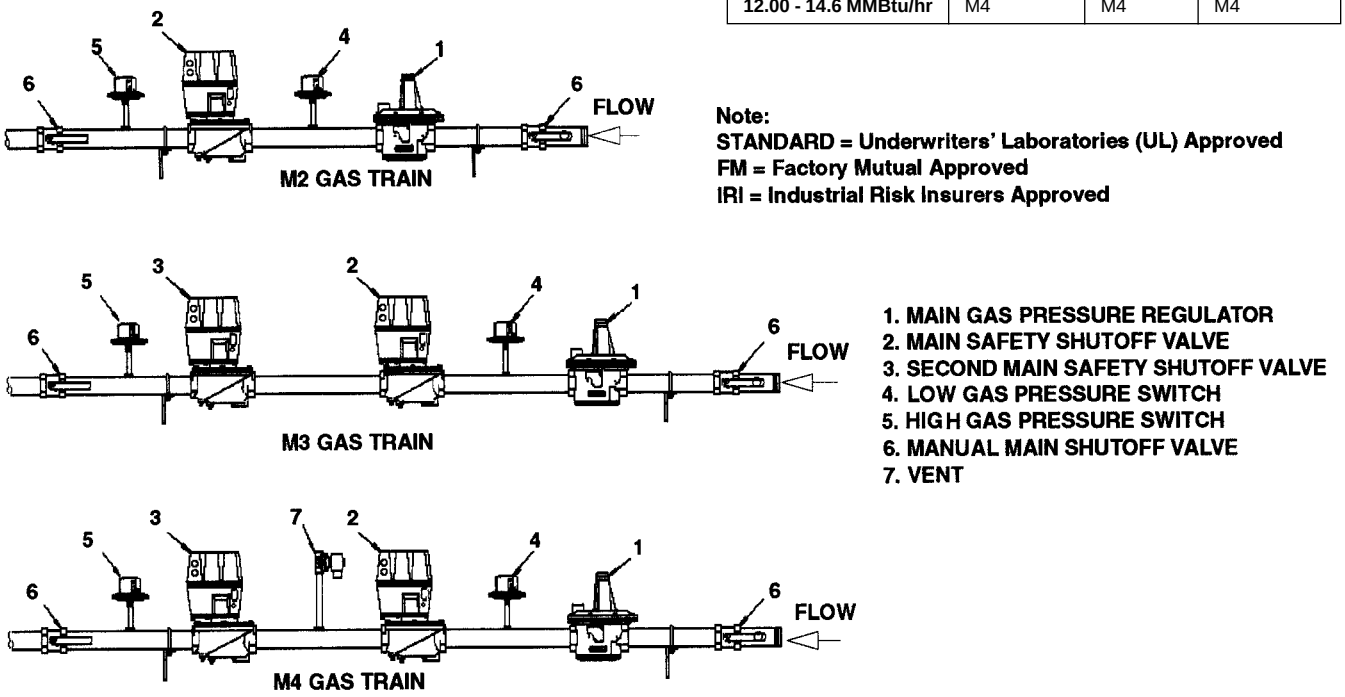


Figure 5-11: Gas Train Configurations

NOTE: Gas train configurations are subject to change. The above configurations reflect components at the date of this Operation and Maintenance manual publication date.

Where:

HHV = The higher heating value of natural gas (1000 Btu/ft^3). Contact your local gas company for an exact measurement.

P_{atm} = Atmospheric pressure in inches of mercury.

P_{gas} = Gas pressure ahead of the volumetric flow meter in inches of mercury.

T_{gas} = Gas temperature at the volumetric flow meter in °F.

RATE = Natural gas rate taken with the volumetric flow meter in ft^3/second.

S = Seconds.

12. Adjust the high fire excess air rate using the high-fire shutter adjustment (see Figure 5-9 for location).
13. Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel flow at the low-fire position in accordance with the burner data plate minimum gas-pressure rating.
14. Adjust the low-fire (see Figure 5-9) damper again to obtain the correct low-fire excess air level within the range of 5-6% O_2.

E. Burner Adjustments, Single Fuel, Oil-fired (Pressure Atomization)

This section of the manual presents detailed procedures for initial startup of an oil-fired combustion system.

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excess oxygen in the flue gas accordingly.

> **⚠ CAUTION**
>
> *This burner is designed to burn only those fuels shown on the burner data plate. Burning fuels not specified on the data plate could cause damage to the equipment.*

The following procedures assume that the pre-startup tasks, checklists, and adjustments discussed in this manual have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment specified in Section C should be available on site.

> **⚠ CAUTION**
>
> *Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage to the equipment. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner.*

CONTROLS SETUP. Complete the following combination system control setup steps before beginning the oil-fired burner startup procedure:

1. Check the linkages to confirm that they are securely fastened and ready for operation.

   NOTE: The linkages have been factory-set and tested, although they may require fine adjustment for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with Figure 5-9.

2. Place the burner switch to the OFF position (see Figure 1-3).
3. Place the Manual/Auto mode switch to the MANUAL position.
4. Place the manual flame control potentiometer to the CLOSED (low-fire) position.
5. Completely open the low-fire and high-fire shutters.

STARTUP. Proceed with initial startup of the oil-fired system as follows:

1. Turn on the electrical power for the burner, boiler, and related components.
2. Verify that the oil metering valve is nearly open.

   NOTE: Opening the oil metering valve reduces oil flow to the burner.

3. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.
4. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.

   Note: If the pilot is established, the flame safeguard will energize the two oil solenoid valves (this is accompanied by a click from the solenoid valves and illumination of the FUEL VALVE light) and the oil burner should ignite on low-fire.

5. After the main flame has been established, the oil pressure entering the burner nozzle should be read (by reading the oil pressure gauge downstream of the oil solenoid valves) to get an initial estimate of the fuel oil input rate. Oil pressure should be about 80 psi when operating at low-fire. Adjust the oil metering valve if the actual pressure is not within the range of 80 to 90 psi.
6. Operate the boiler at low fire until it is thoroughly warmed. Then, modulate to high fire by turning the manual flame potentiometer to the OPEN position. This will cause the oil metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. Check the excess air in the flue gas (see Table 5-2 for acceptable excess O_2 levels), while modulating to high-fire. Adjust the oil pressure if needed.
7. Set the high-fire fuel input pressure to match the maximum oil pressure specification on the burner data plate by adjusting the fuel input. The oil metering valve should be in the fully closed position and the fuel pressure should be about 300 psi.
8. Adjust the high-fire shutter to obtain the correct excess air level (see Figure 5-9 for the adjustment location).
9. Modulate to low fire using the manual flame control. Be sure O_2 levels are within limits in Table 5-1.
10. Set the proper fuel input for low fire by adjusting the linkage to drive the oil metering valve to the proper position (see Figure 5-9 for oil metering valve linkage adjustments).
11. Adjust low fire air shutter to obtain 4.5-5.5% O_2
12. Check intermediate positions for proper combustion. Adjust the linkage, as required, to match the fuel and air ratios indicated in Table 5-2.

13. Modulate and recheck combustion air at different firing rates. When large adjustments are made at one rate, they may adversely affect settings at another rate.

F. BURNER ADJUSTMENTS, COMBINATION

Note: The operator must consider and allow for normal variations in air and fuel, which would reduce the range of excessive oxygen in the flue gas accordingly.

This section of the manual presents procedures to be followed for initial startup of a combination ProFire burner.

⚠ CAUTION

This burner is designed to burn only those fuels shown on the burner data plate. Burning fuels not specified on the data plate could cause damage to the equipment.

These procedures assume that the pre-startup tasks, checklists, and adjustments discussed in this manual have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment specified in Section C should be available on site.

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 re-started and adjusted using natural gas as fuel. Combustion adjustment of the combination burner for natural gas involves balancing the input gas rates only against the existing flow of combustion air, as established initially for oil-firing. Do not readjust the air shutters when tuning the combination burner for combustion of natural gas.

⚠ CAUTION

Attempting initial burner startup with insufficient knowledge of the equipment and startup procedures can result in serious damage. The operator must be totally familiar with the entire startup and adjustment process before attempting to operate the burner.

CONTROLS SETUP. Complete the following system control setup steps before beginning the combination burner startup procedure:

INPUT (MMBtu/hr)	MINIMUM O_2 (%)	MAXIMUM O_2 (%)
SIZE 1		
1.6	2.5	5.0
2.1	2.5	5.5
2.5	2.5	5.0
SIZE 2		
2.1	3.0	5.0
2.5	3.0	5.0
2.9	2.5	5.0
3.4	2.5	5.0
4.2	2.5	4.5
SIZE 3		
4.2	3.0	5.5
5.2	2.5	5.0
6.3	2.5	5.0
8.4	2.5	4.5
	SIZE 4	
8.4	2.5	5.0
10.5	2.5	5.0
12.6	2.5	4.5
14.7	2.5	3.5

Note: Table presents the maximum recommended range of operating levels of excess oxygen in the flue gas for various burner sizes, operating at given levels of natural gas input to the burner. Data is valid for conditions at standard atmospheric temperature and pressure. Results will vary under environmental conditions differing from standard.

Table 5-1: Recommended Stack Gas 0_2 Concentration at Various Rates (Natural Gas)

1. Check the linkages to confirm that they are securely fastened and ready for operation.

   Note: The linkages have been factory-set and tested, although they may require fine tuning for the specific application. If the linkage is not in place, or if the setting has been lost, install the linkage in accordance with Figures 5-9.

2. Place the burner switch in the OFF position (see Figure 1-3).
3. Place the Modulating Mode switch in the MANUAL position.
4. Place the manual flame potentiometer in the CLOSE (low-fire) position.
5. Open the low-fire and high-fire shutters completely.

STARTUP. Proceed with initial startup using oil as follows:

1. Position the fuel selector switch (located inside the control panel) to OIL.
2. Proceed with startup and combustion adjustments using the same procedures defined for oil-fired burner initial startup.
3. After the system has been completely adjusted for oil-firing, place the burner switch to the off position, and position the fuel selector switch to GAS.
4. Place the Manual/Auto mode switch to the MANUAL position.
5. Place the manual flame control potentiometer to the CLOSE (low-fire) position.
6. Close the downstream manual shutoff valve on the burner gas train (closest to the burner).
7. Admit natural gas to the gas train.
8. Verify that the butterfly valve is in a position that is nearly closed.
9. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.
10. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
11. When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by observing the stem move from the CLOSED to the OPEN position.

    NOTE: The downstream manual gas shutoff valve should be in the closed position, for initial boiler startup, to ensure proper operation of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.

12. After the main flame has been established, the gas pressure entering the burner should be read (using the pressure tap between the butterfly valve and the blast tube) to determine an initial estimate of the gas input rate. By doing so, and referring to the burner data plate, an approximation of the burner input can be assessed. Obtain a stable operating point by adjusting the butterfly valve to the pressure indicated on the burner data plate and select the temporary firing rate. This rate for startup is not critical, but merely an acceptable starting point to begin the high fire adjustment procedures.
13. After a few seconds, the 0_2 analyzer should have an accurate reading of the 0_2 present in the flue gas. Table 5-1 provides a representation of the acceptable 0_2 range for the gas burner. Normally, the 0_2 levels are set between 3 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).
14. Operate the boiler at low fire until it is thoroughly warmed. Then increase the fuel input to the boiler by turning the manual flame potentiometer towards open in small increments. This will cause the butterfly valve to open farther, allowing more gas into the burner. While increasing the input, observe that the 0_2 levels remain within the range shown in Table 5-1. Adjust the gas 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).
15. Adjust the high fire gas input to match the maximum rating. At high fire, the butterfly valve should be near the full open position (readjust linkage if required). Adjust the gas pressure to obtain the correct fuel input. (Maximum pressure specified on the burner specification plate.)

    If a dedicated gas meter is available, the following formula may be used to check fuel flow. Conduct this measurement while operating at a constant rate.

    NOTE: Some meters may require 6.0 IN. H_20 correction to Pgas. Consult meter calibration data.

    Where:

$$\text{Gas Input} = (\text{HHV}) \times \left[\frac{\text{Patm} + \text{Pgas}}{29.92}\right] \times \left[\frac{520}{\text{Tgas} + 460}\right] \times \left[3600 \frac{\text{s}}{\text{hr}}\right] \times \left[\text{RATE} \frac{\text{ft}^3}{\text{s}}\right] = \left[\frac{\text{Btu}}{\text{hr}}\right]$$

    HHV = The higher heating value of natural gas (1000 Btu/ft^3). Contact your local gas company for an exact measurement.

    P_{atm} = Atmospheric pressure in inches of mercury.

    P_{gas} = Gas pressure ahead of the volumetric flow meter in inches of mercury.

    T_{gas} = Gas temperature at the volumetric flow meter in °F.

    RATE = Natural gas rate taken with the volumetric flow meter in ft^3/second

    S = Seconds.

    NOTE: It is unnecessary to readjust the position of the high-fire or low-fire shutters after having been set for oil firing.

16. Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel pressure at

the low-fire position in accordance with the burner data plate minimum gas-pressure rating.

FUEL FLOW ADJUSTMENTS. Fuel flow rates are adjusted to provide the design-rated heat inputs into the burner at both high-fire (maximum rate) and low-fire (minimum rate) operating conditions. The maximum and minimum fuel input flow rates for the burner are identified on the data plate (see Figure 5-10). Natural gas flow rates are specified in cfh (cubic feet per hour), and fuel oil flow rates are specified in gph (gallons per hour).

Fuel flow rate adjustment for both natural gas and oil is accomplished by regulating the fuel pressure against a fixed diameter orifice (nozzle). The methods for accomplishing the pressure regulation, however, are different for natural gas and oil.

The method for regulating the natural gas flow rate (manifold pressure) is as follows:

1. Maximum flow rate is established by operating the burner at high-fire with the butterfly valve (Figure 2-2) fully open, then adjusting the manifold pressure to the maximum as specified on the data plate (Figure 5-10). Maximum manifold pressure is obtained by adjusting the main gas pressure regulator on the gas train while operating the burner at high-fire.
2. Gas flow modulation for turndown is accomplished by throttling the flow rate with the butterfly valve. The flow restriction of the partially closed butterfly valve reduces the flow of gas through the burner nozzle. The butterfly valve throttling position is controlled by linkage from the main air shutter shaft, which is operated by the modulating motor.

With the modulating motor positioned for low-fire operation, the butterfly valve linkage is adjusted to provide the minimum pressure in the nozzle manifold, as specified on the burner data plate.

The method for regulating the fuel-oil flow rate (nozzle pressure) is as follows:

1. Maximum flow rate is established by operating the burner at high-fire with the oil metering valve (Figure 2-4) in a nearly closed position with the modulating motor set at the high-fire position. In this position, the flow of fuel oil through the oil by-pass is minimal, resulting in nearly maximum flow pressure from the pump. High-fire oil flow adjustment is accomplished by adjusting the linkage to the oil metering valve so that the burner nozzle pressure equals the maximum oil pressure specification on the burner data plate.
2. Oil pressure modulation for turndown to low-fire operation is accomplished by increasing the flow rate of oil through the oil by-pass loop, which reduces pressure in the burner nozzle. This is accomplished by setting the modulating motor to the low-fire position, which causes the oil metering valve to open. While in this position, the oil metering valve linkage can be adjusted so that the burner nozzle pressure equals the minimum oil pressure specification on the burner specification plate.

INPUT (MMBtu/hr)	MINIMUM O2 (%)	MAXIMUM O2 (%)
SIZE 1		
1.6	2.5	5.0
2.1	2.5	5.5
2.5	2.5	5.0
SIZE 2		
2.1	3.0	5.0
2.5	3.0	5.0
2.9	2.5	5.0
3.4	2.5	5.0
4.2	2.5	4.5
SIZE 3		
4.2	3.0	5.5
5.2	2.5	5.0
6.3	2.5	5.0
8.4	2.5	4.5
	SIZE 4	
8.4	2.5	5.0
10.5	2.5	5.0
12.6	2.5	4.5
14.7	2.5	3.5

Note: Table presents the maximum recommended range of operating levels of excess oxygen in the flue gas for various burner sizes, operating at given levels of natural gas input to the burner. Data is valid for conditions at standard atmospheric temperature and pressure. Results will vary under environmental conditions differing from standard.

Table 5-2: Recommended Stack Gas O_2 Concentration At Various Rates (Light Oil)

G. START-UP, OPERATING AND SHUTDOWN - ALL FUELS

Depending upon the fuel being burned, the applicable previous sections in Chapter 5 should be reviewed for preliminary instructions.

The fuel selector switch should be, accordingly, set to either oil or gas.

Set the manual-automatic switch (Figure 2-1) to "manual" and turn the manual flame control to "close."

Turn burner switch to "ON." The load demand light should glow. The low-water level light should remain out, indicating a safe water level in the boiler. The programmer is now sequencing. See Chapter 4 for sequence details.

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

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

⚠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. Failure to follow these instructions could result in serious personal injury or death

⚠WARNING

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

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

In the case of a steam boiler, CLOSE THE VENT VALVE (Figure 1-2) when the steam begins to appear.

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

If the flame at low fire provides insufficient heat to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the manual flame control in one point increments to no higher than 1/4 of the modulation motor rotation. Operate at the increased fuel input rate for a period of time until an increase is noted in pressure or temperature.

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

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

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

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

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

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

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

When the burner is shut down normally, by either the operating limit control or by manually switching the burner off, the load demand light no longer glows.

Shutdown through conditions causing safety or interlock controls to open will actuate the flame failure light (and alarm if so equipped) and the load demand light will remain lit. The cause of this type of shutdown will have to be located, investigated, and corrected before operation can be resumed. Refer to the troubleshooting section in Chapter 7.

Shutdown - When the operating limit control setting is reached to open the circuit or if the burner switch is turned "off," the following sequence occurs.

The fuel valve is deenergized and the flame is extinguished. The timer begins operation and the blower motor continues running to force air through the furnace in the post-purge period.

At the end of the programmed post-purge period, the blower motor is turned off. The air pump motor of an oil-fired burner is also turned off. The timer has returned to its original starting position and stops. The unit is ready to re-start.

⚠WARNING

It is advisable to check for tight shut-off 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 personal injury or death

H. CONTROL OPERATIONAL TESTS 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 shut off point. If the load is heavy, the header valve can be closed or throttled until the pressure increases. Observe the steam gauge to check the cut off 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 cut-out 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.

Check for tight shut-off of all fuel valves. Despite precautions and strainers, foreign material may lodge under a valve seat and prevent tight closure. Promptly correct any conditions that cause leakage.

Notes

CHAPTER 6

Adjustment Procedures

A. GENERAL

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

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

Prior to placing the boiler into service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts and setscrews to be sure that no damage has occurred, or that adjustments have not changed during shipment and installation.

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

B. LINKAGE - MODULATING MOTOR AND AIR DAMPER

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

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

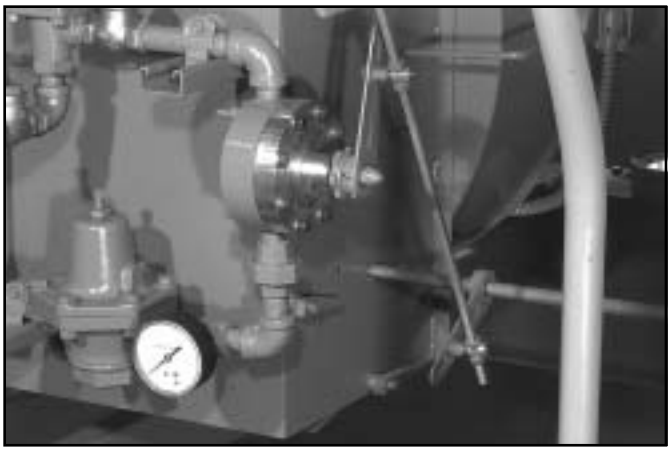
In linkage adjustments there are several important factors that must serve as guides.

1. The modulating motor must be able to complete its full travel range.

⚠ CAUTION

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

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



1. ADJUST THE LINKAGE TOWARD THE DRIVE SHAFT FOR LESS MOVEMENT.
2. ADJUST AWAY FROM THE DRIVE SHAFT FOR MORE LINKAGE MOVEMENT.

Figure 6-1: Linkage Assembly - Combination Gas and Oil

Prior to initially firing a boiler it is advisable to check for free movement of the linkage by electrically driving the damper motot. The damper motor must be allowed to complete its full stroke and the damper must move freely from low to high fire position. Adjustment of linkage connected to a gas butterfly valve is described in Section Q of Chapter 6.

C. MODULATING MOTOR

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

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

D. MODULATING MOTOR SWITCHES - LOW FIRE AND HIGH FIRE

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

Factory replacement motors have the cams preset. The low fire start switch is set to make the red and yellow leads at approximately 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° the 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.

E. BURNER OPERATING CONTROLS - GENERAL

Note: Adjustments to the boiler operating controls should be made by an authorized Cleaver-Brooks Service Technician.

The standard boiler operating control package consists of three separate controls, the High Limit Control, Operating Limit Control and the Modulating control.

The High Limit Control senses the hot water temperature or steam pressure. It is used as a safety limit to turn the burner off in the event the operating limit control fails. The high limit control should be set sufficiently above the operating limit control to avoid nuisance shutdowns.

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

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

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

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

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

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

Separate and independent controls affect modulated firing and burner on-off cycling. Figure 6-4 depicts a typical setting relationship of the operating limit control, modulating control and the high limit control.

