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CLEAVER-BROOKS MODEL FLX PACKAGED BOILER

Operation, Service, and Parts Manual

**1,500,000 to
12,000,000 Btu/hr
Hot Water and
Steam
Fuel: Light Oil, Gas
or Combination**



Manual Part No. 750-177 r4

6/2001

Cleaver  **Brooks**®

DIVISION OF AQUA-CHEM, INC.

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 H ₂ O	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LWCO	Low-Water Cut-Off
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

MODEL FLX PACKAGED BOILER

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Fuel: Light Oil, Gas or Combination



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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 him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

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

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

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

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

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

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

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

GENERAL DESCRIPTION

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A. General

The information in this manual applies directly to Cleaver-Brooks FLX Model boilers in sizes ranging from 1,500,000 to 12,000,000 Btu/hr input.

Fuel Series

700- Gas

100-No.2 Oil

200 - Combination Gas & No.2 Oil

Design Pressure

160 psig hot water

15 psig steam

150 psig steam

CAUTION

The care taken in placing the boiler into initial service is vital to continuous, reliable operation. If the boiler is to be used for temporary heat (for example in new construction), properly treated water must be used. Failure to do so can be detrimental to the boiler.



Figure 1-1: FLX Cut Away

B. The Boiler

The Cleaver-Brooks Model FLX is a five-pass steel boiler with flexible watertubes formed and arranged so as to direct the flow of combustion gases through the boiler. The pressure vessel conforms to Section I or IV of the ASME code. The pressure vessel consists of the formed tubes, the external downcomer, and the top and bottom drums to which they connect. The heated area of the pressure vessel is contained within a gas tight insulated casing that is composed of removable formed steel panels.

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.

The Model FLX boiler is a packaged watertube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, refractory, and appropriate boiler trim.

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 and high pressure applications. Low pressure boilers are limited to 15 psig design pressure, and are typically used for heating applications. High pressure boilers are limited to 150 psig design pressure, and are typically used for process steam applications.

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. 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 15 psig and hot water boilers designed for 250°F at 160 psi or less are constructed in accordance with Section IV, Heating Boilers, of ASME Code. Steam boilers designed for 150 psig are constructed in accordance with Section I, Power Boilers, of the ASME Code.

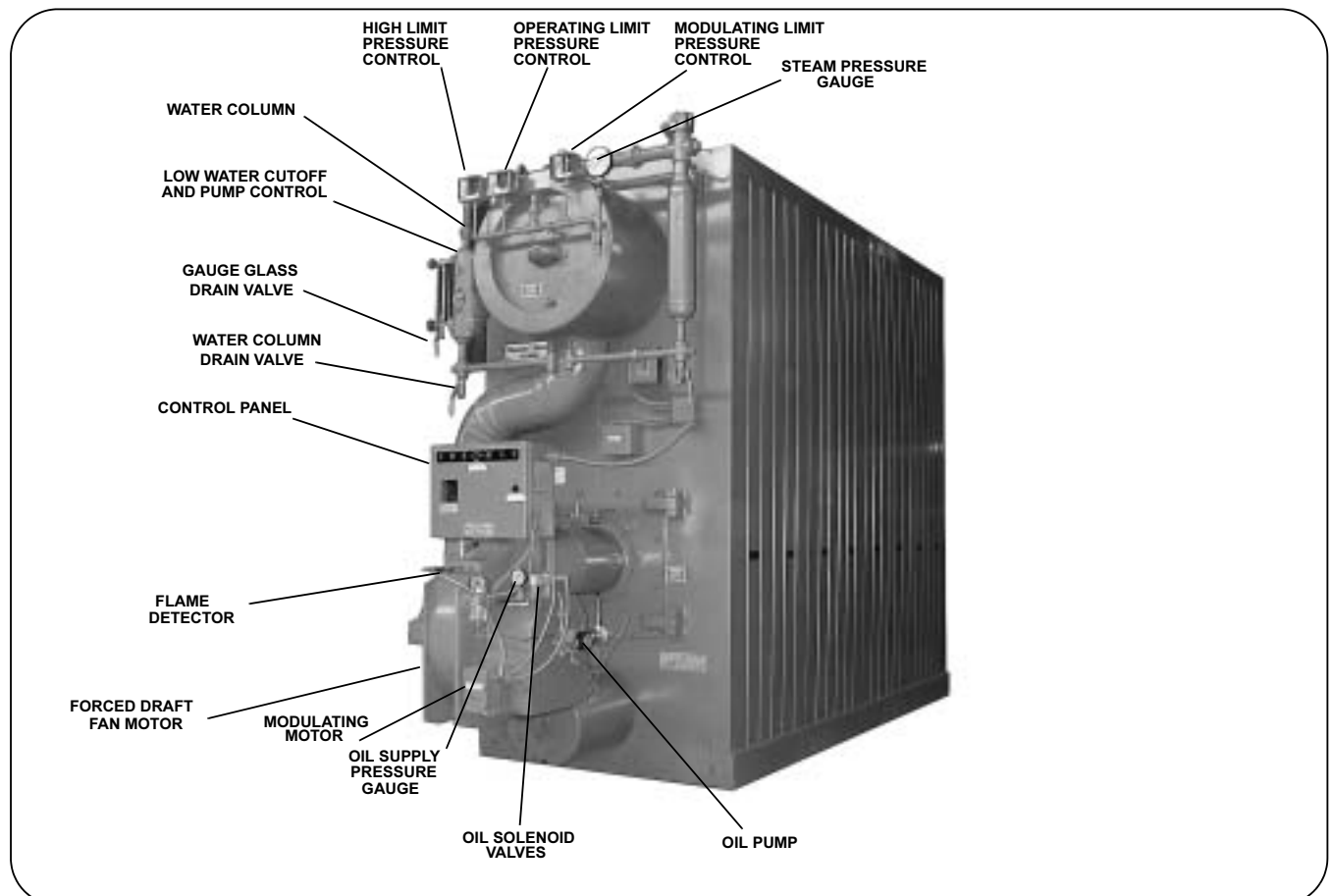
D. Steam Controls (All Fuels)

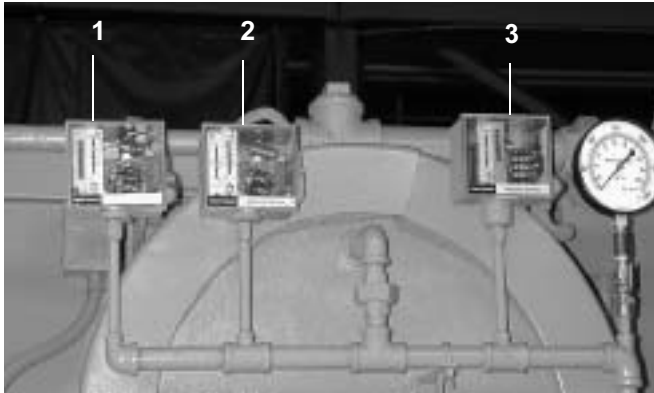
1. Operating Limit Pressure Control (Figures 1-2 and 1-3): Breaks a circuit to stop burner operation on a rise of boiler pressure at a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.
2. High Limit Pressure Control (Figure 1-2 and 1-3): Breaks a circuit 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 equipped with a manual reset.

3. Modulating Limit Pressure Control (Figure 1-2 and 1-3): Senses changing boiler pressures and transmits the information to the modulating motor to change the burner firing rate when the manual-automatic switch is set on “automatic.”
4. Low Water Cutoff and Pump Control (Figure 1-2, 1-4 and 1-5): 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.
5. Water Column Assembly (Figure 1-2): Houses the low-water cutoff and pump control and includes the water gauge glass, gauge glass shutoff cocks.
6. Water Column Drain Valve (Figure 1-2): Provided so that the water column and its piping can be flushed regularly to assist in maintaining cross-connecting piping and in keeping the float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low-water cutoff for the same purpose.
7. Gauge Glass Drain Valve (Figure 1-2): Provided to flush the gauge glass.
8. Safety Valve(s) (Figure 1-6 and 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

⚠ 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.





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

Figure 1-3: Steam Controls



Figure 1-4: Low Water Cut Off (LWCO)



Figure 1-5: Low Water Cut Off Pump Control (Cutaway)

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.

⚠ 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 1-7): Indicates the boiler internal water pressure.
2. Water Pressure Gauge (Figure 1-7): Indicates the internal pressure of the boiler.
3. Operating Limit Temperature Control (Figure 1-7): Breaks a circuit to stop burner operation on a rise of boiler temperature at a selected setting. It is adjusted to



Figure 1-6: Safety Valve Cutaway

stop or start the burner at a preselected operating temperature.

4. High Limit Temperature Control (Figure 1-7): 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 is equipped with a manual reset.
5. Modulating Temperature Control (Figure 1-7): 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.”
6. 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.
7. Auxiliary Low Water Cutoff (Not Shown) (Optional): Breaks the circuit to stop burner operation if the water

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

8. Safety Valve(s) (Figure 1-6 and 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

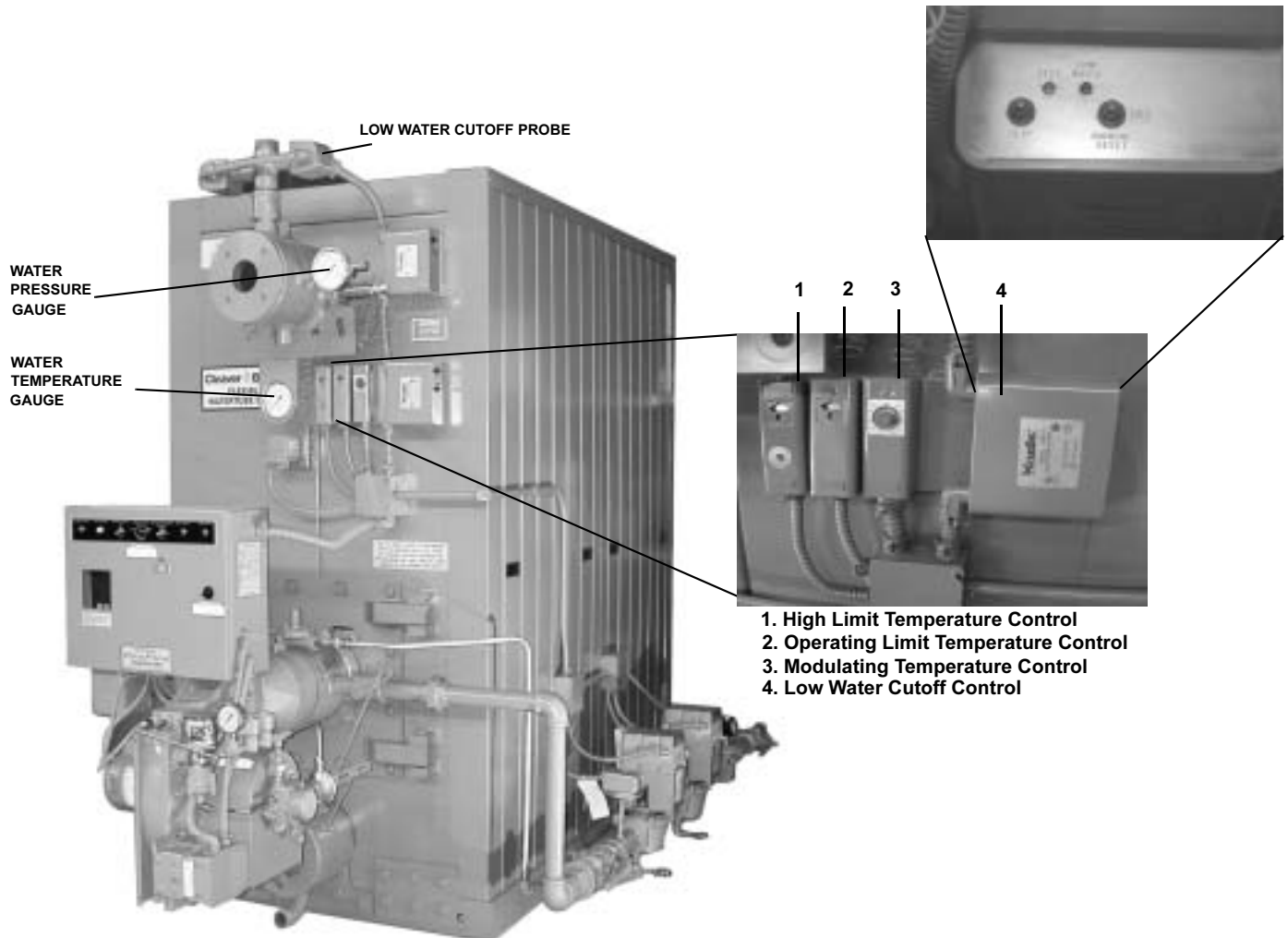


Figure 1-7: Hot Water Controls

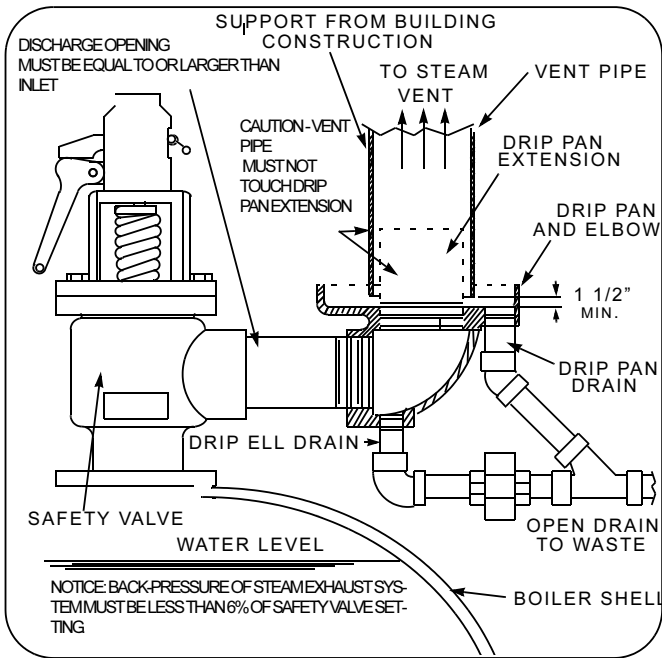


Figure 1-8: Recommended Piping For Steam Relief Valve (Not furnished by Cleaver-Brooks)

remove side outlet valves by using a pipe or wrench in the outlet.

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.

CHAPTER 2

ProFire Burner Operation and Control

A. GENERAL	1
B. BURNER	1
C. RECOMMENDED FUELS AND VENTILATION	2
D. CONTROLS AND COMPONENTS	2

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: If the boiler is not equipped with a ProFire burner, Please refer to the specific Operation and Maintenance manual for the burner supplied.

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.

A. GENERAL

The information provided in this manual covers ProFire burners installed on Flextube 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 1.5 to 12.0 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:

GP - W - X - Y - Z

Where:

GP designates the burner orientation, blower housing down.

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

- 100-Light Oil
- 200- Light Oil and Natural Gas
- 700- Natural Gas

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:

GP - 700 - 2 - 3.5 - IRI

MODEL NO.		150	200	250	300	350	400	450	500	550	600	700	800	900	1000	1100	1200
Comb Air (Dry)	Gas (scfh)	15480	20640	25800	30960	36120	41280	46440	51600	56760	61920	72240	82560	92280	103200	113520	123840
	(lb/hr)	1207	1609	2012	2414	2817	3219	3621	4024	4426	4828	5633	6438	7243	8048	8853	9658
	Oil (scfh)	17050	22733	28414	34098	39782	45463	51146	56831	62514	68196	79562	90928	102294	113662	125028	136394
	(lb/hr)	1269	1692	2115	2538	2961	3384	3807	4231	4654	5077	5923	6769	7640	8462	9308	10154

NOTES:

1. Natural gas @ 1000 Btu/cu-ft.
2. No. 2 oil @ 140,000 Btu/gal.

Table 2-1: Combustion Air Flow Requirements

indicates a blower housing “down” unit 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 light oil (#2), as defined by ASTM D396 - 1978 specification.

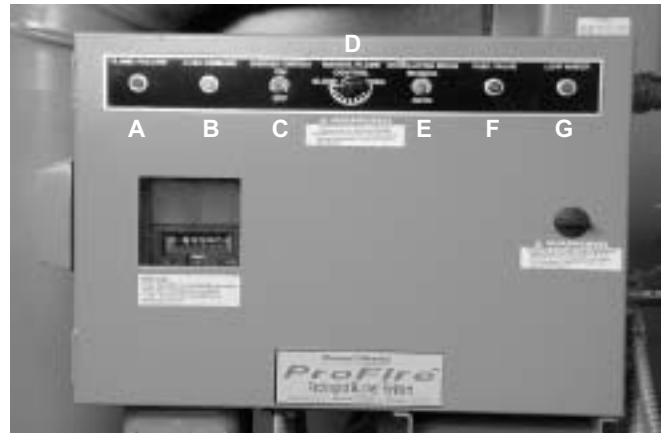
WARNING

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.

Note: Structural enclosures for this equipment must be configured to allow ample flow of combustion and ventilation air. See Table 2-1 for combustion air volume requirements.

D. CONTROLS AND COMPONENTS

The burner can be equipped with special operating controls, various types of flame safeguard systems, and/or a system to minimize NOx emissions. 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 and 2-2 for component locations. The



- A. FLAME FAILURE LIGHT
- B. LOAD DEMAND LIGHT
- C. BURNER SWITCH
- D. MANUAL FLAME CONTROL
- E. MANUAL-AUTO SWITCH
- F. FUEL VALVE LIGHT
- G. LOW WATER LIGHT

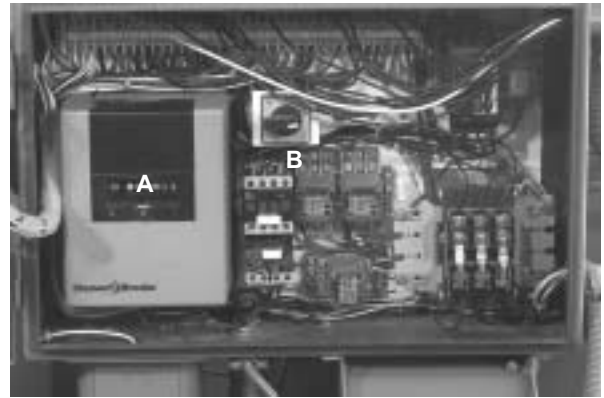
Figure 2-1: Control Cabinet

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. 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.

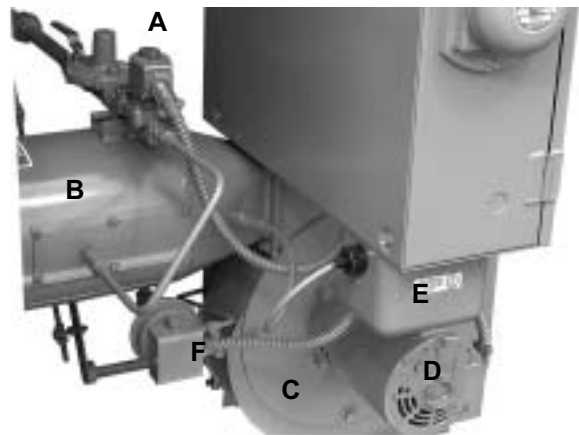
- **Burner Switch:** Activates or deactivates the operating cycle of the flame safeguard control.
- **Manual Flame Control:** When in Manual Mode, it provides manual adjustment of the burner firing rate between low-fire and high-fire operation.
- **Manual-Auto Switch:** Allows the operator to override the automatic boiler controls for manual firing rate adjustment.
- **Fuel Valve Light:** Illuminates (green) when the selected fuel valve is energized.
- **Low Water Light:** Illuminates (red) when the boiler low-water cutoff control is activated.



A. FLAME SAFEGUARD
B. FUEL SELECTION SWITCH

Figure 2-2: Control Cabinet (Open)

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 frequencies. 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. **Fuel Selection Switch (Figure 2-2):** Allows the operator to select either gas or oil as the active fuel on combination burners. (The switch is located inside the control cabinet.)
4. **Pilot Gas Train (Figure 2-3).** 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 2-3).** The blast tube functions as a duct for combustion air, and houses the fuel nozzle(s), gas pilot assembly, diffuser, and air baffle assemblies.
6. **Blower Housing (Figure 2-3).** The blower housing encloses the impeller. The fan drive motor is mounted directly to the blower housing.
7. **Combustion Air Fan Motor (Figure 2-3).** The electric motor drives the combustion air fan and the oil pump (if so equipped).
8. **Ignition Transformer (Figure 2-3).** The ignition transformer produces the high voltage required for spark generation by the pilot electrode(s).
9. **Combustion Air Proving Switch (Figure 2-3).** The combustion air proving switch provides confirmation to the flame safeguard that the combustion air fan is



A. PILOT GAS TRAIN
B. BLAST TUBE
C. BLOWER HOUSING
D. COMBUSTION AIR FAN MOTOR
E. IGNITION TRANSFORMER
F. COMBUSTION AIR PROVING SWITCH

Figure 2-3: ProFire Burner (Left Side)

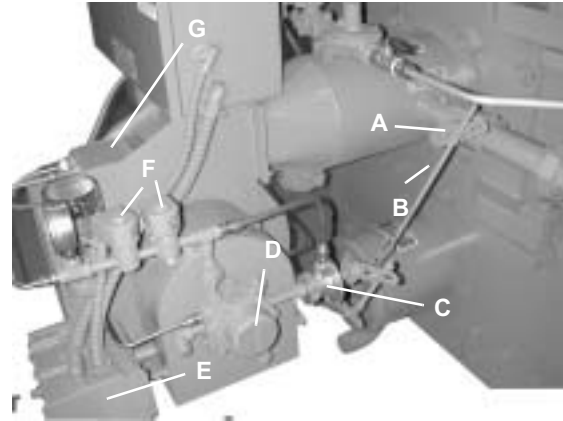


Figure 2-4: Impeller

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

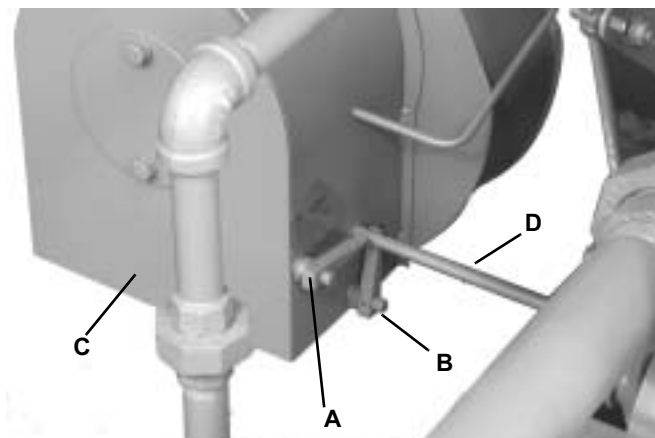
10. Impeller (Figure 2-4). The impeller is designed with backwards-inclined vanes. It is located inside the blower housing, and is driven by the combustion air fan motor. The impeller provides combustion air to the burner assembly. Removing the impeller requires the use of the impeller puller, part number 943-388 (Figure 2-8)
11. Gas Butterfly Valve (Figure 2-5). 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.
12. Valve Linkage (Figure 2-5). 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.
13. Oil Metering Valve (Figure 2-5). 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.
14. Oil Pump (Figure 2-5). The oil pump provided for oil burning is coupled to an extension of the combustion air fan shaft.
15. Modulating Motor (Figure 2-5). 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.
16. Oil Solenoid Valves (Figure 2-5). 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.
17. Rear Cap (Figure 2-5). The rear cap contains the locking setscrew for adjustment of the diffuser relative to the air baffle, and also the flame scanner for the flame safeguard. The rear cap must be removed to enable removal of the oil gun assembly.
18. Low-Fire Shutter (Figure 2-6). 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.
19. High-Fire Shutter (Figure 2-6). 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.

20. Airbox (Figure 2-6). 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.
21. Main Air Shutter Shaft (Figure 2-6). 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.



**A. GAS BUTTERFLY VALVE
 B. VALVE LINKAGE
 C. OIL METERING VALVE
 D. OIL PUMP
 E. MODULATING MOTOR
 F. OIL SOLENOID VALVES
 G. REAR CAP**

Figure 2-5: Oil And Gas Piping To Burner



**A. LOW-FIRE SHUTTER
 B. HIGH-FIRE SHUTTER
 C. AIRBOX
 D. MAIN AIR SHUTTER SHAFT**

Figure 2-6: Airbox and Shutters

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 Cut-off And Alarm	Operator	Refer to instructions.
Weekly		
Low-water Fuel Cut-off 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 (see “Combustion safety controls”).
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.
Semi- Annually		
Low-water Fuel Cut-off 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.

Figure 2-7: Recommended Test Schedule

ITEM	ACCOMPLISHED BY	REMARKS
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 Change Over 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.

Figure 2-7: Recommended Test Schedule (Continued)



Special Tools

The Impeller puller, 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 2-8: Impeller Puller Part Number
943-388**

Notes:

CHAPTER 3

Pressure Vessel Care

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A. GENERAL

This chapter is devoted primarily to the waterside care of the pressure vessel.

Proper water supply and treatment are essential to boiler life and length of service. Proper water treatment will pay dividends in the form of longer life, less downtime, and prevention of costly repairs.

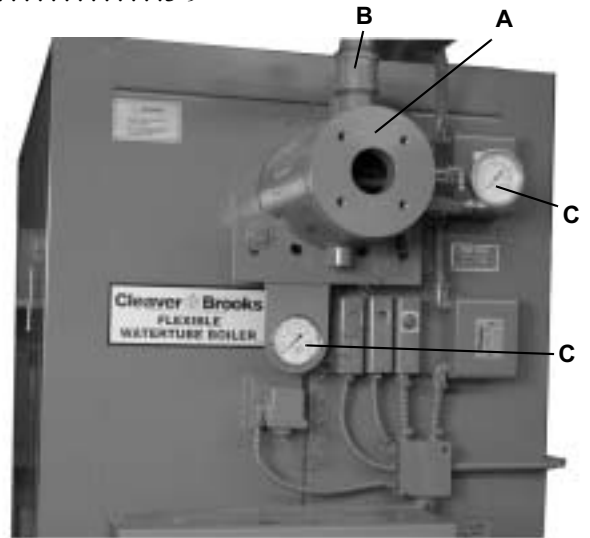
Hot water boilers require proper circulation. The system must be operated as intended by its designer in order to avoid the possibility of thermal shock with severe stress to the pressure vessel.

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 local Cleaver-Brooks authorized representative.

B. WATER REQUIREMENTS (HOT WATER BOILERS)

Air Removal

The hot water outlet (Figure 3-1) is located in the top drum of the boiler. This location reduces the possibility of released air (which is trapped at the top of the drum) from entering the system. Any air (or oxygen) that may be released in the boiler will collect at the top of the upper drum, where it will escape through the air vent tapping (Figure 3-1). The tapping must be properly piped to the expansion tank or a stand pipe and air bleeder to remove gases that collect at the top of the drum.



A. HOT WATER OUTLET
B. AIR BLEED TAPPING
C. PRESSURE/TEMPERATURE GAUGES

Figure 3-1: Upper Drum (Hot Water)

Continuous Flow

The system must be piped and the controls arranged so that there will be water circulation through the boiler under all operating conditions. Constant circulation through the boiler eliminates the possibility of stratification within the unit.

Refer to Fig. 3-1 to determine the maximum GPM circulation rate of boiler water in relation to full boiler output and system temperature drop.

MODEL NO.	DT = 20°F		DT = 40°F		DT = 60°F		DT = 80°F		DT = 100°F	
	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM	DP (PSIG)	GPM
FLX-150	1.14	122.0	0.30	61.1	0.13	41.1	0.08	30.8	0.05	24.4
FLX-200	1.14	162.3	0.30	81.1	0.13	54.1	0.08	40.6	0.05	32.5
FLX-250	1.77	202.8	0.46	101.4	0.21	67.6	0.12	50.7	0.08	40.6
FLX-300	1.85	243.4	0.48	121.7	0.22	81.1	0.12	60.9	0.08	48.7
FLX-350	2.49	284.0	0.65	142.0	0.29	94.7	0.17	71.0	0.11	56.8
FLX-400	1.35	324.5	0.35	162.3	0.16	108.2	0.09	81.1	0.06	64.9
FLX-450	1.71	365.1	0.44	182.6	0.20	121.7	0.11	91.2	0.08	73.0
FLX-500	2.03	405.7	0.54	202.8	0.25	135.2	0.14	101.4	0.09	81.1
FLX-550	2.50	446.3	0.67	223.1	0.31	148.7	0.17	111.5	0.11	89.2
FLX-600	2.99	486.8	0.77	243.4	0.35	162.3	0.20	121.7	0.13	97.4
FLX-700	1.75	567.9	0.45	284.0	0.21	189.3	0.12	142.0	0.08	113.6
FLX-800	2.27	649.1	0.59	324.5	0.27	216.4	0.15	162.3	0.10	129.8
FLX-900	2.85	730.2	0.74	365.1	0.33	243.4	0.19	182.6	0.12	146.0
FLX-1000	4.08	811.4	1.02	405.6	0.42	270.4	0.25	202.8	0.15	163.6
FLX-1100	4.42	892.6	1.15	446.2	0.48	297.4	0.28	223.0	0.18	178.4
FLX-1200	6.20	973.6	1.60	486.8	0.59	324.6	0.31	243.4	0.22	194.8

Table 3-1: Maximum Flow Rates for Hot Water Boilers

CAUTION

In order to avoid damage to the equipment, a circulating pump should be interlocked with the burner so that the burner cannot operate unless the circulating pump is running.

It is recommended that the system circulating pumps be kept running, even though the heat users do not require hot water. The relief device or bypass valve will allow continuous circulation through the boiler and will help prevent rapid replacement of boiler water with “cold” zone water.

CAUTION

The operator should determine that a circulation of water exists through the boiler before initial firing or when firing after the unit has been drained and refilled. A reduced circulation of water or no water circulation through the boiler when the burner is operating may result in damage to the equipment.

System Pressure

The design of the system and the usage requirements often will dictate the pressure exerted upon the boiler. Some systems are pressurized with nitrogen. Caution must be

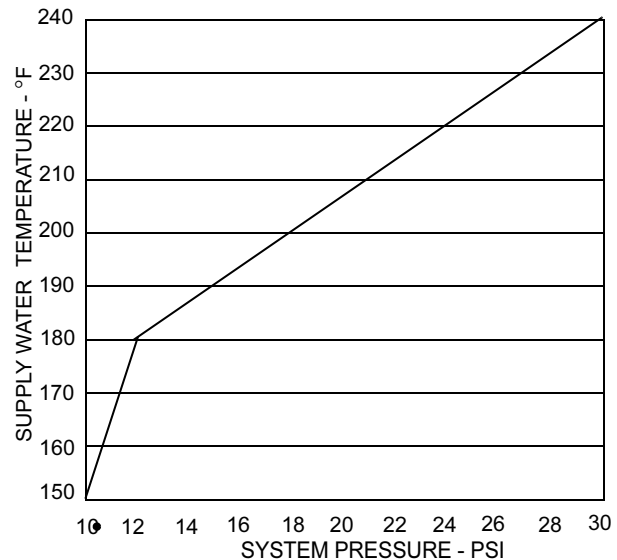


Figure 3-2: Minimum System Operating Pressure

exercised to make sure that the proper relationship of pressure to temperature exists within the boiler so that all of its internal surfaces are fully wetted at all times. It is for this reason that the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in Figure 3-3.

It is advisable to install a thermometer in the return line to indicate return water temperature. With the return water temperature and the supply water temperature to the system known, the temperature differential will be established. Knowing the flow rate, the operator easily can detect any excessive load condition and take appropriate corrective action.

Pressure Drop

There will be a pressure drop of less than 4 psi through all standardly equipped Cleaver-Brooks boilers operating in any system that has more than the 20°F temperature drop. This drop will vary with boiler size and circulation rate. For specific information, refer to table 3-1, Minimum Flow Rates for Hot Water Boilers.

Minimum Boiler Outlet Water Temperature

The minimum recommended operating boiler outlet water temperature is 150°F. When water temperatures lower than 150°F are used, the combustion gases are reduced in temperature to a point where the water vapor in the gases condenses. A result of condensation is that fireside corrosion occurs in the boiler and breeching. The condensation problem is more severe on a unit that operates intermittently or is oversized for the actual load. This is not a matter that can be controlled by boiler design, since an efficient boiler extracts all the possible heat from the combustion gases.