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

In normal operation, the burner will shut down whenever the pressure or temperature rises above setting **A**. At that point the switch in the operating limit control will open. As the pressure or temperature drops back to **B**, the operating limit control closes and the burner will restart. The modulating control will signal the modulating motor to be in a low fire position. If the load demands exceed the low fire input potential, the modulating control will

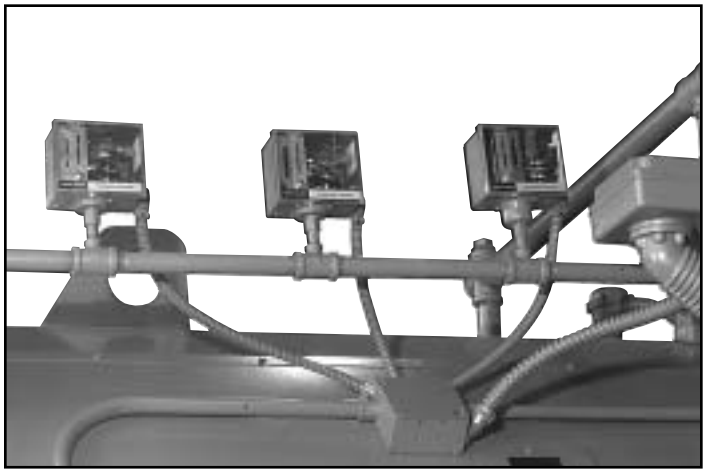


Figure 6-2: Steam Operating Controls

Figure 6-3: Hot Water Operating Controls

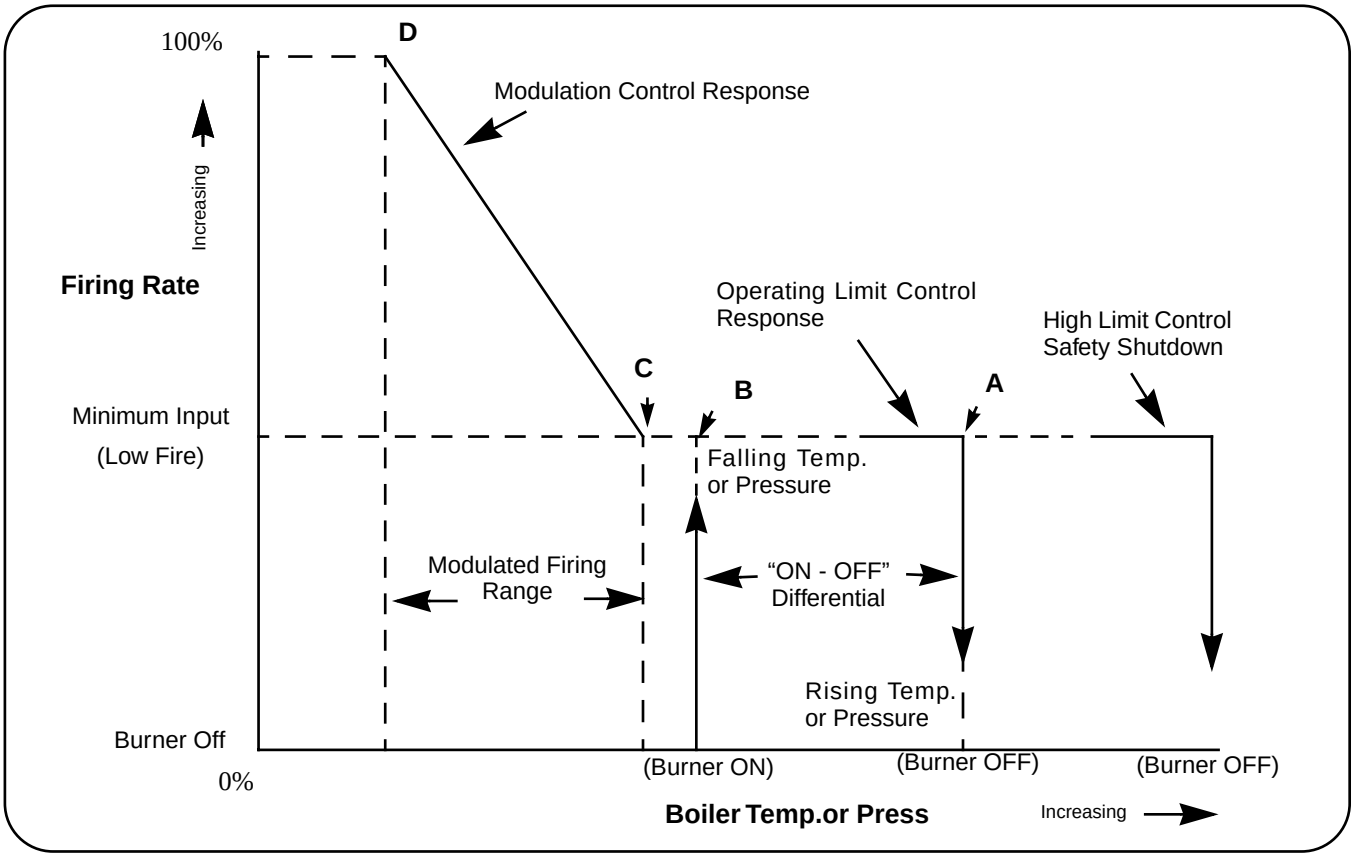


Figure 6-4: Firing Graph

increase the firing rate proportionately as pressure or temperature falls toward point **D**. The modulating motor will stop at any intermediate point between **C** and **D** whenever the fuel input balances the load requirement.

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

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

The firing graph (Figure 6-4) shows that point **B** and point **C** do not coincide. Extreme load conditions could require the points be closely matched.

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

Note: On-Off cycling in excess of 8 cycles per hour will shorten the life of the combustion air motor and cause excessive wear on switch gear and pilot electrodes.

If points B and C overlap when restart occurs, the burner would drive to a higher firing position immediately after the main flame was proven.

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

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

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

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

Ideally, the boiler operating controls should be set under actual load conditions. Especially under new construction conditions, the boiler is initially started and set to operate

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

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

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

The operating limit control should now be adjusted and the differential established. In an installation that does not require a very close control of steam pressure or water temperature the adjustable differential (Figure 6-4 A to B) should be set as wide as conditions permit, since a wide setting will provide less frequent burner cycling.

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

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

F. MODULATING PRESSURE CONTROL (Steam)

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

Figure 6-5: Steam Operating Controls

⚠ CAUTION

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

G. OPERATING LIMIT PRESSURE CONTROL (Steam)

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

H. HIGH LIMIT PRESSURE CONTROL (Steam)

Set “cut-out” (burner off) pressure on the main scale using the adjusting screw. The control will break a circuit when pressure reaches this point. The setting should be sufficiently above the operating limit pressure control to avoid shutdowns, and preferably not exceed 90% of safety valve setting. The control requires manual resetting after tripping on a pressure increase. To reset, allow pressure to return to normal and then press the reset button.

1. MODULATING TEMPERATURE CONTROL
2. OPERATING TEMPERATURE CONTROL
3. HIGH LIMIT TEMPERATURE CONTROL

Figure 6-6: Hot Water Controls

I. MODULATING TEMPERATURE CONTROL (Hot Water)

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

⚠ CAUTION

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

J. OPERATING LIMIT TEMPERATURE CONTROL (Hot Water)

Set "cut-out" (burner off) temperature on the scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw. The "cut-in" (burner on) temperature is the cut-out temperature MINUS the differential. The differential is adjusted from 5 to 30° F.

K. HIGH LIMIT TEMPERATURE CONTROL (Hot Water)

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

L. LOW WATER CUTOFF DEVICES (Steam and Hot Water)

No adjustment is required since LWCO controls are preset by the original manufacturer. However, if the water level is not maintained as shown in Figure 3-1, inspect the devices immediately and replace as required.

M. COMBUSTION AIR PROVING SWITCH

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

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

Note: On an oil fired boiler, the atomizing air proving switch (AAPS) must also be closed.

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

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

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

N. ATOMIZING AIR PROVING SWITCH

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

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

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

Since the adjustment of the air switch may be made either during the damper closed or damper open position of prepurge, it is also possible to make the adjustment with the relay stopped in the damper open position in a similar manner to the adjustment of the combustion air proving switch described in Section M.

After making the adjustment, recycle the control to be sure that normal operation is obtained. The TEST switch must be set to RUN position.

O. GAS PILOT FLAME ADJUSTMENT

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

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

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

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

To Measure and Adjust Pilot:

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

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

2. Connect the micro-ammeter as outlined earlier.
3. Turn the burner switch on. Let the burner go through the normal prepurge cycle. When the ignition trial period is signaled, set the test switch to the TEST position to stop the sequence.
4. If the pilot flame is not established within 10 seconds, turn off the burner switch. Repeat the lighting attempt.

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

5. When the pilot flame is established, and with the pilot adjusting cock wide open, remove the flame detector from the burner plate. The pilot flame can then be observed through this opening.

⚠WARNING

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

⚠WARNING

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

6. To make the final adjustment, slowly close the gas pilot adjusting cock until the flame can no longer be seen

through the sight tube. Then slowly open the cock until a flame providing full sight tube coverage is observed.

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

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

Table: 6-1 Standard Gas Train Data

BHP	STD PIPE SIZE	MAX 1 PSI INLET			MAX 10 PSI INLET		
		MIN SUPPLY PRSS.			MIN SUPPLY PRSS.		
		UL	FM	IRI	UL	FM	IRI
Cingfiguration		(M2)	(M2)	(M4)			
125	2”	11.1”	11.1”	11.1”			
Cingfiguration		(M3)	(M3)	(M4)			
150	2”	17.6”	17.6”	17.6”			
200	2 1/2”	18.5”	18.5”	18.5”			
250	2 1/2”	22.4”	22.4”	22.4”			
Cingfiguration		(M4)	(M4)	(M4)			
300	2 1/2”				36.4”	36.4”	36.4”
350	3”				40.3”	40.3”	40.3”

* Gas Pressure Regulator is 1 1/2”

Note: See Figure 5-11 for gas train configuration details

The flame signal indicated on the annunciator type relay should not be less than 10 Vdc, and may be as high as 20 Vdc or greater.

The reading must be steady. If the reading fluctuates, recheck the adjustment. Be sure that the flame detector is properly seated and that the lens is clean.

8. Return the test switch to the RUN position.

9. If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.

10. The reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in paragraph 7. If there are any deviations, refer to the trouble shooting section in the technical bulletin.

P. GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas. Regulating the gas produces a steady, dependable flame that yields high combustion efficiency at rated performance yet prevents overfiring. See Table 6-1 for the standard gas train data. Once the optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency. Since the gas pressure regulator itself is usually furnished by others, detailed adjustment instructions and adjusting procedures recommended by the manufacturer should be followed.

Pressure

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

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

The pressure requirement varies with boiler size, altitude, and type of gas train. Refer to Table 6-1 for standard pressure require-ments.

The pressures listed are based on 1000 Btu/cu-ft natural gas at elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from Table 6-2.

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

Table: 6-2 Pressure Correction Factors

Gas Flow

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

Input = Btu/Hr

Output = Btu/ Hr

Gas Glow = Ft^3/Hr

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

$$\text{GAS FLOW} = \frac{\text{INPUT}}{\text{GAS BTU's/Ft}^3}$$

$$= \frac{\textbf{OUTPUT @ 100\%}}{\textbf{EFFICIENCY x GAS BTU's/Ft}^3}$$

Pressure Correction

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

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

To express the volume obtained from an actual meter reading into cubic feet at base pressure, it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 6-2

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

As an example:
Assume that a 300 horsepower boiler is installed at 2,000 feet above sea level; is equipped with a standard gas train and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

Pressure

Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 36.4" WC gas pressure at sea level (Table 6-1). Table 6-2 indicates a correction factor of 1.07 for 2,000 feet. Multiplying the results in a calculated net regulated gas requirement of approximately 38.9" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input and "correct" this answer by applying the correction factor for 3 psig (Table 6-2).

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

OR

$\frac{12{,}550{,}000}{1{,}000}$ = 12,550 CFH (At 14.7 Ib-atmospheric base pressure)

THEN

$\frac{12{,}550}{1.18}$ = 10,635 CFH

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 12,550 CFH (at base pressure) will be delivered.

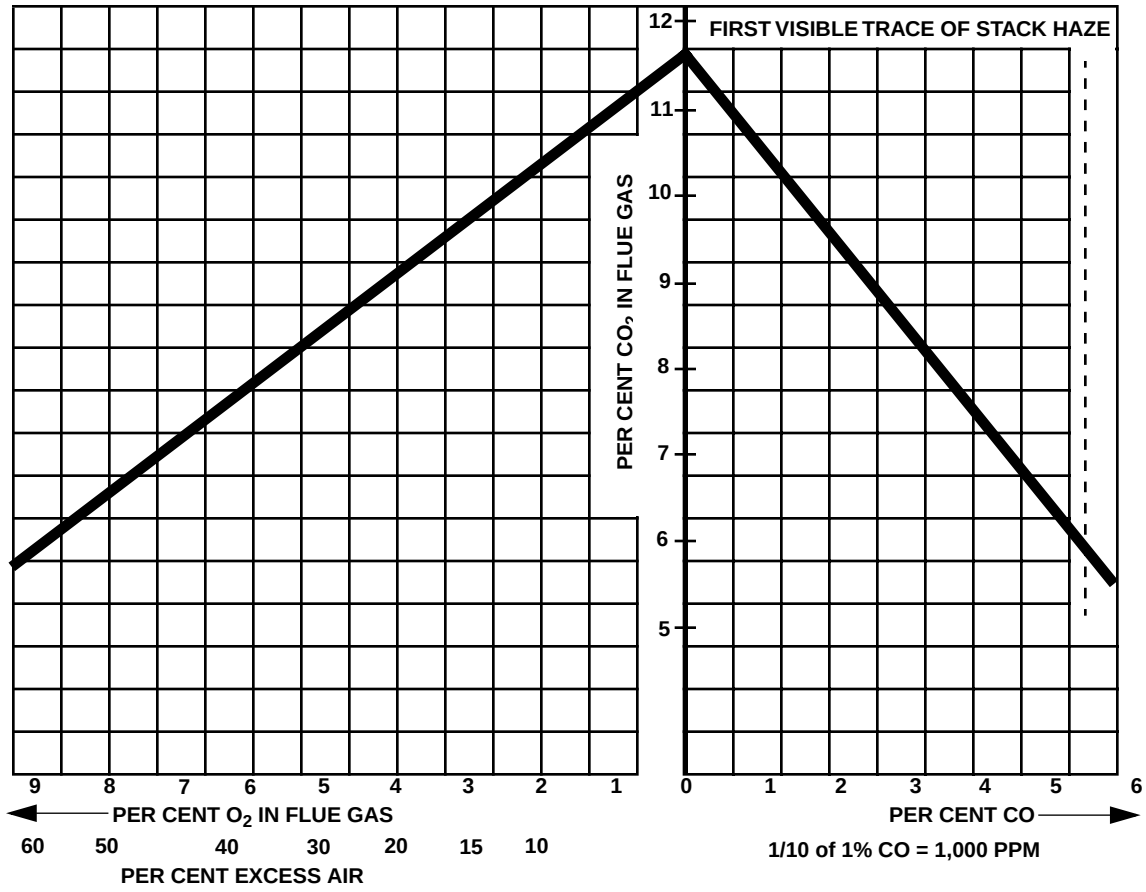


Figure 6-7: Flue Gas Analysis Chart for Natural Gas

Checking Gas Flow

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

Final adjustment of the gas fuel is carried out by means of the adjusting rods and linkage arms (See Figure 6-8), while performing a combustion efficiency analysis. See Section Q for details.

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

Q. GAS FUEL COMBUSTION ADJUSTMENT

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

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

There must always be excess air in the combustion process to account for changes in boiler room temperature and atmospheric conditions, and to ensure the combustion is on the proper side of the combustion curve (See Figure 6-7).

Figure 6-8: Butterfly Gas Valve

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

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

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

It's important to understand what the readings shown on an instrument refer to when setting combustion in a boiler. To assist with this understanding Figure 6-7 shows the relationship between O_2 levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

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

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

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

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

Using information from Section P of Chapter 6, determine the standard conditions of gas pressure and flow for the size boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.

Basically, gas adjustments are made with a gas pressure regulator, which controls the pressure and with the butterfly gas valve (Figure 6-8) which directly controls the rate of flow.

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

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

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

Determine the actual gas flow from a meter reading. (See section P of Chapter 6.) With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following the manufacturer's directions for regulator adjustment.

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

If the fuel input is correct, but the O_2 values do not fall within this range, the highfire air damper may need to be adjusted. Adjustment of the air damper is described in Section D of Chapter 5.

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

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

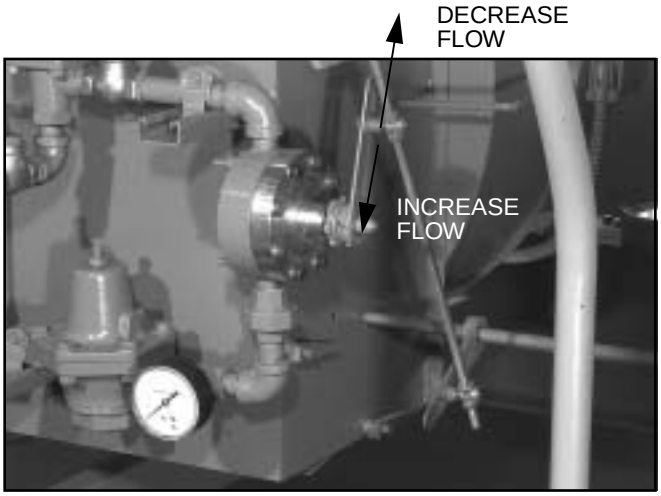


Figure 6-9: Fuel Oil Valve

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. The adjustment is made to the metering valve by means of the adjustable linkage. Flow rate is highest when the Butterfly valve actuating rod assembly is closest to jackshaft. See Figure 6-9.

Use Figure 6-10 for initial setup and positioning of the linkage.

⚠WARNING

The linkage settings shown on Figure 6-10 and Figure 6-11 are approximate settings for set up and first time firing of the burner. Initial set up and firing must only be performed by a quilifyed Cleaver-Brooks service representitave. Appropriate instrimuntation and equipment must be utilized for burner set up and adjustment. Failure to follow this warning could result in serious personal injury or death.

Standard Burner Low Fire Adjustment

The fuel input should be adjusted to approximately 25% of that at high fire. At low fire the O_2 flue gas reading should be between 6-7%.

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

R. LOW-GAS-PRESSURE SWITCH

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

Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored. Be sure that the mercury switch equipped control is level.

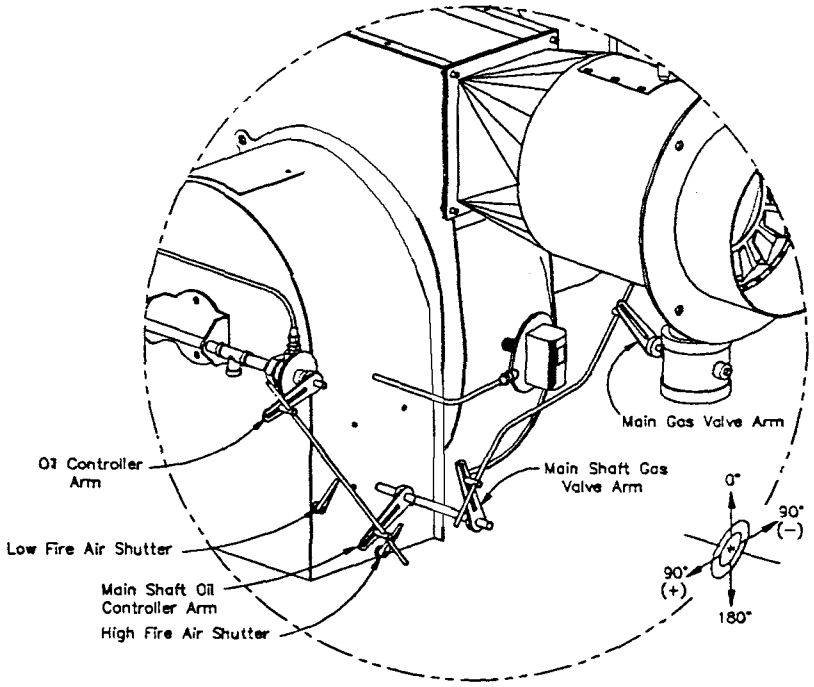


Figure 6-10: Initial Burner Linkage Setup

CEW (Type "F") Burners

SYSTEM TYPE	DESCRIPTION See Detail "B"	LINKAGE ARM ANGULAR ORIENTATION (In Degrees) BOILER HORSEPOWER / INPUT (MMbh)						ROD CLAMP POSITION FROM CENTER POINT (In Inches) BOILER HORSEPOWER / INPUT (MMbh)					
		125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7	125 5.23	150 6.28	200 8.37	250 10.5	300 12.6	350 14.7
STRAIGHT GAS AND GAS / AIR ATOMIZED OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	+20	+20	+28	+15	+15	+15	2.50	2.50	2.50	3.00	3.00	3.00
	MAIN GAS VALVE ARM	+25	+15	+30	-15	-15	-10	3.50	4.00	3.00	3.75	3.75	3.75
	GAS VALVE SETTING (Deg. Open)	20	10	10	10	20	15	--	--	--	--	--	--
GAS WITH PRESSURE ATOMIZATION OIL COMBINATION	MAIN SHAFT GAS VALVE ARM	+20	+20	-10	--	--	--	2.50	2.50	2.25	--	--	--
	MAIN GAS VALVE ARM	+30	+20	+35	--	--	--	3.25	4.00	3.75	--	--	--
	GAS VALVE SETTING	28	15	20	--	--	--	--	--	--	--	--	--
					--	--	--				--	--	--
PRESSURE ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM	+90	+80	+50	--	--	--	2.00	3.00	3.25	--	--	--
	OIL CONTROLLER ARM	+32	+40	+40	--	--	--	3.75	3.25	3.00	--	--	--
	OIL VALVE SETTING (Ref. No.)	5.5	11	9.5	--	--	--				--	--	--
					--	--	--				--	--	--
AIR ATOMIZED #2 OIL	MAIN SHAFT OIL CONTROLLER ARM				+115	+115	+115				2.50	3.00	3.25
	OIL CONTROLLER ARM				-20	-20	-15				3.00	3.75	3.25
	OIL VALVE SETTING (Ref. No.)				1.5	1.5	2						

Figure 6-11: Linkage Settings in Degrees and Inches.

S. HIGH-GAS-PRESSURE SWITCH

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

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure falls. Be sure that the mercury switch equipped control is level.

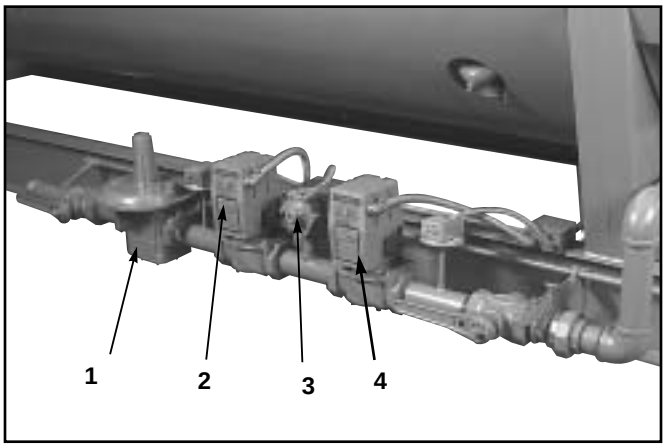
T. FUEL OIL PRESSURE

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

U. FUEL OIL COMBUSTION ADJUSTMENT

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

Burner efficiency is measured by the amount or percentage of O_2 present in the flue gas. O_2 readings determine the total amount or excess air in the combustion process, above the point of stoichiometric combustion or perfect combustion. Stoichiometric combustion however, is the reference point used when setting fuel/air ratios in a boiler.



1. REGULATOR

2. LOW GAS PRESSURE SENSOR .

3. MAIN GAS VALVE

4. MAIN GAS VENT VALVES

Figure 6-12: Gas Train Pressure Switches

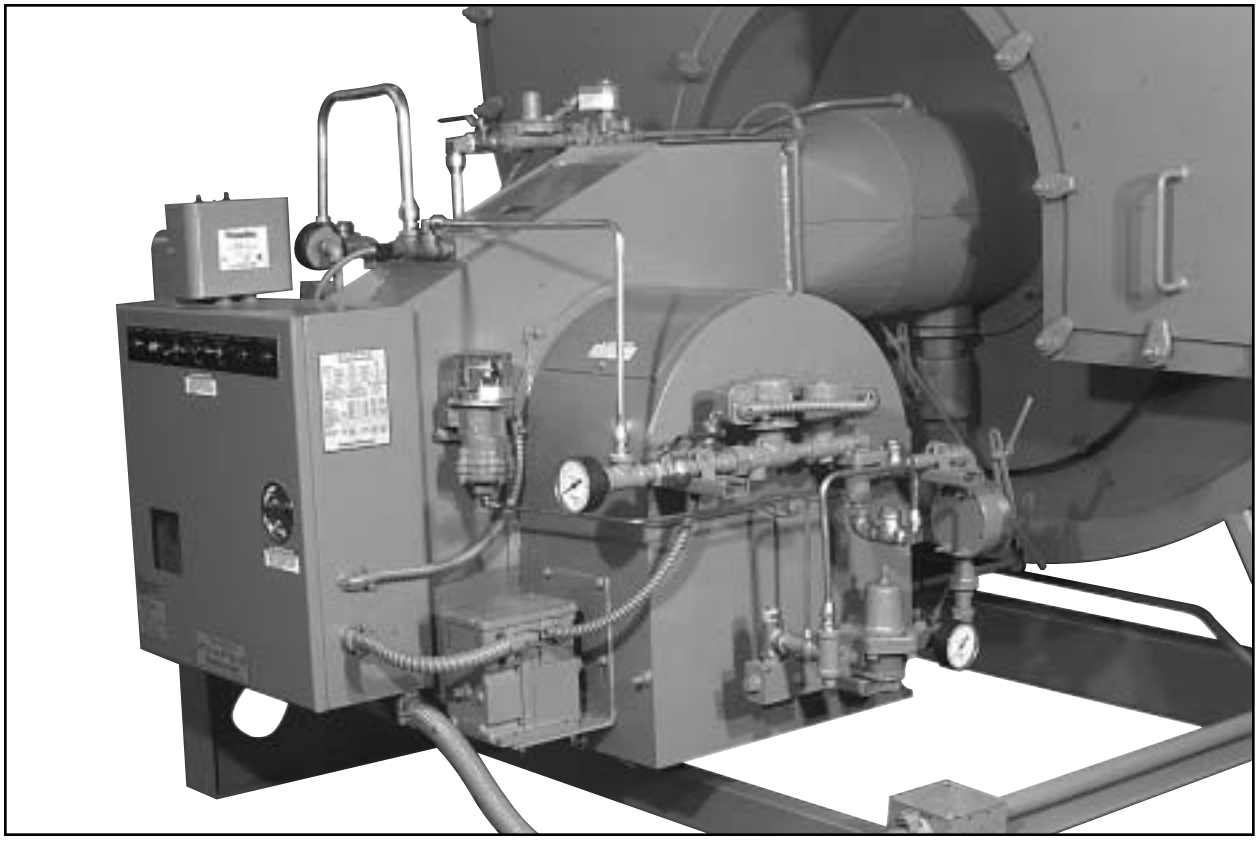


Figure 6-13: ProFire Burner With Gas Pilot

There must always be excess air in the combustion process to account for changes in boiler room conditions and to ensure the combustion is on the proper side of the combustion curve (See Figure 6-7).

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

Most flue gas analyzers in use today measure the content, by percentage, of oxygen (O_2) and in some cases, smoke. Carbon dioxide (CO_2) is not normally measured with modern gas analyzers, but may be displayed as a calculation.

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

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

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

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

Take a flue gas analysis reading. If necessary, adjust the fuel pressure regulator to increase or decrease oil pressure. Adjustments to the pressure should be done before attempting to adjust the linkage.

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

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of fuel at that setting. The adjustment is made to linkage by sliding the push rod in or out on the linkage arm. Flow rate is highest when the push rod assembly is closest to the jackshaft. See Figure 6-9.

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

Notes

CHAPTER 7

TROUBLE SHOOTING

⚠WARNING

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

⚠WARNING

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

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.

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

The 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 trouble shooting much easier. Costly down-time or delays can be prevented by systematic checks of actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may 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.

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

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

BURNER STAYS IN LOW FIRE	1. Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor.
	4. Defective modulating control.
	5. Binding or loose, 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.

Problem	Cause / Checks
SHUTDOWN OCCURS DURING FIRING	7. Improper air/fuel ratio (lean fire). A. Slipping linkage. B. Damper stuck open. C. Fluctuating fuel supply. 1). Temporary obstruction in fuel line. 2). Temporary drop in gas pressure. 8. Interlock device inoperative or defective.

MODULATING MOTOR DOES NOT OPERATE	1. Manual-automatic switch in wrong position.
	2. Linkage loose or jammed.
	3. Motor does not drive to open or close during pre-purge or close on burner shutdown. A. Motor defective. B. Loose electrical connection. C. Damper motor transformer defective.
	4. Motor does not operate on demand. A. Manual/automatic switch in wrong position. B. Modulating control improperly set or inoperative. C. Motor defective. D. Loose electrical connection. E. Damper motor transformer defective.

CHAPTER 8

INSPECTION AND MAINTENANCE

A. GENERAL

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, and yearly maintenance activities provides a valuable guide and aids in obtaining economical and lengthy service from Cleaver-Brooks equipment. A boiler inspection schedule is shown in Figure 8-2. It is important to realize that the frequency of inspection will depend on variable conditions: such as load, fuel, system requirements, boiler environment (indoor/outdoor) etc.

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

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

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.

Periodic Inspection

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

Inspections are usually, though not necessarily, scheduled for periods of normal boiler down time, such as an off season. This major inspection can often be used to accomplish maintenance, replacement or repairs that cannot easily be done at other times. Inspection also serves as a good basis for establishing a schedule for annual, monthly, or other periodic maintenance programs.

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

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

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

Cleaver-Brooks boilers are designed, engineered, and built to provide long life and excellent service. Good operating

practices and conscientious maintenance and care will assure efficiency and economy from their operation, and will contribute to many years of performance.

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

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

B. FIRESIDE CLEANING

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

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

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

Refer to Section O of Chapter 8 for instructions on properly closing rear heads.

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

The fireside should be thoroughly cleaned prior to any extended lay-up of the boiler. Depending upon circumstances, a protective coating may be required. See Section I in Chapter 3.

C. WATER LEVEL CONTROLS

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

Always be sure of the boiler water level. On steam boilers, the water column should be blown down daily. Check samples of boiler water and condensate in accordance with procedures recommended by your local Cleaver-Brooks authorized representative. Refer to Sections G and H in Chapter 3 for blowdown instructions and internal inspection procedures.

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

Steam Boiler

Figure 8-1 shows the low-water cutoff plate which is attached to a steam boiler. The instructions should be followed on 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.

On a steam boiler, the head mechanism of the low-water cutoff device(s) should be removed from the bowl at least

Figure: 8-1 Low-Water Plate

DAILY	WEEKLY	MONTHLY	SEMI ANNUALLY	ANNUALY
•Check water level •Check combustion visually •Blow down boiler •Blow down water column •Record feedwater pressure/temperature •Record flue gas temperature •Record oil pressure and temperature •Record gas pressure •Record atomizing air pressure •Record boiler water supply and return temperatures •Record makeup water usage •Record steam pressure •Note unusual conditions, noises, etc. •Treat water according to the established program	•Check for tight closing of fuel valve •Check fuel and air linkage •Check indicating lights and alarms •Check operating and limit controls •Check safety and interlock controls •Check for leaks, noise, vibration, unusual conditions, etc.	•Inspect burner •Inspect for flue gas leak •Inspect for hot spots •Check cams •Check for tight closing of fuel valve •Check fuel and air linkage •Check indicating lights and alarms •Check operating and limit controls •Check safety and interlock controls •Check for leaks, noise, vibration, unusual conditions, etc. •Analyze Combustion	•Clean low water cutoff •Clean oil pump strainer, filter •Clean air cleaner and air/oil separator •Clean air pump coupling alignment •Inspect refractory •Remove and clean oil preheater	•Clean fireside surfaces •Clean breeching •Inspect waterside surfaces •Check operation of safety valves

Figure: 8-2 Recommended Boiler Inspection Schedule

semi-annually to check and clean the float ball, the internal moving parts, and the bowl or water column. Figure 8-3 shows a cutaway of the low water cutoff.

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

Hot Water Boiler.

It is impractical to blowdown the low-water cutoff devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require 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. If equipped with a probe type LWCO with a test switch, the control should be tested per the manufactures instructions on the regulator

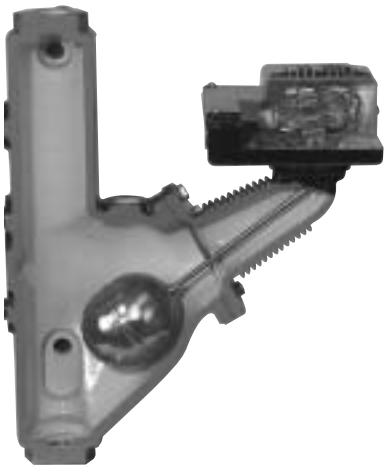


Figure: 8-3 Low Water Cutoff - Cutaway

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

It is recommended that the boiler is off and cool when the glass is replaced. However if the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by opening the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.

⚠ WARNING

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

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.

⚠ CAUTION

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

E. MAINTENANCE AND CARE OF THE PROFIRE BURNER

⚠ CAUTION

The following measures must be taken to guard against possible long-term damage to the burner.

STRAINERS. It is recommended that all oil firing burners be equipped with an oil strainer (if not included with the burner) to prevent particles from clogging the nozzle. The largest opening in the strainer should be.028 inches with a minimum of 15 square inches open area. Check to be sure the strainer is marked to handle the fuel flow at the maximum flow rate of the pump. It is essential to follow the strainer manufacturer's maintenance schedule to ensure proper filtration.

OIL NOZZLE. The oil nozzle is a critical part of the burner. Inside the nozzle lies a small screen that keeps out any particles not caught by the strainer. These particles will interfere with the normal oil flow pattern exiting the nozzle. During initial operation, it may be necessary to inspect and clean the nozzle and screen frequently.

IMPELLER. The backwards inclined impeller requires cleaning once a year. If a sharp decrease in performance is seen, check the impeller blades for dirt buildup.

⚠ WARNING

Shut off and lock out all electrical power to the burner before performing any service or maintenance that requires removal of electrical equipment cover or component parts. Failure to follow these instructions could result in serious personal injury or death.

PILOT. The pilot should be checked monthly for loosening of

BLOWER MOTOR FUSE SIZING

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

FUSE SIZES ABOVE ARE CLASS RK5 DUAL ELEMENT, TIME DELAY.

TABLE AT RIGHT SHOWS VENDOR TYPES

	BUSSMAN	GOULD	LITTELFUSE
0-250 V	FRN	TR	FLN
251-600 V	FRS	TRS	FLS

Figure: 8-4 Fuse Sizing Chart

components and carbon buildup.

DIFFUSER. The diffuser should be checked and cleaned monthly to prevent soot buildup.

OIL PUMP (Oil Fired Units). The oil pump is a critical component. When firing gas for a long periods of time, disconnect the flexible coupling between the combustion motor shaft and the oil pump shaft (if the oil pump is burner mounted). This is accomplished by removing the airbox cover and loosening the two setscrews on the flex coupling. Disconnecting the oil pump eliminates wear.

PILOT REMOVAL. When removal of the pilot assembly is required, first be sure that the fuel supply is shut off, then proceed as follows:

- 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.

LOCK DOWN AND LAY UP PROCEDURES. 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.

MAINTENANCE SCHEDULE. Refer to the following check list for recommended periodic testing of the combustion system components:

Mechanical inspection, cleaning, and/or replacement of the following must be completed per the minimum frequency indicated:

Weekly: Check all burner linkages for tightness, and tighten if required.

Monthly:

1. Remove, inspect and clean the flame scanner for soot buildup.
2. Check and clean the diffuser for soot buildup.
3. Check the pilot assembly for loosening of components, foreign objects, erosion or carbon buildup.

Annually:

1. Replace or clean the oil strainer element (oil fired units).
2. Clean the combustion air impeller.

F. 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 a low pressure air. Take care not to damage the mechanism.

Examine any mercury tube switches for damage or cracks. Dark scum over the normally bright surface of the mercury, may lead to erratic switching action. Be certain that controls are correctly leveled. The piping leading to the pressure control actuators should be cleaned, if necessary. Covers should be left on controls at all times.

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

⚠ CAUTION

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

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

Power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended. Information given in Figure 8-4 is included for guidance to fuse requirements.

G. 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.

⚠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 personal injury or death.

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.

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. Since there is no flame to be detected, the program relay will signal the condition. The ignition circuit will deenergize 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.

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) deenergize 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.

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 deenergized 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.

H. OIL BURNER MAINTENANCE

The burner should be inspected for evidence of damage due to improperly adjusted combustion. Any soot buildup on the diffuser or the oil nozzle should be removed. The setting of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked. See Section B in Chapter 5.

Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel.

Light Oil Strainers

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

Cleaning Oil Nozzle

The design of the burner makes it unnecessary to clean the oil nozzle during periods of operation. A routine check and any necessary cleaning should be made during off periods or when the burner is firing on gas.

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

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

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

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

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

Ignition System

For best results, maintain the proper gap and dimensions of the ignition electrode(s). Figure 5-5 shows the proper settings.

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

Check ignition cables for cracks in the insulation. Also see that all connections between the transformer and the electrodes are tight.

I. GAS BURNER MAINTENANCE

The gas burner components should be inspected for evidence of damage due to improperly adjusted combustion. Combustion adjustments should be checked monthly. See Section T in Chapter 6.

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

Check the electrode setting for any cracks that might be present on the porcelain insulator. Replace the electrode if cracking is evident, since cracking can cause grounding of the ignition voltage. Inspect the tip of the electrode for signs of pitting, combustion deposits and wear, and dress as required with a fine file. See Figure 5-5 for electrode settings.

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

J. MOTORIZED GAS VALVE

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

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

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

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

K. SOLENOID VALVES

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

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

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

⚠WARNING

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

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

L. AIR CONTROL DAMPER, LINKAGE

The burner air control damper should be checked for free movement as a part of the monthly inspection. Any resistance to movement or excessive play in the support bearing should be investigated and corrected before the burner is put back in operation.

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

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

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

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

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

⚠ CAUTION

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

Note: If the boiler is installed in a dusty location, check the vanes occasionally for deposits of dust or dirt. These buildups can cause a decrease in air capacity, or lead to an unbalanced condition or cause damage to the equipment.

M. SAFETY VALVES

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

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

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

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

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

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.

N. REFRACTORY

The boiler is shipped with completely installed refractory. The refractory consists of the rear head, the inner door, and the furnace liner. Normal maintenance requires little time and expense, and prolongs the operating life of the refractory.

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

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

Furnace Liner

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

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

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

Depending upon the design pressure of the boiler, the furnace may be of the corrugated type. It is necessary to fill in the corrugation valleys under the furnace liner tile from 4 o'clock

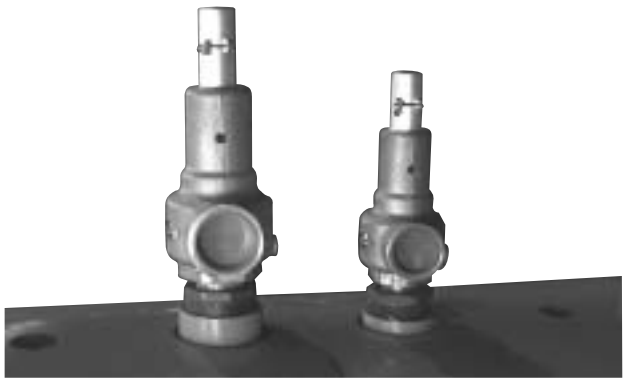


Figure: 8-5 Safety Valves

to 8 o'clock with insulating cement. The liner tile should be fitted tightly against the crown of the corrugation.

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

Rear Door

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

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

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

Therefore, before assuming that refractory requires reworking:

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

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

After opening the rear door, clean the flange surface of the door with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Remove all dried sealing material. Wash-coat the lower half of the rear door refractory prior to closing (see Figures 8-10 and 8-11).

O. OPENING AND CLOSING DOORS

1. Opening Front or Rear Door

Before opening the doors, tighten the nut on the davit arm to create slight tension (See Figure 8-6.) 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.

2. Rear Access Plug

Access to the first to second gas pass turn around area is accomplished through the removal of the rear plug. The access plug for the 78" and 96" firetube weighs approximately 120 pounds. The 60"firetube weighs approximately 95 pounds. Two people make the handling of the access plug easier. When resealing the access plug area, be sure the sealing area is clean and free of old gasket material and rust. Secure 2" blanket insulation to the inside of the plug with a 2" overlap around the circumference of the plug refractory. Attach one wrap of 1" rope to the inner access sealing area an two wraps of 1/2" rope to the outside area. Insert the plug and tighten evenly (see Figures 8-7, 8-8 and 8-9).

⚠ CAUTION

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

3. Closing and Sealing Doors

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

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

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

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

Figure: 8-6 Tighten Davit Nut

Figure: 8-7 Removing Rear Access Plug

P. LUBRICATION

Electric Motors

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

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

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

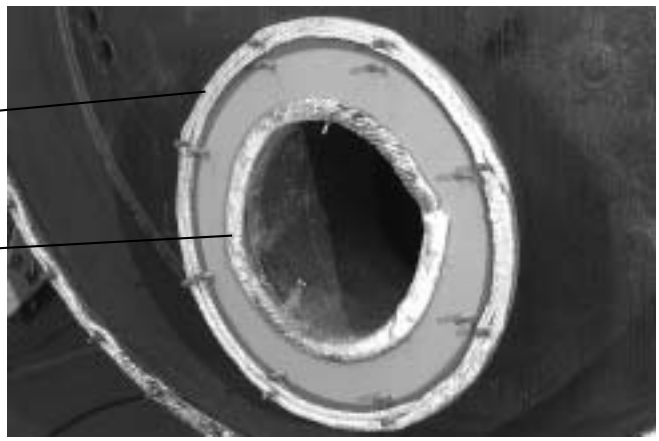


Figure: 8-8

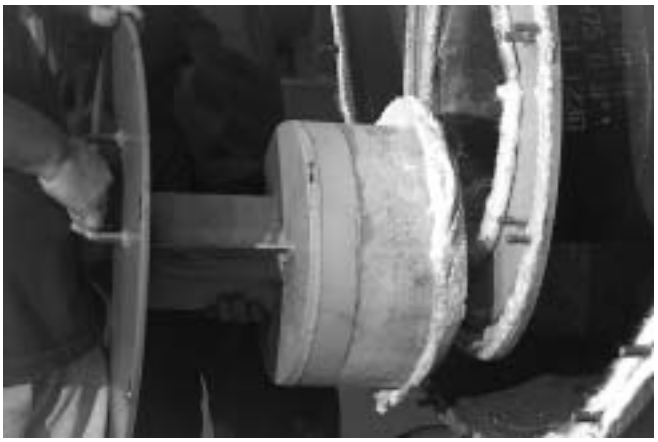


Figure: 8-9 Replacement Of Rear Access Plug

Figure: 8-10 Rear Door Open

Figure: 8-11 Replace Gasket

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 nationally 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

Control Linkage

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

Solenoid and Motorized Valves

Solenoid valves and motorized valves require no lubrication.