Note: In order to maintain a minimum outlet water temperature of 150°F the low limit of the Operating Temperature Control should be set at least 10° higher.

If the operating water temperature going to the system must be lower than 150°F, the operating boiler outlet water temperature should still be held to a minimum of 150°F. Mixing valves are used to reduce the supply temperature going to the system.

Note: The minimum return water temperature through the boiler is 120°F.

CAUTION

Three-way valves and system controls should be installed or set so that the boiler cannot be bypassed. A reduced circulation of water or no water circulation through the boiler when the burner is operating may result in damage to the equipment.

Multiple Boiler Installations

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

Variations in water temperature and firing rates will result if care is not taken to ensure proportional flow through the boilers. In extreme cases, differences in firing rates could result in a net header water temperature below the desired temperature.

C. WATER REQUIREMENTS (STEAM BOILERS)

Deaeration

The most important factor in the life of a steam pressure vessel is the proper conditioning of the boiler feed water. Corrosive gasses, such as oxygen and carbon dioxide, must be removed from the feed water in order to prevent degradation of the pressure vessel. For this reason Cleaver-Brooks recommends the use of a deaeration system as an integral part of a complete boiler installation. If circumstances do not allow the implementation of a deaeration system, then serious consideration should be given to effective alternatives such as a feed water preheater combined with a chemical oxygen scavenger. Complete boiler water chemistry parameters are given in Table 3-3.

Feed Water Supply

The internal dynamics of the Model FLX steam boilers require the capability to deliver large quantities of feed water to the boiler on demand. (Feed water inlet Figure 3-3.) Sudden changes in firing rate or operating pressure of the



**Figure 3-3: Feed Water Inlet
Steam Boiler**

BOILER MODEL	150	200	250	300	350	400	450	500	550	600	700	800	900	1000	1100	1200
Minimum Feed Rate (gpm)	4.9	6.6	8.2	9.9	11.6	13.2	14.9	16.5	18.2	19.8	23.1	26.4	29.7	33.0	36.3	39.6

Note: Feedwater to the boiler must be at least 60 °F, for minimum performance, 212 °F is preferred.

Table 3-2: Minimum Boiler Feed Water Flow Rates (Steam Boiler)

Silica	150 ppm
Specific Conductance	3500 µmho/cm
Total Alkalinity	300 ppm as C _a CO ₃
Total Hardness	0 ppm as C _a CO ₃
Oxygen (O ₂)	7 ppb
pH	10
Total Iron	0.05 ppm
Oily Matter	1 ppm

Table 3-3: Boiler Water Quality Limits (Steam Boilers)

boiler will initiate a “call for water” from the make-up controller, which will require that the feed water be delivered to the boiler in sufficient quantities to prevent a low water cutoff trip. Table 3-2 lists the minimum feed water flow requirements for the various boiler models. In addition, feed water must be warmed to a minimum of 60°F. in order to ensure reliable operation of the boiler. The feed water supply should be adjusted to deliver water to the boiler at or above these minimum rates.

D. WATER TREATMENT

Properly treated boiler water will result in maximum effectiveness and long trouble-free life of the pressure vessel. Contact your local Cleaver-Brooks Representative or water management consultant for complete information on how to prevent damage resulting from inadequate water treatment.

The objectives of water treatment in general are to:

1. Prevent hard scale and soft sludge deposits that inhibit heat transfer and that could lead to overheated metal and costly downtime and repairs.
2. Eliminate corrosive gases in the supply or boiler water.

To accomplish these objectives, the boiler requires proper water treatment before and after introduction of water into the unit. The selection of pretreatment processes depends upon the water source, its chemical characteristics, the amount of makeup water needed, system operation practices, etc.

Because of the variables involved, no one “boiler compound” can be considered a “cure-all”; nor is it advisable to experiment with homemade treating methods. A sound treatment program should include a periodic analysis of the water in the system.

The internal or waterside surfaces of the pressure vessel should be inspected at sufficient intervals to detect the presence of any corrosion, pitting, contamination, or accumulations of foreign matter. If any of these conditions are detected, contact your local Cleaver-Brooks authorized Representative for advice on corrective action. It is recommended that a properly sized water meter be installed in the raw water makeup line to accurately determine the amount of raw water admitted to the boiler. It is a false assumption that a hot water boiler does not require water treatment. Even though a hot water unit generally operates on a closed system and blowdown seldom is practiced, the need remains to be alert to system water losses. Knowing the amount of makeup water admitted to the system will aid in maintaining proper waterside conditions.

E. BLOWDOWN

A steam boiler requires periodic blowdown of the boiler and water column (Figure 3-4). Blowdown is the removal of some of the concentrated water from the boiler and the water level



Figure 3-4: Low Water Cutoff and Gauge Glass with Blowdown Valve

control system, in order to lower the concentration of solids in the water.

Solids are introduced to the boiler with the feedwater, even though this water may be treated prior to use. These solids become less soluble when the water is heated and evaporated, and tend to accumulate on heating surfaces.

Periodic blowdown and chemical treatment are necessary to prevent concentration of solids in the boiler water, and attachment of these solids to waterside heating surfaces (scaling).

Scale has a low heat transfer value and acts as an insulating barrier on heating surfaces. A buildup of scale will result in lower operating efficiency and, consequently, higher fuel consumption. More importantly, scale buildup can result in overheating of boiler metal. This can result in tube failures or other pressure vessel damage.

CAUTION

Boiler and water level control blowdown must be performed on a regular basis to ensure that concentrated solids are removed from the boiler and in order to avoid damage to the equipment.

Water column and gauge glass blowdown valves are located on the water column assembly. The boiler blowdown tapping(s) can be found at the bottom of the lower drum.

Most blowdown lines are provided with two valves. These are generally a quick-opening valve nearest the boiler and a slow-opening globe-type valve downstream. Valves will vary depending upon pressure involved and the make or manufacturer.

Blowdown Procedure

Blowdown is most effective when the boiler water is hot and the burner is being fired at the lowest rate. This ensures that the water in the boiler is being circulated, and that the solids in the water are in suspension.

WARNING

Be sure that the blowdown piping is in good condition, the discharge vents are clear of obstruction, and that the waste is piped to a safe point of discharge, in order to avoid serious personal injury or death.

If a quick-opening valve and globe-type or slow-opening valve are installed, the quick-opening valve is normally opened first and closed last. Control of the water released from the boiler is accomplished with the slow-opening valve.

CAUTION

When initially opening the blowdown valve, open the valve slowly to heat the discharge piping. Failure to follow this procedure could result in rapid expansion and damage to the piping.

The drop of the water level in the gauge glass can be used in determining the length of time that the blowdown valve is left open. This is to be used as a reference only, as proper water analysis on a regular basis will serve as an indicator of the effectiveness of the blowdown procedures used.

CAUTION

Do not pump the lever action valve open and closed when draining water during blowdown. The hydraulic forces resulting from this pumping action could break the valve bodies or pipe fittings in the blowdown lines.

Blowdown valves should be closed in a specific order after draining water for blowdown. Close the downstream (slow opening) valve first, followed by the quick-opening valve next to the boiler. Open the downstream valve slightly to release the water trapped between the valves, then close the valve again.

The water column and gauge glass should be blown down by draining until the water in the gauge glass is clear. Open and close the water column and gauge glass blowdown valves slowly, allowing the water in the gauge glass to rise to a normal level before repeating the process.

Under no circumstances should a blowdown valve be left open and unattended during the blowdown operation.

Frequency of Blowdown

In practice, the boiler blowdown valve(s) should be opened periodically in accordance with a set operating schedule. Frequency and duration of the blowdown are to be determined by chemical analysis of boiler water and waterside boiler condition, as observed during regular inspections.

From an economy standpoint, frequent short blowdown is preferred to irregularly scheduled, lengthy blowdown. This is particularly true when the suspended solids content of the water is high.

F. CLEANING

Although it may be necessary to clean the system, information in this chapter deals primarily with cleaning the boiler under isolated conditions.

System piping connected to the boiler may contain oil, grease, or other foreign matter. These impurities must be removed to prevent damage to the heating surfaces of the pressure vessel. Chemical cleaning generally is necessary in this case and the entire system should be drained after cleaning. Consult your local Cleaver-Brooks authorized representative for recommended cleaning compounds and application procedures. For information on Boilout, see Section G, in this chapter.

Pressure Vessel

Cleaning of the waterside of the pressure vessel should be done during the course of initial installation. The waterside of the pressure vessel must be cleansed of grease, sludge, and foreign material. Such deposits will shorten the life of the pressure vessel and interfere with the efficient operation and function of control or safety devices. In addition, deposits might cause unnecessary and expensive rework, repairs, and downtime.

The pressure vessel and the hot water system represent in effect, a closed system. Although individual components of the system may already have been cleaned, it is possible that:

1. The cleaning was not adequate.
2. An old system was partially or totally involved.
3. Conditions may have prevented an adequate cleaning of the piping.

Therefore, it is recommended that the entire system be cleaned, after installation of all components is completed. The pressure vessel waterside should be inspected on a periodic basis. An inspection will reveal the true internal conditions and will serve as a check against conditions indicated by chemical analysis of the boiler water. An inspection should be performed 3 months after the initial start up, then at regular 6, 9, or 12 month intervals thereafter. The frequency of periodic inspections will depend upon the internal conditions found, the particular installation, and the operating conditions that the boiler is subjected to.

If any deterioration or unusual conditions are observed, contact your local Cleaver-Brooks authorized Representative for recommendations.

Boiler Size	150-250	300-350	400-600	700-900	1000-1200
Water Capacity (US gal.) Hot Water	91	106	174	228	269
Water Capacity (US gal.) Steam - Flooded	194	215	293	464	562

Table 3-4: Water Capacity

G. BOILOUT

Any oil, grease, or other contamination found to be present on waterside heating surfaces should be removed promptly by boiling out the unit with an alkaline detergent solution.

Note: Before boiling out, the burner must be ready for firing. Refer to the burner manual for details. The operator must be familiar with the boilout procedures outlined in this section.

Cleaver-Brooks recommends the use of CB3900,(P/N 797-1797) an alkaline, detergent-based product suitable for cleaning all internal surfaces in heating and process boilers. Contact your local Cleaver-Brooks authorized representative for additional information or assistance.

If the system is to be cleaned with the boiler, consider the additional water content of the system in determining the

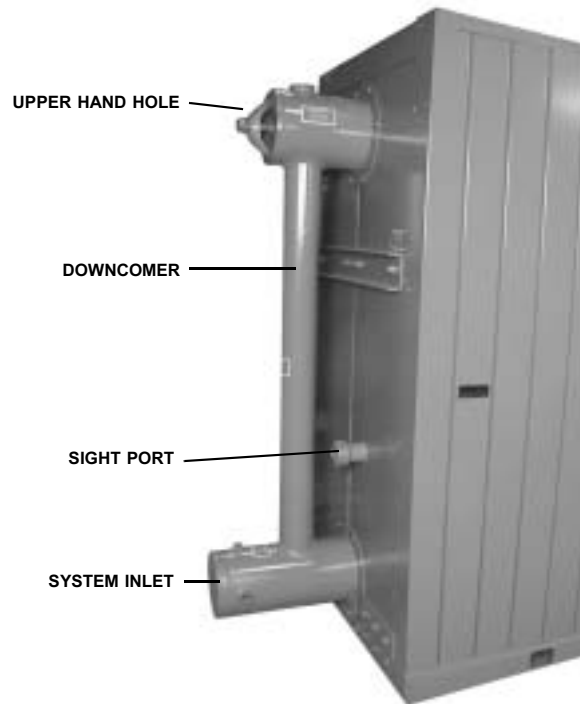


Figure 3-5: Rear Panel (Hot Water Boiler)

amount of chemical required. The water capacity of Cleaver-Brooks FLX Boilers is listed in Table 3-4.

Boilout Procedure

1. Prepare the boiler for firing by taking the standard precautions. Check for any situations that might present a hazard.
2. Remove upper and lower drum handhole covers and inspect all internal waterside surfaces. Remove debris

and wash all internal surfaces, including tubes. It may be necessary to use a high pressure hose or a wash out lance to flush out inaccessible areas. Reinstall the lower drum handhole cover. (Use standard service gaskets during the boilout procedure.)

3. The relief valve(s) must be removed before adding the boilout solution so that neither the solution nor the contaminants that it may carry can come in contact with the valve(s). Use care in removing, handling, and reinstalling these valves.

Note: For relief valve installation information, refer to Chapter 8, Section E. "Controls."

4. Replace the regular gauge glass with a temporary gauge glass that can be discarded after the cleaning (steam boilers).
5. An overflow pipe should be connected to one of the top boiler openings and routed to a safe point of discharge. A relief valve tapping is usually used for this purpose. The overflow connection to the boiler should incorporate a tee fitting for adding cleaning solution to the boiler.
6. Fill the unit with clean water to a point just below the access port in the upper drum. It is important that the water used for the filling process is at a temperature of 70°F or above.
7. Add the recommended amount of Cleaver-Brooks 3900, using a chemical pump. Never pump the cleaning chemical into the boiler before adding water.

WARNING

The chemicals used in this procedure are corrosive to eyes and skin. Always refer to the Material Safety Data Sheet to ensure that the proper safety equipment and precautions are present. Failure to heed this warning could result in serious personal injury or death.

8. Reinstall the upper handhole cover.
9. Continue to fill the boiler until it is full (indicated by flow from the overflow connection).
10. Recheck the burner, gauge glass, pressure gauge, feedwater supply and the position of all valves. Make sure that all water feeding and level indicating apparatus are in proper working condition.
11. Fire the boiler intermittently at the burners lowest fire rate until the water reaches the boiling point. The water should be held at this temperature for at least five hours.

Note: Do not produce pressure in the boiler.

12. Throughout the entire process, each blow-down point or valve should be blown at least once every two hours. The total amount of water blown from all points each time should be approximately one-half gauge glass, this amount being equally divided among the various manual blowdown points and continuous blowdown system. Blow the surface and/or continuous blow-down points first, followed by the other blowdown points lower on the boiler. After each blowdown cycle, the water level should be brought back to full. If the total alkalinity in the cleaning solution falls to a level below 3000 ppm, it may be necessary to add additional Cleaver-Brooks 3900, using a chemical pump.
13. Allow a small amount of fresh water to enter the boiler in order to create a slight overflow that will carry off surface impurities. Continue to boil and overflow until the water clears.
14. It is difficult to provide specific recommendations regarding the duration of the cleaning process. In general, a period of 18 to 36 hours will prove sufficient to internally clean the water-side of the boiler. The condition of the water blown from the boiler is the best indicator as to whether the cleaning process is complete.
15. Discontinue firing, and allow the water to cool. After letting the water cool to 120°F or less, drain the boiler.

WARNING

Be sure to drain the hot water to a safe point of discharge to avoid the possibility of scalding, serious personal injury or death.

16. Remove the drum handhole cover, and wash the waterside surfaces thoroughly, using a high pressure water stream. Direct the water stream into each individual tube. If possible, this washing should be done from the bottom up. A wash out lance is available from your local Cleaver-Brooks authorized representative.
 17. Inspect the waterside surfaces. If they are not clean, repeat the boilout procedures.
 18. Replace the handhole covers (using new gaskets) and reinstall the relief valve(s).
- Note: Refer to Chapter 8, Section E, "Controls" for information regarding proper installation of relief valves.**
19. If the boiler is to be put into service immediately, fill the boiler with clean, treated water and fire the burner until the water has been heated to at least 180°F to drive off any dissolved gases that might otherwise corrode the metal.
 20. If the boiler is not to be put into immediate service, refer to the section on boiler layout procedures in this chapter.

H. WASHING OUT

Depending on system integrity, feedwater quality, or operating conditions, the water side of the boiler may need to be washed out on occasion.

In theory, a hot water system and boiler that have been initially cleaned, filled with clean, treated water, and with no makeup water added, will require no further cleaning or treatment. However, minor system leaks may allow the admission of additional water or air into the boiler.

Introduction of raw (untreated) makeup water or air to a hot water boiler may lead to pitting, corrosion, or formation of sludge, sediment, or scale on the pressure vessel waterside.

The waterside condition of steam boilers can be likewise affected by feedwater quality, load demands, operating conditions, or blowdown practices.

The waterside of a hot water or steam boiler should be cleaned and inspected no later than three months after the boiler is put into service. Subsequent cleaning of waterside surfaces should be performed as indicated through periodic inspection.

In order to thoroughly wash out the waterside of the pressure vessel, the handhole covers at the ends of the upper and lower drums must be removed. The interior surfaces of the drums should be washed with a high pressure hose. Tubes should be cleaned by directing a high pressure stream of water into the end of each tube, first from the bottom, and then from the top drum.

Note: A washout lance for this purpose is available from your local Cleaver- Brooks authorized representative.

Control and water column connections on steam boilers should be checked for accumulated deposits, and cleaned as required.

After waterside cleaning has been completed, replace the handhole covers, using new gaskets.

Note: Handhole cover gaskets are installed dry; that is, without application of a sealing compound.

I. PERIODIC INSPECTION

Insurance regulations or local codes and good maintenance will require that the pressure vessel be inspected periodically by an authorized inspector. Sufficient notice is generally required to allow removal of the boiler from service and preparation for inspection. An internal inspection may be required before cleaning or flushing.

Have the following information available for the inspector: boiler design, dimensions, generating capacity, operating pressure and temperature, time in service, defects found previously, and any repairs or modifications made to the unit. Reference records of previous inspections also should be

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

When shutting down a boiler, the load should be reduced gradually and the pressure vessel should be cooled at a rate that avoids a temperature differential that can cause harmful stresses. Normally, all pressure should be relieved before a vessel is drained in order to prevent uneven contraction and temperature differential that can cause tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces.

Note: Check to see that system valves, feedwater valves, all fuel valves, expansion tank, and electrical switches are shut off prior to opening the handholes or the burner access door. After proper cooling and draining of the vessel, flush out the waterside with a high pressure water stream. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion or leakage.

Fireside surfaces also should be cleaned so that metal surfaces, welds, joints, tube fittings, and any previous repairs can be readily checked.

WARNING

To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight is recommended during an internal inspection.

Fireside Inspection

Access for inspection of the firing chamber, or furnace, is gained through the hinged burner door. Inspection of the upper pass requires removal of the side casing panels and second and fourth pass cover plates. Refer to Chapter 8, Section C, "Fireside Cleaning," for information regarding outer and inner casing removal.

Fireside tube surfaces should be checked for corrosion or accumulation of soot. Use a vacuum cleaner and wire brush to remove light corrosion or soot.

Localized, heavy corrosion on fireside tube surfaces may indicate a leaking tube or ferrule connection. If a tube or tube ferrule leak is indicated, the source of the leakage must be found and repaired before putting the boiler back in service. A leak from a tube-to-drum connection may require removal and reseating of the tube. A heavily corroded or leaking tube must be replaced in order to assure continued reliable operation of the boiler. Information regarding tube replacement can be obtained from your local Cleaver-Brooks authorized representative.

Waterside Inspection

Check all water piping and valves for leaks, wear, corrosion, and other damage. Replace or repair the piping and valves as necessary. Inspection covers at one end of the upper and lower drums provide access to the interior of the drums for visual inspection or washout. The interior surfaces of the drums should be examined for any sign of corrosion or accumulation of deposits.

J. PREPARATION FOR EXTENDED LAYUP

Many boilers used for heating or seasonal loads or for standby service may have extended periods of non-use. The procedures outlined in this section are designed to allow a boiler to be kept off line for any period of time without damage to the unit. Special care must be taken so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion. Operating boilers can be protected from corrosion and scale by applying various chemical treatments and monitoring the system on a regular basis. However, boilers that are taken off line, even for short intervals, are susceptible to oxygen attack. Boiler drums and/or tubes may sustain pitting type damage during either wet or dry layup if proper precautions are not taken.

Oxygen solubility at ambient (off-line) temperatures can be many times that of normal boiler operating temperatures. The higher the oxygen concentration, the greater the oxygen corrosion potential. Problems also can occur as a result of improper shutdown procedures, where settled solids can dry in a hard, adherent deposit.

Care must be taken to prevent fireside corrosion, especially when firing oil that contains sulfur. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation during cooling. Moisture and any sulfur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid can be serious. An acid solution could eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

Too many conditions exist to lay down definite rules for individual installations. In general, there are two methods of storage: wet or dry. Your local Cleaver-Brooks authorized representative can recommend the better method based on the circumstances of your particular installation. Regardless of the method employed, the boiler should be thoroughly cleaned and inspected prior to storage. With either method, common sense dictates a periodic recheck of fireside and waterside conditions during layup to meet the requirements of special or job site conditions.

Preparing The Boiler For Layup

To prepare a boiler for layup, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, exposed drum surfaces, and refractory.

CAUTION

The insulating refractory covering the top of the bottom drum must be protected from damage when work is being done in the boiler furnace area. Damage to the insulation may eventually cause damage to the boiler itself.

Generally, a good brushing will clean fireside surfaces. Use a wire brush for metal surfaces and a soft bristle brush for the refractory. Sweep away or vacuum any accumulation.

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

It is recommended that the burner air inlet be blocked to prevent the flow of warm, moist air through the boiler.

CAUTION

A label should be affixed to the burner advising that the air inlet has been blocked. Failure to remove the air inlet block when attempting to operate the burner may result in damage to the equipment.

Dry Storage

Dry storage generally is used for boilers that are to be out of service for some time or for boilers that might be subjected to freezing conditions. With the dry storage method, the boiler must be thoroughly dried because any moisture would cause corrosion. Drying can be accomplished by the use of a small stove or heater.

Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, and other combustion products as soon as possible after shutdown.

All openings to the pressure vessel, such as handholes or inspection ports, should be closed tightly. Feedwater and system valves should be closed. Dampers should be closed to prevent air from reaching the fireside surfaces.

Steps must be taken to eliminate moisture by placing moisture-absorbing materials on trays inside the boiler. Two moisture-absorbing materials are: quick-lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume). As soon as the material is in place, close all boiler openings and blank all connections.



Materials described in this section may be considered hazardous under the U.S. Occupational Safety and Health Act of 1970. Material Safety Data Sheets should be obtained and understood prior to the use of these products to avoid the possibility of serious personal injury or death.

Wet Storage

Note: It is always best to consult with a water treatment consultant before proceeding with extended layup.

Wet storage is used when the boiler will be out of service for shorter periods of time, when a boiler is held in standby conditions, or in cases where dry storage is not practical. The boiler held in wet storage can be brought back into service more quickly than one held in dry storage. However, the

possibility of freezing temperatures must be considered. Again, take care to protect metal surfaces. Because of the number of variables, it is difficult to offer definite recommendations. However, it is suggested that the pressure vessel be drained, thoroughly cleaned internally, and refilled 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 in order to drive off oxygen in the water.

Tightly close all connections and apply a small positive pressure to compensate for the vacuum that will develop as the unit cools to room temperature. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen often is used to pressurize the vessel.

The boiler water should be tested weekly as long as the unit is in storage. Additional chemicals may be required to prevent internal corrosion. If more chemicals are added, it is desirable to circulate the boiler water for a short time by means of an external pump.

Contact your local Cleaver-Brooks authorized representative for water treatment chemicals or assistance.

Notes

CHAPTER 4

Sequence Of Operation

A. General	4-1
B. Circuit And Interlock Controls	4-1
C. Sequence Of Operation - Oil Or Gas.	4-2
D. Flame Loss Sequence	4-3

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.

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

- Blower motor starter
- 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 interlock circuit

- Main gas valve auxiliary switch (MGVAS)
- Oil valve auxiliary switch (OVAS)

Blower Motor Starter Circuit

- Blower motor starter (BMS)

Running Interlock Circuit

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)

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

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

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.

High Fire Proving Circuit

- High fire switch (HFS)

Running Interlock and Limit Circuit

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

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.

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

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

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

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

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

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.

Note: An oil-fired burner may be equipped with a direct spark rather than a gas pilot. The ignition sequence of both is identical.

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

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

With a proven pilot, the main fuel valve(s) (OV or MGCV) 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 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 and cam assembly to provide modulated firing rates.

Note: Normal operation of the burner should be with the manual-automatic 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 Shutdown-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.

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. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 or 15 seconds later. The flame detecting circuit will respond to 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 then 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 trouble shooting section in the operating manual and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent.

The program relay has the capability to self-diagnose and to display a code or message that indicates the failure condition. Refer to the control bulletin for specifics and suggested remedies. Familiarity with the program relay and other controls in the system can be obtained by studying the contents of the manual 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	MNEMONIC	DESCRIPTION
A			
A	Amber (Color Of Pilot Light)	BS	Burner Switch
AAFL	Atomizing Air Failure Light	BSS	Boiler Selector Switch
AAFR	Atomizing Air Failure Relay	BWPM	Booster Water Pump Motor
AAPL	Atomizing Air Proven Light	BWT	Booster Water Thermostat
AAPS	Atomizing Air Proving Switch	C	
AAPS-B	Atomizing Air Proving Switch- Burner	CAFL	Combustion Air Failure Light
AAPS-C	Atomizing Air Proving Switch- Compressor	CAFR	Combustion Air Failure Relay
AASS	Atomizing Air Selector Switch	CAP	Capacitor
AB	Alarm Bell	CAPS	Combustion Air Proving Switch
ACCR	Air Compressor Control Relay	CCCB	Control Circuit - Circuit Breaker
ACM	Air Compressor Motor	CCF	Control Circuit Fuse
ACMCB	Air Compressor Motor Circuit Breaker	CCRS	Control Circuit Reset Switch
ACMF	Air Compressor Motor Fuses	CCT	Control Circuit Transformer
ACMS	Air Compressor Motor Starter	CIPL	Changeover In Progress Light
ACMSI	Air Compressor Motor Starter Interlock	CL	Canopy Light
AH	Alarm Horn	CLS	Canopy Light Switch
ALFR	Assured Low Fire Relay	COPS	Changeover Pressure Switch
ALWCO	Auxiliary Low Water Cutoff	COR	Changeover Relay
AM	Ammeter	COTD	Changeover Time Delay
AMS	Atomizing Media Switch	CPOL	Control Power on Light
AOV	Auxiliary Oil Valve	CR	Control Relay
APR	Air Purge Relay	CSSS	Control System Selector Switch
APV	Air Purge Valve	CWPM	Circulating Water Pump Motor
AR	Alarm Relay	CWPMCB	Circulating Water Pump Motor Circuit Breaker
AS	Auxiliary Switch (Suffix)	CWPMF	Circulating Water Pump Motor Fuses
ASR	Alarm Silencing Relay	CWPMS	Circulating Water Pump Motor Starter
ASS	Alarm Silencing Switch	CWPMSI	Circulating Water Pump Motor Starter Interlock
ASV	Atomizing Steam Valve	CWPR	Circulating Water Pump Relay
AT	Annunciator Transformer	CWPS	Circulating Water Pump Switch
AWCBDS	Auxiliary Water Column Blowdown Switch	CWSV	Cooling Water Solenoid Valve
B		D	
B	Blue (Color of Pilot Light)	D	Denotes Digester Gas Equipment (Prefix)
BC	Bias Control	DCVM	Direct Current Voltmeter
BDCS	Breeching Damper Closed Switch	DG	Draft Gauge
BDOS	Breeching Damper Open Switch	DGHPV	Digester Gas Housing Purge Valve
BDRS	Blowdown/Reset Switch	DHWC	Deaerator High Water Control
BFPL	Boiler Feed Pump Light	DHWL	Deaerator High Water Light
BFPM	Boiler Feed Pump Motor	DHWR	Deaerator High Water Relay
BFPMCB	Boiler Feed Pump Motor Circuit Breaker	DISC	Disconnect (Entrance Switch)
BFPMF	Boiler Feed Pump Motor Fuses	DLWC	Deaerator Low Water Control
BFPMS	Boiler Feed Pump Motor Starter	DLWL	Deaerator Low Water Light
BFPS	Boiler Feed Pump Switch	DLWR	Deaerator Low Water Relay
BFTS	Back Flow Temperature Switch	DM	Damper Motor
BHS	Boiler - Header Switch	DMT	Damper Motor Transformer
BIOL	Boiler in Operation Light	DNS	Day-Night Switch
BIOR	Boiler In Operation Relay	DODE	Delay On Deenergization (Timer)
BM	Blower Motor	DOE	Delay On Energization (Timer)
BMCB	Blower Motor Circuit Breaker	DPS	Damper Positioning Switch
BMCR	Blower Motor Control Relay	DS	Door Switch
BMF	Blower Motor Fuses	E	
BMPR	Blower Motor Power Relay	EDS	Emergency Door Switch
BMPSP	Blower Motor Purge Switch	ESS	Emergency Stop Switch
BMR	Blower Motor Relay	ETM	Elapsed Time Meter
BMS	Blower Motor Starter	F	
BMSI	Blower Motor Starter Interlock	FADM	Fresh Air Damper Motor
BMSS	Boiler Master Selector Switch	FADR	Fresh Air Damper Relay
		FD	Flame Detector

Figure 4-1: Electrical Nomenclature

MNEMONIC	DESCRIPTION	MNEMONIC	DESCRIPTION
FDJB	Flame Detector Junction Box	H/LWA	High Low Water Alarm
FDPS	Flow Differential Pressure Switch	HLC	High Limit Control
FFA	Flame Failure Alarm	HLFC	High-Low Fire Control
FFL	Flame Failure Light	HLPC	High Limit Pressure Control
FFR	Flame Failure Relay	HLTC	High Limit Temperature Control
FGR	Flue Gas Recirculation	HMC	Header Modulating Control
FGRCDTD	Flue Gas Recirculation Cool Down Time Delay	HOPL	High Oil Pressure Light
FGRCPS	Flue Gas Recirculation Cam Position Switch	HOPR	High Oil Pressure Relay
FGRFM	Flue Gas Recirculation Fan Motor	HOPS	High Oil Pressure Switch
FGRFMS	Flue Gas Recirculation Fan Motor Starter	HOLC	Header Operating Limit Control
FGRFMSI	Flue Gas Recirculation Fan Motor Starter Interlock	HOTL	High Oil Temperature Light
FGRMVL	Flue Gas Recirculation Manual Valve Limit Switch	HOTR	High Oil Temperature Relay
FGRTD	Flue Gas Recirculation Time Delay	HOTS	High Oil Temperature Switch
FORS	First Out Reset Switch	HPCO	High Pressure Cutoff
FPM	Feed Pump Motor	HSPC	High Steam Pressure Control
FPMS	Feed Pump Motor Starter	HSPL	High Steam Pressure Light
FPR	Feed Pump Relay	HSPR	High Steam Pressure Relay
FPS	Feed Pump Switch	HSTC	High Stack Temperature Control
FRI	Firing Rate Interface	HSTL	High Stack Temperature Light
FRP	Firing Rate Potentiometer (O2 Trim)	HSTS	High Stack Temperature Switch
FS	Flow Switch	HWAR	High Water Alarm Relay
FSS	Fuel Selector Switch	HWC	High Water Control
FSSM	Flame Signal Strength Meter	HWCO	High Water Cutoff
FVEL	Fuel Valve Energized Light	HWL	High Water Light
FVL	Fuel Valve Light		I
FVR	Fuel Valve Relay	(I.C.)	Instantaneously Closed
FWC	Feed Water Control	(I.O.)	Instantaneously Open
FWVT	Feed Water Valve Transformer	IL	Ignition Light
	G	INT	Interval (Timer)
G	Green (Color Of Pilot Light)	IR	Ignition Relay
GGL	Gauge Glass Light	IT	Ignition Transformer
GOL	Gas Operation Light		J
GOR	Gas-Oil Relay	JPP	Jackshaft Position Potentiometer
GOS	Gas-Oil Switch		L
GOR	Gas-Oil Relay	LAMPS	Low Atomizing Media Pressure Switch
GPS	Gas Pressure Sensor	LASPS	Low Atomizing Steam Pressure Switch
GPV	Gas Pilot Valve	LDL	Load Demand Light
GPVV	Gas Pilot Vent Valve	LDPS	Low Differential Pressure Switch
GR	Gas Relay	LDS	Low Draft Switch
GSSV	Gas Sensor Solenoid Valve	LFAV	Low Fire Air Valve
GVEL	Gas Valve Energized Light	LFGV	Low Fire Gas Valve
GVTS	Gas Valve Test Switch	LFHTD	Low Fire Hold Time Delay
	H	LFL	Low Fire Light
HATC	High Ambient Temperature Control	LFOV	Low Fire Oil Valve
HBWTC	High Boiler Water Temperature Control	LFPS	Low Fire Pressure Switch
HBWTL	High Boiler Water Temperature Light	LFR	Low Fire Relay
HFAV	High Fire Air Valve	LFS	Low Fire Switch
HFGV	High Fire Gas Valve	LFS-A	Low Fire Switch - Air
HFL	High Fire Light	LFS-F	Low Fire Switch - Fuel
HFOV	High Fire Oil Valve	LFS-G	Low Fire Switch - Gas
HFPS	High Furnace Pressure Switch	LFS-O	Low Fire Switch - Oil
HFS	High Fire Switch	LFTC	Low Fire Temperature Control
HFS-A	High Fire Switch - Air	LGPL	Low Gas Pressure Light
HGPL	High Gas Pressure Light	LGPR	Low Gas Pressure Relay
HGPR	High Gas Pressure Relay	LGPS	Low Gas Pressure Switch
HGPS	High Gas Pressure Switch	LIAPS	Low Instrument Air Pressure Switch
HHFL	Header High Fire Light	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
MFVV	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

MNEMONIC	DESCRIPTION
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

A. General Preparation for Initial Startup 5-1
B. Startup Procedures 5-5
C. Burner Adjustments, Single Fuel Natural Gas 5-7
D. Burner Adjustments, Single Fuel Oil Fired 5-11
E. Burner Adjustments, Combination 5-14
F. Startup, Operating and Shutdown - All Fuels 5-19
G. Control, Operational Tests and Checks 5-20


A. GENERAL PREPARATION FOR INITIAL STARTUP

Note: If the boiler is not equipped with a ProFire burner. Please refer to the specific Operation and Maintenance manual for the burner supplied.

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 this should be reviewed prior to firing. The wiring diagram should also have been studied, along with the firing sequence outlined in Chapter 4.

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

 **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.

 **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 damper and metering valves and cams. The check can be done by loosening the linkage at the damper motor connecting arm and manipulating the linkage by hand.

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

Note: All work on the burner should be performed by qualified persons knowledgeable in safe practices and 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 / Canadian Underwriter's Laboratories (UL/cUL) and the responsible insurance carrier if applicable (Figure 5-3 shows the configuration of the gas train for various insurance requirements).

The pilot gas train is supplied with the burner, and is factory-installed. Figure 5-3 illustrates the pilot gas train configuration.

Fuel oil piping for oil-fired systems is shown pictorially in Figures 2-5 and 5-2. 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.

CAUTION

Oil circulation back to the tank is required at all times. Do not start the burner with closed stop valves in the return lines or serious damage will occur

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

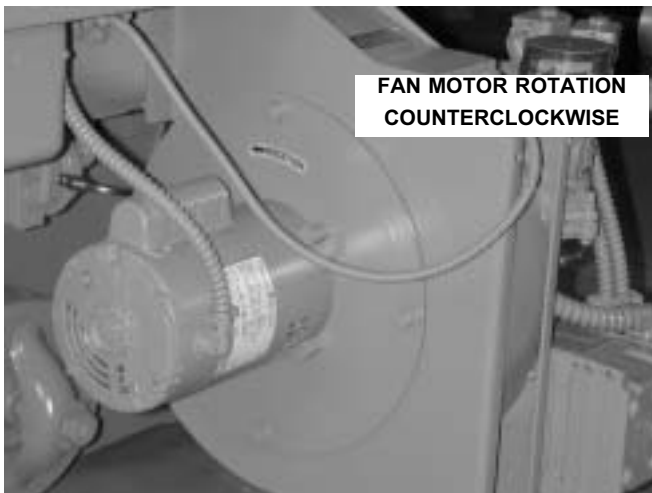


Figure 5-1: Fan Motor

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.

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.

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 5-8). 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 (Figure 5-9 and 5-11). 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, diffuser, and air baffle components must be correctly set (Figures 5-5, 5-6 and 5-7). Normally 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/diffuser 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/diffuser assembly as follows:

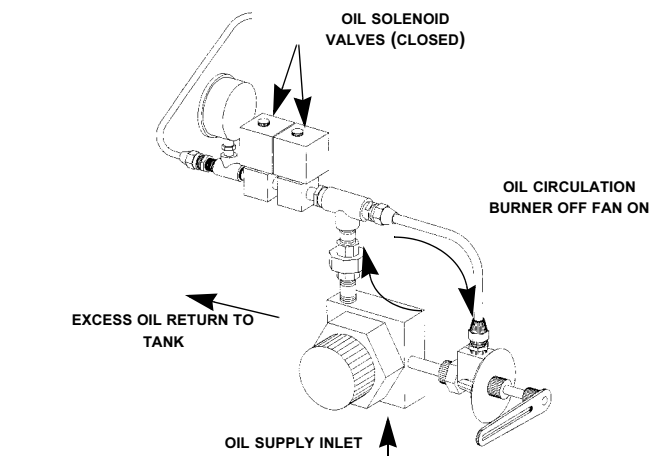
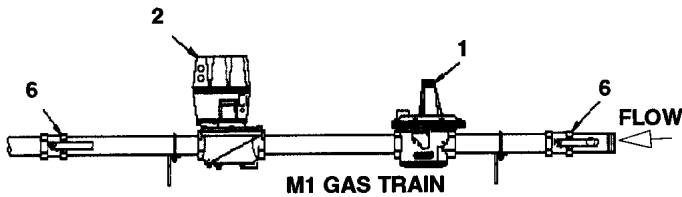


Figure 5-2: Oil Pump Circulation

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.

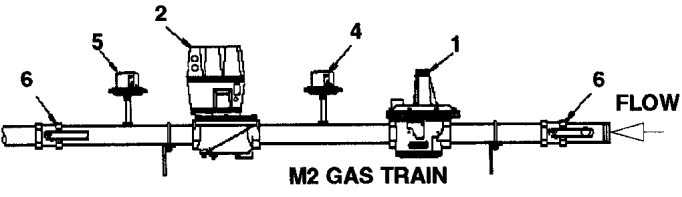
- A. Lock out and tag the electrical power supply to the burner to prevent inadvertent operation during checkout or maintenance activities.
 - B. Disconnect the high-voltage power supply from the oil-spark-ignition electrodes (if installed).
 - C. Disconnect the oil piping from the end of the blast tube.
 - D. Remove the fasteners that secure the nozzle/diffuser assembly to the top of the fan housing, and remove the nozzle/diffuser 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).



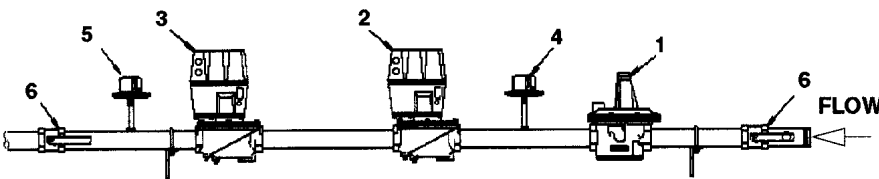
M1 GAS TRAIN

BURNER RATINGS	GAS TRAIN INSURANCE DESIGNATION		
	STANDARD	FM	IRI
1.5 - 2.5 MMBtu/hr	M1	M2	M4
2.51 - 5.00MMBtu/hr	M2	M2	M4
5.01 - 12.00 MMBtu/hr	M3	M3	M4

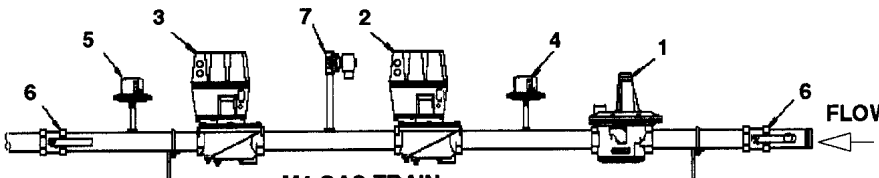
Note:
STANDARD = Underwriters' Laboratories (UL) Approved
FM = Factory Mutual Approved
IRI = Industrial Risk Insurers Approved



M2 GAS TRAIN



M3 GAS TRAIN



M4 GAS TRAIN

- 1. MAIN GAS PRESSURE REGULATOR
- 2. MAIN SAFETY SHUTOFF VALVE
- 3. SECOND MAIN SAFETY SHUTOFF VALVE
- 4. LOW GAS PRESSURE SWITCH
- 5. HIGH GAS PRESSURE SWITCH
- 6. MANUAL MAIN SHUTOFF VALVE
- 7. SOLENOID VENT

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

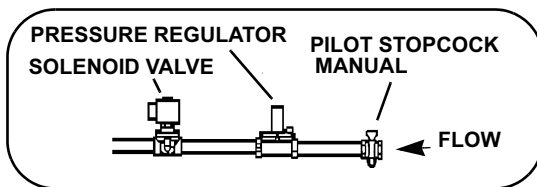


Figure 5-3: Pilot Gas Train

3. Refer to Figure 5-7 and measure the distance from the tip of the nozzle to the diffuser (Dimension "A"). If necessary, adjust the position of the diffuser as follows:
 - A. Loosen the locking screws on the diffuser clamp.
 - B. Slide the diffuser clamp along the length of the burner pipe until the correct dimension is achieved.
 - C. Tighten the diffuser clamp securely to the burner pipe. Apply a Lock-tight type compound to the screws before tightening.

4. Carefully install the adjusted nozzle/diffuser assembly into the burner. Then re-connect the oil supply and high-voltage power cable to the assembly.
5. The diffuser-to-air baffle dimension "B" must now be checked and adjusted (see Figure 5-6 for correct dimension). Check and adjust to dimension "B" as follows:

- A. Open the burner mounting door on the boiler. Swing the burner out to expose the diffuser and air baffle.
- B. Measure the distance between the leading edge of the diffuser and the front face of the inner ring on the air baffle assembly.
- C. If adjustment is required, loosen the burner pipe locking setscrew (located on the rear cap at the top of the fan housing) and slide the burner pipe in or out to achieve the correct "B" dimension.
- D. Tighten the oil pipe locking setscrew securely.
- E. Swing the burner and mounting door into the closed position on the boiler and fasten the door securely.

B. 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 set 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 5-8) for minimum and maximum natural gas pressure requirements.

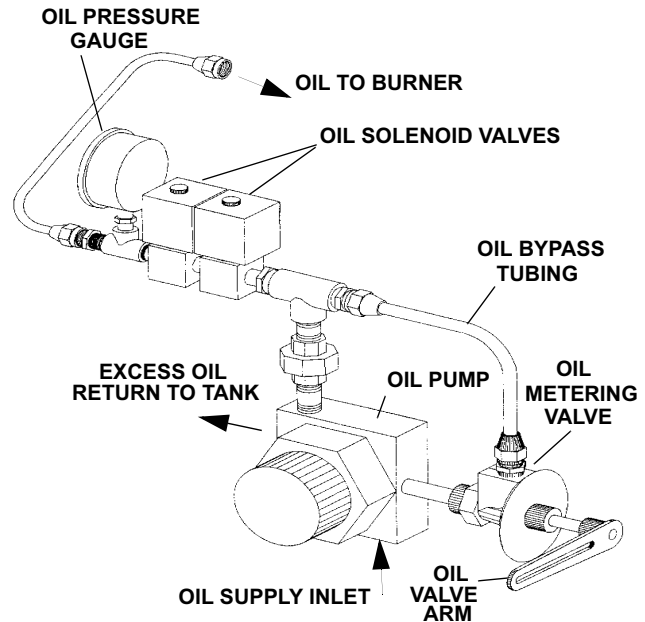


Figure 5-4: Oil Piping Schematic

- For oil burners confirm that the oil tank is adequately 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.
- Provide the following test equipment on site:
 - 1) Combustion analyzer for O₂.

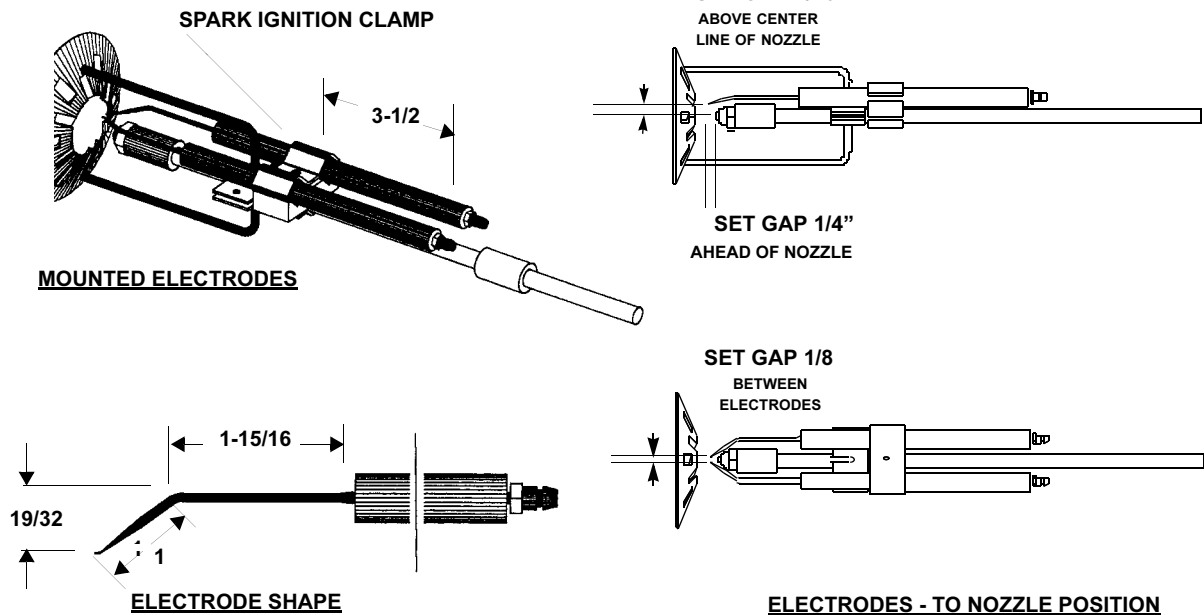


Figure 5-5: Direct Spark Ignition Electrode Adjustment Dimensions

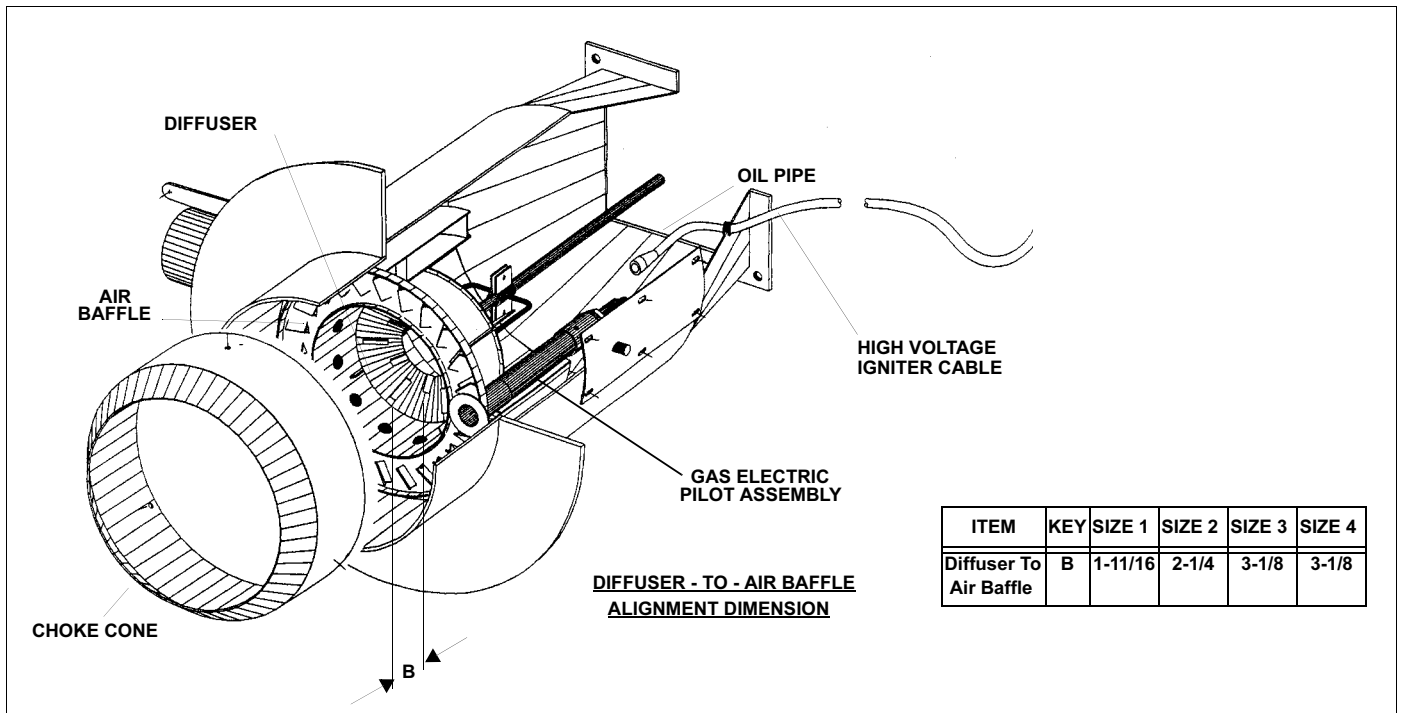


Figure 5-6: Blast Tube

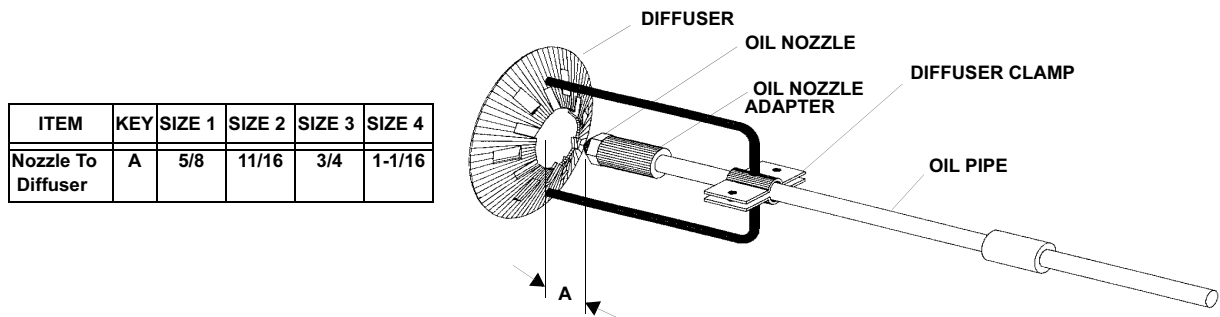


Figure 5-7: Nozzle / Diffuser / Air Baffle Alignment

- 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.

⚠ WARNING

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

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 NO_x 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 and maintained to yield smoke spot levels less than a #2 spot (ASTM D2156 Shell-Bacharach Scale) to minimize soot build-up in the boiler.

C. 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 excessive 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 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment, should be available on site and installed.

WARNING

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

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 (see Figure 5-9 and 5-11).

ProFireTM Packaged Burner System

	Gas (CFH) Gaz (PCH)	Press. (In. WC) (Po. col. d'eau)	Liquid (GPH) Fluide (GPH)	Press. (PSI) (LPC)
Input Range Gamme De Puissance	Max.	Min.	Max.	Min.
	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Fuel Type Type de combustible	Heating Value Valeur calorifique	Overfire Draft (Max.) Tirage maximum dans le foyer (In. W.C.) (Po. col. d'eau)
<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>

Load Charge	Current Characteristics Caractéristiques Electriques
	HP VOLTS PH. HZ. AMPS. FUSE
Main Circuit principal	<input type="text"/>
Control Circuit Circuit de controle	<input type="text"/>
Fan Motor Moteur du ventilateur	<input type="text"/>
Air Compressor Compresseur d'air	<input type="text"/>
Circulating Pump Pompe Circulating	<input type="text"/>
Oil Heater Chaleur Huile	<input type="text"/>
Control Circuit Circuit de controle	<input type="text"/>
Transformer	PRIMARY <input type="text"/> SECONDARY <input type="text"/>



Cleaver Brooks
BY DESIGN AND MACHINE, INC. MILWAUKEE, WISCONSIN

SPECIFICATION PLATE

BOILER MODEL NO.


MODEL	FUEL SERIES	SIZE	PRESSURE	CAPACITY
		1		

SERIAL NO. 2

INSTALL ON NON-COMBUSTIBLE FLOOR. MIN. CLEARANCES FROM COMBUSTIBLE MATERIAL:
FRONT 48", REAR 18", SIDES 18", TOP & FLUE PIPES 18"
ADEQUATE ACCESS MUST BE MAINTAINED FOR SERVICE.

3 STRATFORD, ONT.

3 THOMASVILLE, GA.



Cleaver Brooks
DIV., AQUA-CHEM, INC. MILWAUKEE, WISCONSIN

118-2947

NAME PLATE

Figure 5-8: ProFire Burner Nameplate and Specification Plate

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.
3. Place the Manual/Auto mode switch to the MANUAL position.
4. Place the manual flame control potentiometer in the CLOSED (low-fire) position.
5. Check the presetting of the air shutters. (If the linkage is loose and no pre-settings are available, start with the shutter in the full open position).

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). Reset Low Gas Pressure Switch (if applicable).
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 O₂ analyzer should have an accurate reading of the O₂ present in the flue gas. Table 5-1 shows the acceptable O₂ range for the gas burner. Normally, O₂ 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).
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 O₂ 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. H₂O correction to P_{gas}. Consult meter calibration data.

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

Where:

HHV = The higher heating value of natural gas (1000 Btu/ft³). 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 ft³/second.

S = Seconds.

12. Adjust the high fire excess air rate using the high-fire shutter adjustment (see Figure 5-9 for location).

DESCRIPTION	INPUT RATE MMBtu/hr.															
	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	10.0	11.0	12.0
LINKAGE ARM ANGULAR ORIENTATION (IN DEGREES)																
1 Main Shaft Gas Valve Arm (Combination)	31	30	25	32	35	30	50	20	23	23	25	25	22	50	45	45
2 Main Gas Valve Arm (Combination)	54	65	52	72	70	70	60	45	45	45	45	45	46	55	55	40
1 Main Shaft Gas Valve Arm (Gas Only)	31	30	30	32	35	25	25	20	23	23	25	25	22	50	45	45
2 Main Gas Valve Arm (Gas Only)	50	55	55	65	65	70	55	40	38	40	40	40	40	55	55	40
3 Butterfly Valve Setting (Combination)	34	25	22	25	30	25	25	25	25	25	27	25	24	20	20	20
3 Butterfly Valve Setting (Gas Only)	28	18	25	20	25	20	20	20	20	25	20	20	20	20	20	20
ROD CLAMP POSITION FROM CENTER POINT (IN INCHES)																
1 Main Shaft Gas Valve Arm (Combination)	2.38	2.13	2.13	2.50	2.50	3.25	2.75	3.50	3.75	3.75	3.50	3.50	3.50	2.75	2.50	2.50
2 Main Gas Valve Arm (Combination)	2.50	3.00	3.63	3.50	4.00	3.50	4.25	4.50	4.25	4.25	4.25	4.25	4.50	4.50	4.50	4.50
1 Main Shaft Gas Valve Arm (Gas Only)	2.38	2.50	2.25	2.50	2.50	3.25	3.50	3.50	3.75	3.75	3.50	3.50	3.50	2.75	2.50	2.50
2 Main Gas Valve Arm (Gas Only)	2.50	3.00	2.25	3.50	3.50	3.50	3.25	4.50	4.25	4.25	4.25	4.25	4.50	4.50	4.50	4.50

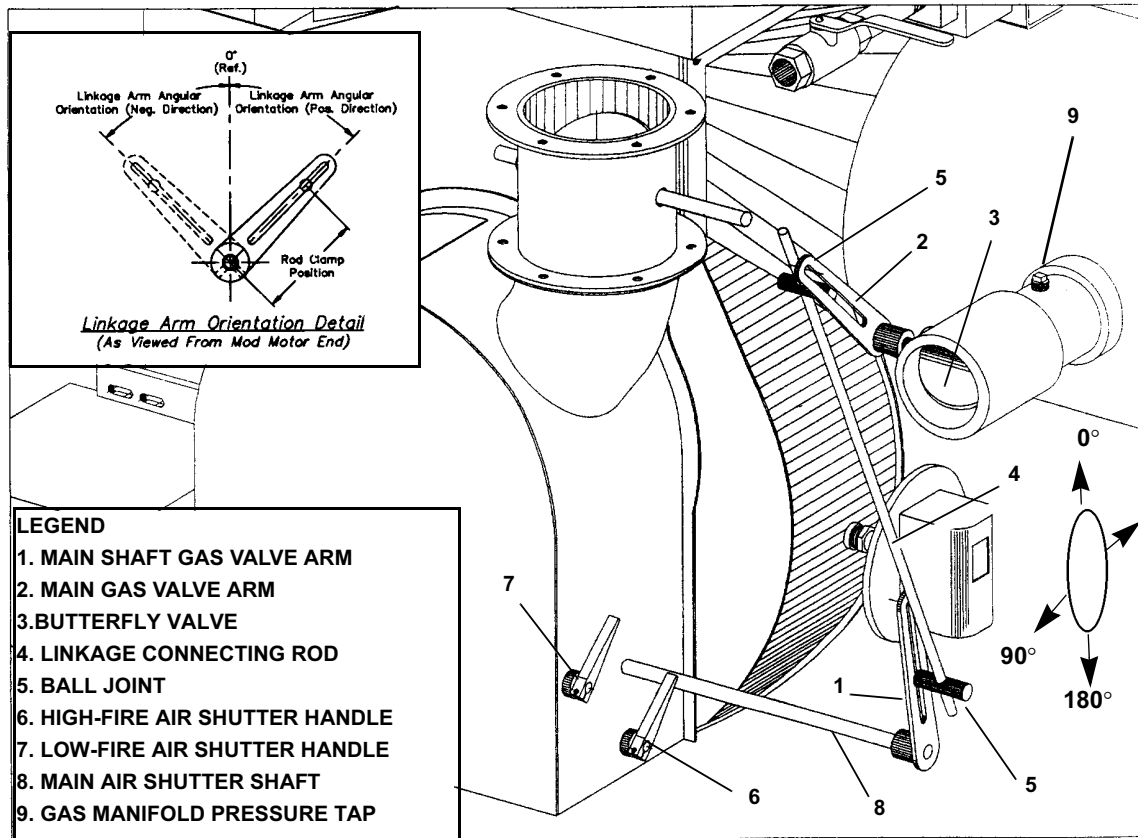


Figure 5-9: Natural Gas System Control Linkage

13. Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel flow and pressure 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 3-5% O₂.

D. BURNER ADJUSTMENTS, SINGLE FUEL, OIL-FIRED

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 excessive oxygen in the flue gas accordingly.

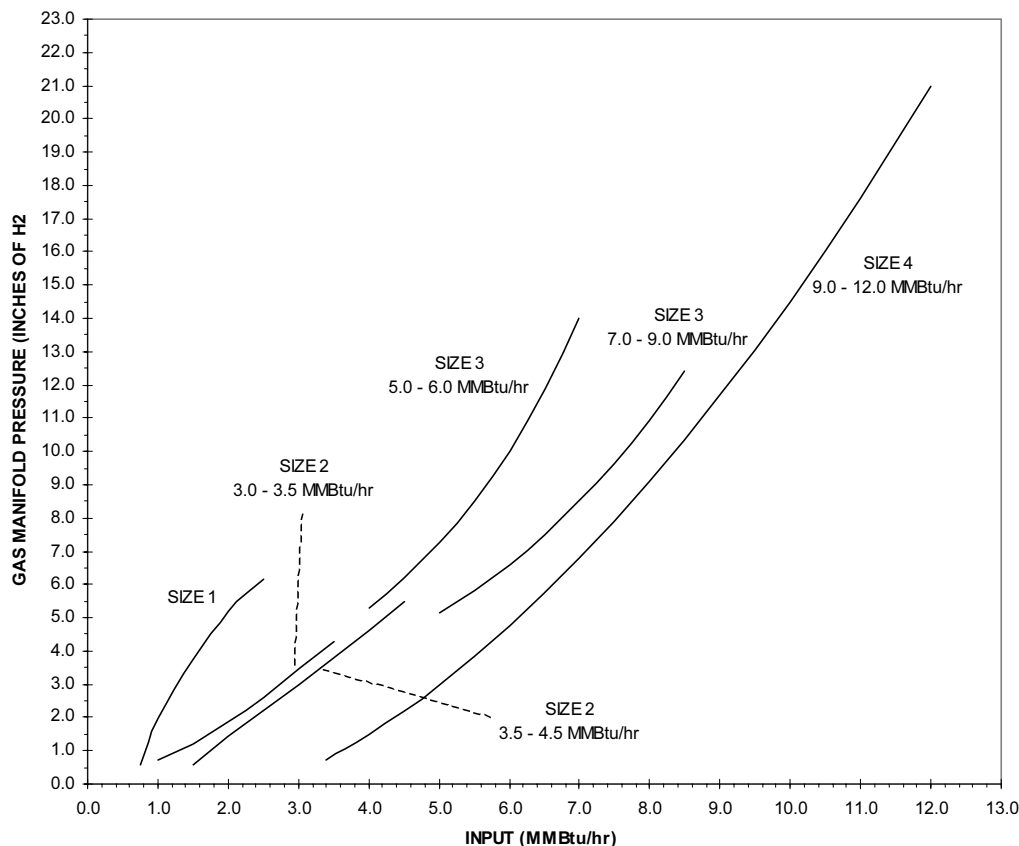
⚠ CAUTION

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 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment should be available on site.

⚠ WARNING

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



- NOTES:**
1. The excess air setting should be sufficient to allow normal variations in air and fuel without abnormal excess air levels, per Table 5-1.
 2. Do not operate the burner at firing rates or fuel pressures higher than the maximum, or lower than the minimum indicated on the burner specification plate as shown in Figure 5-8.

Figure 5-10: Natural Gas Input Pressure Curves

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 (see Figure 5-11).

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 5-11.

2. Place the burner switch to the OFF position.
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. Check the presetting of the air shutters. (If the linkage is loose and no pre-settings are available, start with the shutter in the full open position).
6. When a gas pilot is used, open the valve in the gas pilot line.

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.

INPUT (MMBtu/hr)	MINIMUM O ₂ (%)	MAXIMUM O ₂ (%)
SIZE 1		
0.7	3.0	9.0
0.9	3.0	9.0
1.0	3.0	9.0
1.5	2.5	9.0
2.0	2.0	5.5
2.5	2.0	5.0
SIZE 2		
1.5	3.0	8.0
2.0	3.0	8.0
2.5	3.0	8.0
3.0	3.0	8.0
3.5	3.0	7.0
4.0	3.0	5.0
4.5	3.0	5.0
SIZE 3		
4.5	2.5	7.5
5.0	2.5	7.5
5.5	2.5	7.0
6.0	2.5	6.5
6.5	2.5	6.0
7.0	2.5	5.5
7.5	2.5	5.0
8.0	2.5	5.0
8.5	2.5	5.0
9.0	2.0	4.5
SIZE 4		
10.0	2.5	5.0
11.0	2.5	5.0
12.0	2.0	4.5
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 O₂ Concentration at Various Rates (Natural Gas)

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 O₂ 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 set to the nameplate pressure.

NOTE: Refer to the curves of burner input rate versus oil pressure (Figures 5-12, 5-13 and 5-14) to determine the oil input rate at any given oil pressure for the specific installed burner nozzle size. Nozzle capacity is stamped on the nozzle body.

8.