Q. COMBUSTION

The frequency of burner adjustments depends upon several factor, including; type of burner, type of fuel, load conditions, ambient temperature, climatic variables, and general maintenance practices.

The air-fuel ratio should be checked monthly in order to alert the operator to losses in efficiency, which do not produce visible flame change. Any time maintenance is performed on the burner linkage, the air-fuel ratio should be checked. Readjustment of the burner may be required due to variations in fuel composition. A combustion analyzer should be used to adjust air-fuel ratio for maximum operating efficiency. If your burner requires adjustments, contact your local Cleaver-Brooks authorized representative for assistance.

CHAPTER 9

CEW ProFire Parts 125-350 HP

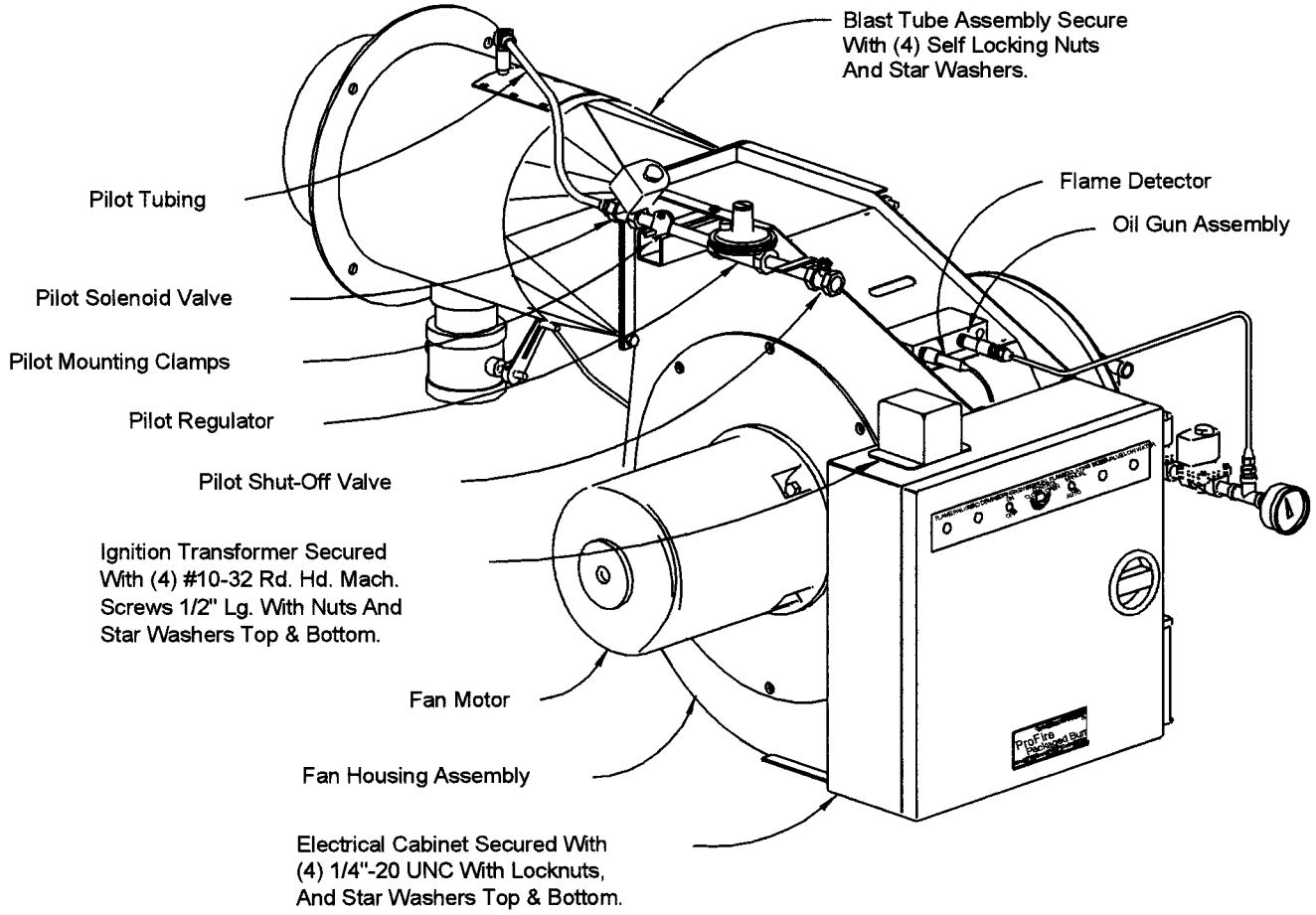
The following is a list of the boiler components, which may need replacement over the life of the boiler, depending on the burner's operating conditions and use. Replacement parts should be ordered from your local Cleaver-Brooks authorized representative. When ordering, refer to:

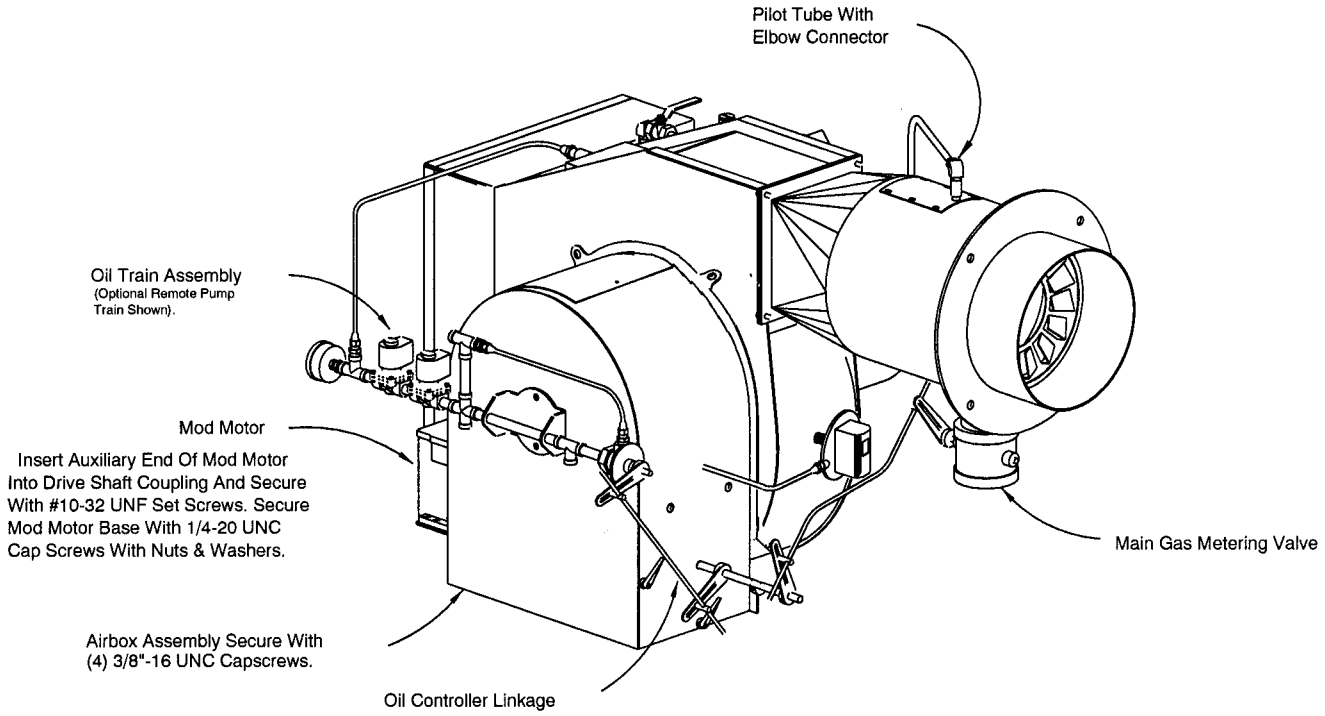
Note: The information in the following parts section relates to equipment available at the publication date of this Operation and Maintenance manual.

Refer to component listing supplied with the boiler for accurate requirements. Also, components supplied will depend on options and insurance requirements at the time of order.

CEW ProFire Parts Table of Contents

Pressure Vessel Parts

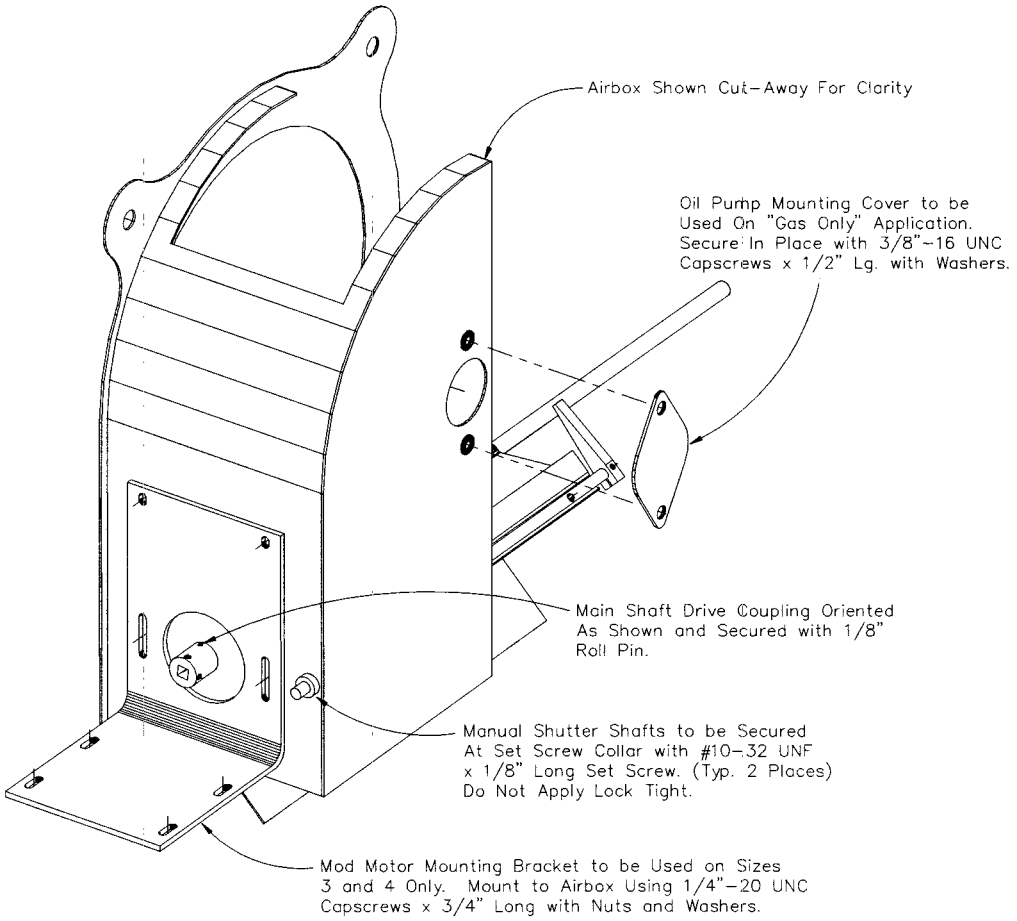




Burner Components

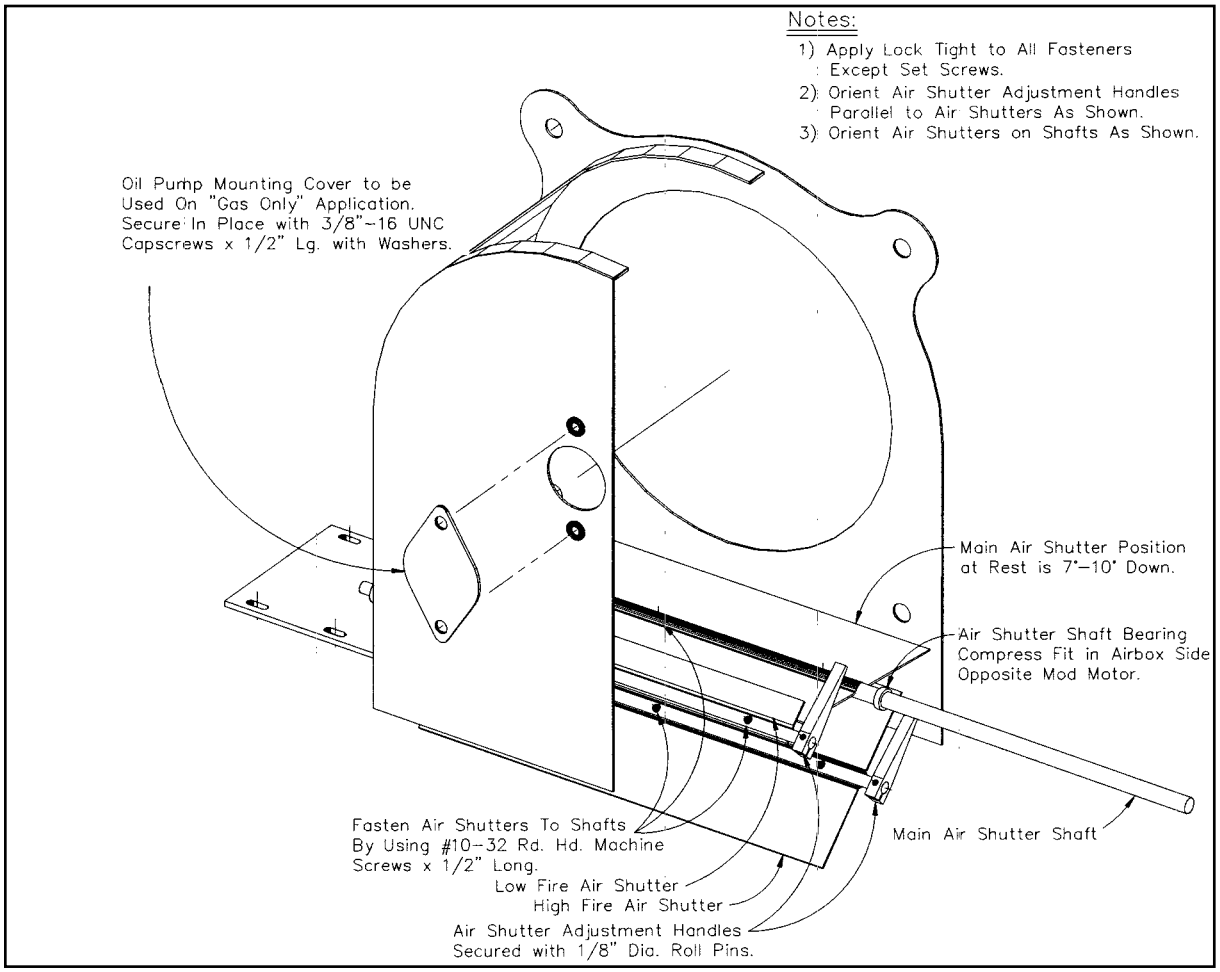
Common Components	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Fan Housing Weldment	1	459B496	1	459B503
Backcap	1	317A104	1	317A105
Sight Port Cover, 1.44 x 3.00	1	851-382	1	851-382
Sight Port Cover Clmp.	2	15A59	2	15A59
Scanner Sight Tube	1	857-1296	1	857-1296
Back Cap Set Screws, 10-32 Skt.	2	860-26	2	860-26
Machine Screws, 10-32 x .25	8	860-81	8	860-81
Modulating Motor	1	894-3466	1	894-3466
Mod Motor Fasteners, .25-20 x .75	8	868-136	8	868-136
Mod Motor Fastener Washer, .25 Flat	8	952-145	8	952-145
Main Capscrew Pkg., .375 x .5	12	868-155	12	868-155
Main Washer Pkg., .375 Flat	14	952-106	14	952-106
Misc. Mounting Nuts, 10-32 Locking	16	841-88	16	841-88
Misc. Mounting Screws				
Air Proving Switch	1	817-2363	1	817-2363
Air Proving Switch Elbow, .25 NPT 90 Deg		N/A		N/A
Air Proving Switch Cap, .25 NPT		N/A		N/A
Air Proving Switch Elbow Conn., .25 ODT	1	845-429	1	845-429
Air Proving Switch Union Nut, .25 ODT	1	845-8	1	845-8
Air Proving Switch Mounting Nipple, .25	1	857-246	1	857-246
Air Proving Switch Tube, .25 ODT	1	939-25	1	939-25
Blast Tube Fasteners, Locking	4	841-88	4	841-89
Blast Tube Fastener Washer, Flat	4	952-145	4	952-133
Pilot Access Cover (Type 'F')	1	19A1341	1	19A1342

Burner Components


Airbox Shown Cut–Away For Clarity
Oil Pump Mounting Cover to be Used On "Gas Only" Application. Secure In Place with 3/8"–16 UNC Capscrews x 1/2" Lg. with Washers.
Main Shaft Drive Coupling Oriented As Shown and Secured with 1/8" Roll Pin.
Manual Shutter Shafts to be Secured At Set Screw Collar with #10–32 UNF x 1/8" Long Set Screw. (Typ. 2 Places) Do Not Apply Lock Tight.
Mod Motor Mounting Bracket to be Used on Sizes 3 and 4 Only. Mount to Airbox Using 1/4"–20 UNC Capscrews x 3/4" Long with Nuts and Washers.

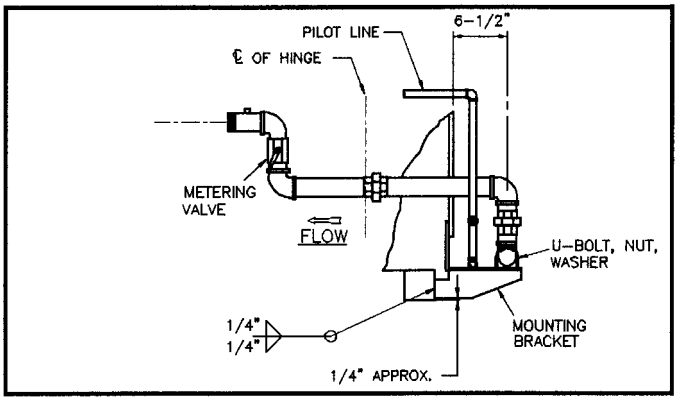
Air Box

Standard Airbox (Note 1)	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Airbox Weldment	1	459B499	1	459B504
Airbox, Oil-Drive Access Cover	1	19B1330	1	19B1337
Access Cover Mtg. Screws, 10-32 x .25	2	860-81	2	860-81
Main Air Shutter	1	108-128	1	108-131
Low-Fire Manual Air Shutter	1	108A127	1	108A130
High-Fire Manual Air Shutter	1	108-129	1	108-132
Air Shutter Mtg. Screws, 10-32 x .25	9	860-81	12	860-81
Main Air-Shutter Shaft	1	74-263	1	74-275
Manual Air-Shutter Shaft	2	74-272	2	74-273
Man. Air Shutter Shaft Setscrew, 10-32 Skt	4	860-453	4	860-453
Air Shutter Adjustment Handle	2	2A355	2	2A355
Adjustment Handle Roll Pin, .125	2	903-138	2	903-138
Main Shutter Shaft Bearing	1	807-428	1	807-428
Main Shaft Drive Coupling, 375 Shaft	1	20B150	1	20B150
Drive Coupling Roll Pin, .125	1	903-212	1	903-212
Drive Coupling Set Screws, 10-32 Skt.	2	860-26	2	860-26
Mod. Motor Mounting Bracket	1	8A3115	1	8A3115