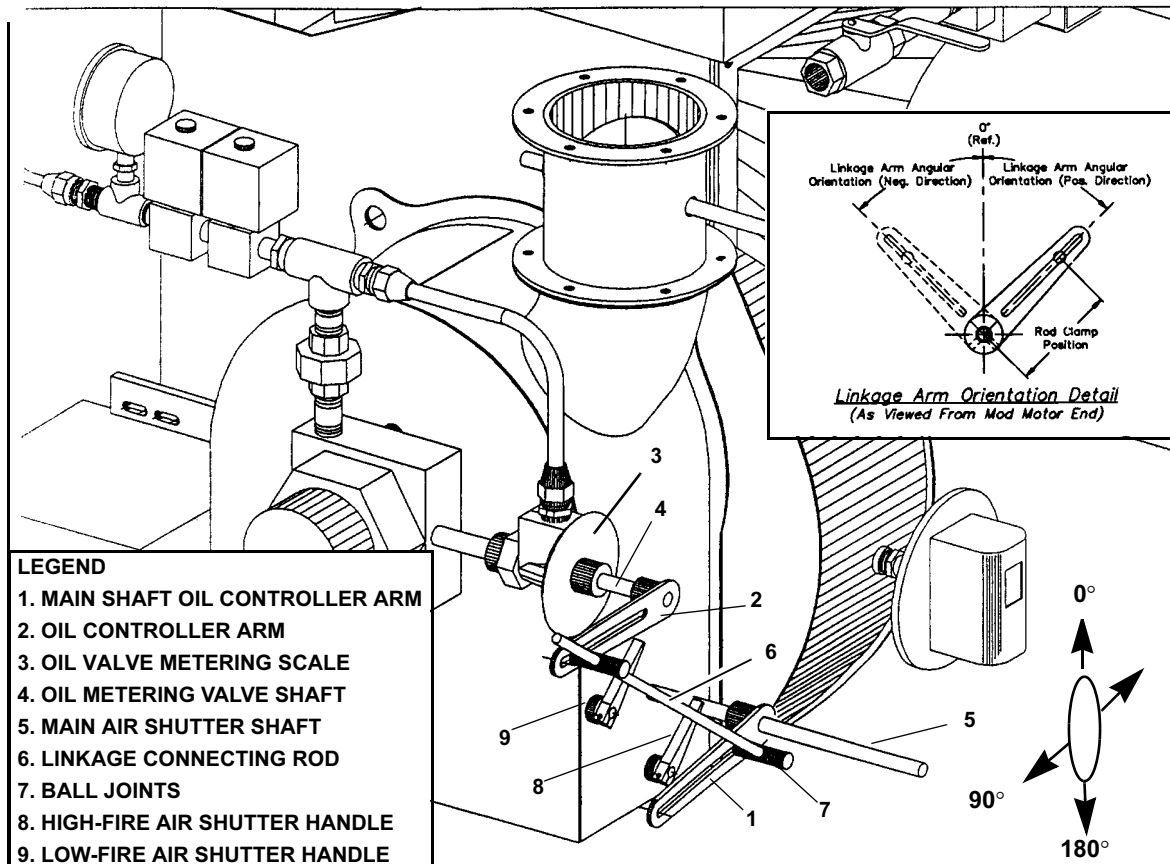
9. Size 4 burners utilize return flow nozzles rather than simplex nozzles used in smaller sizes. See Table 5-3 for nozzle size and oil pressure.

10. Adjust the high-fire shutter to obtain the correct excess air level (see Figure 5-11 for the adjustment location).

11. Modulate to low fire using the manual flame control in accordance with Table 5-2.

12. Set the proper fuel input for low fire by adjusting the linkage to drive the oil metering valve to the proper position (see Figure 5-11 for oil metering valve linkage adjustments).

DESCRIPTION	INPUT RATE MMBtu/hr.																
	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	10.0	11.0	12.0	
LINKAGE ARM ANGULAR ORIENTATION (IN DEGREES)																	
1	Main Shaft Oil Controller Arm	88	94	106	110	110	115	115	125	120	120	120	120	130	125	105	
2	Oil Controller Arm	80	66	52	65	45	75	75	140	95	90	90	55	55	50	50	
ROD CLAMP POSITION FROM CENTER POINT (IN INCHES)																	
1	Main Shaft Oil Controller Arm	2.38	3.38	2.56	3.25	3.25	3.00	3.00	2.25	3.25	3.25	3.50	3.25	3.50	4.25	4.25	4.25
2	Oil Controller Arm	2.13	2.63	1.81	2.25	2.25	3.50	3.50	3.50	2.75	2.75	3.00	2.00	2.00	3.0	2.75	2.25
OIL VALVE SETTING (METERING SCALE ON VALVE)																	
3	Oil Valve Metering Scale setting	13	15.5	17.5	14	13.5	11	10	6	12.5	9.5	10	17.5	17	*	*	*



* Factory Set


Figure 5-11: Oil Fired System Control Linkage

13. Check intermediate positions for proper combustion. Adjust the linkage, as required, to match the fuel and air rates indicated in Table 5-2.
14. 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.

E. BURNER ADJUSTMENTS, COMBINATION GAS AND OIL

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 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment 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.

 WARNING

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:

1. Check the linkages to confirm that they are securely fastened and ready for operation (see Figures 3-2 and 3-4).

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 and 5-11.
2. Place the burner switch in the OFF position.
3. Place the Modulating Mode switch in the MANUAL position.

INPUT (MMBtu/hr)	MINIMUM O2 (%)	MAXIMUM O2 (%)
SIZE 1		
0.7	N/A	N/A
0.9	4.0	9.5
1.0	4.0	9.5
1.5	2.5	8.0
2.0	2.0	5.0
2.5	2.0	5.0
SIZE 2		
1.5	4.0	10.0
2.0	4.0	10.0
2.5	3.5	10.0
3.0	3.0	9.5
3.5	3.0	7.0
4.0	3.0	5.0
4.5	3.0	5.0
SIZE 3		
4.5	3.0	8.5
5.0	3.0	8.5
5.5	2.5	8.0
6.0	2.5	7.0
6.5	2.0	6.0
7.0	2.0	5.0
7.5	2.0	5.0
8.0	2.0	5.0
8.5	2.0	5.0
9.0	2.0	4.5
SIZE 4		
10.0	3.0	5.0
11.0	3.0	5.0
12.0	3.0	4.5

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 light oil 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 O₂ Concentration At Various Rates (Light Oil)

4. Place the manual flame potentiometer in the CLOSE (low-fire) position.
5. Check the presetting of the air shutters. (If the linkage is loose and no pre-settings are available, start with the shutter in the full open position).
6. When a gas pilot is used, open the valve in the gas pilot line.
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.

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.
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.

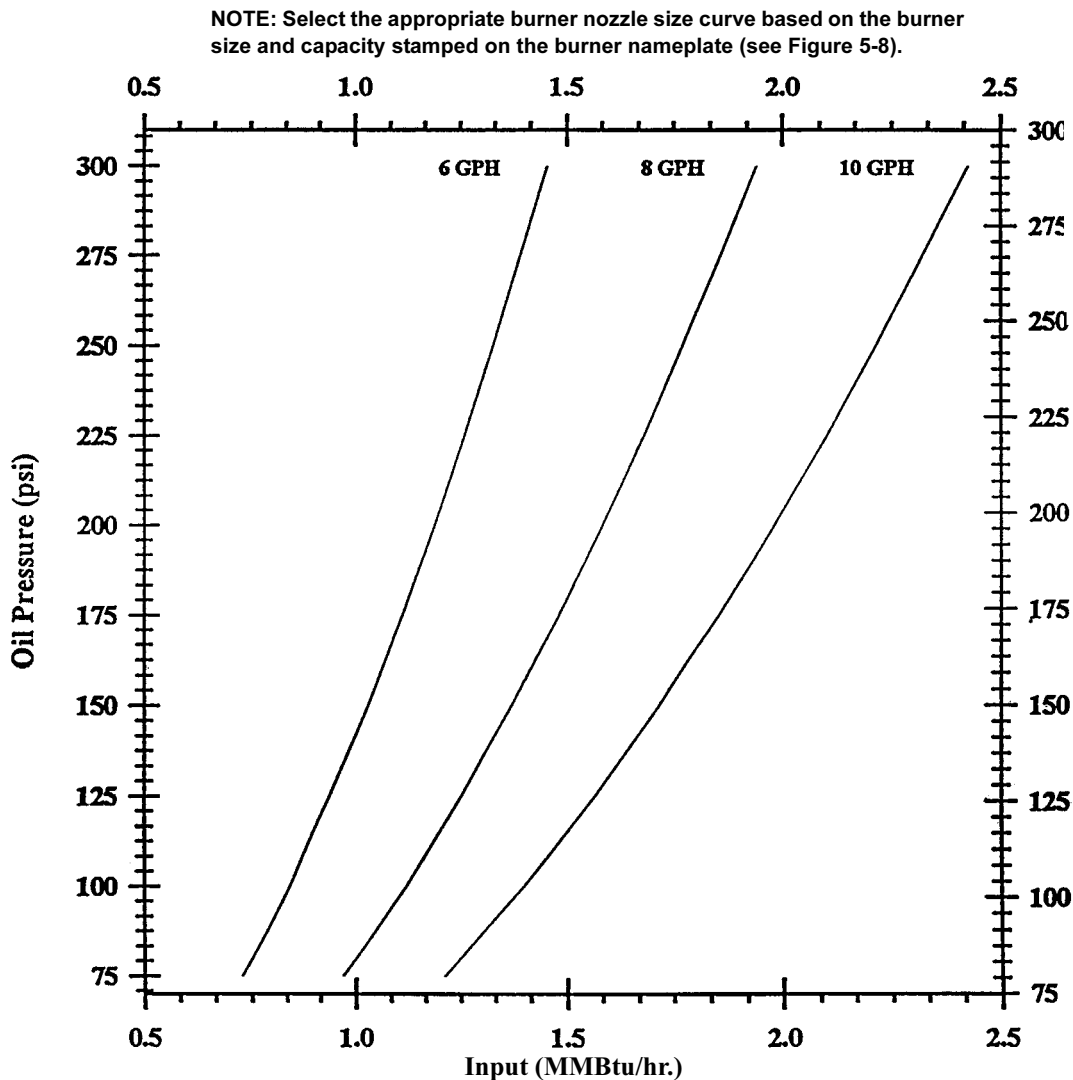


Figure 5-12: Burner Input vs. Oil Pressure and Nozzle Size (Size #1 Burners)

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 Figure 5-10, an approximation of the burner input can be assessed. 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.

13. After a few seconds, the O₂ analyzer should have an accurate reading of the O₂ present in the flue gas. Table 5-1 provides a representation of the acceptable O₂ range for the gas burner. Normally, the O₂ 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

NOTE: Select the appropriate burner nozzle size curve based on the burner size and capacity stamped on the burner nameplate (see Figure 5-8).

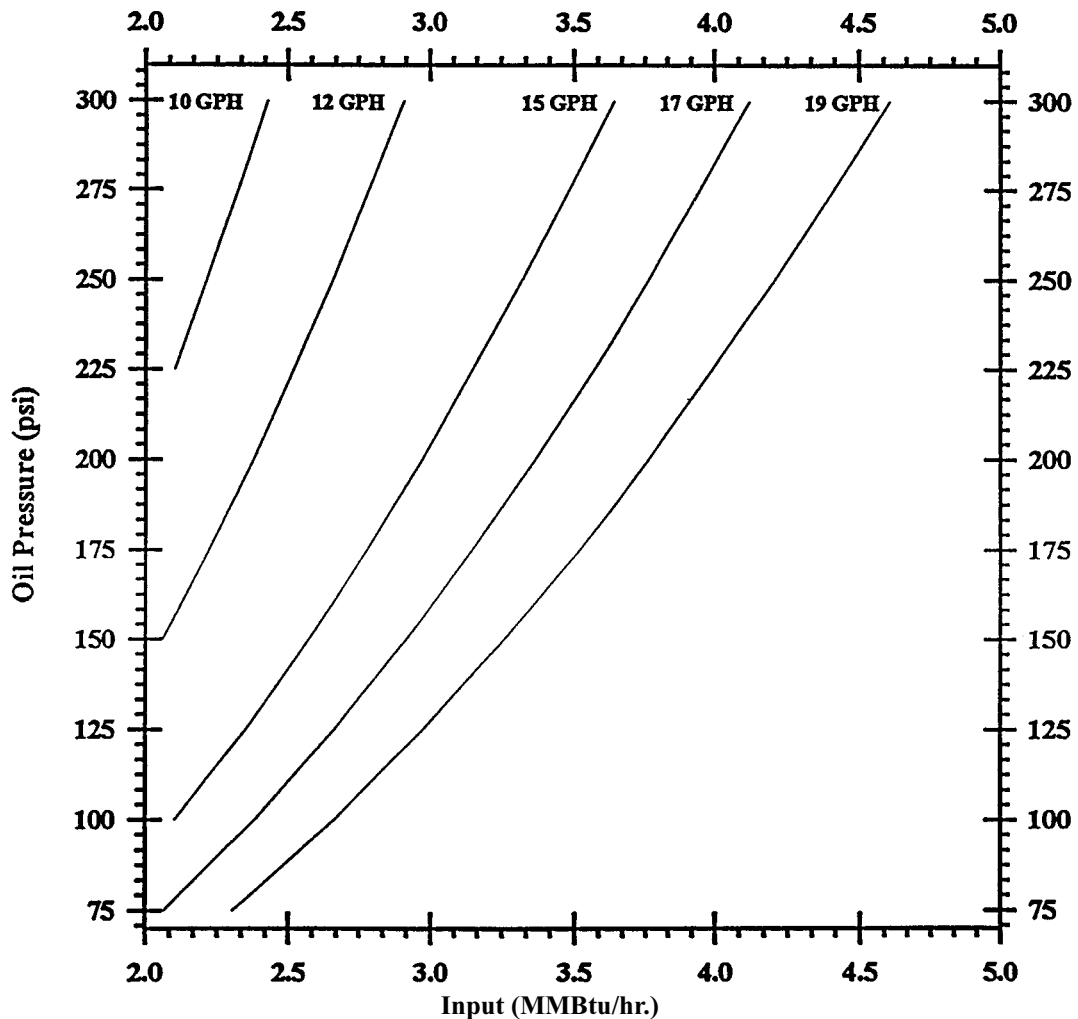


Figure 5-13: Burner Input vs. Oil Pressure and Nozzle Size (Size #2 Burners)

small increments. This will cause the butterfly valve to open farther, allowing more gas into the burner. While increasing the input, observe that the O₂ 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).

- 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. H₂O correction to P_{gas}. Consult meter calibration data.

Where:

HHV = The higher heating value of natural gas (1000 Btu/ft³). 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 ft³/second

S = Seconds.

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

NOTE: Select the appropriate burner nozzle size curve based on the burner size and capacity stamped on the burner nameplate (see Figure 5-8).

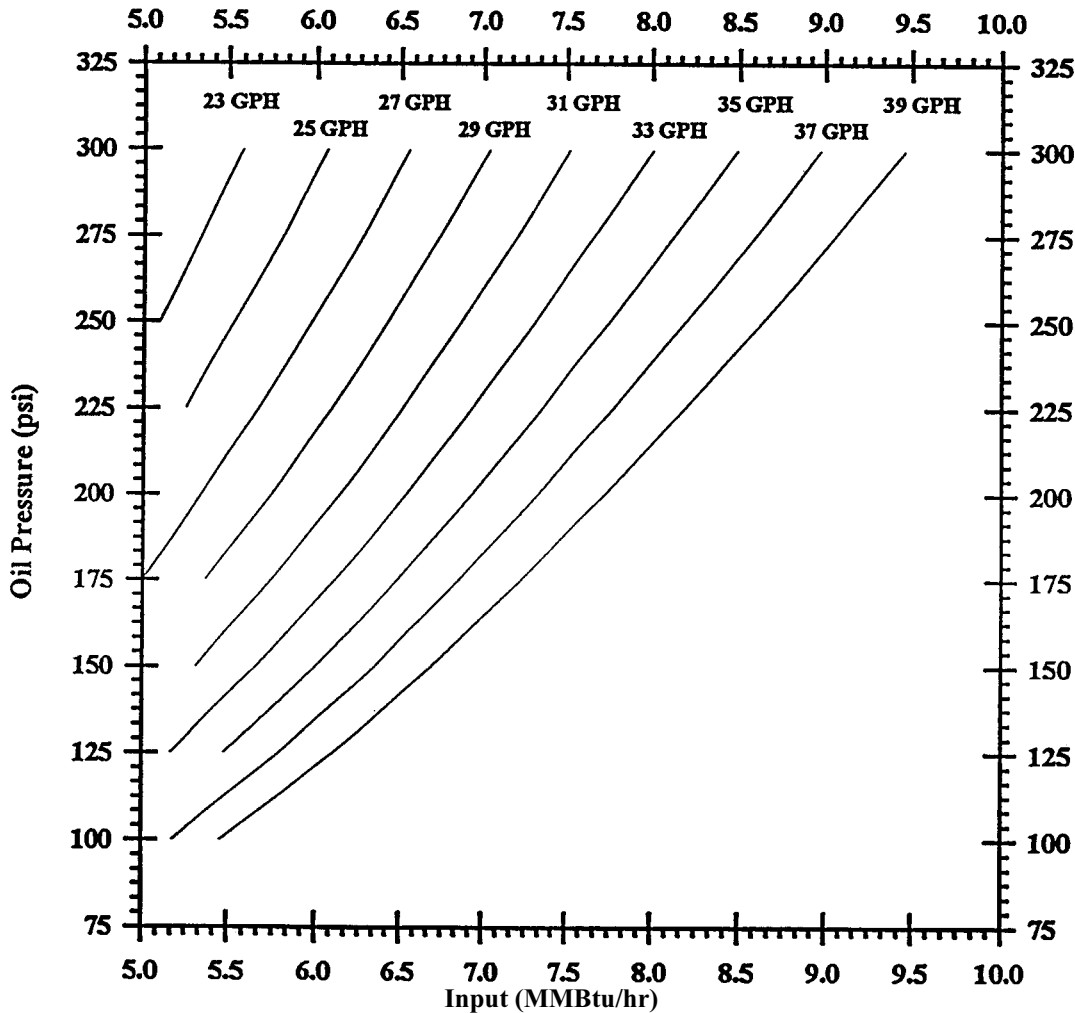


Figure 5-14: Burner Input vs. Oil Pressure and Nozzle Size (Size 3 Burners)

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 5-8). 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 fully open, then adjusting the manifold pressure to the maximum as specified on the data plate. 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.

SIZE 4 BURNERS

INPUT (MMBtu/hr)	FLOW RATE (GPH)		OIL PRESSURE (PSI)	
	max.	min.	max.	min.
10	71.4	23.8	200	82
11	78.6	26.2	185	50
12	85.7	28.6	200	40

Note: Oil pressure is return oil pressure and based on 300 psi pump pressure

Table 5-3: Size 4 Burner Pressure and Flow

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 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 (see Figure 5-8).
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 (see Figure 5-8).

F. STARTUP, 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. In the case of a steam boiler, CLOSE THE VENT VALVE when the steam begins to appear.

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

If the flame at low fire provides insufficient heat to reach normal operating pressure or temperature after 30 minutes, gradually increase the firing rate by turning the manual flame control in one point increments. Operate at the increased fuel input rate for a period of time until an increase is noted in pressure or temperature.

After the boiler is thoroughly warmed, turn the manual flame control to high fire. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. Refer to the adjustment procedures in Chapter 6. After making the high-fire adjustment, manually decrease the firing rate 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 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 timer has returned to its original starting position and stops. The unit is ready to re-start.



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

G. CONTROL OPERATIONAL TEST AND CHECKS

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

The operating limit control may be checked by allowing steam pressure or water temperature to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner 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 the auxiliary 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.

CHAPTER 6

Adjustment Procedures

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Note: If the boiler is not equipped with a ProFire burner. Please refer to the specific Operation and Maintenance manual for the burner supplied.

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 various grades of 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 linkage rod connector is to the drive shaft, the less the arm will travel; the closer the connector is to the driven shaft, the farther that arm will travel.

Figure 6-1 shows the linkage required for a gas-oil combination burner. Prior to initially firing a boiler it is advisable to check for free movement of the linkage. The damper motor must be allowed to complete its full stroke and the damper must move freely from low to high fire position. Adjustment of linkage connected to a gas butterfly valve is described in Section P of Chapter 6.



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

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, verify 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. Refer to the appropriate boiler Operation and Maintenance manual for specific information on boiler startup and operation.

The standard boiler operating control package consists of three separate controls, 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, first be sure all control devices are securely mounted and level. With the temperature sensing control, make sure the sensing bulb is properly bottomed in its well and is secured against movement. Be sure the connecting tubing is not kinked.

The dial settings are generally accurate; although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading. Always adjust control 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 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**.

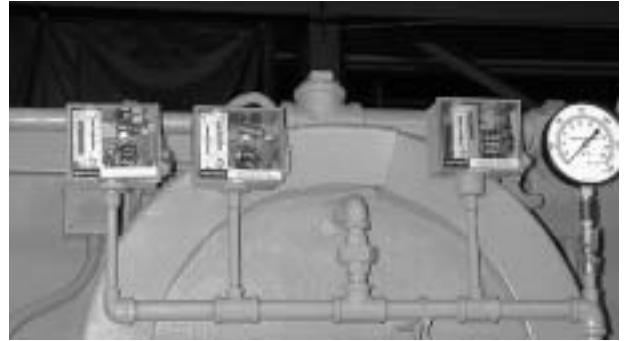


Figure 6-2: Steam Controls



Figure 6-3: Hot Water Operating Controls

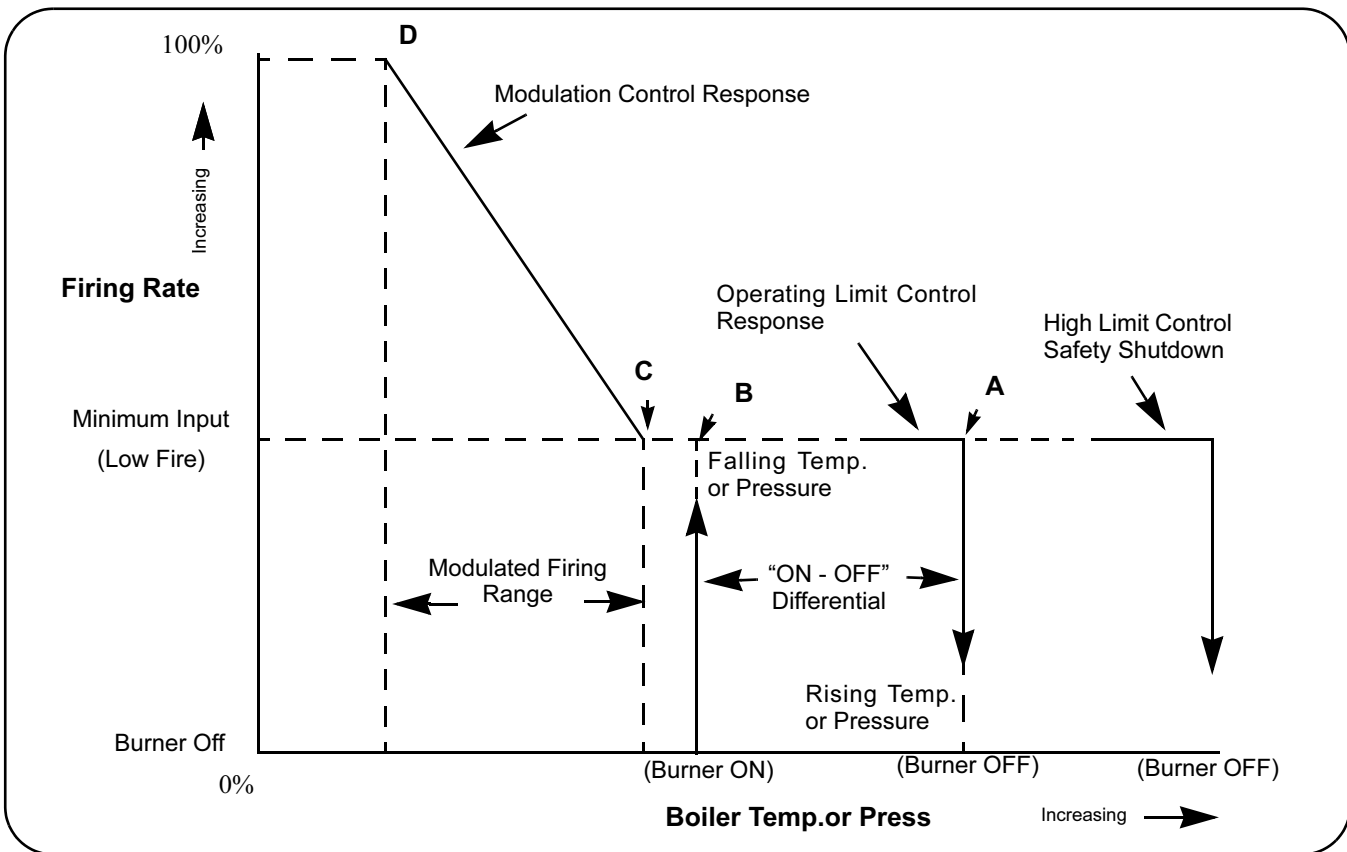


Figure 6-4: Firing Graph

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.

CAUTION

Excessive cycling increases the potential and severity of internal condensation. On-Off cycling should be limited to eight (8) cycles or less per hour to keep the blower motor from overheating and excessive wear on the switch gear and pilot. Failure to follow these instructions could result in damage and premature failure of the equipment.

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 psi.

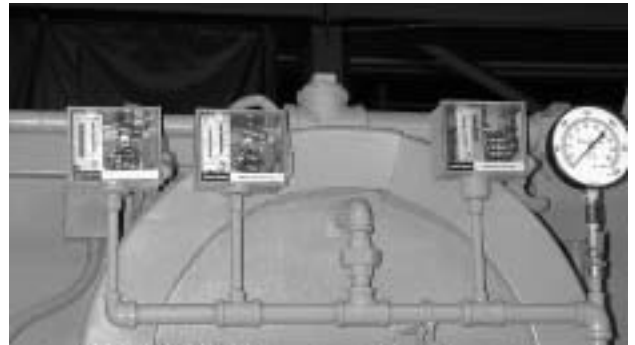


Figure 6-5: Steam Operating Controls

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

Figure 6-6: Hot Water Controls

I. MODULATING TEMPERATURE CONTROL (Hot Water)

Turn the knob on the front of the case (see Figure 6-6) 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 (see Figure 6-6). 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. 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, 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.

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. GAS PILOT FLAME ADJUSTMENT

The size of the gas pilot flame is regulated by adjusting the gas flow through the pilot gas regulator. 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 igniting electrode. 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.

O. GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields highest combustion efficiency at rated performance yet prevents overfiring. 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.

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 "inlet pressure." The gas pressure regulator must be adjusted to achieve the pressure to assure full input.

The inlet pressure requirement varies with boiler size, and types of gas train. Refer to Table 6-3 for pressure requirements.

The pressures listed are based on 1000 Btu/cu-ft natural gas at elevations up to 700 feet above sea level.

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 (Table 6-1).

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

As An Example:

Assume that a 500Flextube boiler is rated for 5MMBtu/hr input is installed and equipped with a standard gas train; and that 1,000 Btu natural gas is available with an incoming gas pressure of 3 psig. The flow requirements can be determined as follows:

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the Btu content of the gas into the burner input (Table 6-1) and "correct" this answer by applying the correction factor for 3 psig (Table 6-2).

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

OR

$$\frac{5,000,000}{1,000} = 5,000 \text{ CFH (At 14.7 lb-atmospheric base pressure)}$$

THEN

$$\frac{5,000}{1.18} = 4237 \text{ CFH}$$

This is the CFH (at line pressure) that must pass through the meter so that the equivalent full input requirement of 5,000 CFH (at base pressure) will be delivered.

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 Fine tuning the linkage adjustments, while performing a combustion efficiency analysis. See Section O 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.

P. 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 O₂ present in the flue gas. O₂ 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.

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 (O₂) and carbon monoxide (CO) either by percent or parts per million (ppm). Carbon dioxide (CO₂) is not normally measured with today's flue gas analyzers, but may be displayed via a calculation.

The O₂ levels through the entire firing range of the burner, low fire to high fire should be tested. Cleaver-Brooks 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 O₂ levels (excess air) and the products of combustion for a typical flue gas analysis (natural gas).

One of the products of combustion is CO₂ (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 O₂ recorded on an instrument equates to percent excess air, I.E. 3% O₂ is approximately 15% excess air and 4% O₂ 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 O₂ readings of between 3% to 5% be attained with less than 400 ppm CO, at high fire.

Using information from Section O 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 6-9) 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 O 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 O₂ should be between 3% and 5% at high fire.

If the fuel input is correct, but the O₂ values do not fall within this range, the air damper settings may need to be adjusted. Adjustment of the air damper linkage is described in Section B of Chapter 6.

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

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

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. Standard Burner Low Fire Adjustment

The fuel input should be adjusted using the linkage to approximately 33% of that at high fire. At low fire the O₂ flue gas reading should be between 3-5%.

If the 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.

MODEL NO.	150	200	250	300	350	400	450	500	550	600	700	800	900	1000	1100	1200
Fuel Consumption Gas (cfh) ^A	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	7000	8000	9000	10000	11000	12000

A. Natural Gas @ 1000 Btu/cu-ft.

Table 6-1: Hot Water and Steam Boiler Ratings

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

MODEL NO.	STD GAS TRAIN SIZE (IN.)	MIN GAS PRESSURE (IN. WC)	BURNER MODEL
FLX-150	2.0	3.7	GP-700-1-1.5
FLX-200	2.0	6.3	GP-700-1-2.0
FLX-250	2.0	8.1	GP-700-1-2.5
FLX-300	2.0	8.0	GP-700-2-3.0
FLX-350	2.0	11.0	GP-700-2-3.5
FLX-400	2.0	13.3	GP-700-2-4.0
FLX-450	2.0	16.9	GP-700-2-4.5
FLX-500	2.0	21.4	GP-700-3-5.0
FLX-550	2.0	19.0	GP-700-3-5.5
FLX-600	2.0	22.6	GP-700-3-6.0
FLX-700	2.0	23.8	GP-700-3-7.0
FLX-800	2.0	38.4	GP-700-3-8.0
FLX-900	2.0	48.3	GP-700-3-9.0
FLX-1000	2.5	31.2	GP-700-4-10.0
FLX-1100	2.5	37.9	GP-700-4-11.0
FLX-1200	3.0	37.2	GP-700-4-12.0

NOTES:

1. Table is based on 1,000 Btu/cu-ft natural gas and elevation up to 1,000 ft.
2. Minimum gas pressure also applies to 200 fuel series burner.
3. Standard regulators suitable for 1 psig maximum inlet pressure.

Q. 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.

R. 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;

Table 6-3: Minimum Required Gas Pressures

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.

S. FUEL OIL PRESSURE AND TEMPERATURE - GENERAL

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

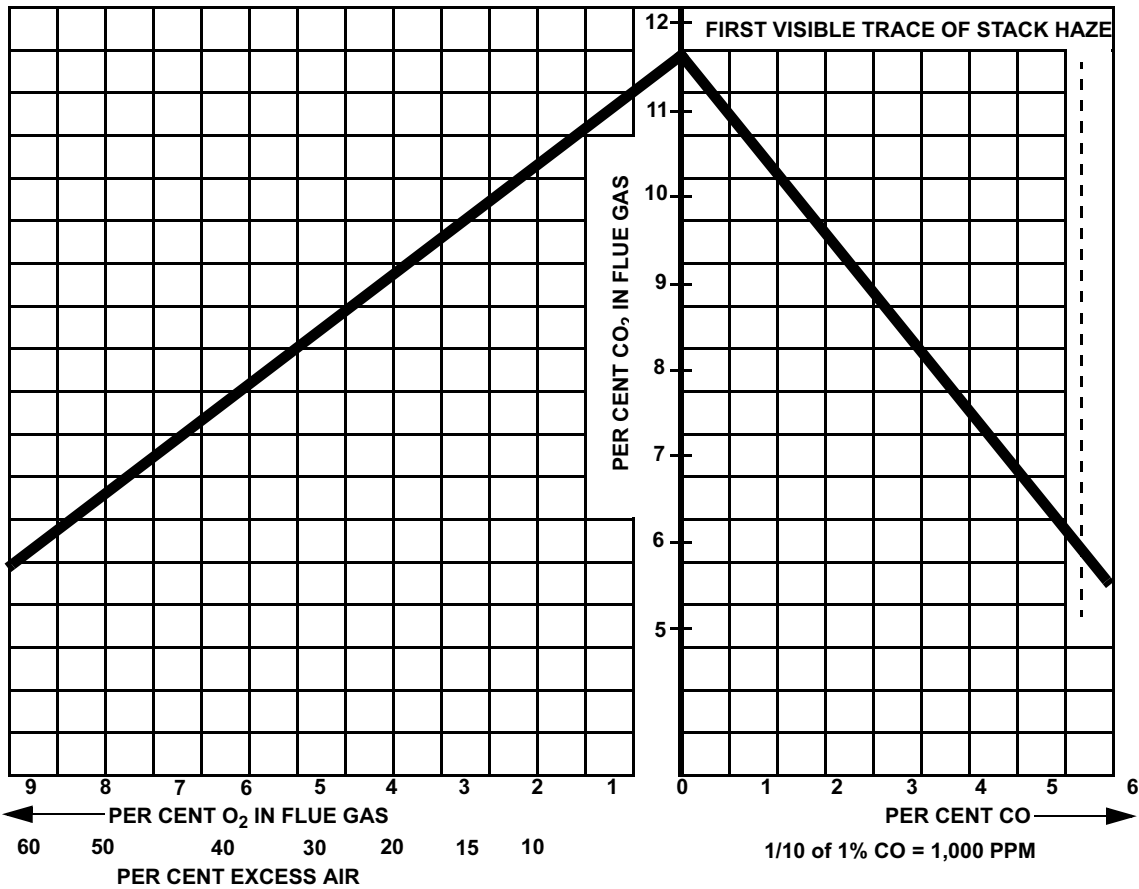


Figure 6-7: Flue Gas Analysis Chart for Natural Gas

Because of variation in oils, including chemical content, source, blends, and viscosity characteristics, the temperatures and pressures listed in Chapter 5, and mentioned in the adjusting of the controls in the following paragraphs, will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. Review of the applicable maintenance instructions given in Chapter 8 will aid in maintaining an efficient fuel system.

T. 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 O₂ present in the flue gas. O₂ 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.

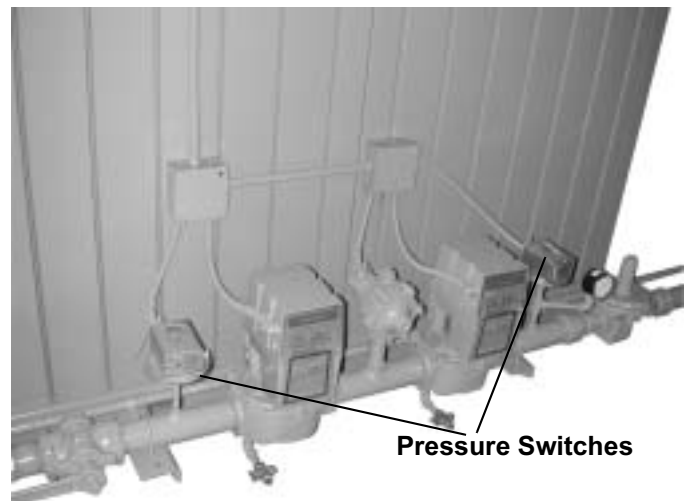


Figure 6-8: Gas Train With High and Low Pressure Switches

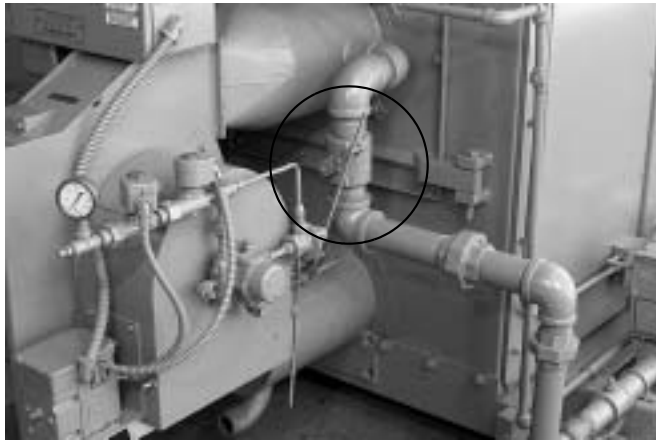


Figure 6-9: Butterfly Gas Valve

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. Cleaver-Brooks 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, as measured in conformance to ASTM D 2156-63T.

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

U. LOW OIL PRESSURE SWITCH

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

Notes

CHAPTER 7

Troubleshooting

 **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.

SYMPTOM	CAUSE	ACTION
NO IGNITION (LACK OF SPARK).	Electrode is grounded, porcelain is cracked.	Replace.
	Improperly Positioned Electrode	Recheck Dimensions
	Loose connection between electrode and ignition transformer.	Reconnect or tighten.
	Defective ignition transformer.	Check transformer winding continuity.
NO IGNITION (SPARK WITH NO FLAME).	Lack of fuel -- no gas pressure, closed fuel valves, etc.	Check fuel supply and valves.
	No voltage to pilot solenoid.	Check electrical connections.
	Defective pilot solenoid valve.	Replace.
	Improperly positioned electrodes.	Recheck dimensions.
	Too much air flow.	Check air shutter position.
PILOT IS PRESENT, BUT NO MAIN FLAME (GAS-FIRED UNITS).	Weak signal to the FS scanner.	Check scanner for dirt buildup on lens.
	Linkage setting is incorrect.	Readjust.
	High or low gas pressure.	Reset switch.
	Fuel valve(s) not operating.	Check wiring circuit to fuel valve(s).
PILOT IS PRESENT, BUT NO MAIN FLAME (OIL-FIRED UNITS).	Weak signal to the FS scanner.	Check scanner for dirt buildup on lens.
	Linkage setting is incorrect.	Readjust.
	Motor - Oil Pump coupling is missing, loose or damaged.	Investigate and repair/replace.
	Oil nozzle, gun assembly, fuel lines are obstructed.	Check lines and gun for foreign objects.
	Fuel valve(s) not operating.	Check wiring circuit to fuel valve(s).
BURNER STAYS IN LOW FIRE.	Manual -- Automatic switch is in incorrect position.	Investigate and repair.
	Defective modulating motor.	Replace.
	Loose linkages	Readjust/tighten setscrews.
BURNER SHUTS DOWN DURING OPERATION.	Defective fuel valve or loose electrical connection.	Investigate and repair.
	Loss or stoppage of fuel supply.	Replenish fuel supply.
	Flame detector is weak or defective.	Repair or replace.
	Lens on scanner is dirty or sight tube is obstructed.	Investigate and repair.
	Operating controls are tripped.	Investigate and repair
	Flame failure due to abrupt changes in fuel delivery.	Investigate and repair
	Foreign objects are present within burner.	Investigate and repair.
BURNER DOES NOT START.	Main disconnect switch is open.	Check switch.
	Loose electrical connection.	Investigate and repair.
	Operating controls are tripped.	Reset and proceed.
	High or low gas pressure.	Investigate and repair

Problem	Solution
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 enclosed.
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 cam, defective switch. B. Damper jammed or linkage binding.
	4. Running interlock circuit not completed. A. Combustion air proving switch defective or not properly set. B. Motor starter interlock contact not closed.
	5. Flame detector defective, sight tube obstructed, or lens dirty.

Problem	Solution
PILOT FLAME, BUT NO MAIN FLAME	1. Insufficient pilot flame.
	2. Gas Fired Unit. A. Manual gas cock closed. B. Main gas valve inoperative. C. Gas pressure regulator inoperative.
	3. Oil fired unit. A. Oil supply cut off by obstruction, closed valve, or loss of suction. B. Supply pump inoperative. C. No fuel. D. Main oil valve inoperative. E. Check oil nozzle, gun and lines.
	4. Flame detector defective, sight tube obstructed or lens dirty.
	5. Insufficient or no voltage at main fuel valve circuit terminal.
BURNER STAYS IN LOW FIRE	1. Pressure or temperature above modulating control setting.
	2. Manual-automatic switch in wrong position.
	3. Inoperative modulating motor.
	4. Defective modulating control.
	5. Binding or loose linkage, 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	Solution
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.
Excessive Rust On Tubes	1. Condensation of the flue gases on cool tubes is causing rust. A Change system so return temperatures are above 120 °F or install blend pump to assure water temperatures entering boiler are above 120 °F.
	2. Open stack or condensate running down stack or breeching. A. Stack should be offset. Insulate and drain stack.
	3. Frequent cold starts. A. Reset controls for less cycling.
Water On Base	1. A cold environment and/or intermittent firing may allow inner casing to heat up above the condensation temperature of the flue gasses. A. Increase temperature of the cold boiler room if possible. B. Verify insulation is in place between inner and outer casing and replace if missing. C. Reset controls for less cycling to allow boiler to run for longer periods of time to heat inner casing above condensation temperature.

Problem	Solution
	<p>2. Cold system startup.</p> <p>A. Any time a boiler is started with a cold system, it will produce condensate until internal surface temperatures exceed 130 °F. Internal condensation will not be produced once a boiler has warmed up. Condensate will dry up after a short time. Limit number of cold starts.</p>
	<p>3. Cold return temperatures.</p> <p>A. Return temperatures below 120 °F. will continually produce condensation. Raise return temperatures above 120 °F.</p>
	<p>4. Gasket leaks allow gases to escape and condense on relatively cool base.</p> <p>A. Gasket may need to be replaced or inner casing not installed per instructions. Install inner casing and gasket per instructions outlined in Chapter 8, Section D.</p>

Notes

CHAPTER 8

Inspection and Maintenance

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A. GENERAL

A well-planned maintenance program will help to avoid unnecessary downtime or costly repairs, promote safety, and aid boiler inspectors in performing required periodic inspections. 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 safe, economical and lengthy service from your Cleaver-Brooks equipment. It is important to realize that the frequency of inspection will depend on variable conditions such as load, fuel, system requirements, boiler environment, etc.

certain repetitive chores, thus providing more 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, permitting prompt corrective action that may prevent extensive repairs or unexpected downtime. Any leaks - fuel, water, steam combustion gases - should be investigated and repaired with all due consideration of the 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.



Shut off electrical power to the boiler when performing any service or maintenance work or work that requires removal of covers or component parts. Failure to heed this warning could result in electrical shock, serious personal injury or death.



Inspection and maintenance should be performed only by trained personnel who are familiar with the equipment. Failure to heed this warning could result in serious personal injury or death.

Good housekeeping practices help maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust, or repair the boiler and 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 semiautomatic in operation, the devices require systematic and periodic maintenance. Any “automatic” feature does not relieve the operator from responsibility. Automatic features do free the operator of

B. PERIODIC INSPECTION

Insurance regulations or local codes may require a periodic inspection of the pressure vessel by an authorized inspector. Inspections are usually scheduled for periods of normal boiler downtime such as during an off season. The major inspection can often be used to accomplish maintenance, replacement, or repair tasks that cannot easily be done at other times. This 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 with an excellent opportunity to perform a detailed check of all components of the boiler, including piping, valves, pumps, gaskets, refractory, etc. Complete cleaning, spot painting or repainting, and the replacement of expendable items, should be planned for and taken care of during this time. If possible, any major repairs or replacements that may be required should be taken care of during the boiler shutdown.

Replacement spare parts, if not on hand, should be ordered well in advance of a shutdown.

Note: Cleaver-Brooks genuine parts should be used to ensure proper operation and to avoid damage to the equipment.

Cleaver-Brooks boilers are designed, engineered and built to give long life and excellent service. Good operating practices and consistent maintenance and care will promote efficiency and economy of operation and contribute to many years of reliable performance from the equipment.

Cleaver-Brooks offers a Planned Maintenance Program that covers many of the items included on this chapter. For more information on the Planned Maintenance Program, contact your local Cleaver-Brooks authorized representative.

C. FIRESIDE CLEANING

Soot and other noncombustible deposits are effective insulators and, if allowed to accumulate on boiler heat exchanger surfaces, will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can absorb moisture and may attract moisture in the form of corrosive acids that will deteriorate fireside metal.

Inspection and cleanout should be performed at frequent intervals, depending upon the boiler's load, type and quality of fuel, internal boiler temperature, and combustion efficiency. Stack temperature can be used as a guide to determine cleanout intervals, since an accumulation of soot deposits will raise the stack temperature.

Access to the furnace for tube and refractory cleaning is provided through a hinged burner door at the front of the boiler. When opening the burner door, first shut off the electrical and fuel supplies and then disconnect all fuel lines at the burner watching to see that there is no interference with field installed piping, wiring, or other obstructions. A temporary platform must be placed inside the furnace in order to protect the bottom drum insulating refractory when working inside the furnace.

WARNING

To avoid the hazard of electrical shock, which could cause serious personal injury or death, the use of a low voltage flashlight is recommended when working inside the boiler furnace area.

Tubes should be brushed with a wire brush to remove any soot or other accumulations. Refractory surfaces should be cleaned, if necessary, with a soft bristle brush. Loose material should be vacuumed from the bottom of the furnace.

D. UPPER PASS CLEANING

Upper pass access is gained through removal of the inner and outer side casing. To remove the outer casing panels, first disconnect and remove any electrical conduit, boxes and brackets attached to the side outer casing. Match mark the outer panels for repositioning. Remove screw (if installed) from frame above each outer panel. Starting with center panel, slide panel up, swing bottom of panel away from boiler and then slide down from the upper frame and set panel aside. After the center panel(s) are removed, the end panels can be slid (approximately 1") towards the center until they free from the corner frame and then removed in the same manner as the center panel(s). If there are only two outer panels (Models 150 through 350), then slide one end panel further into the corner frame to allow the other panel to slide free from the corner frame. If obstructions are present, such as the gas train, there may not be enough room to slide the panel out from under the upper frame. In this case, unscrew the upper frame from the roof and side frames and remove it also.

Match mark all inner casing panels for repositioning later. Inner casing panels must be removed in sequence starting from either end. Remove nuts, washers and clamp angles from the end and bottom of panels. Remove nuts, washers and bolt bars from vertical seams. Loosen nuts on top clamp angles but don't remove until panel is ready to be removed. Inner casing panels can not be removed by pulling panel straight out from boiler because of a 1" gasket retaining strip that overlaps behind the panels. Remove inner casing panels by sliding or angling panel away from remaining panels until the 1" retaining strip has cleared panel and then panel can be removed and set aside.

After removing the inner side casing, the pass cover plates (2nd pass only) must be removed. The cover plates are screwed together and are held in place by tabs inserted between the tubes. Remove the insulation by starting at one end and carefully rolling it up. The insulation blocks can now be removed from the pass opening. Keep the insulation blocks in order once they have been removed so they can be re-installed in the same position. Insulation is removed from the 4th pass in the same manner.

Now that the 2nd (left side) and 4th (right side) pass openings are exposed, cleaning can be done in the same way as the furnace area. Since the 3rd pass is only open on the ends, cleaning is done by pushing a wire brush mounted on a long handle, through from each end. Since the arc of movement is restricted, cleaning the 3rd pass must be done from both sides of the boiler. The fifth pass is cleaned from above the tubes. As in the furnace, loose material should be removed by vacuuming after brushing. The pressure vessel should be inspected for any signs of deterioration after cleaning.

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

Once everything has been cleaned and inspected the boiler can be put back together. Install insulation blocks in the 2nd and 4th pass openings in their previous positions. Spray adhesive on tubes above and below pass opening and install blanket insulation over opening. Install cover plates on 2nd pass (left) side only. If any insulation was removed from under the tubes at bottom of boiler it should be replaced at this time.

Prior to installing the inner casing, inspect studs on boiler and bolt bars for any thread damage. Any damaged threads should be cleaned and chased with a 3/8"-16 die. Apply a small amount of Cleaver-Brooks "Never-Seez" (p.n. 797-1814 or 797-1816) on each stud.

Before the inner casing can be installed, the old gaskets must be removed from the panels and around the perimeter of the boiler and replaced with new ones. After removing the gaskets, the surfaces should be cleaned to allow the new gasket to seal properly. The gasket around the perimeter of the boiler should be one piece with the ends overlapping side by side somewhere along the upper (roof) surface. A small amount of silicone will be required to fill gaps and valleys where the gasket crosses. This includes the roof to end wall seams and the base angle to end wall gaps. It is important that the entire gap between the end wall and the base angle be completely sealed. The seal along the base of the end wall should also be checked and resealed if necessary. The gasket should be positioned to the inside of the studs with a 1/4" gap between the studs and the gasket.

Install gasket on side casing panels so it extends past the top and bottom by 1/4" or more and 1/16" to 1/8" out the back at the top and bottom of the panel. (See Figure 8-1). Starting from one end, set panel edge 1/8" to 1/4" from the studs on the end wall. Install the first lower clamp angle over the respective studs, install washers and start nuts. Any nuts that are difficult to install should be replaced. Place the upper clamp angle over the top studs and install washers and nuts but don't tighten. The end clamp can now be installed and nuts on the end clamp can be snugged up but not completely tightened. Before installing the next panel, apply a small amount of teflon paste to the area where the vertical gasket and the horizontal gaskets will overlap at the top and bottom. This will help ensure an air tight seal. Install the next panel in line being careful to slide the 1" gasket retaining strip behind the panel but under the insulation. Install the bottom and top clamp angles to hold panel in place, but don't tighten. Install the bolt strips, washers and nuts which clamp the panels together. Pull panels together evenly and tighten nuts to 250 to 300 in-lbs. Repeat until all panels are installed and securely bolted together. Now panels can be evenly pulled toward boiler with clamp angles. Tighten all nuts to 250 to 300 in-lbs.

The outer casing panels can now be installed starting with the end panels. Slide each end panel under the upper frame and push the bottom section into the boiler and allowing it to slide down to catch the bottom clamp angle. Then slide the end panels under the corner frames and install any remaining center panels.

The fireside should be thoroughly cleaned prior to any extended layup of the boiler. Depending upon circumstances, a protective coating may be required. See Chapter 3, Section H "Preparation for Extended Layup".

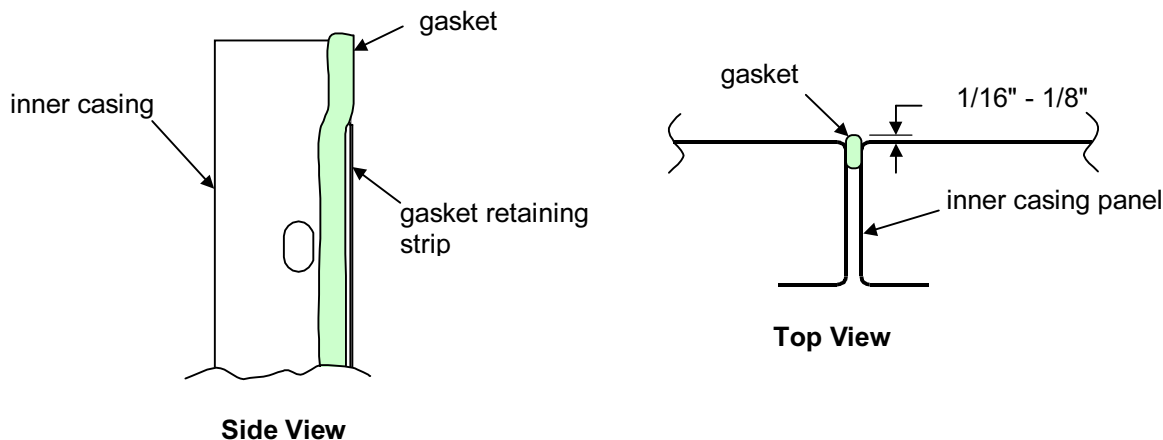


Figure 8-1: Gasket Application to Inner Casing

E. CONTROLS

Relief Valves

The relief valve is a very important safety device and deserves attention accordingly. Proper removal, installation or handling of a relief valve is of primary importance. Exercise care when removing, installing or handling a relief valve to ensure proper operation, long service life, and to ensure that the valve functions as designed.



Improper removal, handling or installation of a relief valve may adversely affect the valve's operation, resulting in serious personal injury or death.

Observe the following precautions when removing, handling or installing relief valves.

- Use only flat jawed wrenches on the flats of the valve
- Do not use a pipe threaded into the outlet to turn a valve
- Apply only a moderate amount of pipe compound to male threads
- Avoid over tightening, which can distort valve seating surfaces
- Do not paint, oil or otherwise cover any interior or working parts of the valve. A relief valve does not require any lubrication or protective coating to work properly.
- Discharge piping must be properly arranged and supported so that its weight does not bear on the relief valve.
- Handle with care a valve that has been removed from the boiler. A dropped valve should be considered as damaged until it has been inspected and passed by the valve manufacturer's authorized representative.



Only properly certified personnel such as the relief valve manufacturer's representative should adjust or repair the boiler relief valves. Failure to heed this warning could result in serious personal injury or death.

Relief valves should be operated only often enough to assure that they are in good working order. Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency and method of testing should be based on the recommendation of your boiler inspector and/or the valve manufacturer, and should be in

accordance with Section IV of the ASME Boiler and Pressure Vessel Code.

Low Water Controls (Hot Water)

Most instances of major boiler damage result from operating with low water. Since low water cutoff devices are set by the original manufacturer, no attempt should be made to adjust these controls in order to alter the point of low water cutoff. If a low water cutoff should become erratic in operation, immediately replace it or contact your local Cleaver-Brooks authorized representative for assistance.

It is essential to verify proper operation of low water cutoff devices as frequently as possible. However, it is impractical to perform daily and monthly maintenance on some models of the low water cutoff devices on a hot water boiler. Hot water systems are fully closed. Daily or monthly maintenance on some models of the low water cutoff devices would involve draining the entire water content of the system and would require makeup and additional feedwater treatment that might not otherwise be necessary.

To verify the proper operation of float style low water cutoff devices, the system must be drained. Remove the operating mechanism from the bowl and check and clean the float ball, internal moving parts, and the bowl housing. Also, check the cross-connecting piping to make certain that it is clean and free of obstruction.

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 makeup 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 remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float bowl, internal moving parts, and the bowl housing. Also check the cross-connecting piping to make certain that it is clean and free of obstruction.



Safe operation of your boiler demands periodic inspection and maintenance of all low water cutoff devices. If controls do not shut off the burner when the water level drops below the safe operating level, or if controls appear in poor physical condition, or become erratic in operation, they must be repaired or replaced at once. Failure to heed this warning could result in serious personal injury or death.

If test-n-check valves are installed on the float style low water cutoff devices, these controls can be tested by opening the blow down valve. The test-n-check valves restrict water flow

when the blow down valve is open allowing water to drain from the control. The test-n-check valves permit testing of the control without draining the entire system therefore allowing regularly scheduled verification of float style low water cutoff.

Low Water Controls (Steam Boilers)

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. The water column should be blown down routinely. Check samples of boiler water and condensate in accordance with procedures recommended by your water consultant. Refer to sections E and I in Chapter 3 for blowdown instructions and internal inspection procedures.

A typical water level control is mounted in the water column and has float actuated mercury switches. One switch is connected to the burner limit circuit and will stop the burner if a low water condition occurs. The other switch is connected to the feedwater circuit to energize a water pump or feeder valve to maintain water at the proper operating level.

Usually, the control is of the automatic reset type and will remake the limit circuit when the water level is restored. Some applications require that a control be equipped with a manual reset mechanism that must be manually reset before the burner can be restarted. This is usually accomplished with the use of a second or auxiliary control that has this feature.

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 previous established levels, check for reasons and correct: Repair or replace as required.

These controls normally function for long periods of time, which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

The controls' operation may be checked by stopping the water supply to the boiler while the burner is operating at low fire. While under constant attendance, allow the water level to drop at a normal rate. Check for proper operation of the feedwater controller and the low water cutoffs.

CAUTION

If a control does not break the circuit to stop the burner at the proper point then shut down the burner immediately. Failure to do so may result in damage to the equipment.

Do not restart until all cross-connecting piping is checked for obstructions. Also check the float bowl. If these are clean, repair or replace the control. Repeat the above test to ensure proper operation prior to returning the boiler to service.

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

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

A scheduled blowdown of the water controls on a steam boiler should be maintained.

Water Gauge Glass

A broken or discolored glass must 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.

If the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by cracking the gauge valves slightly. After glass is warmed up, close the blowdown valve and open the gauge valves completely.

Check trycocks 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.

A blowdown cock is provided on the lower gauge glass fitting and a daily blowdown is recommended.

Electrical Controls

The operating controls should be inspected monthly. Examine the tightness of electrical connections and keep the controls clean. Remove any dust that accumulates on the interior of the controls using low pressure air that is free of moisture and oil. 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 indicates a damaged tube that may lead to erratic switching action. Make certain that controls are correctly leveled. Covers should remain on controls and panels at all times. Dust and dirt can cause excessive wear or overheating of the motor stator and the relay contacts, and affect operation of other controls. The power supply to the boiler must be protected with dual element fuses (fusetrans) or circuit breakers. Similar fuses should be used in branch circuits. Standard one-shot fuses are not recommended.

Flame Safeguard Control

This control requires minimal maintenance because the safety and logic sections are integral and inaccessible, with no accessible contacts. Regularly check to see that the retaining screws holding the chassis to the mounting base are secure, and that the amplifier and the program module are securely inserted.

It is recommended that a spare control be kept on hand and service be rotated between the active and the spare control (programmer).

Note: NOTE: Be sure that the connecting contacts on the control and the base are not bent out of position.

WARNING

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

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

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

Refer to the burner manual for information regarding tests of the flame safeguard system. Contact your local Cleaver-Brooks authorized representative for assistance, if required.

Checking Loss of Flame

With the burner in normal operation at the low fire rate, shut off the main burner fuel valve to interrupt the fuel supply and extinguish the main flame.

The relay must signal the loss of flame, resulting in the fuel valve(s) being deenergized. The control will lock out on a safety shutdown. The flame failure light (and optional alarm) will be activated. The blower motor will stop.

Turn the burner switch off. Reset the safety switch. Reestablish the main fuel supply.

F. OIL BURNER MAINTENANCE

Refer to the burner manual for specific information regarding operation and maintenance of the burner.

Oil strainers should be serviced frequently in order to maintain a free and full flow of fuel to the burner. Installation of a vacuum gauge in the burner supply line between the burner oil pump and the strainer is strongly recommended. Regular observation and recording of the gauge indication will assist in determining when the strainer needs servicing.

Strainer Servicing

The fuel oil strainer element must be removed and cleaned or replaced at regular intervals, or when a rising trend in the burner supply pump suction indicates blockage. When servicing the strainer, fuel supply and return line valves should be shut off. The strainer should be drained of oil and any sediment collected at the bottom of the canister. Remove the cover and withdraw the strainer element. Replaceable elements should be disposed of properly. Reusable elements may be cleaned by immersing them in solvent until attached deposits have been loosened, and then shaking them dry.

WARNING

Use only safety type solvents such as Cleaver-Brooks "Safety Solvent" for cleaning strainers or other components. Work only in a well ventilated area. Do not use gasoline or other flammable liquids as a solvent. Do not dry the strainer elements with compressed air. Failure to heed this warning could result in serious personal injury or death.

Reassemble the strainer, taking care to seal the canister properly to avoid air infiltration and resulting loss of suction. Open the fuel supply and the return line valves.

G. GAS BURNER MAINTENANCE

Refer to the burner sections for specific information regarding operation and maintenance of the burner. The motorized gas valve requires little maintenance, as the operating mechanism is immersed in oil and completely sealed. However, proper operation should be checked on a routine basis.

Keep the outer parts of the valve(s) 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 stem packing gland is the O-ring type. If oil is noticed around the operator base, or if leakage occurs, the valve must be repaired. If the actuator is sluggish or fails to operate, and the oil level is known to be correct, the operator portion should be replaced.

Solenoid Valves

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

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

Solenoid coils can be replaced without removing the valve from the line.


WARNING

Be sure to disconnect the main power supply to the boiler in order to prevent the possibility of electrical shock, which could result in serious personal injury or death.

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

H. REFRACTORY

The boiler is shipped with completely installed refractory. High temperature refractory lines the burner door and floor of the boiler. Front and rear walls, side casing panels, the roof section, the bottom drum and the drum vent are protected with high temperature insulation. Preventive maintenance through periodic inspection will keep the operator aware of


the condition of the refractory and insulation and will guard against unexpected downtime for repairs.

I. CASING SEALS

The most obvious indication of a problem is the appearance of discolored paint on the casing or soot and hot gases escaping at seal joints. It is important that at start-up any problems are noted and corrected before the boiler is put back into operation. The following are areas requiring inspection.

Burner Door

Inspect the area around the door and look for discolored paint or evidence of a combustion gas leakage. If a problem is noted or the door is being opened for scheduled maintenance look for warped sealing surfaces and make sure that the insulation on the front wall around the door has not pushed away from the wall. Cracks may appear in the burner door refractory as a result of expansion and contraction from operation. If cracks are larger than 1/8" when the refractory is cooled, the cracks should be filled with a high temperature bonding air-dry mortar such as Cleaver- Brooks "Corline."


WARNING

Disconnect main power to the boiler and the pilot fuel supply to the burner before the burner door is opened. Electrical power and fuel supply must remain shut off at all times when the burner door is open. Failure to heed this warning could result in serious personal injury or death.

Access to the boiler furnace area is gained through the burner door opening at the front of the boiler. Whenever the burner is opened, the gasket and gasket surfaces of the burner door should be inspected. A good seal between the burner door and the boiler is necessary to prevent leakage of combustion gases and loss of efficiency. Combustion gas leaks can cause hot spots with subsequent damage to the burner door and surrounding refractory. Damaged or hardened gaskets must be replaced before the burner is put back in operation.

If a new gasket is necessary, remove the old gasket and clean the gasket surface on the wall and burner door. A spray adhesive is used to hold the rope gasket in place around the burner opening. A high temperature silicone may be needed to seal under the rope gasket at the wall seams. The rope gasket should wrap around the opening at least two times.

Before the burner door is closed, inspect studs and clean threads if necessary with 1/2"-13 die. Apply a small amount of Cleaver-Brooks "Never-Seez" (p.n. 797-1814 or 797-1816) to the studs. Any nuts that are difficult to thread on studs should be replaced. Door fasteners should be run in and tightened evenly to avoid distorting the door or damaging the

gasket. Start tightening at the top and proceed around the door, alternately tightening opposite fasteners until all are snug. After the boiler is back in operation, check for gas leaks around the door opening, and retighten the fasteners as required to provide a gas-tight seal.

Drum Seals

Inspect the areas around the drum seals and look for soot or hot gas leaks. If a problem is noted look for the source of the leak. Remove the old insulation and sealant from around the drum. Using a pumpable insulation material (p.n. 872-680), fill the void flush with the outside of the wall. Allow the area to set up and apply a thick bead of high temperature silicone around the drum and install the cover plates.

Sight Port

Inspect the area around the sight port for paint discoloration. A hot spot around the rear sight port is caused by either a poor seal between the sight port insulator and the wall, a cracked insulator or a flue gas leak at the sight port cap.

Check the threads of the cap and sight tube. If necessary, clean the threads and/or replace the cap. If the screws that hold the sight glass retainer in place are leaking tighten the screws or replace the cap.

Notes:

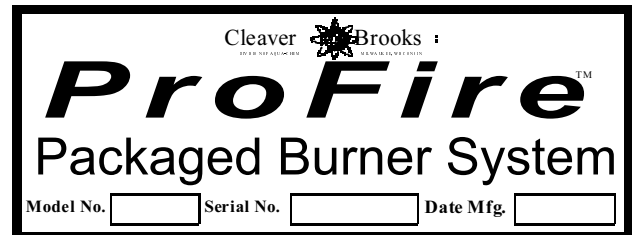
CHAPTER 9

Section 1: ProFire Burner Parts

The following is a brief list of the burner components, which may need replacement over the life of the burner, depending on the burner's operating conditions and use. Replacement parts for the burner or the pressure vessel 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 burner for accurate requirements. Also, components supplied will depend on options and insurance requirements at the time of order.