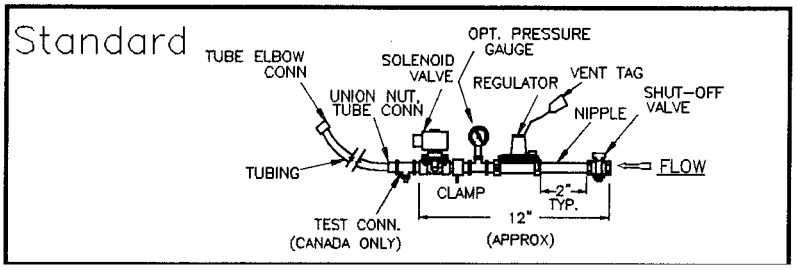


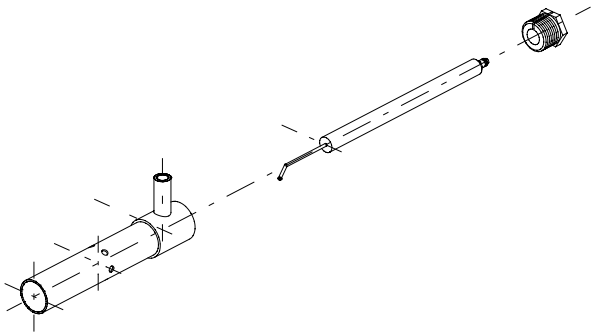
Air Box

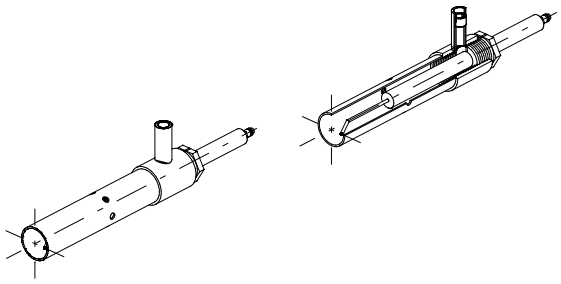
STARTER GAS TRAIN



PILOT GAS TRAIN





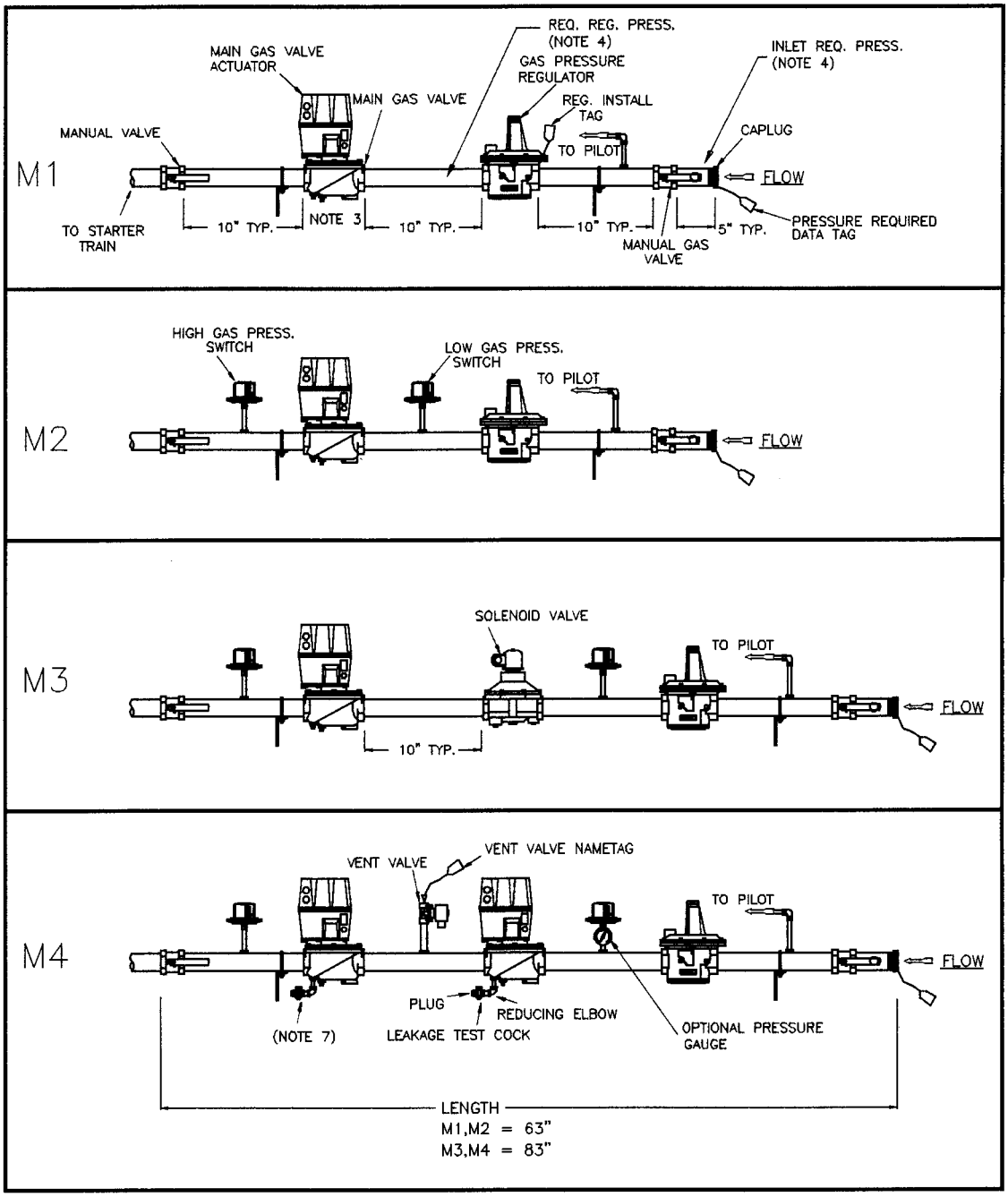


Gas-Electric Pilot, 60 Hz	125-350 hp.	
(Std. All Gas, Gas/Oil, Oil > 5.00 MMbh	Qty.	Part No.
Pilot Assembly	1	284B160
Pilot Tube Elbow Conn., .375 ODT x .125	1	845-662
Pilot Tubing, .375 ODT	1.5	939-413
Pilot Tube Connector, .375 ODT x .5	1	845-314
Pilot Tube Union Nut, .375 ODT	1	845-43
Pilot Solenoid Valve	1	940-278
Pilot Regulator, 1/2" NPT, 2-6" WC	1	918-356
Regulator Inst. Tag	1	118-2062
Pilot Shut-Off Valve, 1/2" NPT	1	825-30
Pilot Train Nipples, 1/2" NPT	2	857-154
Pilot Mounting Clamps	1	928-169
Ignition Cable	1	826-40
Ignition Cable Eltd. Conn.	1	848-166
Ignition Cable Strain Relief	1	848-1145
Ignition Cable Tran Conn.	1	848-157
Ignition Transformer, 6 KV.	1	832-107

Ignition System

Note: Use the chart to the right and the tables on pages 9-8, 9-9 and 9-10 to select your gas train configuration, based on burner size, insurance requirements and gas train pipe size.

BURNER INPUT MBTU	MAIN GAS TRAIN						VALVE TYPE S=SOLENOID M=MOTORIZED					
	TRAIN SIZE (STD)	VENT VALVE SIZE		MAIN TRAIN			STD		FM		IRI	
		STD & FM	IRI	STD (UL)	FM	IRI	STD	POC	STD	POC	STD	POC
1.5–2.5	2	–	1	M1	M2	M4	–	1M	–	1M	2M	–
2.51–5	2	–	1	M2	M2	M4	–	1M	–	1M	2M	–
5.01–10.46	2	–	1–1/4	M3	M3	M4	1S	1M	1S	1M	1M	1M
10.461–12.5	2.5	–	1–1/4	M3	M3	M4	1S	1M	1S	1M	1M	1M
12.51–14.65	2.5	3/4	1–1/4	M4	M4	M4	1S	1M	–	2M	1M	1M



Unused Port Closures (Type 'F' Only	125-200 hp.		250-350 hp.	
(See Notes 2, 4)	Qty.	Part No.	Qty.	Part No.
Ctr. Port Closure Nipple	1	857-146	1	857-146
Ctr. Port Closure Cap	1	858-127	1	858-127
Oil Port Closure Nipple, .25 NPT x SH	1	857-129	1	857-129
Oil Port Closure Cap, .25 NPT x Cap	1	858-126	1	858-126

Gas Components (See Note 4)	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Gas Valve Nipple	1	857-215	1	857-215
Gas Inlet Red. Bsh.		N/A	1	847-454
Gas Metering Valve	1	940-5302	1	940-5302
Gas Mtr. Valve Actuator Arm	1	945-206	1	945-206
Main Shaft Actuator Arm	1	945-205	1	945-205
Mod Linkage Ball Joint	2	945-207	1	945-207
Mod Linkage Rod Nuts	4	869-53	4	869-53
Mod Linkage Drive Rod	0.8	971-137	2	971-137

Gas Trains

Configuration M1	1-1/2 Inch		2 Inch		2-1/2 Inch		3 Inch	
(UL <= 2.500 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Main Gas Valve	1	940-4543	1	940-4544	1	940-4545		
Main Gas Valve Actuator	1	945-143	1	945-143	1	945-143		
Manual Gas Valve	2	941-1946	2	941-1947	2	941-129		
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139		
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062		

Configuration M2	1-1/2 Inch		2 Inch		2-1/2 Inch		3 Inch	
(UL, FM <= 5.00 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Low Gas Pressure Switch	1	817-774	1	817-774	1	817-774		
High Gas Pressure Switch	1	817-2361	1	817-2361	1	817-2361		
Main Gas Valve	1	940-4543	1	940-4544	1	940-4545		
Main Gas Valve Actuator	1	945-143	1	945-143	1	945-143		
Manual Gas Valve	2	941-1946	2	941-1947	2	941-129		
Side Outlet Nipple	2	157-1730	2	157-1722	2	157-1723		
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139		
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062		

Configuration M3	1-1/2 Inch		2 Inch		2-1/2 Inch		3 Inch	
(UL, FM < 12.50 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Low Gas Pressure Switch	1	817-774	1	817-774	1	817-774	1	817-774
High Gas Pressure Switch	1	817-2361	1	817-2361	1	817-2361	1	817-2361
Main Gas Valve	1	940-4543	1	940-4544	1	940-4545	1	940-4546
Main Gas Valve Actuator	1	945-143	1	945-143	1	945-143	1	945-143
Gas Solenoid Valve	1	940-1075	1	940-1054	1	940-1025	1	940-1418
Manual Gas Valve	2	941-1946	2	941-1947	2	941-129	2	941-130
Side Outlet Nipple	2	157-1730	2	157-1722	2	157-1723	2	157-1724
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139	1	118-3139
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062	1	118-2062

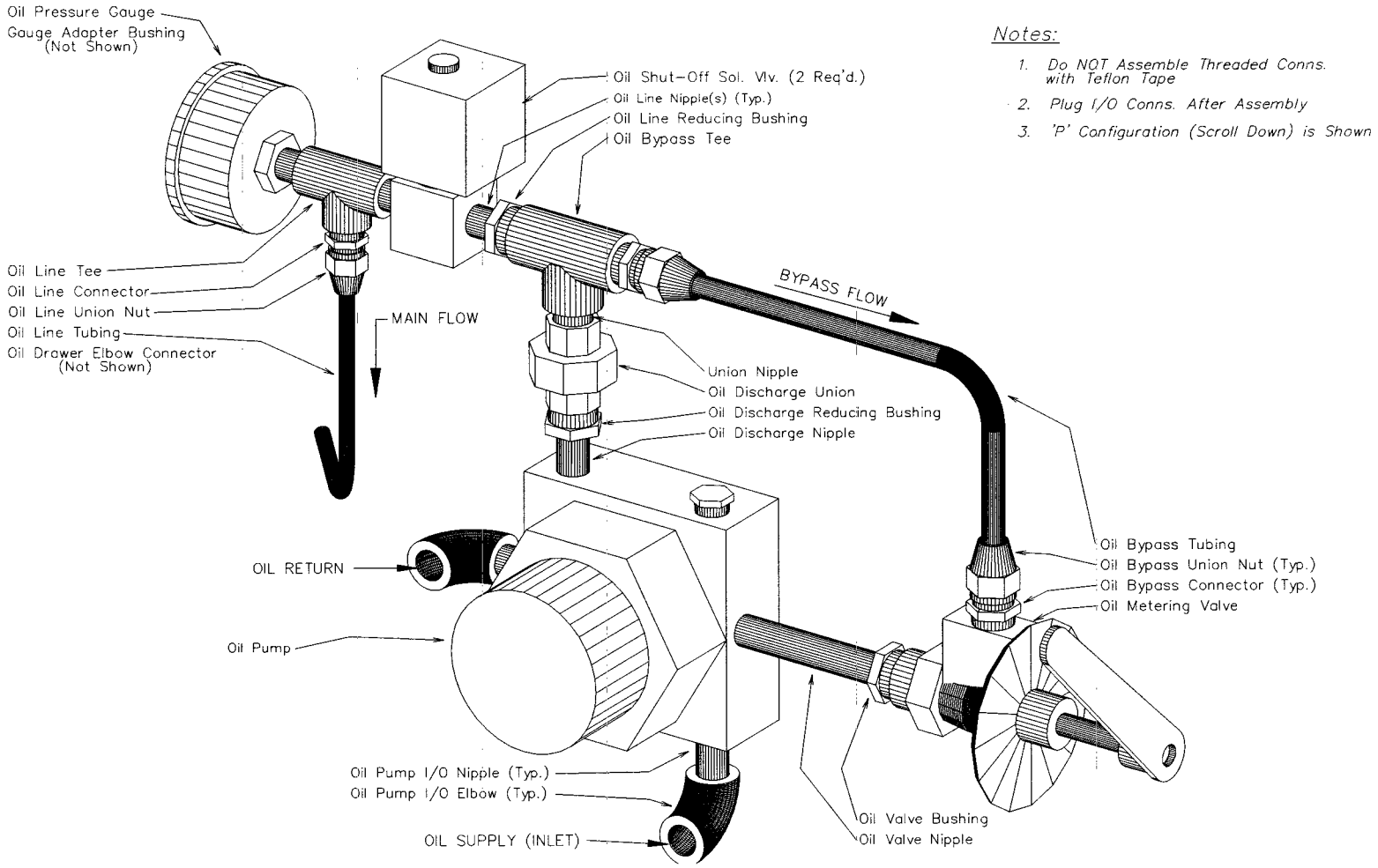
Configuration M4	1-1/2 Inch		2 Inch		2-1/2 Inch		3 Inch	
(UL, IRI <= 5.00 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Low Gas Pressure Switch	1	817-774	1	817-774	1	817-774	1	817-774
High Gas Pressure Switch	1	817-2361	1	817-2361	1	817-2361	1	817-2361
Main Gas Valve	2	940-4538	2	940-4539	2	940-4540	2	940-4541
Main Gas Valve Actuator	2	945-139	2	945-139	2	945-139	2	945-139
Gas Vent Valve	1	948-2	1	948-53	1	948-54	1	948-54
Vent Valve Side Outlet Nipple	1	157-445	1	157-1043	1	157-1042	1	157-1041
Vent Valve Name Tag	1	118-492	1	118-492	1	118-492	1	118-492
Manual Gas Valve	2	941-1946	2	941-1947	2	941-129	2	941-130
Side Outlet Nipple	2	157-1730	2	157-1722	2	157-1723	2	157-1724
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139	1	118-3139
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062	1	118-2062

Configuration M4	1-1/2 Inch		2 Inch		2-1/2 Inch		3 Inch	
(UL, FM, IRI <= 12.50 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Low Gas Pressure Switch	1	817-774	1	817-774	1	817-774	1	817-774
High Gas Pressure Switch	1	817-2361	1	817-2361	1	817-2361	1	817-2361
Main Gas Valve	1	940-4543	1	940-4544	1	940-4545	1	940-4546
Main Gas Valve Actuator	1	945-143	1	945-143	1	945-143	1	945-143
Safety Gas Valve	1	940-4538	1	940-4539	1	940-4540	1	940-4541
Safety Gas Valve Actuator	1	945-139	1	945-139	1	945-139	1	945-139
Gas Vent Valve	1	948-2	1	948-53	1	948-54	1	948-54
Vent Valve Side Outlet Nipple	1	157-445	1	157-1043	1	157-1042	1	157-1041
Vent Valve Name Tag	1	118-492	1	118-492	1	118-492	1	118-492
Manual Gas Valve	2	941-1946	2	941-1947	2	941-129	2	941-130
Side Outlet Nipple	2	157-1730	2	157-1722	2	157-1723	2	157-1724
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139	1	118-3139
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062	1	118-2062

Configuration M4	2 Inch		2-1/2 Inch		3 Inch		4 Inch	
(UL, FM, IRI, NFPA 8501 >= 12.50 MMbh)	Qty.	P/N	Qty.	P/N	Qty.	P/N	Qty.	P/N
Low Gas Pressure Switch	1	817-774	1	817-774	1	817-774	1	817-774
High Gas Pressure Switch	1	817-2361	1	817-2361	1	817-2361	1	817-2361
Main Gas Valve	1	940-4544	1	940-4545	1	940-4546	1	940-4451
Main Gas Valve Actuator	1	945-143	1	945-143	1	945-143	1	945-151
Safety Gas Valve	1	940-4544	1	940-4545	1	940-4546	1	940-4451
Safety Gas Valve Actuator	1	945-143	1	945-143	1	945-143	1	945-151
Gas Vent Valve	1	948-53	1	948-54	1	948-54	1	948-55
Vent Valve Side Outlet Nipple	1	157-1043	1	157-1042	1	157-1041	1	157-631
Vent Valve Name Tag	1	118-492	1	118-492	1	118-492	1	118-492
Manual Gas Valve	2	941-1947	2	941-129	2	941-130	2	941-131
Side Outlet Nipple	3	157-1722	3	157-1723	3	157-1724	3	157-1725
Pressure Req. Data Tag	1	118-3139	1	118-3139	1	118-3139	1	118-3139
Regulator Inst. Tag	1	118-2062	1	118-2062	1	118-2062	1	118-2062
Pressure Gauge	1	850-109	1	850-109	1	850-109	1	850-109
Test Cock	1	825-172	1	825-172	1	825-172	1	825-172

Notes:

1. Use Lubricated Plug Valves, 1.5-inch P/N 941-127, 2.0-inch P/N 941-128 in Lieu of Manual Gas Valves for All Canadian Destinations
2. Use P/N 817-789, Low Gas Pressure Switch for Inputs <= 1500 Mbh ONLY.



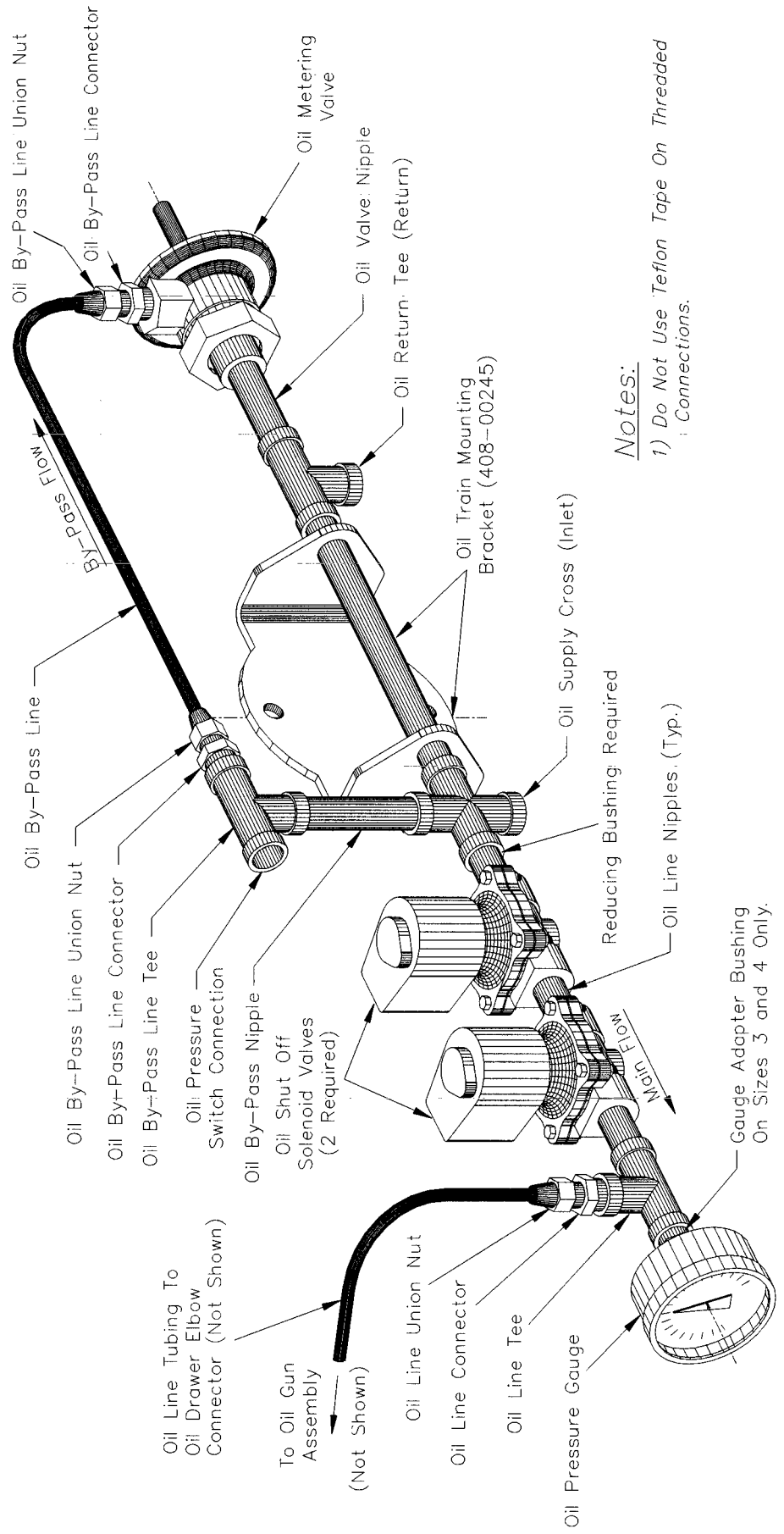
Oil Train Pressure Atomization

Direct Drive, Pressure Atomized Light Oil (Std. Oil, Gas-Oil Fired Units, <= 9.00 MMbh)

Panel Components	Qty.	Part No.
Gas-Oil Selector Switch (See note 1)	1	836-1036

Oil Train Components (See Note 3)	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Oil Discharge Nipple, .25 x SH	1	857-129	1	857-129
Oil Discharge Reducing Bushing, .375 x .25	1	847-1082	1	847-1082
Oil Valve Bushing, .375 x .25	1	847-1082	1	847-1082
Oil Valve Nipple				
Main Oil Valve	2	948-319	2	948-319
Oil Pressure Gauge	1	850-1247	1	850-1247
Gauge Adaptor Bushing	1	847-1082	1	847-1082
Oil Drawer Elbow Connector	1	845-316	1	845-316
Oil Line Connector	1	845-46	1	845-46
Oil Line Union Nut	2	845-43	2	845-43
Oil Line Tubing	1	939-70	1	939-70
Oil Line Nipple	3	857-23	3	857-23
Oil Line Tee	1	859-23	1	859-23
Oil Line Reducing Bushing		N/A		N/A
Oil Bypass Connector, .375 x 0275 OD	2	845-46	2	845-46
Oil Bypass Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Bypass Tubing, .375 ODT x .032	1	939-70	1	939-70
Oil Bypass Tee, .375 NPT	1	859-23	1	859-23
Oil Discharge Union, .375 NPT Union	1	858-160	1	858-160
Union Nipple, .375 x CL	1	857-139	1	857-139
Oil Pump I/O Nipple	2	857-141	2	857-141
Oil Pump I/O Elbow	2	859-79	2	859-79
Oil Nozzle Adapter (Body)	1	899-233	1	899-233
Oil Pipe Collar		18A109		18A110
Oil Pipe (Appox. Lg. Ft.), .125 NPT	2.5	900-409	3.1	900-409
Oil Pipe Reducing Coupling	1	847-718	1	847-718
Oil Pipe Nipple	1	857-146	1	857-146
Oil Port Nipple	1	857-129	1	857-129
Oil Port Cap	1	858-126	1	858-126
Pump Capscrew Pkg., .375-16 x 1, Stl.	2	868-56	2	868-56
Oil Meter Valve Actuator Arm, .76"	1	945-209	1	945-209
Main Shaft Actuator Arm	1	945-205	1	945-205
Mod Linkage Ball Joint, .25-20	2	945-207	2	945-207
Mod Linkage Rod Nuts, .3125-24 Hex Nut	4	869-53	4	869-53
Mod Linkage Drive Rod, .3125 Thd. Rod	0.8	971-137	0.8	971-137
Oil Strainer (See Note 2)	1	843-252	1	843-252

Direct Drive Pressure Atomized Components



Oil Train Pressure Atomization

Remote Pump, Pressure Atomized Light Oil (Opt. Oil, Gas-Oil Fired Units, <= 9.00 MMbh)

Remote Oil Pump Assembly	All Sizes	
	Qty.	Part No.
Motor Starter w/H-O-A	1	
Starter Overloads	1	
Mounting Foot Housing	1	40-643
Drive Shaft Coupling (Pump)	1	819-17
Drive Shaft Coupling (Motor)	1	819-119
Coupling Insert	1	819-48
Housing Access Cover	3	19-1356
Motor Mounting Fasteners, .375 x .5	4	868-155
Access Plt. Fastners, #8-32 x .25	6	860-45
Pump Mounting Fasteners, .313 x .5	2	860-531

Panel Components	Qty.	Part No.
Gas-Oil Selector Switch	1	836-1036

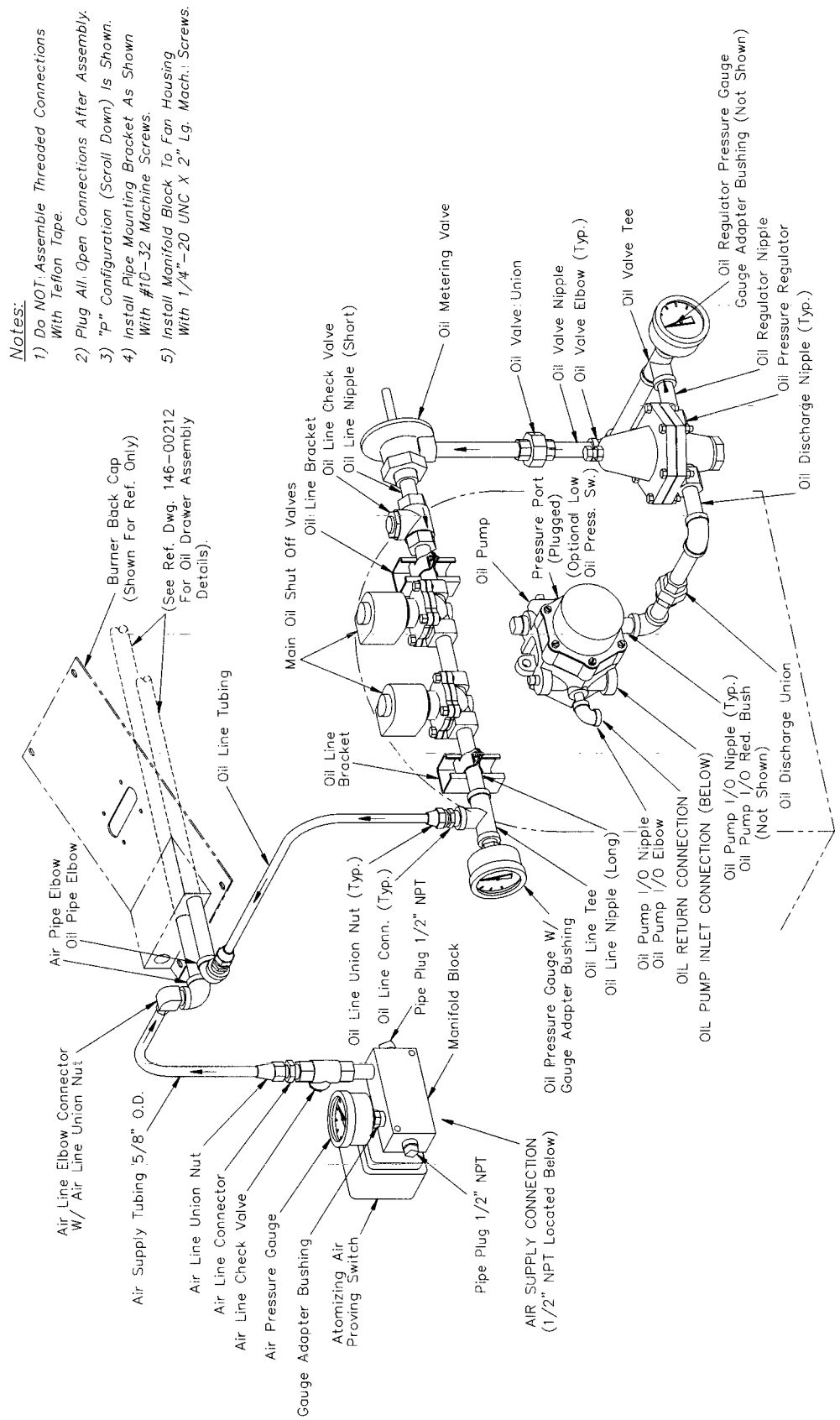
Oil Train Components	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Oil Valve Nipple	1		1	
Main Oil Valve	2	948-319	2	948-319
Oil Pressure Gauge, 2.5", 0-600#	1	850-1247	1	850-1247
Oil Drawer Elbow Connector	1	845-316	1	845-316
Oil Line Connector	1	845-46	1	845-46
Oil Line Union Nut	2	845-43	2	845-43
Oil Line Tubing	1	939-70	1	939-70
Oil Line Nipple	3	857-23	3	857-23
Oil Line Tee	1	859-23	1	859-23
Oil Line Reducing Bushing		N/A		N/A
Oil Bypass Connector, .375 x .375 OD	2	845-46	2	845-46
Oil Bypass Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Bypass Tubing, .375 ODT x .032	1	939-70	1	939-70
Oil Bypass Tee, .375 NPT	1	859-23	1	859-23
Oil Bypass Nipple, .375 NPT x 2.5	1	857-143	1	857-143
Oil Supply Cross, .375 NPT	1	859-261	1	859-261
Oil Return Tee, .375 NPT	1	859-23	1	859-23
Oil Nozzle Adaptor (Body)	1	899-233	1	899-233
Oil Pipe Centering Collar	1	18A109	1	18A110
Oil Pipe (Appox. Lg. Ft.), .125 NPT	2.5	900-409	3.1	900-409
Oil Pipe Red. Coupling	1	847-718	1	847-718
Oil Pipe Nipple	1	857-156	1	857-156
Low Oil Pressure Switch, 15-400#, UL/FM/CS/	1	817-2312	1	817-2312

Oil Train Components Air Atomizing	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Low Oil Sw. Mtg. Screw, .25-20 x 75 Stl.	2	868-136	2	868-136
Low Oil Sw. Tube Conn., .25 ODT x .25 MP	2	845-7	2	845-7
Low Oil Conn. Union Nut, .25 ODT, Short	2	845-8	2	845-8
Low Oil Press Sw. Tube, .25 ODT x .030	1	939-25	1	939-25
Oil Port Nipple	1	857-129	1	857-129
Oil Port Cap	1	858-126	1	858-126
Oil Train Mounting Bracket	1	408B245	1	408B245
Mounting Fasteners, .375-16 x 1, Stl.	2	868-56	2	868-56
Oil Meter Valve Actuator Arm, .76	1	945-209	1	945-209
Main Shaft Actuator Arm	1	945-205	1	945-205
Mod Linkage Ball Joint, .25-20	2	945-207	2	945-207
Mod Linkage Rod Nuts, .3125-24 Hex Nut	4	869-53	4	869-53
Mod Linkage Drive Rod, .3125 Thd. Rod	0.8	971-137	0.8	971-137
Data Tag	1	118-3138	1	118-3138
Oil Strainer (Note 5)	1	843-252	1	843-252
Oil Meter Valve				
Oil Nozzle				

Notes:

1. Burners equiped with this option must be furnished with appropriate oil pump assembly indicated in Table 9.
2. Use NEMA 1 w/HOA Starter P/N 833-494 for 115/230-1-60/50 applications, use NEMA 1 w/HOA Starter P/N 833-776 for tri-3-60/50 applications.
3. NOT required for 'Oil Only' systems.
4. See Ref. Dwg. No. 14600036 for Motor Switchgear Overload selections.

Oil Train Components, Air Atomized



Direct Drive Air Atomization

Direct Drive, Air Atomized Light Oil (Opt. Type 'F', Oil, Gas-Oil Fired Units, <= 8.37 MMbh)

Air Atomization	All Sizes	
	Qty.	Part No.
Air Pressure Gauge, 2.5", 0-100#	1	850-391
Atomizing Air Proving Switch	1	836-418
Air Check Valve, 1/2" NPT	1	940-5689
Air Line Nipple, 1/2" NPT	1	857-153
Air Line Conn., .5 MP x .625 OD	1	845-44
Air Line Elbow Conn., .75 MP x .625 OD	1	845-601
Air Line Union Nut, .625 ODT, Short	2	845-45
Air Line Tubing, .625 ODT x .035	1.5	939-26
Air Pipe Elbow, .375 NPT 90 Deg.	1	859-79
Manifold Port Plug, 1/2" NPT Plug	2	858-266
Manifold Block	1	38B346

Panel Components	Qty.	Part No.
Gas-Oil Selector Switch (See Note 5)	1	836-1036
Compressor Motor Starter	1	(See Note 5)

Oil Train Components (See Note 7)	125-200 hp.		250-350 hp.	
Not available on Sizes 1 & 2	Qty.	Part No.	Qty.	Part No.
Oil Disch. Nipple, .375 NPT x SH	4	857-141	4	857-141
Oil Discharge Union, .375 NPT	1	858-160	1	858-160
Oil Discharge Elbow, .375 NPT 90 Deg.	2	859-79	2	859-79
Oil Regulator Nipple	1		1	
Oil Valve Nipple	2		2	
Oil Valve Tee, .375 NPT	1	859-23	1	859-23
Oil Valve Elbow, .375 NPT 90 Deg.	1	859-79	1	859-79
Oil Valve Union, .375 NPT	1	858-160	1	858-160
Oil Line Nipple (Long), .375 NPT x 3	2	857-144	2	857-144
Oil Line Nipple (Short), .375 x SH	2	857-141	2	857-141
Oil Line Check Valve, .375 NPT	1	940-5670	1	940-5670
Oil Line Tee, .375 NPT	1	859-23	1	859-23
Main Oil Valve, .375 NPT	1	948-292	1	948-292
Oil Pressure Gauge. 2.5", 0-100#	1	850-391	1	850-391
Gauge Adaptor Bush., .375 MP x .25 FP	1	847-1082	1	847-1082
Oil Reg. Pressure Gauge, 2.5", 0-100#	1	850-391	1	850-391
Gauge Adaptor Bushing, .375 MP x .25 FP	1	847-1082	1	847-1082
Oil Line Bracket (Matl.)	0.7	972-572	0.7	972-572
Oil Line Mounting Clamp	2	928-178	2	928-178
Oil Line Connector, .375 MP x .375 OD	1	845-46	1	845-46
Oil Line Elb. Conn., .25 FP x .375 OD	1	845-317	1	845-317
Oil Line Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Line Tubing, .375 ODT x .032	1.9	939-70	2.1	939-70

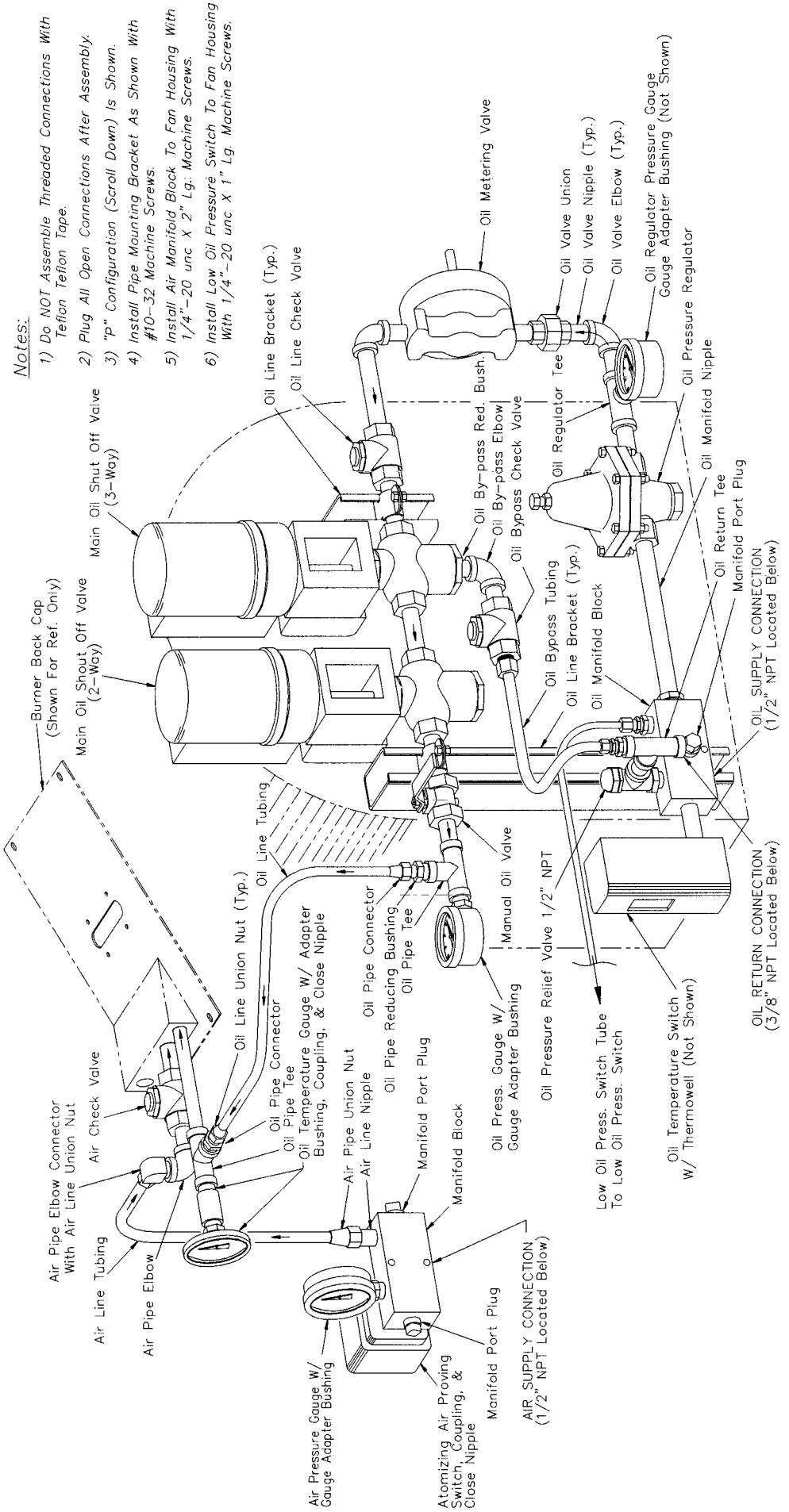
Direct Drive, Air Atomized Components

Oil Train Components (See Note 7)	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Oil Pump I/O Bushing	2	(Note 2)	N/A	N/A
Oil Nozzle Adaptor (Body)	1	100C386	1	100C385
Oil Nozzle Spring	1	82-33	1	82A6
Oil Pipe Elbow Connector	1	845-662	1	845-317
Oil Pipe Conn., .25 MP x .375 OD	1	845-177	1	845-177
Oil Pipe Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Tubing, .375 ODT x .032	2.5	939-70	3.1	939-70
Oil Pipe Coupling, .25 NPT	1	858-19	1	858-19
Oil Pipe Nipple, .25 NPT x 4	1	857-134	1	857-134
Air Pipe Reducing Bushing	1	847-465	1	847-1611
Air Pipe, .375 NPS	2.5	900-75	3.1	900-75
Air Pipe Coupling, .375 NPT	1	858-20	1	858-20
Air Pipe Nipple, .375 NPT x 4	1	857-156	1	857-156
Pump Capscrew Pkg., .375-16 x 1, Stl.	2	868-56	2	868-56
Oil Meter Valve Actuator Arm, .76	1	945-209	1	945-209
Main Shaft Actuator Arm	1	945-205	1	945-205
Mod Linkage Ball Joint, .25-20	2	945-207	2	945-207
Mod Linkage Drive Rod, .3125 Thd. Rod	1.2	971-137	1.5	971-137
Data Tag	1	118-3138	1	118-3138
Oil Strainer (See Note 6)	1	843-252	1	843-252

Notes:

1. Use .375 NPT x SH P/N 857-141 for inputs >= 8.00 MMbh, use .25 NPT x 2 P/N 857-129 for inputs < 8.00 MMbh
2. Use .375 MP x .25 FP P/N 847-1082. NOT Required on Systems with Inputs >= 8.00 MMbh.
3. Burners equiped with this option MUST be supplied with air from a C-B Air Compressor Set, as indicated in Table
4. NOT required for 'Oil Only' systems.
5. See Ref. Dwg. No. 14600036 for Motor Switchgear selections.
6. Ships Loose. This item is optional. Required on IFGR Burners and Burners Destined for Canada.
7. Select Burner Frame Size from Tables 1and 1A.