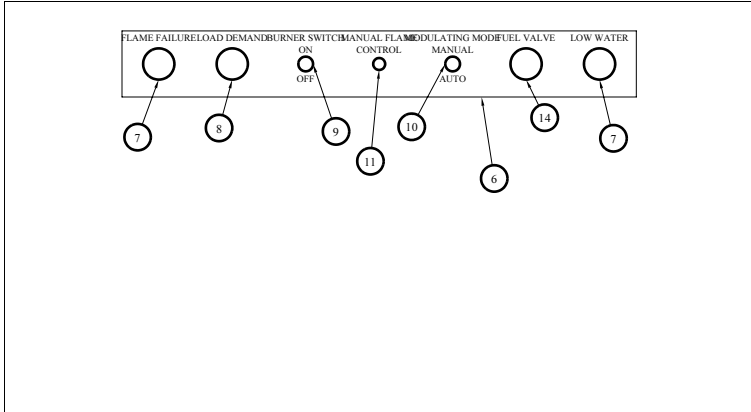
NOTE: Refer to the nameplate for serial number and date codes.

Figure Number	Description	Page Number
9-1	Control Panels	9-2
9-2	Main Gas Train	9-5
9-3	Pilot Gas Train	9-7
9-4	Oil Train Assembly	9-8
9-5	Oil Gun Assembly	9-9
9-6	Fan Drive Assembly	9-9
9-7	Blower Motor	9-10
9-8	Blast Tube Assembly	9-11
9-9	Airbox Assembly	9-12
9-10	Input Dependent Parts	9-13

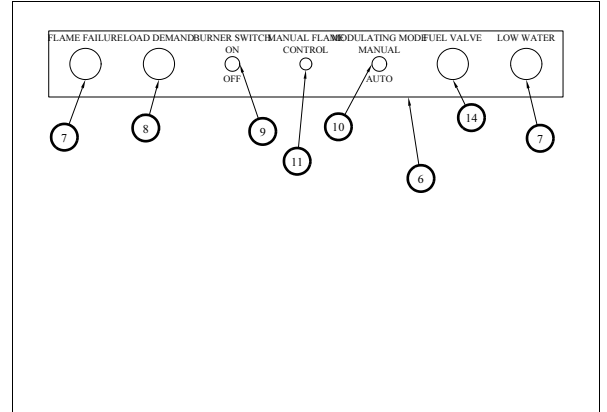
CHAPTER 9

Section 1: ProFire Burner Parts

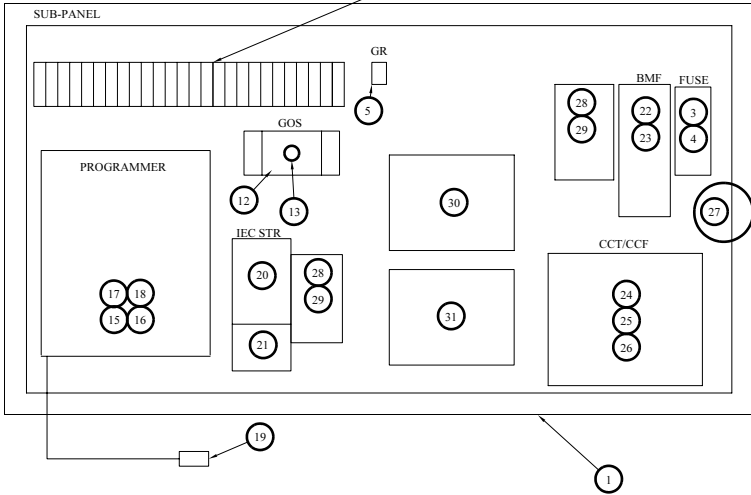
CONTROL PANEL DOOR (FRONT VIEW)



CONTROL PANEL DOOR (FRONT VIEW)



CONTROL PANEL - LARGE



CONTROL PANEL

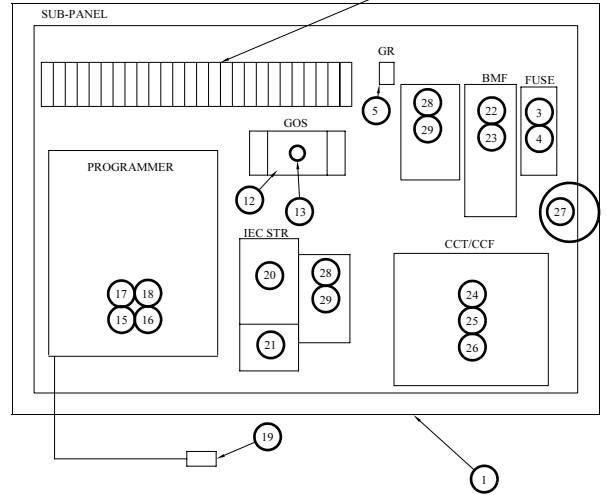


TABLE 2 SIZING CHART (60/50 Hz.)

MOTOR HP	SINGLE PHASE															THREE PHASE															MOTOR HP									
	115					208					230					200					230					460						575								
	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N	FULL LOAD AMP	STR P/N	OL P/N	FUSE AMPS	FUSE P/N
1/3	5.6	2712	-	15	1888	4	2712	-	8	1884	2.8	2712	-	8	1884	-	2665	-	2.25	1871	-1.8	2665	-	4	1877	-9	2665	2672	1.8	1870	.9	2665	2672	1.8	1870	1/3				
1/2	7.4	2712	-	20	1889	-5.4	2712	-	12	1887	3.7	2712	-	10	1886	2.1	2665	2676	5	1879	2.2	2665	2675	5	1879	1.1	2665	2673	2.5	1872	.9	2665	2672	2	1924	1/2				
3/4	9.8	2712	-	30	1891	-7.6	2712	-	15	1888	4.9	2712	-	15	1888	3.1	2665	2676	8	1884	3.2	2665	2676	7	1883	1.6	2665	2674	3.5	1876	1.3	2665	2673	3	1874	3/4				
1	12.8	2666	2681	35	1844	6.5	2665	2679	20	1889	6.4	2665	2679	17.5	1925	3.7	2665	2677	10	1886	3.7	2665	2676	9	1885	1.85	2665	2675	5	1879	1.5	2665	2674	4	1877	1				
1-1/2	18	2668	2682	40	1845	9.1	2666	2680	25	1890	9	2666	2680	20	1889	5	2665	2678	15	1888	5	2665	2677	12	1887	2.5	2665	2676	7	1883	2	2665	2675	5	1879	1-1/2				
2	21	2668	2683	45	1846	-13.2	2666	2681	30	1891	10.5	2666	2681	25	1890	6.3	2665	2679	17.5	1925	5.9	2665	2679	15	1888	2.95	2665	2676	8	1884	2.3	2665	2676	6	1881	2				
3	-34	2670	2685	60	1848	-18.7	2667	2682	35	1844	-17	2667	2682	30	1891	9.3	2665	2680	25	1890	8.2	2665	2680	20	1889	4.1	2665	2677	10	1885	3.1	2665	2677	8	1884	3				
5	-56	2671	2687	100	1852	-30.8	2669	2684	50	1847	-28	2669	2684	50	1847	13.5	2665	2682	35	1844	12.4	2665	2681	30	1891	6.2	2665	2679	20	1889	-6.1	2665	2678	15	1888	5				
7-1/2	-80	-	-	150	1855	-44	-	-	80	1850	-40	-	-	70	1849	21.2	2668	2683	45	1846	19	2668	2682	40	1845	9.5	2666	2680	25	1890	-9	2665	2679	20	1889	7-1/2				
10	-100	-	-	175	1856	-55	-	-	100	1852	-50	-	-	90	1851	-32.2	2670	2685	60	1848	-28	2669	2683	50	1847	-14	2667	2681	30	1891	-11	2666	2680	25	1890	10				

-FULL LOAD AMPS PER NEC TABLES 430-148 & 430-150.
FULL LOAD AMPS PER MANUFACTURER (NAMEPLATE AMPS).

IEC STARTERS (833-XXXX)
IEC OVERLOADS (OL) (833-XXXX)
MOTOR FUSES (832-XXXX)
<= 30 amps CLASS CC TIME DELAY, CURRENT LIMITING REJECTION TYPE
BUSSMAN - LPC
LITTLEFUSE - CCMR
GOULD - ATDR
> 30 amps CLASS J TIME DELAY, CURRENT LIMITING REJECTION TYPE

Figure 9-1: Control Panels (1 of 3)

ITEM	DESCRIPTION	QTY	PART #
1	CABINET, 20W X 14H X 7D W/SUB-BASE	1	848-1128
	CABINET, 25W X 14H X 7D W/SUB-BASE	1	848-1155
2	TERMINAL BLOCK, 30 TERMS	1	434-80
3	FUSE BLOCK	1	848-1147
4	FUSE 5.AMP	1	832-1811
5	GROUND LUG	1	884-78
6	NAMEPLATE	1	118-3135
7	PILOT LIGHT, RED	2	881-323
8	PILOT LIGHT, WHITE	2	881-322
9	BURNER SWITCH	1	836-471
10	MAN-AUTO SWITCH	1	836-474
11	MANUAL FLAME CONTROL	1	836-209
12	SWITCH BRACKET	1	8-801
13	GAS-OIL SWITCH	1	836-1036
14	PILOT LIGHT, GREEN	1	881-324
15	PROGRAMMER CHASSIS	1	TABLE 9-1A
16	PROGRAMMER MODULE	1	TABLE 9-1A
16a	PROGRAMMER DISPLAY	1	TABLE 9-1A
17	PROGRAMMER AMPLIFIER	1	TABLE 9-1A
18	PROGRAMMER BASE	1	TABLE 9-1A
19	FLAME DETECTOR	1	TABLE 9-1A
20	CONTACTOR	1	TABLES 9-1B & 9-1C
21	OVERLOAD	1	TABLES 9-1B & 9-1D
22	BLOWER MOTOR FUSES	1	TABLE 9-1E
23	BLOWER MOTOR FUSE MODULE	1	832-1892
24	CONT. CIRCUIT XFMR (1/2 KVA) (208V)	1	832-1801
	CONT. CIRCUIT XFMR (1/2 KVA) (230.460V)	1	832-1802
	CONT. CIRCUIT XFMR (1/2 KVA) (230.460V)	1	832-1803
25	CCF-1 FUSES	2	TABLE 9-1F
26	CCF-2 FUSE	1	832-1811
27	LATCH	1	875-63
28	RELAY	OPT	833-2261
29	RELAY BASES	OPT	833-2263
30	WARRICK E-2	1	833-1954

TABLE 9-1A. PROGRAMMERS

	Chassis	Programmer	Display	Amplifier	Base	Scanner
PROGRAMMER	ITEM 15	ITEM 16	ITEM 16a	ITEM 17	ITEM 18	ITEM 19
FIREYE E110 (UV)	833-2708	833-2710	—	833-2385	833-2214	817-2309
C-B CB110 (UV)*	833-2709	833-2711	—	833-2585	833-2581	817-2309
FIREYE D10-5065 (UV)	833-2255	833-2254	—	833-2257	833-2214	817-2309
C-B CB100 E (UV)	833-2709	833-2583	833-2714	833-2585	833-2581	817-2309
FIREYE E100 (UV)	833-2708	833-2383	833-2713	833-2385	833-2214	817-2309
C-B CB-780 (UV)	833-2718	833-2730	833-2727	833-2724	833-2725	817-1743
C-B CB-70 (UV)	833-2292	NOT USED	—	833-2207	833-1966	817-1743
HONEYWELL BC7000 (UV)	833-2402	833-2401	—	NPN	833-2236	817-1743
C-B CB-40 (UV)	833-2201	NOT USED	—	833-2207	833-1966	817-1743

* DENOTES STANDARD

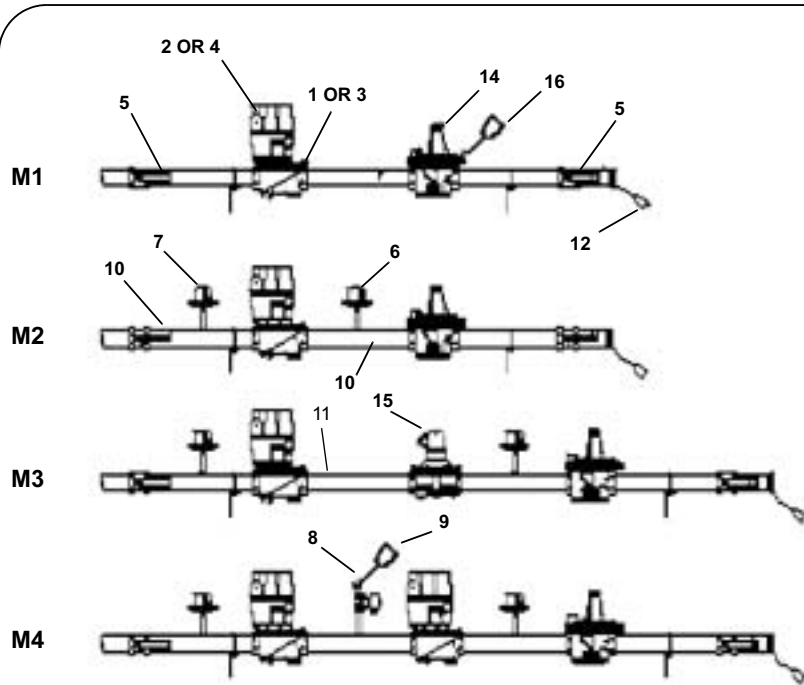
Figure 9-1: Control Panels (2 of 3)

TABLE 9-1B. SIZING CHART												
MOTOR HP	SINGLE-PHASE				THREE-PHASE							
	115		230		200		230		460		575	
	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD
1/3	8	-	8	-	1	-	1	-	1	A	1	A
1/2	8	-	8	-	1	E	1	D	1	B	1	A
3/4	8	-	8	-	1	E	1	E	1	C	1	B
1	2	J	1	H	1	F	1	E	1	D	1	C
1-1/2	4	K	2	I	1	G	1	F	1	E	1	D
2	4	L	2	J	1	H	1	H	1	E	1	E
3	6	N	3	K	1	I	1	I	1	F	1	F
5	7	P	5	M	1	K	1	J	1	H	1	G
7-1/2	-	-	-	-	4	L	4	K	2	I	1	H
10	-	-	-	-	6	N	5	L	3	J	2	I

TABLE 9-1C. CONTACTOR		
IND. AMP	TABLE 2 CODE	PART #
9	1	833-2665
12	2	833-2666
18	3	833-2667
25	4	833-2668
32	5	833-2669
40	6	833-2670
55	7	833-2671
	8	833-2712

TABLE 9-1D. OVERLOAD		
AMP RATING	TABLE 2 CODE	PART #
.63-1	A	833-2672
1-1.6	B	833-2673
1.25-2	C	833-2674
1.6-2.5	D	833-2675
2.5-4	E	833-2676
4-6	F	833-2677
5.5-8	G	833-2678
7-10	H	833-2679
9-13	I	833-2680
12-18	J	833-2681
17-25	K	833-2682
23-32	L	833-2683
23-32	M	833-2684
30-40	N	833-2685
37-50	O	833-2686
48-65	P	833-2687

Figure 9-1: Control Panels (3 of 3)



Burner Ratings	Gas Train Insurance Designation		
	Standard	FM	IRI
1.5 - 2.5 MMBtu/hr	M1	M2	M4
2.51 - 5.00 MMBtu/hr	M2	M2	M4
5.01 - 12.00 MMBtu/hr	M3	M3	M4

ITEM NO.	DESCRIPTION	QTY	PART NO.			
			1 — 1/2"	2"	2 — 1/2"	3"
1	VALVE (STD)	TABLE 9-2B	940-4538	940-4539	940-4540	940-4541
2	ACTUATOR (STD)	TABLE 9-2B	945-139	945-139	945-139	945-139
3	VALVE (POC)	TABLE 9-2B	940-4543	940-4544	940-4545	940-4546
4	ACTUATOR (POC)	TABLE 9-2B	945-143	945-143	945-143	945-143
5	MANUAL SHUT-OFF VALVE ^A	2	941-1946	941-1947	941-129	941-130
6	LOW GAS PRESSURE SWITCH (1-26")	1	817-789	817-789	817-789	817-789
	LOW GAS PRESSURE SWITCH (3-21")	1	817-774	817-774	817-774	817-774
7	HIGH GAS PRESSURE SWITCH	1	817-1935	817-1935	817-1935	817-1935
8	MAIN VENT VALVE (3/4")	1	948-2	—	—	—
	MAIN VENT VALVE (1")	1	—	948-53	—	—
	MAIN VENT VALVE (1 - 1/4")	1	—	—	948-54	948-54
9	VENT VALVE NAMEPLATE	1	118-492	118-492	118-492	118-492
10	S.O. NIPPLE (GPS)	1	157-1730	157-1722	157-1723	157-1724
11	S.O. NIPPLE (MGVV 3/4")	1	157-445	—	—	—
	S.O. NIPPLE (MGVV 1")	1	—	157-1043	—	—
	S.O. NIPPLE (MGVV 1 - 1/4")	1	—	—	157-1042	157-1041
12	PRESSURE REQUIRED NAMEPLATE	1	118-3139	118-3139	118-3139	118-3139
14	MAIN REGULATOR ^B	1	SEE TABLE 9-2A			
15	SOLENOID VALVE	1	940-1075	940-1054	940-1025	940-1418
16	REGULATOR VENT TAG	1	118-2062	118-2062	118-2062	118-2062

A. USE P/N 941-127 ON 1-1/2" TRAIN & 941-128 ON 2" TRAIN FOR ORDERS DESTINED FOR CANADA.

Figure 9-2: Main Gas Train (1 of 3)

Table 9-2A

INPUT MMBtu	MAN. PRESS. IN. WC (GROSS)	TRAIN SIZE	REG SET PRESS.		STANDARD PRESS. (1 PSI MAX INLET)					HIGH PRESS (10 PSI MAX INLET & ALL CANADA)				
			1 VALVE M1,M2	2 VALVES M3,M4	1 VALVE M1,M2	2 VALVES M3,M4	MODEL NO.	SPRING RANGE	PART NO.	1 VALVE M1,M2	2 VALVES M3,M4	MODEL NO.	SPRING RANGE	PART NO.
1.5 (Size 1)	2.6	1-1/2	3.7	4.4	4.6	5.3	RV-81	3-5	918-543	5.5	6	210-D	3-5	918-499
		2	2.8	3	3.7	3.9	RV-81 (1.5")	1-3.5	918-732	4.4	4.6	210-D (1.5")	1-3.5	918-734
		2	2.8	3	3.1	3.3	RV-91	1-3.5	918-733	3.4	3.6	210-E	1-3.5	918-735
2.0 (Size 1)	4.3	1-1/2	6.2	7.4	7.7	9	RV-81	4-8	918-155	9	10.2	210-D	4-8	918-300
		2	4.7	5	6.3	6.6	RV-81 (1.5")	3-5	918-543	7.5	7.8	210-D (1.5")	3-5	918-499
		2	4.7	5	5.3	5.5	RV-91	3-5	918-716	5.7	6	210-E	3-5	918-146
2.5 (Size 1)	4.9	1-1/2	7.6	9.4	10.1	11.9	RV-81	5-12	918-704	12	13.8	210-D	5-12	918-259
		2	5.6	6	8.1	8.5	RV-81 (1.5")	4-8	918-155	10	10.4	210-D (1.5")	4-8	918-330
		2	5.6	6	6.5	6.9	RV-91	4-8	918-716	8.1	8.5	210-E	4-8	918-282
2.0 (Size 2) Derated	1.3	1-1/2	3.2	4.4	4.8	6	RV-81	3-5	918-543	6	7.2	210-D	3-5	918-499
		2	1.7	2	3.3	3.6	RV-81 (1.5")	1-3.5	918-732	4.5	4.8	210-D (1.5")	1-3.5	918-734
		2	1.7	2	2.3	2.6	RV-91	1-3.5	918-733	2.7	3	210-E	1-3.5	918-735
2.5 (Size 2) Derated	2.2	1-1/2	5	6.7	7.5	9.2	RV-81	4-8	918-155	9.4	11.1	210-D	4-8	918-300
		2	2.9	3.3	5.4	5.8	RV-81 (1.5")	1-3.5	918-732	7.3	7.7	210-D (1.5")	1-3.5	918-734
		2	2.9	3.3	3.8	4.7	RV-91	1-3.5	918-733	4.5	4.9	210-E	1-3.5	918-735
3.0 (Size 2)	3.4	1-1/2	7.5	10.2	11	13.7	RV-81	5-12	918-704	13.8	16.5	210-D	5-12	918-259
		2	4.4	4.9	8	8.5	RV-81 (1.5")	3-5	918-543	10.7	11.2	210-D (1.5")	3-5	918-499
		2	4.4	4.9	5.6	6.2	RV-91	3-5	918-716	6.7	7.2	210-E	3-5	918-146
3.5 (Size 2)	4.9	1-1/2	10.3	14	15.1	18.8	RV-81	5-15	918-730	18.8	22.5	210-D	5-15	918-644
		2	6.2	7	11	11.8	RV-81 (1.5")	4-8	918-155	14.7	15.5	210-D (1.5")	4-8	918-330
		2	6.2	7	7.9	8.7	RV-91	4-8	918-716	9.3	10.1	210-E	4-8	918-282
		2-1/2	5.7	6.2	6	6.6	RV-111	4-8	918-150	-	-	-	-	-
4.0 (Size 2)	5.4	1-1/2	12.4	17.2	18.7	23.4	RV-81	10-22	918-547	23.5	28.3	210-D	10-22	918-610
		2	7	8	13.3	14.3	RV-81 (1.5")	4-8	918-155	18.1	19.1	210-D (1.5")	4-8	918-330
		2	7	8	9.2	10.2	RV-91	4-8	918-140	11	12	210-E	4-8	918-282
		2-1/2	6.4	7.2	6.9	7.6	RV-111	4-8	918-150	-	-	-	-	-
4.5 (Size 2)	6.9	2	9	10.3	16.9	18.2	RV-81 (1.5")	5-12	918-704	23.1	24.4	210-D (1.5")	5-12	918-259
		2	9	10.3	11.8	13.1	RV-91	5-12	918-715	14.1	15.4	210-E	5-12	918-5
		2-1/2	8.2	9.1	8.7	9.6	RV-111	5-12	918-661	9.5	10.4	210-G	5-12	918-234
4.0 (Size 3) Derated	6	2	7.6	8.6	13.9	14.9	RV-81 (1.5")	5-15	918-704	18.7	19.7	210-D (1.5")	5-12	918-259
		2	7.6	8.6	9.8	10.8	RV-91	5-15	918-715	11.8	12.6	210-E	5-12	918-5
		2-1/2	7	7.8	7.4	8.2	RV-111	5-12	918-661	-	-	-	-	-
4.5 (Size 3) Derated	7.5	2	9.6	10.9	17.5	18.8	RV-81 (1.5")	5-12	918-730	23.7	25	210-D (1.5")	5-15	918-644
		2	9.6	10.9	12.4	13.7	RV-91	5-12	918-650	14.7	16	210-E	5-15	918-647
		2-1/2	8.8	9.7	9.4	10.3	RV-111	5-12	918-661	10.1	11	210-G	5-12	918-234
5.0 (Size 3)	9.1	2	11.7	13.3	21.4	23	RV-81 (1.5")	5-15	918-730	29.1	30.78	210-D (1.5")	5-15	918-644
		2	11.7	13.3	15.1	16.7	RV-91	5-15	918-650	18	19.6	210-E	5-15	918-647
		2-1/2	10.6	11.7	11.3	12.4	RV-111	5-12	918-661	12.2	13.3	210-G	5-12	918-234
		3	10	10.7	10.6	11.3	RV-111	5-12	918-719	-	-	-	-	-
5.5 (Size 3)	10.1	2	N/A	14.9	N/A	-	-	-	-	N/A	35.9	210-D (1.5")	10-22	918-610
		2	N/A	14.9	N/A	19	RV-91	5-15	918-650	N/A	22.5	210-E	5-15	918-647
		2-1/2	N/A	13.4	N/A	14.2	RV-111	5-15	918-729	N/A	15.3	210-G	5-15	918-731
		3	N/A	11.9	N/A	12.7	RV-111	5-12	918-719	N/A	-	-	-	-
6.0 (Size 3)	6.8	2	N/A	12.8	N/A	-	-	-	-	N/A	37.8	210-D (1.5")	5-15	918-644
		2	N/A	12.8	N/A	17.7	RF-91	5-15	918-650	N/A	21.8	210-E	5-15	918-647
		2-1/2	N/A	10.6	N/A	11.6	RV-111	5-12	918-661	N/A	12.9	210-G	5-12	918-234
		3	N/A	9	N/A	10	RV-111	5-12	918-719	N/A	-	-	-	-
7.0 (Size 3)	9.3	2	N/A	17.1	N/A	23.8	RV-91	10-22	918-705	N/A	29.4	210-E	10-22	918-169
		2-1/2	N/A	14.4	N/A	15.8	RV-111	5-15	918-661	N/A	17.5	210-G	5-15	918-731
		3	N/A	12.2	N/A	13.5	RV-111	5-15	918-698	N/A	-	-	-	-
8.0 (Size 3)	12.1	2	N/A	22.4	N/A	-	-	-	-	N/A	38.4	210-E	10-22	918-169
		2-1/2	N/A	18.9	N/A	20.6	RV-111	10-22	918-59	N/A	22.9	210-G	10-22	918-270
		3	N/A	16	N/A	17.8	RV-111	10-22	918-699	N/A	19	210-G	10-22	918-65
		4	N/A	13.4	N/A	14	RV-131	10-22	918-203	N/A	-	-	-	-
9.0 (Size 3)	15.1	2	N/A	28	N/A	-	-	-	-	N/A	48.3	210-E	15-30	918-161
		2-1/2	N/A	23.5	N/A	-	-	-	-	N/A	28.6	210-G	15-30	918-283
		3	N/A	19.9	N/A	22.1	RV-111	10-22	918-699	N/A	23.7	210-G	10-22	918-65
		4	N/A	16.8	N/A	17.6	RV-131	10-22	918-203	N/A	-	-	-	-
7.0 (Size 4) Derated	8.2	2	N/A	16	N/A	22.7	RV-91	10-22	918-705	N/A	28.3	210-E	10-22	918-169
		2-1/2	N/A	13.4	N/A	14.7	RV-111	5-15	918-661	N/A	16.5	210-G	5-15	918-731
		3	N/A	11.1	N/A	12.4	RV-111	5-12	918-719	N/A	-	-	-	-

Figure 9-2. Main Gas Train (2 of 3)

Table 9-2A

INPUT MMBtu	MAN. PRESS. IN. WC (GROSS)	TRAIN SIZE	REG SET PRESS.		STANDARD PRESS. (1 PSI MAX INLET)					HIGH PRESS (10 PSI MAX INLET & ALL CANADA)				
			1 VALVE M1,M2	2 VALVES M3,M4	1 VALVE M1,M2	2 VALVES M3,M4	MODEL NO.	SPRING RANGE	PART NO.	1 VALVE M1,M2	2 VALVES M3,M4	MODEL NO.	SPRING RANGE	PART NO.
8.0 (Size 4) Derated	11.4	2	N/A	21.7	N/A	-	-	-	-	N/A	37.7	210-E	15-30	918-161
		2-1/2	N/A	18.2	N/A	19.9	RV-111	10-22	918-59	N/A	21.2	210-G	10-22	918-270
		3	N/A	15.3	N/A	17	RV-111	10-22	918-699	N/A	18.3	210-G	10-22	918-65
		4	N/A	12.7	N/A	13	RV-131	10-22	918-203	N/A	-	-	-	-
9.0 (Size 4)	13.5	2	N/A	26.4	N/A	-	-	-	-	N/A	46.7	210-E	15-30	918-161
		2-1/2	N/A	21.9	N/A	-	-	-	-	N/A	27	210-G	15-30	918-283
		3	N/A	18.3	N/A	20.5	RV-111	10-22	918-699	N/A	22.1	210-G	10-22	918-65
		4	N/A	15.2	N/A	15.6	RV-131	10-22	918-203	N/A	-	-	-	-
10.0 (Size 4)	14.4	2-1/2	N/A	25	N/A	-	-	-	-	N/A	31.2	210-G	15-30	918-283
		3	N/A	20.5	N/A	23.2	RV-111	10-22	918-699	N/A	25.2	210-G	10-22	918-65
		4	N/A	17.3	N/A	18.2	RV-131	10-22	918-203	N/A	-	-	-	-
11.0 (Size 4)	17.6	2-1/2	N/A	30.4	N/A	-	-	-	-	N/A	37.9	210-G	20-42	918-682
		3	N/A	25	N/A	-	-	-	-	N/A	30.6	210-G	15-30	918-338
		4	N/A	21.1	N/A	22.2	RV-131	10-22	918-203	N/A	-	-	-	-
12.0 (Size 4)	21.4	3	N/A	30.4	N/A	-	-	-	-	N/A	37.2	210-G	20-42	918-521
		4	N/A	24.4	N/A	25.7	RV-131	10-22	918-203	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 = Standard.
 3. Select High Pressure Regulator for All Canadian Destinations.
 4. Increase indicated gas pressure 4% per 1000' MSL.
 Standard =

Figure 9-2. Main Gas Train Continued (2 of 3)

TABLE 9-2B

BURNER INPUT MMBtu	MAIN GAS TRAIN												VALVE TYPE				OVERALL LENGTH	
	TRAIN SIZE (STD)	VENT VALVE SIZE		MAIN TRAIN			STARTER	S=SOLENOID M=MOTORIZED						MAIN GAS TRAIN				
		STD & FM	IRI	STD	FM	IRI	TRAIN	STD		FM		IRI		M1, M2 (APPROX)	M3, M4 (APPROX)			
								STD	POC	STD	POC	STD	POC					
1.5-2.5	2	-	1	M1	M2	M4	S1	-	1M	-	1M	2M	-	63"	83"			
2.51-4.99	2	-	1	M2	M2	M4	S1	-	1M	-	1M	2M	-	63"	83"			
5	2.	-	1	M2	M2	M4	S2	-	1M	-	1M	2M	-	63"	83"			
5.01-9	2.0	-	1-1/4	M3	M3	M4	S2	1S	1M	1S	1M	1M	1M	63"	83"			
9.01-12	2.5	-	1-1/4	M3	M3	M4	S2	1S	1M	1S	1M	1M	1M	63"	83"			

Figure 9-2. Main Gas Train (3 of 3)

ITEM NO.	DESCRIPTION	QTY	PART NO.
			1 — 1/2"
1	PILOT VALVE	1	948-343
2	PILOT REG (2 - 6") [SIZES 1 & 2]	1	918-356
	PILOT REG (4 - 12") [SIZES 3 & 4]	1	918-717
3	PILOT GAS COCK	1	825-30
4	PILOT TUBE ELBOW CONNECTOR	1	845-662
5	PILOT TUBE CONNECTOR	1	845-314
6	PILOT TUBE UNION NUT	1	845-43
7	PILOT TUBING	1	939-413
8	PILOT MOUNTING CLAMP	1	928-169
9	PILOT NIPPLE (1/2")	2	857-154
10	TAG — REGULATOR VENT	1	118-2062

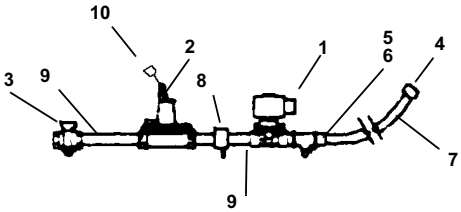
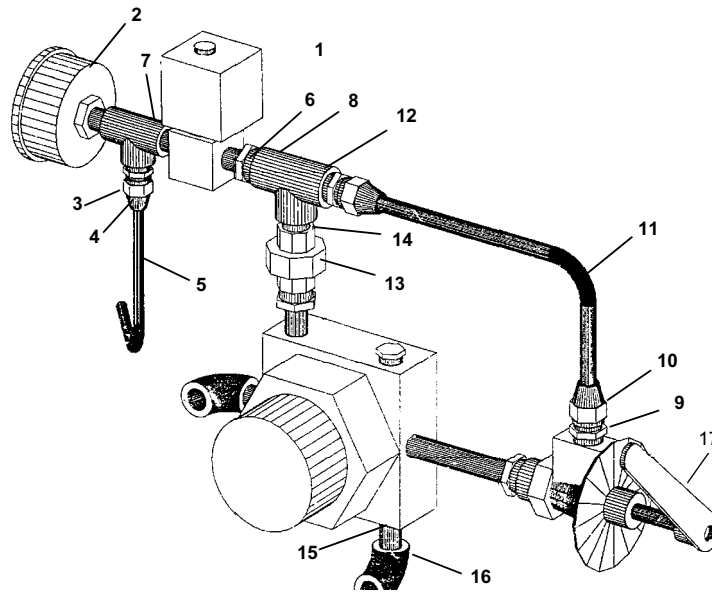