Oil Train Components



Air Atomization

Air Atomized Pressure Loop Heavy, Light Oil System (Opt. Type 'F', Oil, Gas-Oil Fired Units, <= 14.5 MMbh)

Air Train	All Sizes	
	Qty.	Part No.
Air Pressure Gauge, 2.5", 0-100#	1	850-391
Atomizing Air Proving Switch	1	836-418
Air Check Valve, 1/2" NPT	1	940-5689
Air Line Nipple, 1/2" NPT	1	857-153
Air Line Connector, .5 MP x .625 OD	1	845-44
Air Line Elbow Conn., .75 MP x .625 OD	1	845-601
Air Line Union Nut, .625 ODT, Short	2	845-45
Air Line Tubing, .625 ODT x .035	1.5	939-26
Air Pipe Elbow, .375 NPT 90 Deg.	1	859-79
Manifold Port Plug, 1/2" NPT Plug	2	858-266
Manifold Block	1	38B346

Panel Components	Qty.	Part No.
Gas-Oil Selector Switch	1	836-1036
Oil Heater Contactor		(See Note 3)
Compressor Motor Starter		(See Note 3)

Oil Train Components (Note 5)	125-200 hp.		250-350 hp.	
	Qty.	Part No.	Qty.	Part No.
Manifold Block	1	38B346	1	38B346
Manifold Port Plug, .375 NPT	1	858-974	1	858-974
Oil Temperature Switch	1	836-65	1	836-65
Oil Manifold Nipple	1	857-144	1	857-156
Oil Regulator Nipple	2	857-141	2	857-153
Oil Regulator Tee	1	859-23	1	859-24
Oil Reg. Pressure Gauge, 2.5", 0-100#	1	850-391	1	850-391
Gauge Adaptor Bushing	1	847-1082	1	847-612
Oil Valve Nipple	3		3	
Oil Valve Elbow	2	859-79	2	859-80
Oil Valve Union	1	858-160	1	858-367
Oil Valve Adapter Bushing	2	847-1082		N/A
Oil Line Nipple (Long)	3	857-144	3	857-156
Oil Line Nipple (Short)	2	857-141	2	857-153
Oil Line Check Valve	1	940-5670	1	940-5689
Manual Oil Valve, .375NPT, 175#	1	941-2155	1	941-1811
Oil Line Tee	1	859-23	1	859-24
Oil Pressure Gauge, 2.5", 0-100#	1	850-391	1	850-391
Gauge Adaptor Bushing	2	847-1082	2	847-612
Oil Line Bracket (Matl.)	1	972-566	1	972-566
Oil Line Mounting Clamp	3	928-178	3	928-169
Oil Line Connector	2	845-46	1	845-314
Oil Line Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Line Tubing, .375 ODT x .032	1	939-70	1	939-70
Low Oil Pressure Switch, 15-400#, UL/FM/CSA	1	817-2312	1	817-2312
Low Oil Sw. Mtg. Screw, .25-20 x .75, Stl.	2	868-136	2	868-136

Air Atomized Components

Oil Train Components	125-200 hp.		250-350 hp.	
Not available on Sizes 1 & 2	Qty.	Part No.	Qty.	Part No.
Low Oil Sw. Tube Conn., .25 ODT x .25 MP	2	845-7	2	845-7
Low Oil Conn. Union Nut, .25 ODT, Short	2	845-8	2	845-8
Low Oil Press Sw. Tube, .25 ODT x .030	1	939-25	1	939-25
Oil Pressure Relief Valve, 1/2" NPT, 115#	1	940-5692	1	940-5692
Oil Relief Valve Nipple, 1/2" NPT x SH	2	857-153	2	857-153
Oil Return Tee, 1/2" NPT	1	859-24	1	859-24
Oil Bypass Red. Bushing, .5 MP x .375 FP	2	847-613	2	847-613
Oil Bypass Elbow, .375 NPT 90 Deg.	1	859-79	1	859-79
Oil Bypass Check Valve, .375 NPT	1	940-5670	1	940-5670
Oil Bypass Conn., .375 MP x .375 OD	2	845-46	2	845-46
Oil Bypass Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Bypass Tubing, .375 ODT x .032	1	939-70	1	939-70
Oil Nozzle Adaptor (Body)	1	100C386	1	100C385
Oil Nozzle Spring	1	82-33	1	82A6
Oil Pipe Elbow Connector	1	845-662	1	845-317
Oil Pipe Connector, .25 MP x .375 OD	1	845-177	1	845-177
Oil Pipe Union Nut, .375 ODT, Short	2	845-43	2	845-43
Oil Tubing, .375 ODT x .032	2.5	939-70	3.1	939-70
Oil Pipe Coupling, .25 NPT	1	858-19	1	858-19
Oil Pipe Nipple, .25 NPT x 4	1	857-134	1	857-134
Oil Temperature Gauge, 2", 50-300 Deg.	1	937-49	1	937-49
Oil Pipe Tee, .375 NPT	1	859-23	1	859-23
Oil Pipe Red. Bushing, .375 MP x .25 FP	2	847-1082	2	847-1082
Air Pipe Reducing Bushing	1	847-465	1	847-1611
Air Pipe, .375 NPS	2.5	900-75	3.1	900-75
Air Pipe Coupling, .375 NPT	1	858-20	1	858-20
Air Pipe Nipple, .375 NPT x 4	1	857-156	1	857-156
Oil Meter Valve Actuator Arm, .76	1	945-209	1	945-209
Main Shaft Actuator Arm , 1/2"	1	945-205	1	945-205
Mod Linkage Ball Joint, .25-20	2	945-207	2	945-207
Mod Linkage Drive Rod, .3125 Thd. Rod	1.2	971-137	1.5	971-137
Data Tag	1	118-3138	1	118-3138
Oil Strainer (Note 4)	1	843-252	1	843-252

Oil Train Components

Fan Components, 60 Hz
Gas Fired (Std. Also: Remote Oil, Gas - Remote Oil)

Burner Size	Boiler Size	Input	Max Alt.	Motor Hp		Impeller	Cone
Size 3 Burner	125 Hp	5230 MBH	3500	** 2	* 2	192-296	97-255
			8000	** 3	* 3	192-297	97-255
			11000	** 5	* 5	192-298	97-255
	150 Hp	6280 MBH	2500	** 3	* 3	192-297	97-255
			4500	** 5	* 5	192-298	97-255
			11000	** 5	*7.5	192-299	97-257
	200 Hp	8370 MBH	1500	** 5	*7.5	192-299	97-257
Size 4 Burner	200 Hp	8370 MBH	9500	** 5	*7.5	192-299	97-258
			11000	** 7.5	*7.5	192-310	97-258
	250 Hp	10460 MBH	2000	** 5		192-299	97-258
			9500	** 7.5		192-310	97-258
			11000	** 10		192-311	97-258
	300 Hp	12560 MBH	2500	** 7.5		192-310	97-258
			4500	** 10		192-311	97-258
	350 hp	14650 MBH	1000	** 10		192-311	97-258

** Motor hp. Gas, or remote Oil Pump.

* Motor hp. Oil, Direct Drive.

Firing Head Components, 60 Hz
Standard Systems

Burner Size	Boiler Size	Input	Max Alt.	Diffuser	Blast Tube
125-200 hp.	125 Hp	5230 MBH	3500	275A274	286B15
			8000	275A274	286B15
			11000	275A274	286B15
	150 Hp	6280 MBH	2500	275A274	286B15
			4500	275A274	286B15
			11000	275A274	286B15
	200 Hp	8370 MBH	1500	275A274	286B15
250-350 hp.	200 Hp	8370 MBH	9500	275A275	286B16
			11000	275A275	286B16
	250 Hp	10460 MBH	2000	275A275	286B16
			9500	275A275	286B16
			11000	275A275	286B16
	300 Hp	12560 MBH	2500	275A275	286B16
			4500	275A275	286B16
	350 Hp	14650 MBH	1000	275A275	286B16

Fan Components And Burner Head

5230 MBH	2.5	1-1/2	n/a	23.6	n/a	---	---	n/a	42.6	918-540
(Size 3)		2	n/a	7.3	n/a	---	---	n/a	26.3	918-330
		2	n/a	7.3	n/a	11.1	918-140	n/a	14.2	918-282
125 HP		2-1/2	n/a	5.7	n/a	6.5	918-150	n/a	---	---
6280 MBH	5.2	1-1/2	n/a	36.1	n/a	---	---	n/a	63.5	918-654
(Size 3)		2	n/a	12.2	n/a	---	---	n/a	39.6	918-644
		2	n/a	12.2	n/a	17.6	918-650	n/a	22.1	918-647
150 HP		2-1/2	n/a	9.7	n/a	10.8	918-661	n/a	12.2	918-234
		3	n/a	7.9	n/a	9	918-273	n/a	---	---
8370 MBH	11.3	2	n/a	29.3	n/a	---	---	n/a	40.8	918-161
(Size 3)		2-1/2	n/a	19.1	n/a	21	918-59	n/a	23.5	918-270
200 HP		3	n/a	15.6	n/a	17.5	918-699	n/a	18.9	918-65
		4	n/a	13	n/a	13.7	918-760	n/a	---	---
8370 MBH	4.4	---	n/a	---	n/a	---	---	n/a	---	---
(Size 4)		2	n/a	15.7	n/a	25.3	918-705	n/a	33.2	918-169
(Derated)		2-1/2	n/a	11.8	n/a	13.7	918-661	n/a	16.2	918-234
200 HP		3	n/a	8.7	n/a	10.6	918-719	n/a	12	918-234
10460 MBH	7.9	2	n/a	26	n/a	---	---	n/a	53.4	918-161
(Size 4)		2-1/2	n/a	19.5	n/a	22.4	918-59	n/a	26.3	918-270
250 HP		3	n/a	14.6	n/a	17.5	918-698	n/a	19.7	918-65
		4	n/a	11.1	n/a	12.1	918-761	n/a	---	---
12555 MBH	12	2-1/2	n/a	26	n/a	---	---	n/a	37.9	918-283
(Size 4)		3	n/a	21.8	n/a	24.7	918-699	n/a	29.2	918-65
300 HP		4	n/a	15.3	n/a	16.7	918-760	n/a	---	---
14650 MBH	16.8	2-1/2	n/a	36.8	n/a	---	---	n/a	52.2	918-682
(Size 4)		3	n/a	30.1	n/a	---	---	n/a	40.3	918-521
350 HP		4	n/a	22.9	n/a	24.9	918-759	n/a	---	---

Notes:
1. 'n/a' - Not Approved for Single Valve Service at Indicated Input
2. Regulator Connection Sizes Match the Gas Train Size Except Where Indicated
3. Select High Pressure Regulator for All Canadian Destinations
4. Increase indicated Gas Pressures 4% per 1000' MSL.

Gas Pressure Regulator

Oil Metering Valves - All Sizes

5000 MBH	1	940-5318
5231 MBH	1	940-5635
5500 MBH	1	940-5318
6000 MBH	1	940-5318
6280 MBH	1	940-5318
7000 MBH	1	940-5318
8000 MBH	1	940-5318
8370 MBH	1	940-5635
9000 MBH	1	940-5635

Oil Drive Couplings and Adapter Shafts

	Drive Couplings		Adapter Shafts	
Fan Motor	Qty.	Part No.	Qty.	Part No.
125-200 hp.				
2	1	819-243	1	1A825
3	1	819-243	1	1A825
5	1	819-241	1	1A826
7.5	1	819-241	1	1A826
250-350 hp.				
5	1	819-244	1	1A826
7.5	1	819-244	1	1A826

Oil Nozzle Selections, Type 'F'

Input	Qty.	Oil Nozzle	Part No.	Qty.	Oil Nozzle	Part No.
125-200 hp.						
3348 MBH	1	7 GPH 60 Deg.	899-243	---	---	---
4185 MBH	1	8.5 GPH 60 Deg.	899-222	1	9 GPH 60 Deg.	899-201
5230 MBH	2	11 GPH 60 Deg.	899-223	---	---	---
6280 MBH	2	13 GPH 60 Deg.	899-226	---	---	---
8370 MBH	1	17 GPH 60 Deg.	899-230	1	18 GPH 60 Deg.	899-234
250-350 hp.						
8370 MBH	1	17 GPH 60 Deg.	899-230	1	18 GPH 60 Deg.	899-234

Pressure Atomized Light Oil, Delivery Components

Pressure Atomization Systems (300 psi)
60 Hz

5231 MBH	37.4	1	901-1544	0.75
5500 MBH	39.3	1	901-1544	0.75
6000 MBH	42.9	1	901-1544	0.75
6280 MBH	44.9	1	901-1544	0.75
7000 MBH	50.0	1	901-1544	0.75
8000 MBH	57.1	1	901-1544	0.75
8370 MBH	59.8	1	901-1545	1
9000 MBH	64.3	1	901-1545	1

Direst Drive Air Atomizated Light Oil Systems (75 psi)
60Hz

5231 MBH	37.4	1	901-1544	0.75
6280 MBH	44.9	1	901-1544	0.75
8370 MBH	59.8	1	901-1545	1

Oil Pump Selections

Air Compressor

5231 MBH	1	2 HP, Belt Dr. 2"
6280 MBH	1	2 HP, Belt Dr. 2"
8370 MBH	1	2 HP, Belt Dr. 2"

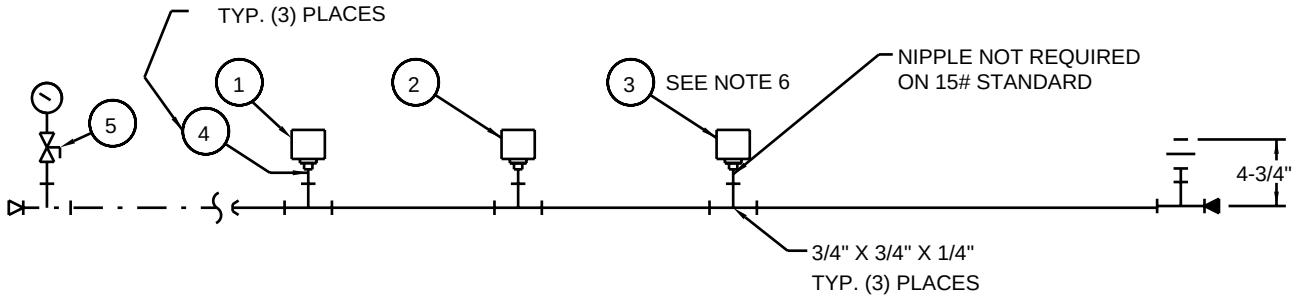
Oil Pressure Regulators

5231 MBH	1	918-739	1	940-5635
6280 MBH	1	918-739	1	940-5635
8370 MBH	1	918-739	1	940-5635

Direct Drive Air Atomized Light Oil Systems

Vessel Type	Description	Quantity	60” (125-200 HP)	78” (250-400 HP)	96” (500-800 HP)
30# HW	HAND HOLE	6	853-935	853-935	853-935
	MANWAY	1	853-939	853-939	853-939
125# HW	HAND HOLE	6	853-935	853-935	853-935
	MANWAY	1	853-939	853-939	853-939
15# STEAM	HAND HOLE	6	853-935	853-935	853-935
	MANWAY	1	853-939	853-939	853-939
150# STEAM	HAND HOLE	6	853-935	853-935	853-935
	MANWAY	1	853-939	853-939	853-939
200# STEAM	HAND HOLE	6	853-1042	853-1042	853-1042
	MANWAY	1	853-1044	835-1044	835-1044
250# STEAM	HAND HOLE	6	853-1042	853-1042	853-1042
	MANWAY	1	853-1044	835-1044	835-1044

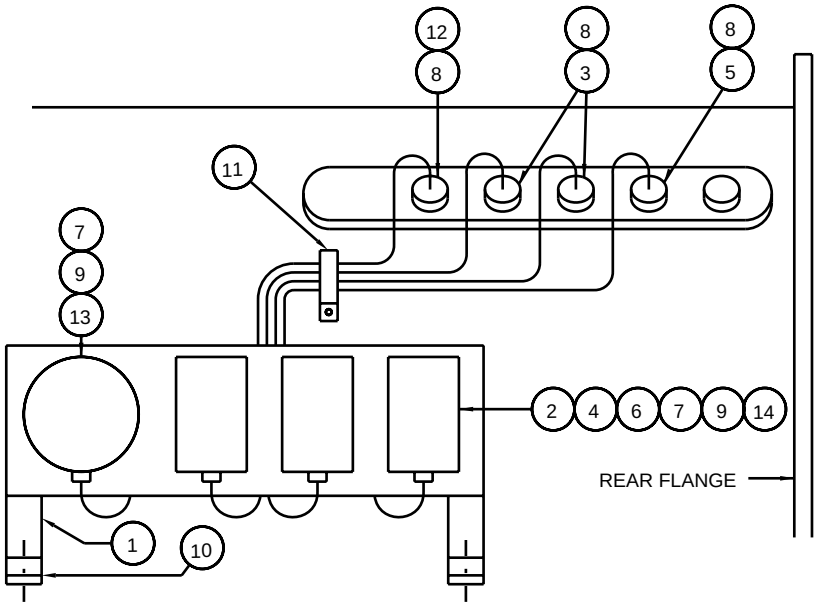
Water Side Gaskets



300 #	150#- 250 #	16#- 150#	15#	BILL OF MATERIAL				
PART NO.	PART NO.	PART NO.	PART NO.	ITEM	QTY	PART NO.	DESCRIPTION	USED ON
817-111	817-111	817-110	817-16	1	1	SEE TABLE	CONTROL PRESSURE (OLC)	
817-900	817-900	817-109	817-415	2	1	SEE TABLE	CONTROL PRESSURE (HLC)	-
817-234	817-234	817-204	817-251	3	1	SEE TABLE	CONTROL PRESSURE (MC)	
857-726	857-448	857-448	857-448	4	3	SEE TABLE	NIPPLE - 1/4" x 1-1/2"	-
941-318	825-31	825-31	825-31	5	1	SEE TABLE	GAUGE COCK - 1/4"	

Steam Pressure Controls

ITEM	CB70/CB100/E100 240-280 DEG F. HTHW QTY	P/N	CB70/CB100/E100 281-360 DEG F. HTHW QTY	P/N	CB70/CB100/E100 30-125 HW QTY	P/N
1	1	8-995	1	8-995	1	8-967
	1	8-995	1	8-995	1	8-995
2	1	817-1249	1	817-1249	1	817-1244
3	2	817-699	2	817-699	2	817-399
4	1	817-1281	1	817-1257	1	817-1050
5	1	817-1028	1	817-1028	1	817-378
6	1	817-698	1	817-700	1	817-400
7	9	860-4	9	860-4	9	860-4
8	2	847-152	2	847-152	4	847-152
9	9	869-9	9	869-9	9	869-9
13	1	937-710	1	937-710	1	937-59
	1	937-673	1	937-673	1	937-27
14	2	008-01317	2	008-01317	-	-



BILL OF MATERIAL					
ITEM	QTY	PART NO.	DESCRIPTION	WHERE USED	OPTION STD
1	-	-	BRACKET (8B937)	60"	D3
	-	-	BRACKET (8B937)	78" & 96"	D3
2	-	-	TEMPERATURE CONTROL (MC)	-	D3
3	-	-	WELL SEPARABLE	-	D3
4	-	-	TEMPERATURE CONTROL (HLC)	-	D3
5	-	-	WELL SEPARABLE	-	D3
6	-	-	TEMPERATURE CONTROL (OLC)	-	D3
7	-	-	MACH. SCR. #10-32 x 3/4"	-	--
8	-	-	BUSHING RED 3/4" x 1/2"	-	--
9	-	-	NUT MACH. SCR. #10-32	-	--
10	4	841-571	SHT. MTL. SCR. #10-32 x 5/8"	-	--
11	1	928-39	STRAP - PIPE	-	--
12	1	817-641	SOCKET SEPARABLE	-	D3
13	-	-	THERMOMETER	60"	D3
	-	-	THERMOMETER	78" & 96"	D3
14	-	-	MTG.BRACKET	-	D3

Note: If a Hawk control is used, see the Hawk manual for parts required

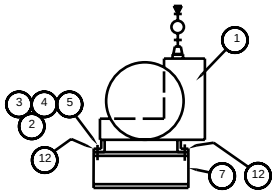
Hot Water Temperature Controls

NOTES:
1. UNLESS OTHERWISE NOTED, ALL PIPE TO BE 1/2" SCH. 40 ASTM A120 WELDED BLACK STL. AND ALL FITTINGS TO BE 150# M.I..

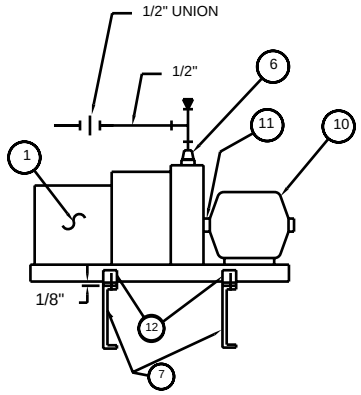
2. ALL DIMENSIONS ARE APPROX.
3. Air compressor (air atomizing) is optional on 125-200 hp.

ITEM	QTY 60"	QTY 78"	PART NO.	DESCRIPTION	USED ON	OPTION
1	1		615-23	COMPRESSOR ASSY 182T/184T MTR FRAME	60"/78"	
2	4		869-36	NUT 5/16"-18	-	
3	8	4	868-104	CAPSCREW, HEX. HD. 5/16"-18 X 1" LG.	-	
4	8	4	952-114	LOCKWASHER, 5/16"	-	
5	8	4	952-133	WASHER, 5/16"	-	
6	1		847-56	BUSHING, RED. 1" X 1/2"		
					CB 200S-225S	
7	2		972-94	CHANNEL, 6" X 8.2# X 9 1/2" LG.	-	
8	1		928-44	CLAMP, PIPE, 1/2"	-	
9	1		841-1407	SCREW, SELF TAP, 1/4"-20 X 5/8" LG.	-	
10	1		SEE TABLE	MOTOR, 2 HP , 1200 SRPM, (SEE NOTE 3)	60"	
	1		SEE TABLE	MOTOR, 3 HP , 1800 SRPM	78"	
11	1		819-00158	COUPLING, HALF	-	
12	4		972-37	ANGLE, 2" X 2" X 1/4" X 2" LG	-	

	125-200 hp.			250-350 hp.		
ITEM	200-208V (60 HZ)	230/460V (60 HZ)	600V (60 HZ)	200-208V (60 HZ)	230/460V (60 HZ)	600V (60 HZ)
10	894-3661	894-3662	894-2788	894-3430	894-3653	894-3432



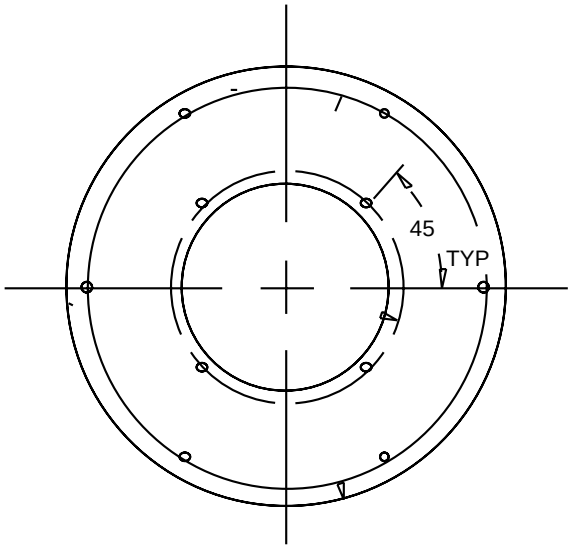
FRONT ELEVATION



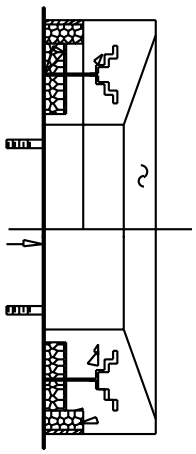
SIDE ELEVATION

Air Comperessor, CEW

			CEW ITEM #1					
BOILER DIA.	BOILER (HP)	BURNER SIZE	15 PSI Stm	30 PSI HW	125 PSIHW	150 st. PSI	150 hw. PSI	200 PSI
60"	125	2	059-5864	059-5864	059-5864	059-5864	059-5864	059-6631
	ALT. 125	3	059-5866	059-5866	059-5868	059-5868	059-5868	059-5868
	150	3	059-5866	059-5866	059-5868	059-5868	059-5868	059-5868
	200	3	059-5866	059-5866	059-5868	059-5868	059-5868	059-5868
	ALT. 200	4	059-6632	059-6632	059-6613	059-6613	059-6613	059-6633
78"	250	4	059-6634	059-6634	059-6614	059-5876	059-5876	059-6614
	300	4	059-6634	059-6634	059-6614	059-6614	059-6614	059-6614
	350	4	059-5875	059-5875	059-6614	059-6614	059-6614	059-6614



FRONT VIEW



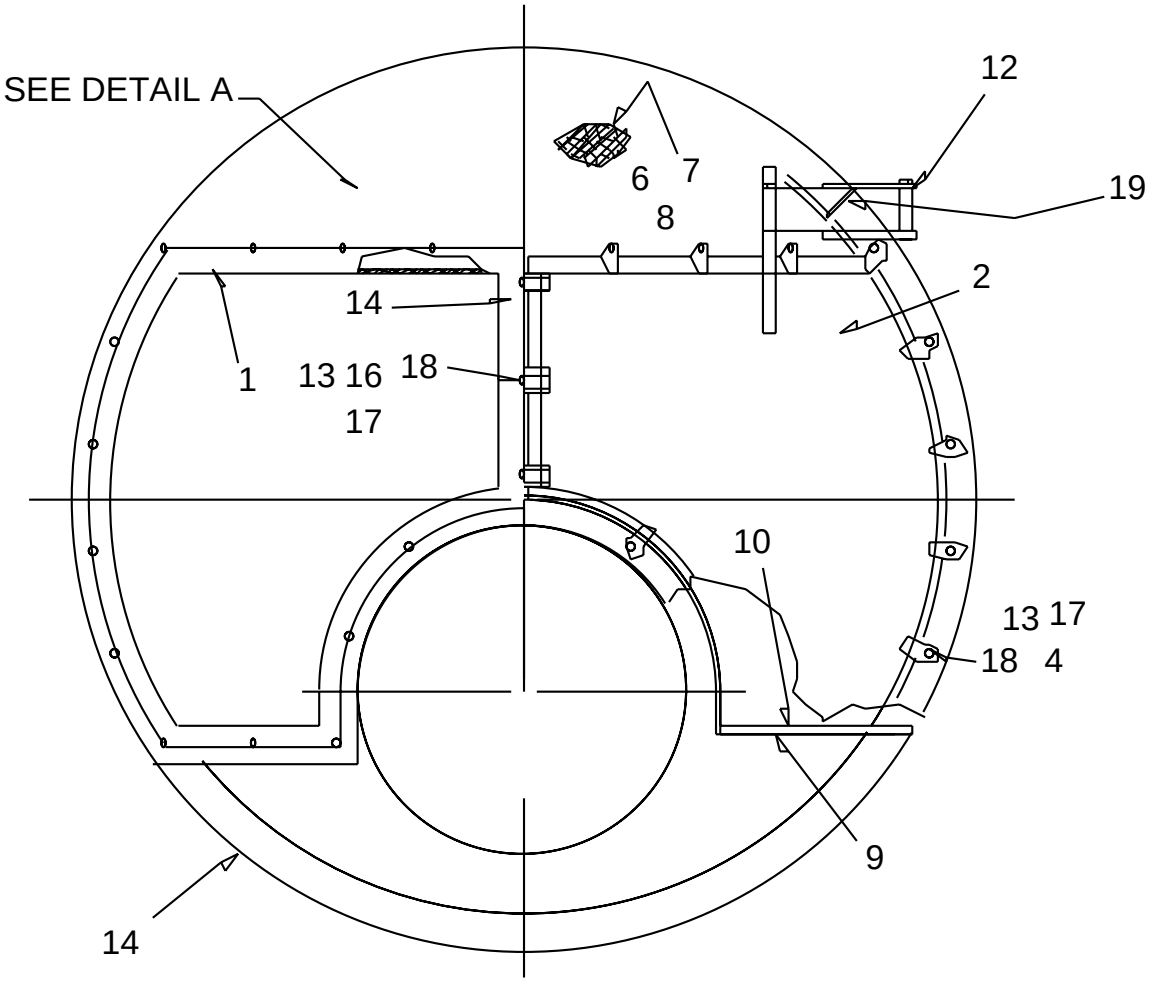
SECTIONAL SIDE VIEW

Dry Oven 60"-78" CEW
Profire Burners

Front Door and Smoke Box Components								
	Qty	125-200 hp.	Qty.	250-450 hp.	Qty	500-800 hp.	Qty	100-225s
Front Smoke Box, Left Side	1	465-2023	1	465-2027	1	465-2029	1	465-2025
Front Smoke Box, Right Side	1	465-2024	1	465-2028	1	465-2030	1	465-2026
Gasket, Front Door	2	872-0846	2	872-848	2	872-849	2	872-847
Stud, 1/2” X 2” *	29	841-331	39	841-331	43	841-331	28	841-1613 *
Nut, 1/2” Brass	29	869-29	39	869-29	43	869-29	56	869-29
Locking Lug	26	103-375	36	103-375	40	103-375	26	103-375
Adhesive	1	872-571	1	872-571	1	872-571	1	872-571
Hinge Assy.	2	462-24	2	462-24	2	462-24	2	462-24
Washer, 1/2”	29	952-108	39	952-108	43	952-108		–
Channel Lug	3	149-917	2	149-917	3	149-917	2	149-917

* Stud length is 2- 1/2” for 60” Ohio Special

Front Door and Smoke Box Components

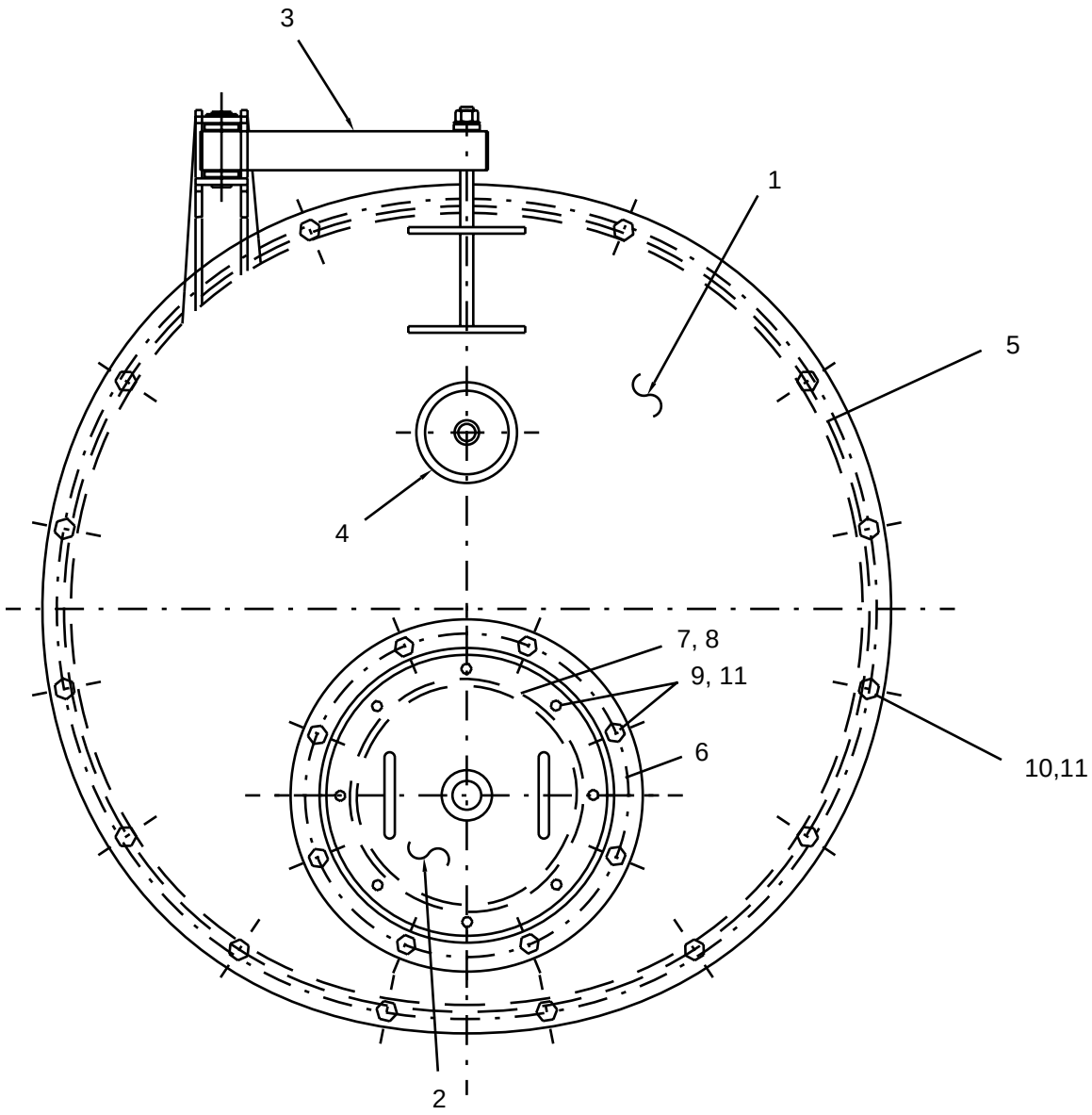


FRONT VIEW

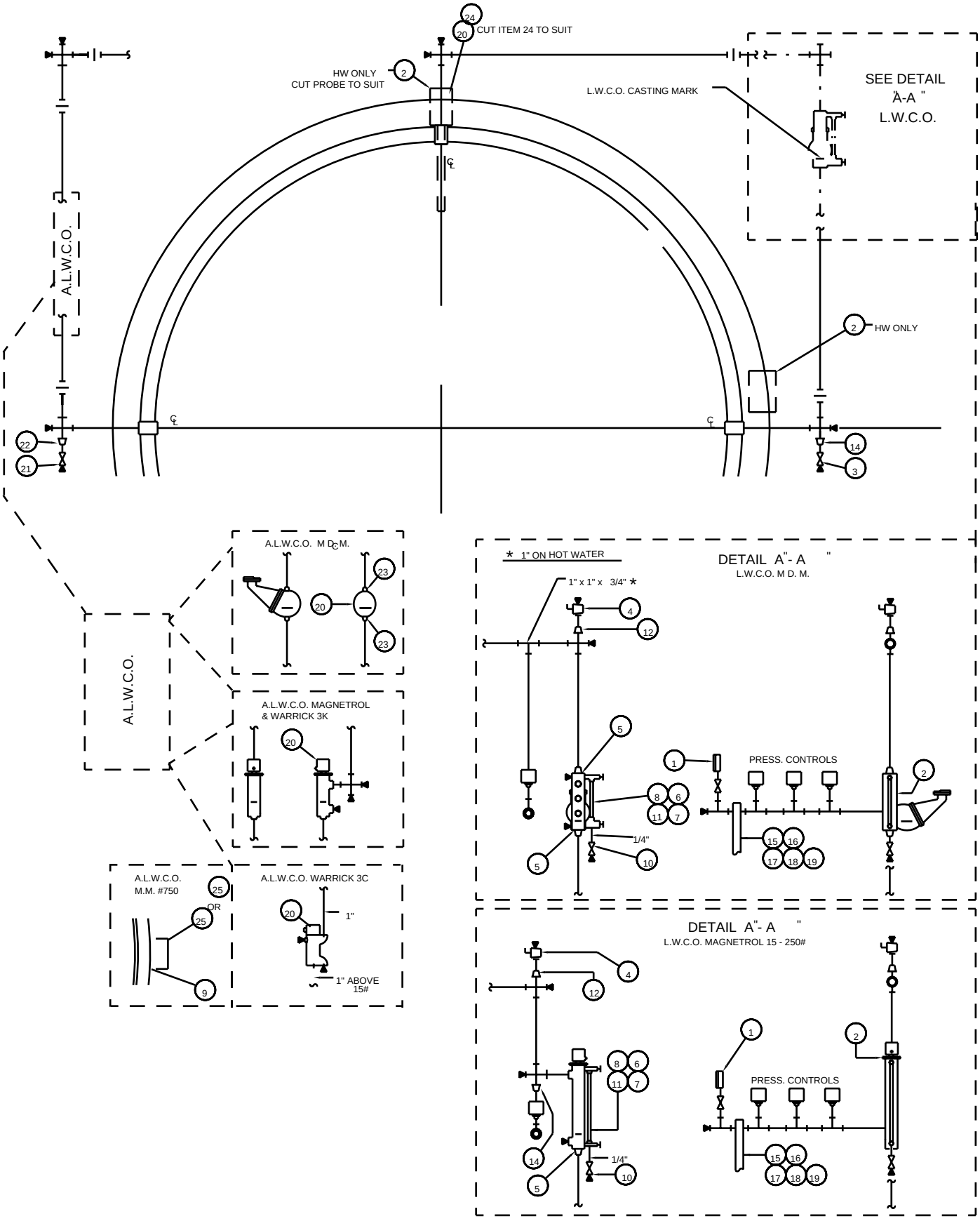
Front Door Details
125-200 HP CEW 60"

	ITEM	QTY	PART NO.	DESCRIPTION	USED ON	OPTION
W/O RELIEF DOOR	1	1	457-C-3374	REAR DOOR, INSULATED	96"	43
		1	457-C-3376	REAR DOOR, INSULATED	78"	43
		1	457-C-3358	REAR DOOR, INSULATED	60"	43
		1	457-3391	REAR DOOR, INSULATED	60" Ohio Special	43
W/ 12" RELIEF DOOR	1	1	457-3375	REAR DOOR, INSULATED	96"	46
		1	457-3377	REAR DOOR, INSULATED	78"	46
		1	457-3365	REAR DOOR, INSULATED	60"	47
W/ 7" RELIEF DOOR	1	1	NOT USED	REAR DOOR, INSULATED	96"	--
		1	NOT USED	REAR DOOR, INSULATED	78"	--
		1	457-3364	REAR DOOR, INSULATED	60"	46
	2	1	158-110	CRAWLWAY PLUG ASSEMBLY (158-B-108)	96"	A2
		1	158-109	CRAWLWAY PLUG ASSEMBLY (158-B-108)	78"	A2
		1	158-109	CRAWLWAY PLUG ASSEMBLY (158-B-108)	60"	A2
	3	1	462-C-23	HINGE DETAILS	96"	A2
		1	462-C-21	HINGE DETAILS	78"	A2
		1	462-C-22	HINGE DETAILS	60"	A2
	4	1	428-A-17	COMBUSTION RELIEF DOOR, 7"	SEE NOTE	46
		1	428-A-37	COMBUSTION RELIEF DOOR, 12"	SEE NOTE	46
	5	1	872-850	GASKET, DOOR, REAR	96	
		1	872-851	GASKET, DOOR, REAR	78	
		1	872-856	GASKET, DOOR, REAR	60" & OHIO SPECIAL	
		1	872-852	GASKET, DOOR, REAR	60"	
	6	1	872-853	GASKET, DOOR, REAR ACCESS HOLE	ALL	
	7	1	872-855	GASKET, ASSESS PLUG- FIRESIDE	ALL	
	8	1	872-854	GASKET, ASSESS PLUG- DOOR SIDE	ALL	
	9	16	841-289	STUD, 1/2"-13UNCX1-1/2"	96	
		16	841-289	STUD, 1/2"-13UNCX1-1/2"	78	
		16	841-289	STUD, 1/2"-13UNCX1-1/2"	60" & OHIO SPECIAL	
	10	30	868-102	BOLT, HEX, 1/2"-13UNC	96	
		24	868-102	BOLT, HEX, 1/2"-13UNC	78	
		20	868-102	BOLT, HEX, 1/2"-13UNC	60" & OHIO SPECIAL	
	11	46	869-15	NUT, HEX, 1/2"-13UNC	96	
		40	869-15	NUT, HEX, 1/2"-13UNC	78	
		36	869-15	NUT, HEX, 1/2"-13UNC	60" & OHIO SPECIAL	
	12	1	872-571	ADHESIVE, SUPERTAK SPRAY	ALL	

Rear Door



Rear Door



Water Column

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

	ITEM	QTY	PART NO	DESCRIPTION	USED ON
WARRICK	20	1	817-740	CONTROL, AUX. L.W.C.O. WARRICK 3E2B	✿ 30#-200#
WARRICK		1	817-1020	CONTROL, AUX. L.W.C.O. WARRICK 3E3B	✿ 30#-200#
M D. M.		1	817-MM	CONTROL, AUX. L.W.C.O. MM 750MT-120	✿ 15#-250#
	24	2	67-533	ROD,ELECTRODE, 1/4" DIA X 24" LG.	✿ 3E2B
		3	67-533	ROD,ELECTRODE, 1/4" DIA X 24" LG.	✿ 3E3B

EXTERNAL A.L.W.C.O.

	ITEM	QTY	PART NO	DESCRIPTION	USED ON
M D. M.	20	1	817-98	CONTROL, AUX. L.W.C.O. (AUTO RESET)	15#
		1	817-97	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	150#
		1	817-306	CONTROL, AUX. L.W.C.O. (MANUAL RESET)	200-250#
MAGNETROL	20	1	817-301	CONTROL, AUX. L.W.C.O.	15-250#
		1	817-1251	CONTROL, AUX. L.W.C.O.	300#
WARRICK	20	1	817-2372	CONTROL, AUX. L.W.C.O. WARRICK 3C2A	15-250#
		1	817-820	CONTROL, AUX. L.W.C.O. WARRICK 3C3B	15-250#
		1	817-2259	CONTROL, AUX. L.W.C.O. WARRICK 3K3A	15-250#

ITEM	QTY	PART NO M.D. M.	PART NO MAGNETROL	DESCRIPTION	USED ON
1	1	850-230		PRESSURE GAUGE- 6" DIA	15# ST
	1	850-222		PRESSURE GAUGE- 6" DIA	150-200# ST
	1	850-134		PRESSURE GAUGE- 6" DIA	250# ST CB125S-175S
	1	850-320		PRESSURE GAUGE- 6" DIA	250# ST
	1	850-400		PRESSURE GAUGE- 6" DIA	300# ST
	1	850-223		PRESSURE GAUGE- 6" DIA	30# HW
	1	850-283		PRESSURE GAUGE- 6" DIA	60# HW
	1	850-221		PRESSURE GAUGE- 6" DIA	125# HW
	1	850-222		PRESSURE GAUGE- 6" DIA	150# HW
2	1	817-226	817-163	LOW WATER CUT-OFF	15# ST
	1	817-95	817-163	LOW WATER CUT-OFF	150# ST
	1	817-303	817-163	LOW WATER CUT-OFF	200-250# ST
	1	———	817-1962	LOW WATER CUT-OFF	300# ST
1	-	-	———	-	
	1	817-2305	CONTROL, WATER LEVEL PROBE TYPE, MDL. 750		ALL HW
	1	817-2306	REMOTE SENSOR, PROBE HOLDER, MDL. 750		
	1	817-2307	PROBE EXT., 24"LG, FOR REMOTE SENSOR, MDL. 750		
3	1	941-1790		VALVE, BALL 3/4"	15-200# ST
	1	941-401		VALVE, GLOBE 3/4"	250# ST
	2	941-401		VALVE, GLOBE 3/4"	300# ST
4	1	825-31		COCK, UNION, BRASS	15-250# ST
	1	———	941-318	VALVE, GLOBE 1/4", BRASS	300# ST
5	2	847-472	———	BUSHING 1-1/4" X 1"	200-250# ST
	1	———	847-432	BUSHING 1-1/4" X 1"	15-150# ST
	1	———	847-472	BUSHING 1-1/4" X 1"	200-250# ST
	2	———	847-472	BUSHING 1-1/4" X 1"	300# ST
6	1	851-199	851-38	GAUGE GLASS	15-250# ST
	1	———	851-321	GAUGE GLASS	300# ST
7	4	912-85	———	ROD, GAUGE GLASS	15-250# ST
	2	———	912-38	ROD, GAUGE GLASS	15-250# ST
8	1	825-132		SET, GAUGE GLASS	15-200# ST
	1	825-352		SET, GAUGE GLASS	250# ST
	1	———	825-357	SET, GAUGE GLASS	300# ST
9	1	059-6628		SIZED PLATE, #14 x 7" x 11"	M.M #750
10	1	941-55		VALVE, BALL 1/4"	15-200# ST
	1	941-318		VALVE, GLOBE, 1/4"	250-300# ST

ITEM	QTY	PART NO 15-150#	PART NO 200-250#	PART NO 300#	DESCRIPTION	USED ON
11	*	830-28			CHAIN SASH	250-300 ST
12	1	847-424	847-467		BUSHING 1" X 1/4"	ALL ST
13	1	———	———	847-612	BUSHING 1/2" X 1/4"	MAGNETROL
14	1	847-426	847-469		BUSHING 1" X 3/4"	MAGNETROL ST ONLY
15	1	928-46			THINWALL CLAMP 1"	HW
	1	928-45			THINWALL CLAMP 3/4"	ST
16	1	868-405			CAPSCREW HEX. HD. 1/4-20 x 3/4" LG.	-
17	2	952-145			WASHER, PLAIN 1/4"	-
18	1	952-92			LOCKWASHER 1/4"	-
19	1	869-21			NUT 1/4"-20	-
20	1	SEE TABLE			CONTROL, AUX. L.W.C.O.	
21	1	941-1790			VALVE, BALL 3/4"	15-200#
	1	941-401			VALVE, BALL 3/4"	250-300#
22	1	847-426			BUSHING 1" x 3/4"	15-150#
	1	847-469			BUSHING 1" x 3/4"	200-250#
23	2	847-472			BUSHING 1-1/4" x 3/4"	200-250#

Notes

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