Figure 9-3. Pilot Gas Train



ITEM	DESCRIPTION	SIZE 1		SIZE 2		SIZE 3		SIZE 4	
		REQ	PART NO.	REQ	PART NO.	REQ	PART NO.	REQ	PART NO.
1	OIL SHUT-OFF SOLENOID VALVE	2	948-320	2	948-320	2	948-319	2	948-319
2	OIL PRESSURE GAUGE	1	850-1247	1	850-1247	1	850-1247	1	850-1247
NS	GAUGE ADAPTER BUSHING	0	N/A	0	N/A	1	847-1082	1	847-1082
NS	OIL DRAWER ELBOW CONNECTOR	1	845-137	1	845-137	2	845-316	2	845-316
3	OIL LINE CONNECTOR	1	845-7	1	845-7	-	845-46	-	845-46
4	OIL LINE UNION NUT	2	845-8	2	845-8	2	845-43	2	845-43
5	OIL LINE TUBING	1	939-25	1	939-25	1	939-70	1	939-70
6	OIL LINE NIPPLE	2	857-129	2	857-129	2	857-23	2	857-23
7	OIL LINE TEE	1	859-22	1	859-22	1	859-23	1	859-23
8	OIL LINE REDUCING BUSHING	1	847-1082	1	847-1082	0	N/A	0	N/A
9	OIL BYPASS CONNECTOR	2	845-46	2	845-46	2	845-46	2	845-46
10	OIL BYPASS UNION NUT	2	845-43	2	845-43	2	845-43	2	845-43
11	OIL BYPASS TUBING	1	939-70	1	939-70	1	939-70	1	939-70
12	OIL BYPASS TEE	1	859-23	1	859-23	1	859-23	1	859-23
13	OIL DISCHARGE UNION	1	858-160	1	858-160	1	858-160	1	858-160
14	UNION NIPPLE	1	857-139	1	857-139	1	857-139	1	857-139
15	OIL PUMP I/O NIPPLE	2	857-129	2	857-129	2	857-141	2	858-141
16	OIL PUMP I/O ELBOW	2	859-78	2	859-78	2	859-79	2	859-79
NS	OIL PUMP CAPSCREW PKG.	2	868-56	2	868-56	2	868-56	2	868-56
17	MAIN SHAFT ACTUATOR ARM	1	945-206	1	945-206	1	945-205	1	945-205
NS	MOD LINKAGE BALL JOINT	2	945-207	2	945-207	2	945-207	2	945-207
NS	MOD LINKAGE DRIVE ROD	0.4	971-137	0.6	971-137	0.8	971-137	0.8	971-137
NS	OIL STRAINER (NOTE 1)	1	843-252	1	843-252	1	843-252	1	843-252

NOTE: 1. OIL STRAINER REQUIRED ON UNITS DESIGNATED FOR CANADA AND UNITS SHIPPED WITH FGR

2. NS = Not Shown

Figure 9-4. Oil Train Assembly

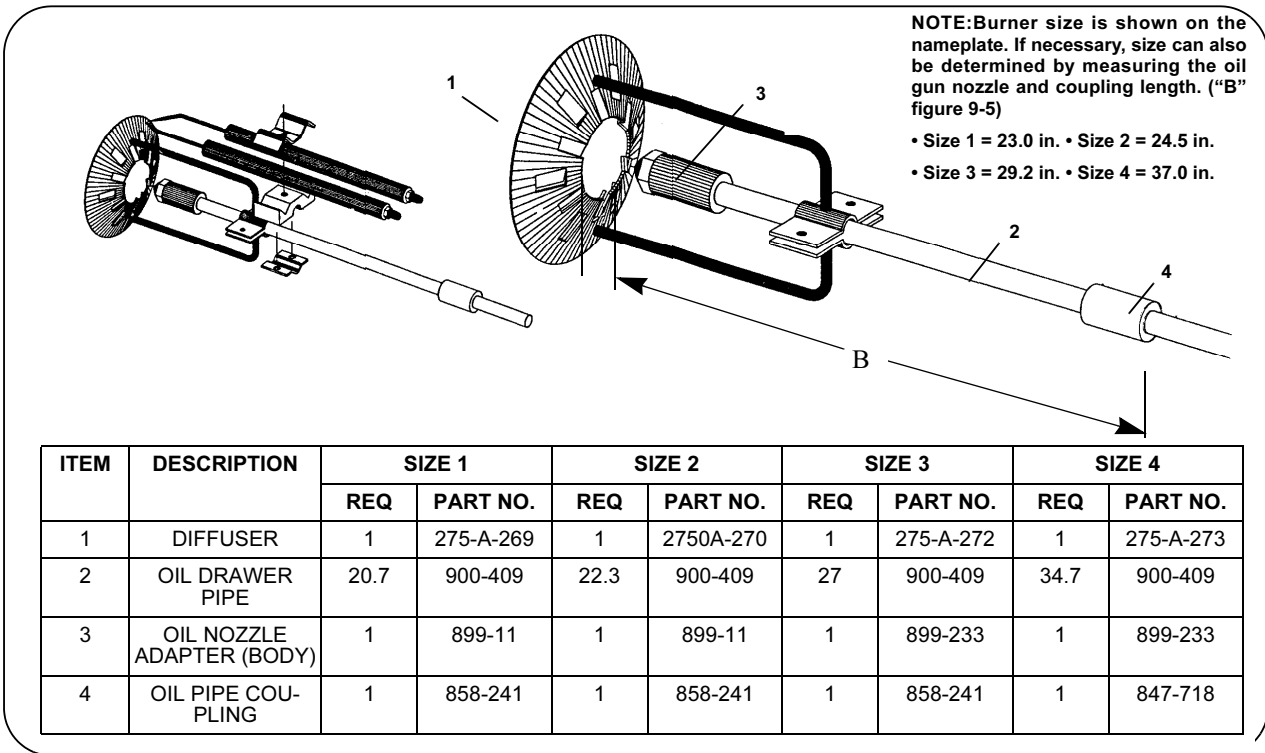


Figure 9-5. Oil Gun Assembly

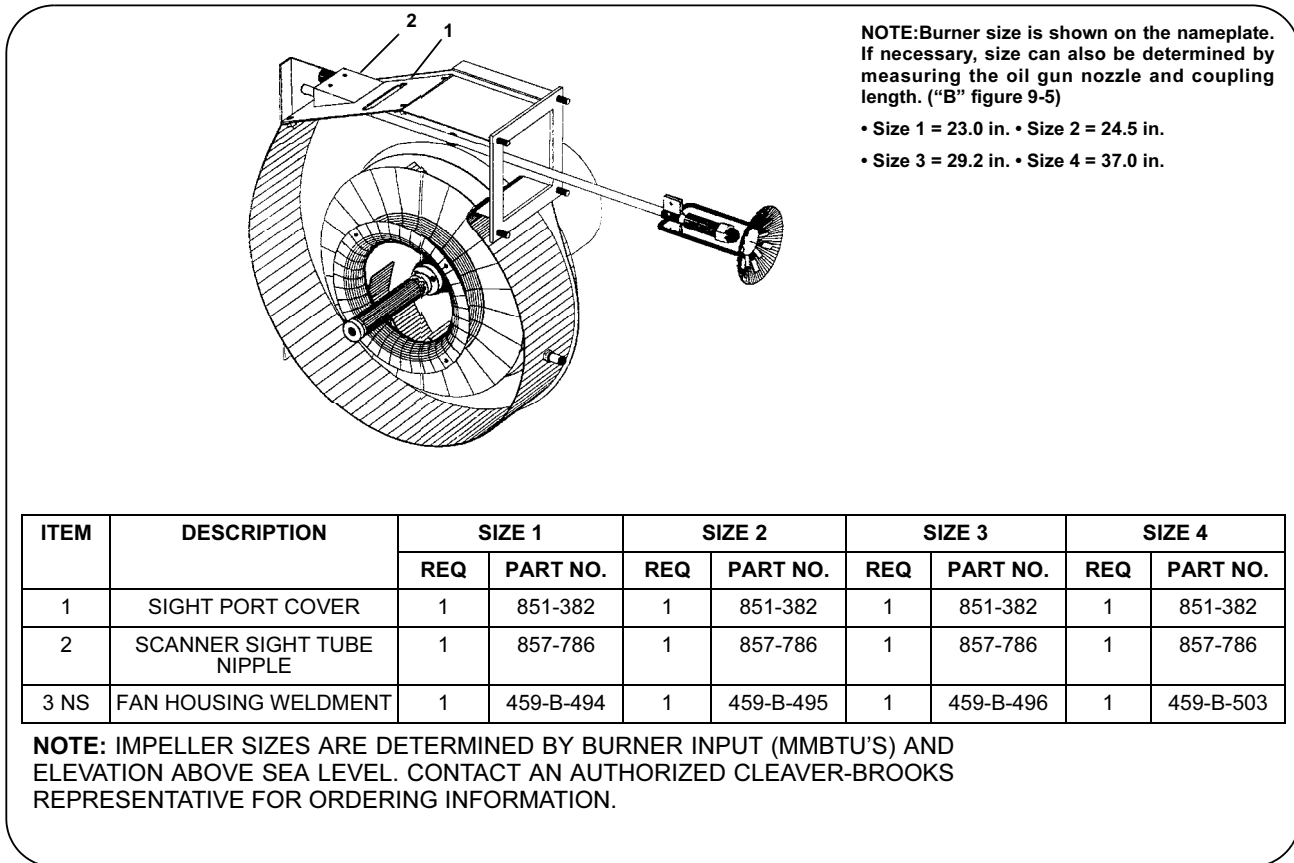
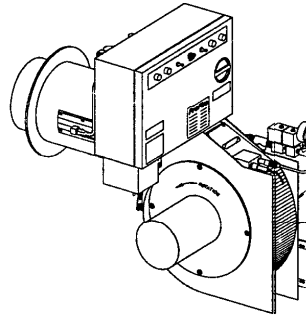


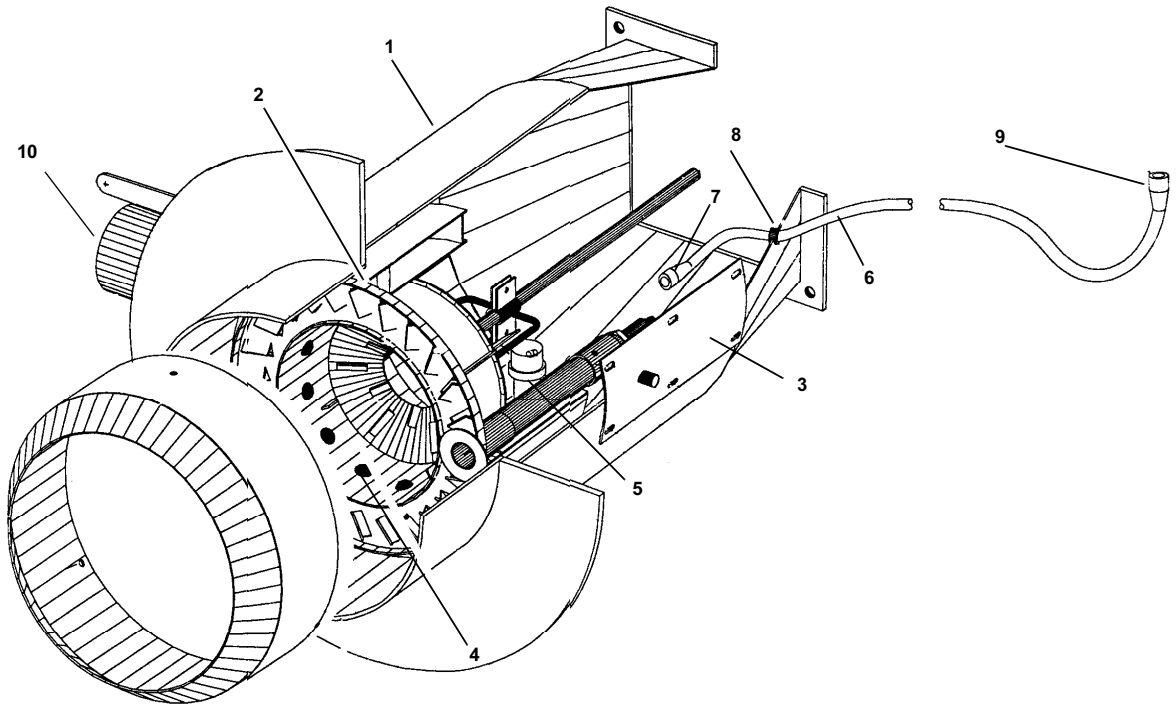
Figure 9-6. Fan Drive



MOTOR HP	OPEN DRIP PROOF (O.D.P.)			TOTALLY ENCLOSED (T.E.F.C.)		
	200/230/460	575/600	115/230	200/230/460	575/600	115/230
1/3	894-3580	894-3598	894-3590 *	894-3608	894-3626	894-3618
1/2	894-3581	894-3599	894-3591 *	894-3609	894-3627	894-3619
3/4	894-3582	894-3600	894-3592 *	894-3610	894-3628	894-3620
1	894-3583 *	894-3601	894-3593	894-3611	894-3629	894-3621
1-1/2	894-3584 *	894-3602	894-3594	894-3612	894-3630	894-3622
2	894-3585 *	894-3603	894-3595	894-3613	894-3631	894-3623
3	894-3586 *	894-3604	-	894-3614	894-3632	-
5	894-3587 *	894-3605	-	894-3615	894-3633	-
7-1/2	894-3588 *	894-3606	-	894-3616	894-3634	-
10	894-3687*	894-3699		894-3696	894-3700	

* Standard Voltage

Figure 9-7. Blower Motor



NOTE: Burner size is shown on the nameplate. If necessary, size can also be determined by measuring the oil gun nozzle and coupling length. ("B" figure 8-5)

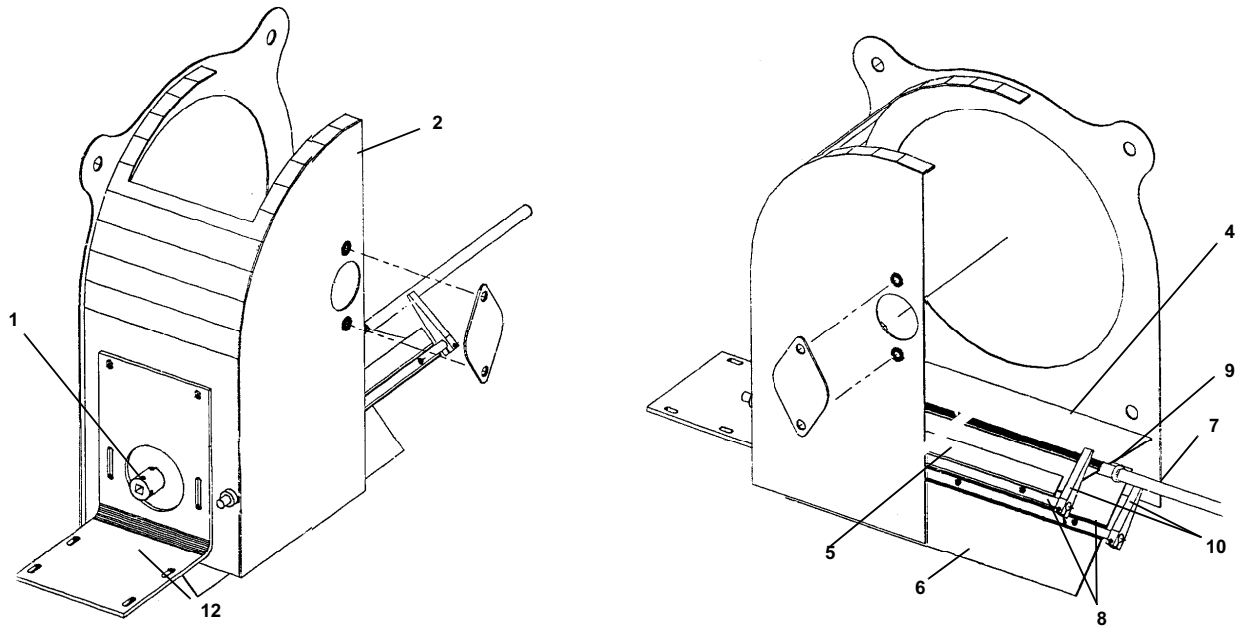
- Size 1 = 23.0 in. • Size 2 = 24.5 in.
- Size 3 = 29.2 in. • Size 4 = 37.0 in.

ITEM	DESCRIPTION	SIZE 1		SIZE 2		SIZE 3		SIZE 4	
		REQ	PART NO.	REQ	PART NO.	REQ	PART NO.	REQ	PART NO.
1	BLAST TUBE WELDMENT	1	286-B-13	1	286-B-14	1	286-B-15	1	286-B-16
2	AIR BAFFLE	1	261-A-295	1	261-A-296	1	261-A-303	1	261-A-304
3	PILOT ACCESS COVER	1	19-1324	1	19-1325	1	19-1331	1	19-1339
4	RADIAL ORIFICE SPUD	6	42-A-11	10	42-A-11	12	42-A-11	14	42-A-13
5	PILOT ASSEMBLY	1	284-161	1	284-161	1	284-A-162	1	284-A-162
6	IGNITION CABLE	1	826-40	1	826-40	1	826-40	1	826-40
7	IGNITION CABLE PILOT CONNECTOR	1	848-166	1	848-166	1	848-166	1	848-166
8	IGNITION CABLE STRAIN RELIEF	1	848-1145	1	848-1145	1	848-1145	1	848-1145
9	IGNITION CABLE TRANSFORMER CONN.	1	848-157	1	848-157	1	848-157	1	848-157
10	BUTTERFLY VALVE	1	940-5300	1	940-5301	1	940-5302	1	940-5302
NS	IGNITION TRANSFORMER	1	832-107	1	832-107	1	832-107	1	832-107

Figure 9-8. Blast Tube Assembly

NOTE: Burner size is shown on the nameplate. If necessary, size can also be determined by measuring the oil gun nozzle and coupling length. ("B" figure 8-5)

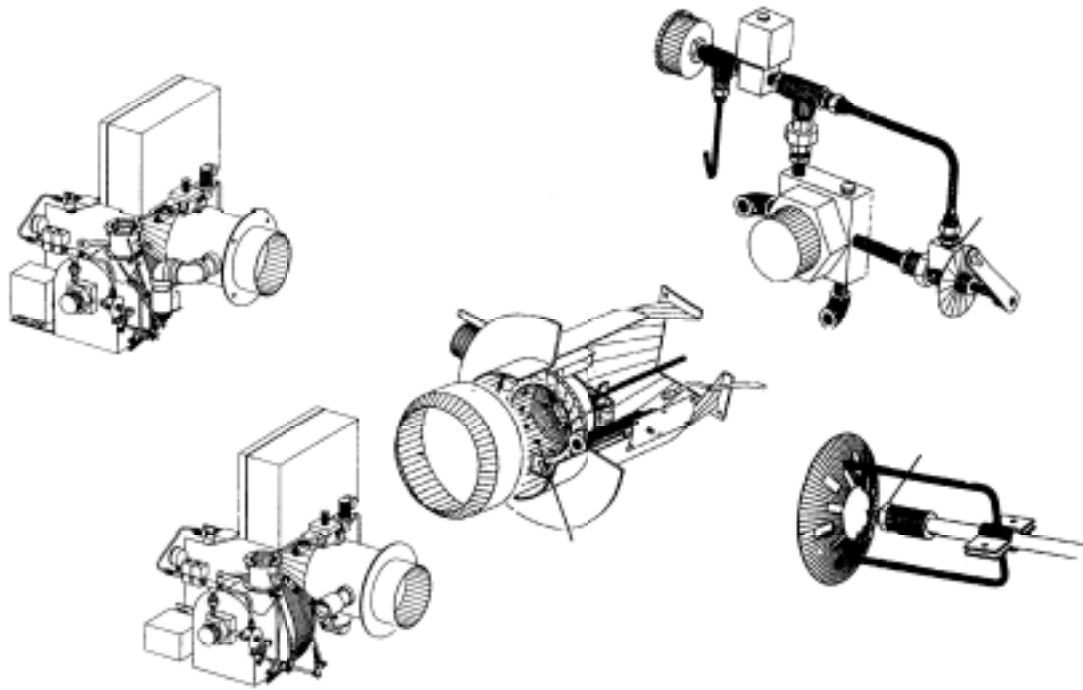
- Size 1 = 23.0 in. • Size 2 = 24.5 in.
- Size 3 = 29.2 in. • Size 4 = 37.0 in.



ITEM	DESCRIPTION	SIZE 1		SIZE 2		SIZE 3		SIZE 4	
		REQ	PART NO.	REQ	PART NO.	REQ	PART NO.	REQ	PART NO.
1	MAIN SHAFT DRIVE COUPLING	1	20-B-149	1	20-B-149	1	20-B-150	1	20-B-150
2	AIR BOX	1	459-B-497	1	459-B-498	1	459-B-499	1	459-B-504
3	MOTOR MOUNT PLATE NS	1	59-5386	1	59-5387	1	59-5402	1	59-5471 (10 hp) 59-5564 (5&7-1/2 hp)
4	MAIN AIR SHUTTER	1	108-122	1	108-125	1	108-128	1	108-131
5	LOW-FIRE MANUAL AIR SHUTTER	1	108-A-121	1	108-A-124	1	108-A-127	1	108-A-130
6	HIGH-FIRE MANUAL AIR SHUTTER	1	108-123	1	108-126	1	108-129	1	108-132
7	MAIN AIR SHUTTER SHAFT	1	74-256	1	74-257	1	74-263	1	74-275
8	MANUAL AIR SHUTTER SHAFT	2	74-B-268	2	74-271	1	74-272	1	74-273
9	AIR SHUTTER SHAFT BEARING	1	807-429	1	807-429	1	807-428	1	807-428
10	AIR SHUTTER ADJUSTMENT HANDLE	2	2-A-355	2	2-A-355	2	2-A-355	2	2-A-355
11	MODULATING MOTOR NS	1	894-3466	1	894-3466	1	894-3466	1	894-3466
12	MODULATING MOTOR MOUNTING PLATE		NA		NA	1	8-A-3115	1	8-A-3115

NS = Not Shown

Figure 9-9. Airbox Assembly



INPUT DEPENDENT ITEMS			GAS	OIL				
INPUT MMBtu	CHOKE CONE	AIR PROVING SWITCH	ORIFICE SPUDS	OIL DRIVE SHAFT ADP*	COUPLING ASSY*	WEBSTER OIL PUMP*	OIL NOZZLES	OIL METERING VALVE
1.5	97-B-248	817-2362	(14) 42-A-10	1-A-825	819-242	901-1436	899-220	940-5303
2	97-B-248	817-2362	(14) 42-A-10	1-A-825	819-242	901-1436	899-222	940-5303
2.5	97-B-248	817-2362	-	1-A-825	819-242	901-1436	899-225	940-5303
3	97-251 (97-B-249)	817-2362	(18) 42-A-10	1-A-825	819-242	901-1436	899-226	940-5328
3.5	97-251 (97-B-249)	817-2362	(18) 42-A-10	1-A-825	819-242	901-1436	899-228	940-5328
4	97-251 (97-B-249)	817-2362	-	1-A-825	819-242	901-1437	899-230	940-5328
4.5	97-251 (97-B-249)	817-2362	-	1-A-825	819-242	901-1437	899-231	940-5328
5	97-B-253	817-2363	(22) 42-A-10	1-A-825	819-243	901-1437	899-221 899-223	940-5318
5.5	97-B-253	817-2363	(22) 42-A-10	1-A-825	819-243	901-1544	899-223 899-224	940-5318
6	97-B-253	817-2363	-	1-A-825	819-243	901-1544	899-224 899-226	940-5318
7	97-B-252	817-2363	-	1-A-826	819-241	901-1544	899-227 899-228	940-5318
8	97-B-252	817-2363	-	1-A-826	819-241	901-1544	899-229 899-229	940-5318
9	97-B-252	817-2363	-	1-A-826	819-241	901-1545	899-231 899-231	940-5635
10	97-B-254	817-2363	N/A	1-A-826	819-244	901-1569	899-245	940-5635
11	97-B-254	817-2363	N/A	1-A-826	819-244	901-1569	899-246	940-5635
12	97-B-254	817-2363	N/A	1-A-911	819-244	901-1569	899-247	940-5635

* Ignore these items when using remote oil pump option

Figure 9-10. Input Dependent Parts

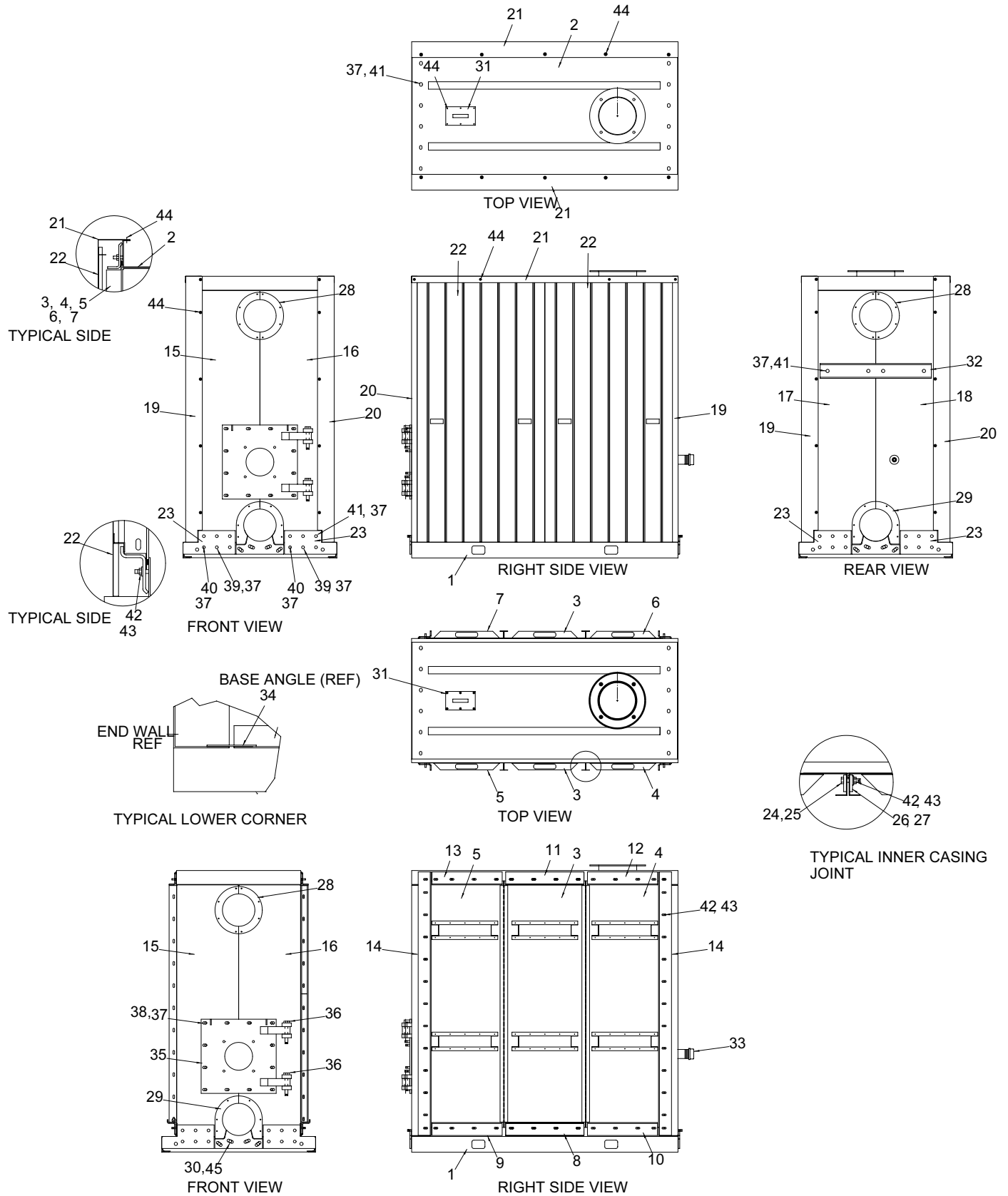
NOTES

CHAPTER 9B

Section 2: Casing Parts



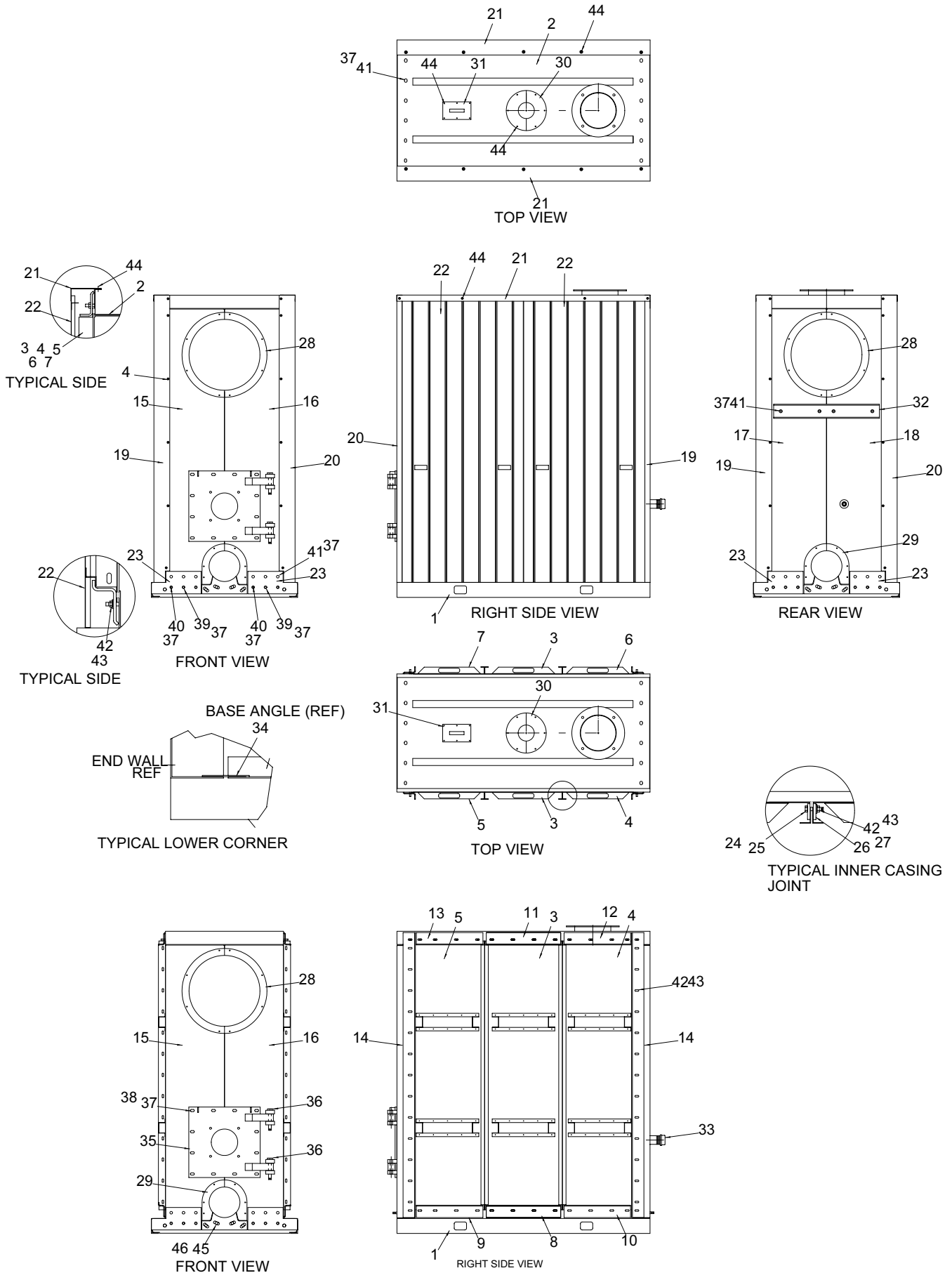
	Page Number
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ASSEMBLY, CASING (350) H.W., FLEXTUBE	9-20
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ASSEMBLY, CASING (1100) STEAM, FLEXTUBE	9-34



ASSEMBLY, CASING (250) H.W., FLEXTUBE

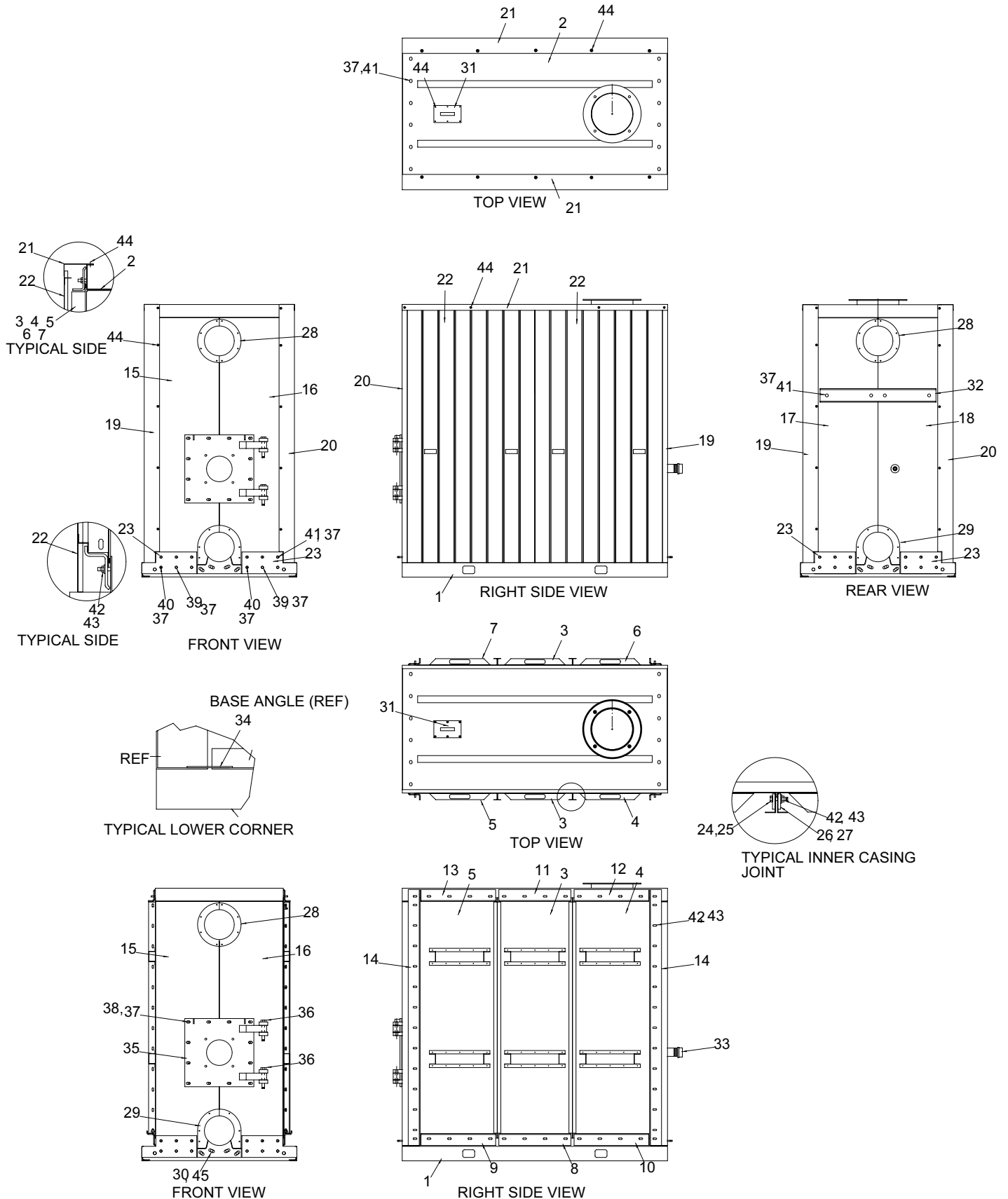
ITEM	REQ.	DESCRIPTION	250 HOT WATER PART NO.
1	1	Base	315-726
2	1	Roof	315-731
3	2	Inner casing - center	315-732
4	1	Inner casing - right rear	315-733
5	1	Inner casing - right front	315-734
6	1	Inner casing - left rear	315-735
7	1	Inner casing - left front	315-736
8	2	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-738
10	2	Inner casing bolt angles-lower end RR/LF	315-739
11	2	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-741
13	2	Inner casing bolt angles-upper end RF/LR	315-742
14	4	Inner casing bolt angles-end	315-743
15	1	Front wall-left	315-744
16	1	Front wall-right	315-745
17	1	Rear wall-left	315-746
18	1	Rear wall-right	315-747
19	2	Outer casing strips-lf/rr corner	315-748
20	2	Outer casing strips-lr/rf corner	315-749
21	2	Outer casing strips-top	315-750
22	4	Outer casing	315-751
23	4	Plate,base to wall	315-754
24	4	Inner casing bolting strips-upper w/bolts	315-755
25	4	Inner casing bolting strips-lower w/bolts	315-756
26	4	Inner casing bolting strips-upper w/o bolts	315-757
27	4	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-207
29	2	Sealing plate, lower drum	315-694
30	8	Washer, flat, 5/8"	952-321
31	1	Sealing plate, Lifting lug	315-262
32	1	Rear wall stiffener	149-859
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	52	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	28	Nut, hex hd., 1/2"	869-144
42	144	Washer, flat, 3/8"	952-298
43	144	Nut, hex hd., 3/8"	869-30
44	72	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-188

Note : Varies on burner



ASSEMBLY, CASING (250) STEAM, FLEXTUBE

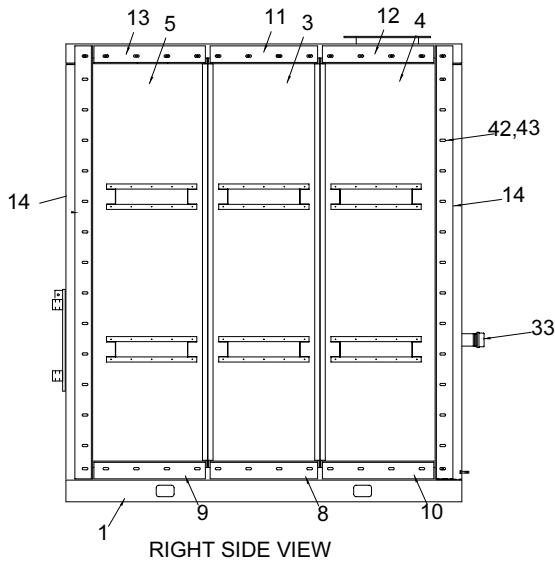
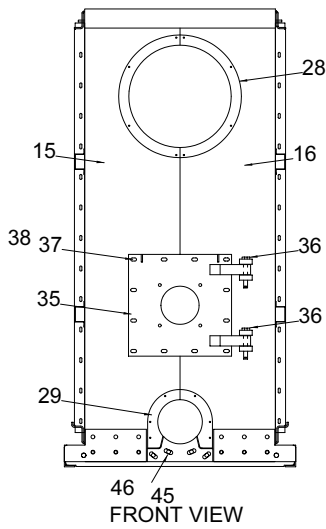
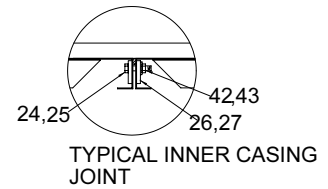
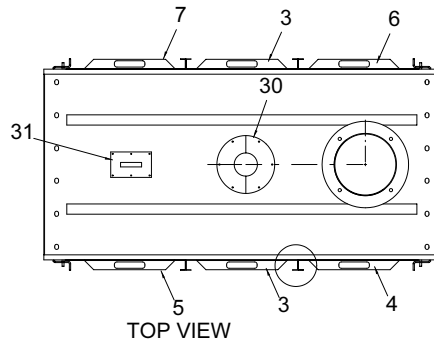
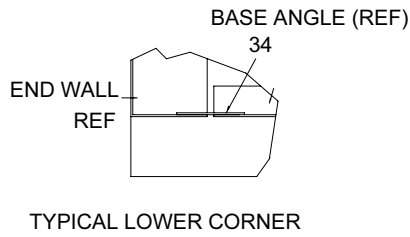
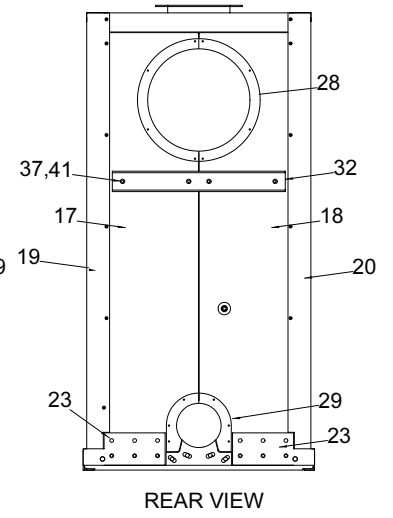
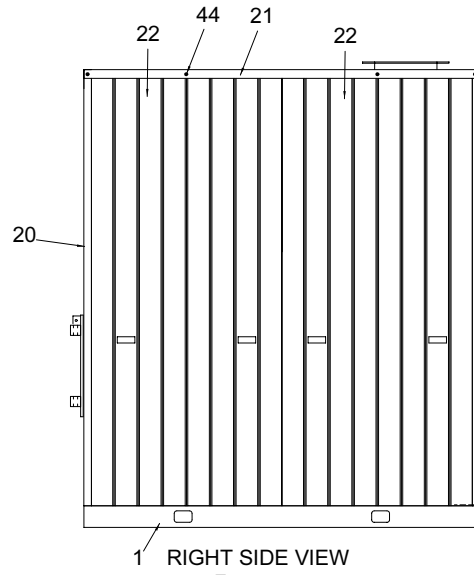
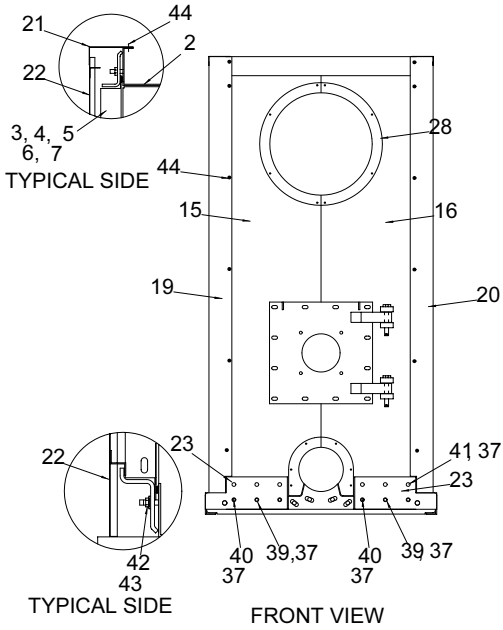
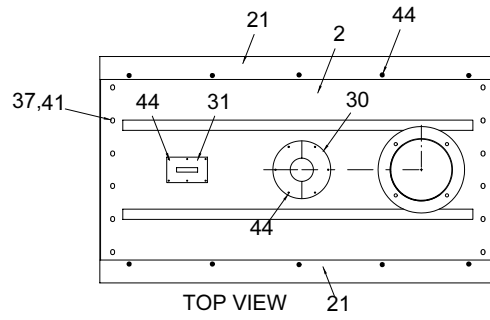
ITEM	REQ.	DESCRIPTION	250 STEAM PART NO.
1	1	Base	315-726
2	1	Roof	315-844
3	2	Inner casing - center	315-845
4	1	Inner casing - right rear	315-846
5	1	Inner casing - right front	315-847
6	1	Inner casing - left rear	315-848
7	1	Inner casing - left front	315-849
8	2	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-738
10	2	Inner casing bolt angles-lower end RR/LF	315-739
11	2	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-741
13	2	Inner casing bolt angles-upper end RF/LR	315-742
14	4	Inner casing bolt angles-end	315-850
15	1	Front wall-left	315-851
16	1	Front wall-right	315-852
17	1	Rear wall-left	315-853
18	1	Rear wall-right	315-854
19	2	Outer casing strips-lf/rr corner	315-855
20	2	Outer casing strips-lr/rf corner	315-856
21	2	Outer casing strips-top	315-750
22	4	Outer casing	315-858
23	4	Plate,base to wall	315-754
24	4	Inner casing bolting strips-upper w/bolts	315-859
25	4	Inner casing bolting strips-lower w/bolts	315-756
26	4	Inner casing bolting strips-upper w/o bolts	315-860
27	4	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-209
29	2	Sealing plate, lower drum	315-694
30	1	Sealing ring, Steam outlet	315-219/517
31	1	Sealing plate, Lifting lug	315-262
32	1	Rear wall stiffener	149-859
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	52	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	28	Nut, hex hd., 1/2"	869-144
42	160	Washer, flat, 3/8"	952-298
43	160	Nut, hex hd., 3/8"	869-30
44	82	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188
46	8	Washer, flat, 5/8"	952-321



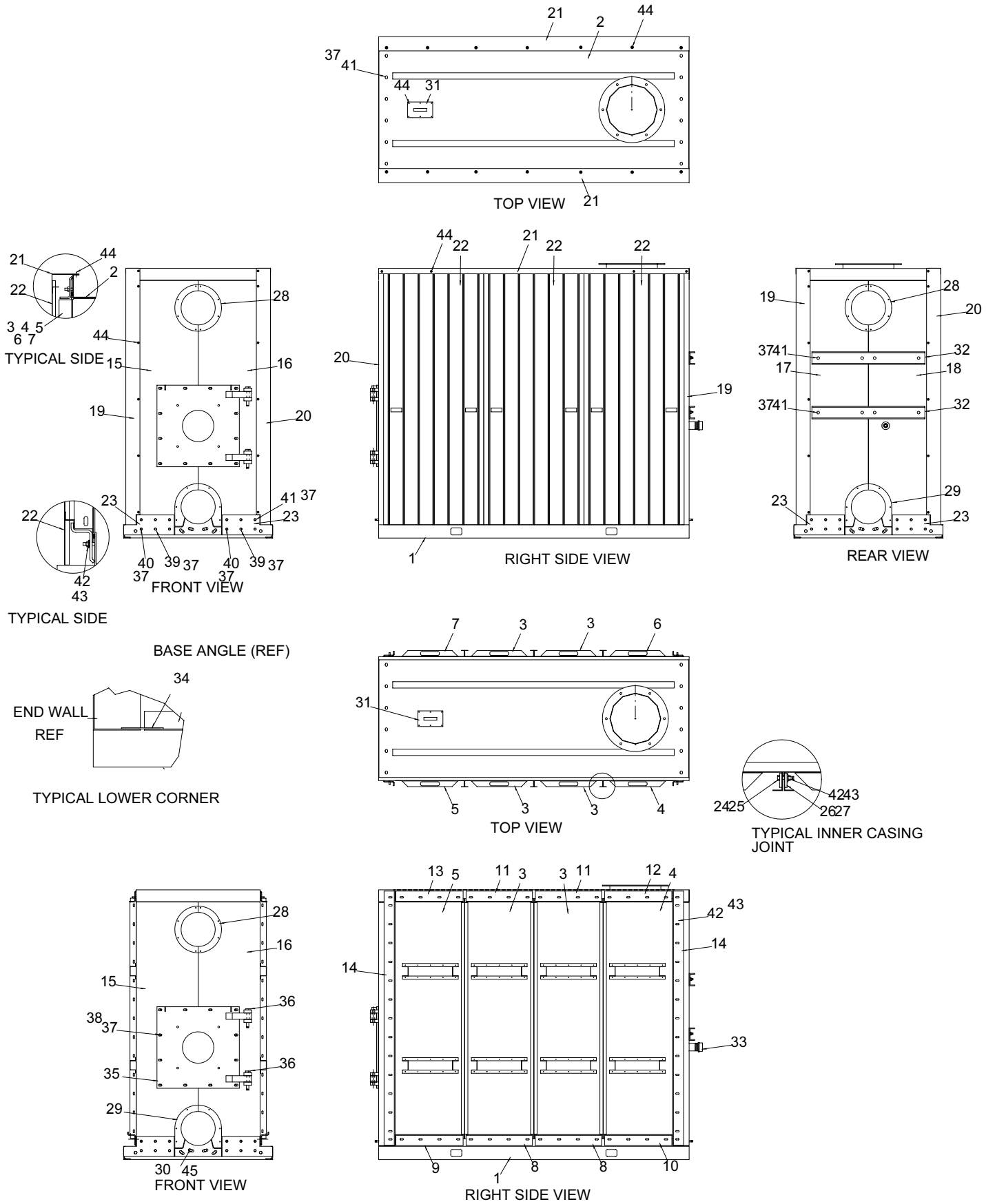
ASSEMBLY, CASING (350) H.W., FLEXTUBE

ITEM	REQ.	DESCRIPTION	350 HOT WATER PART NO.
1	1	Base	315-727
2	1	Roof	315-759
3	2	Inner casing - center	315-760
4	1	Inner casing - right rear	315-761
5	1	Inner casing - right front	315-762
6	1	Inner casing - left rear	315-763
7	1	Inner casing - left front	315-764
8	2	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-765
10	2	Inner casing bolt angles-lower end RR/LF	315-766
11	2	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-767
13	2	Inner casing bolt angles-upper end RF/LR	315-768
14	4	Inner casing bolt angles-end	315-769
15	1	Front wall-left	315-770
16	1	Front wall-right	315-771
17	1	Rear wall-left	315-772
18	1	Rear wall-right	315-773
19	2	Outer casing strips-lf/rr corner	315-774
20	2	Outer casing strips-lr/rf corner	315-775
21	2	Outer casing strips-top	315-777
22	4	Outer casing	315-778
23	4	Plate,base to wall	315-780
24	4	Inner casing bolting strips-upper w/bolts	315-781
25	4	Inner casing bolting strips-lower w/bolts	315-756
26	4	Inner casing bolting strips-upper w/o bolts	315-782
27	4	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-207
29	2	Sealing plate, lower drum	315-694
30	8	Washer, flat, 5/8"	952-321
31	1	Sealing plate, Lifting lug	315-262
32	1	Rear wall stiffener	149-860
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	52	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	28	Nut, hex hd., 1/2"	869-144
42	152	Washer, flat, 3/8"	952-298
43	152	Nut, hex hd., 3/8"	869-30
44	74	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188

Note : Varies on burner



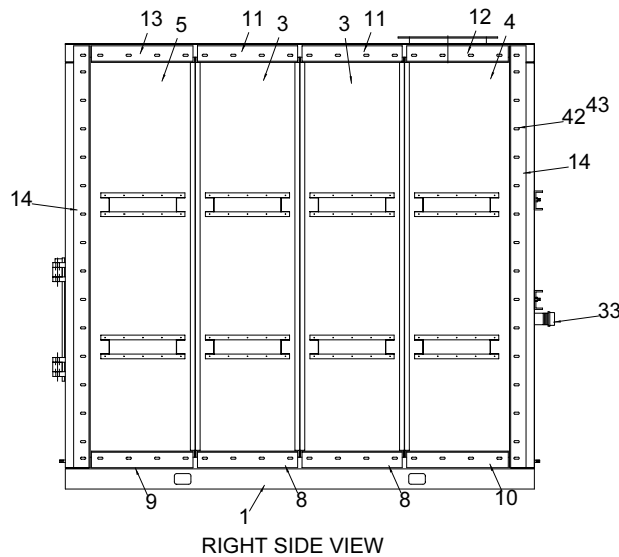
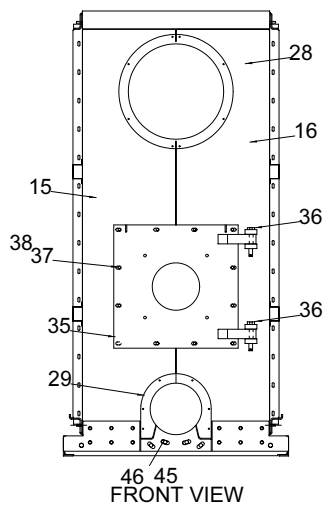
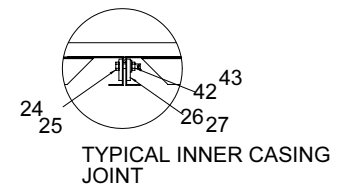
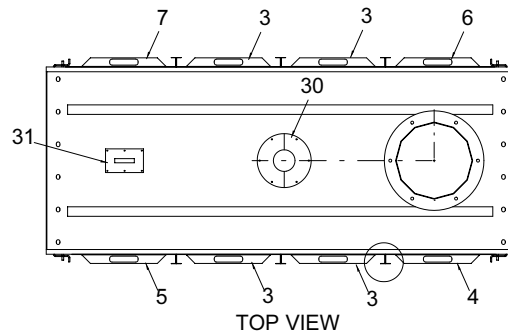
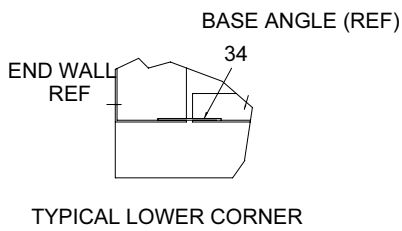
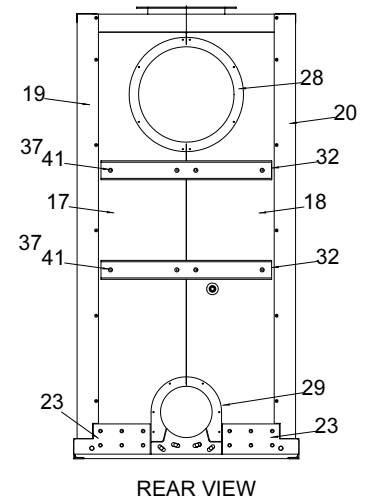
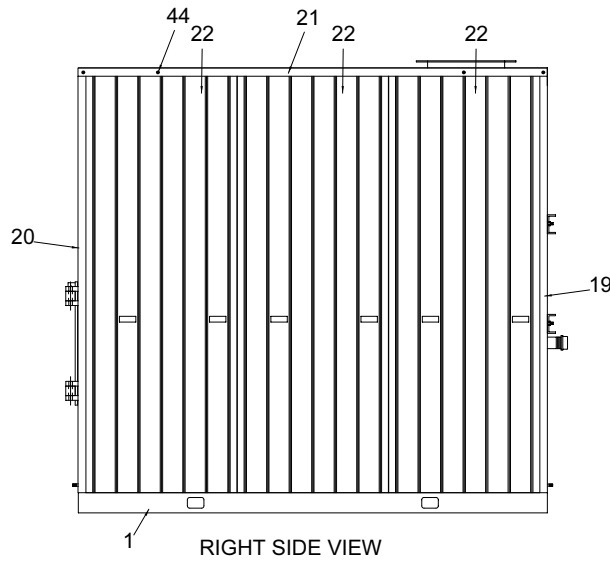
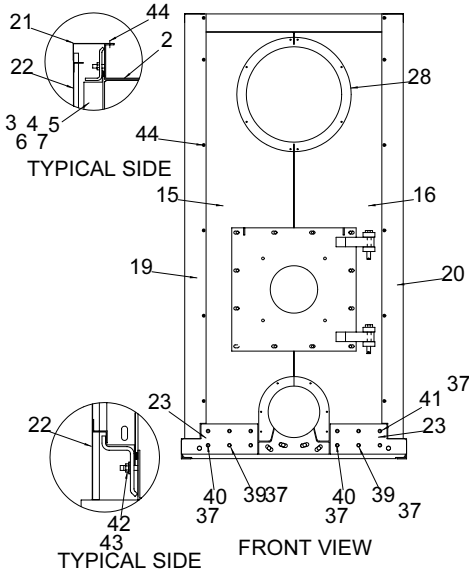
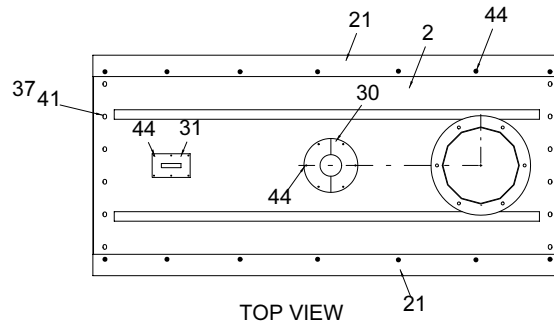
ITEM	REQ.	DESCRIPTION	350 STEAM PART NO.
1	1	Base	315-727
2	1	Roof	315-861
3	2	Inner casing - center	315-862
4	1	Inner casing - right rear	315-863
5	1	Inner casing - right front	315-864
6	1	Inner casing - left rear	315-865
7	1	Inner casing - left front	315-866
8	2	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-765
10	2	Inner casing bolt angles-lower end RR/LF	315-766
11	2	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-767
13	2	Inner casing bolt angles-upper end RF/LR	315-768
14	4	Inner casing bolt angles-end	315-867
15	1	Front wall-left	315-868
16	1	Front wall-right	315-869
17	1	Rear wall-left	315-870
18	1	Rear wall-right	315-871
19	2	Outer casing strips-lf/rr corner	315-872
20	2	Outer casing strips-lr/rf corner	315-873
21	2	Outer casing strips-top	315-777
22	4	Outer casing	315-875
23	4	Plate,base to wall	315-780
24	4	Inner casing bolting strips-upper w/bolts	315-876
25	4	Inner casing bolting strips-lower w/bolts	315-756
26	4	Inner casing bolting strips-upper w/o bolts	315-877
27	4	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-209
29	2	Sealing plate, lower drum	315-694
30	1	Sealing ring, Steam outlet	315-220/518
31	1	Sealing plate, Lifting lug	315-262
32	1	Rear wall stiffener	149-860
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	52	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	28	Nut, hex hd., 1/2"	869-144
42	160	Washer, flat, 3/8"	952-298
43	160	Nut, hex hd., 3/8"	869-30
44	80	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188
46	8	Washer, flat, 5/8"	952-321



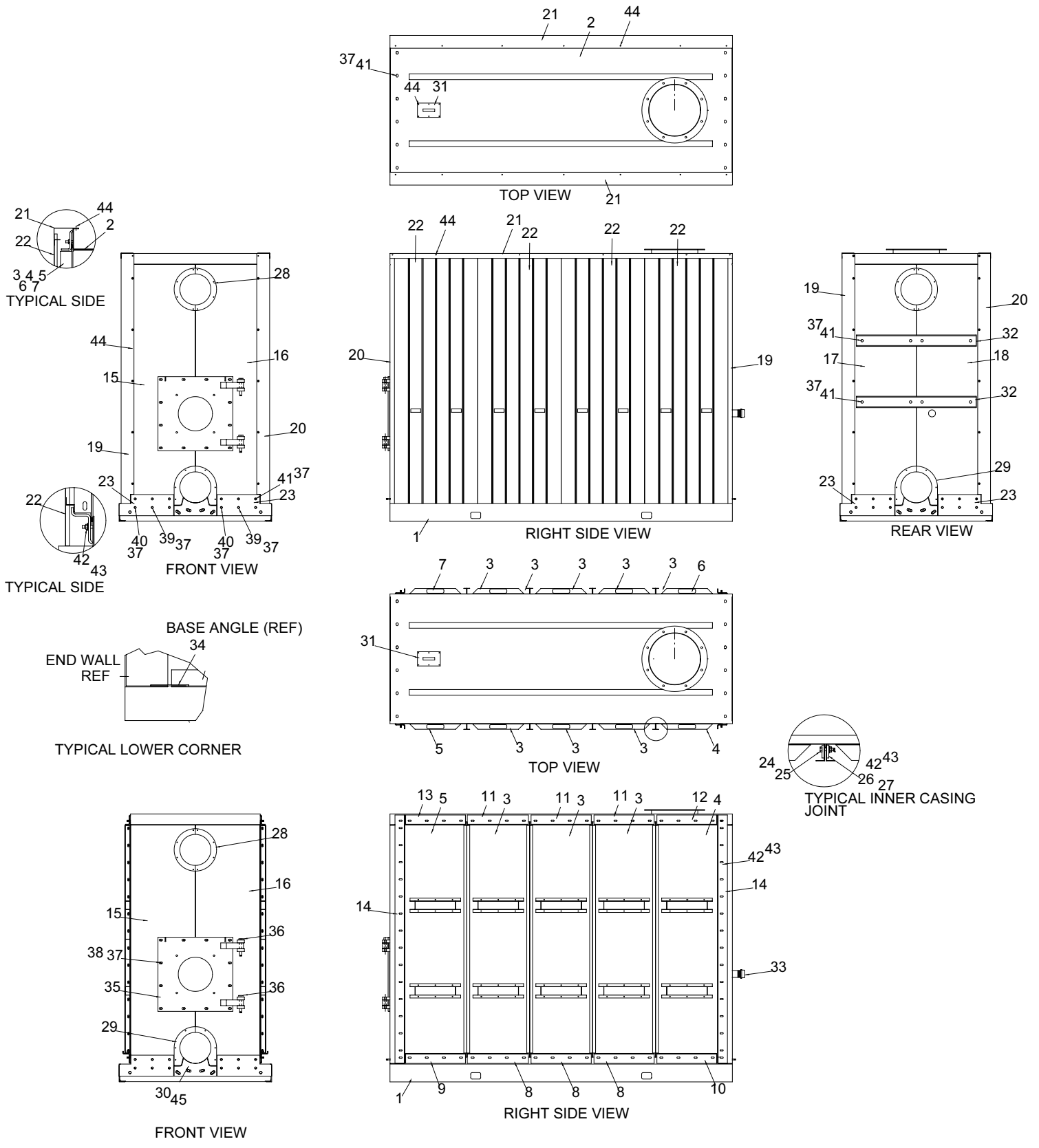
ASSEMBLY, CASING (500) H.W., FLEXTUBE

ITEM	REQ.	DESCRIPTION	500 HOT WATER PART NO.
1	1	Base	315-728
2	1	Roof	315-783
3	2	Inner casing - center	315-784
4	1	Inner casing - right rear	315-785
5	1	Inner casing - right front	315-786
6	1	Inner casing - left rear	315-787
7	1	Inner casing - left front	315-788
8	4	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-789
10	2	Inner casing bolt angles-lower end RR/LF	315-790
11	4	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-791
13	2	Inner casing bolt angles-upper end RF/LR	315-792
14	4	Inner casing bolt angles-end	315-793
15	1	Front wall-left	315-794
16	1	Front wall-right	315-795
17	1	Rear wall-left	315-796
18	1	Rear wall-right	315-797
19	2	Outer casing strips-lf/rr corner	315-798
20	2	Outer casing strips-lr/rf corner	315-799
21	2	Outer casing strips-top	315-801
22	6	Outer casing	315-802
23	4	Plate,base to wall	315-780
24	6	Inner casing bolting strips-upper w/bolts	315-804
25	6	Inner casing bolting strips-lower w/bolts	315-756
26	6	Inner casing bolting strips-upper w/o bolts	315-805
27	6	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-208
29	2	Sealing plate, lower drum	315-695
30	8	Washer, flat, 5/8"	952-321
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-861
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	202	Washer, flat, 3/8"	952-298
43	202	Nut, hex hd., 3/8"	869-30
44	82	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188

Note : Varies on burner



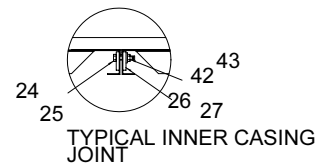
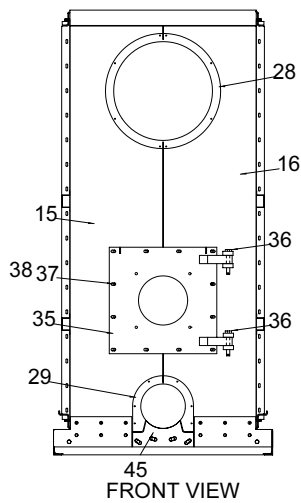
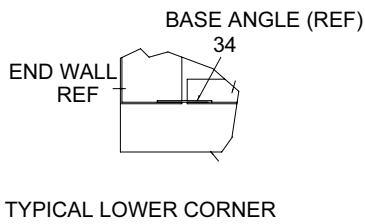
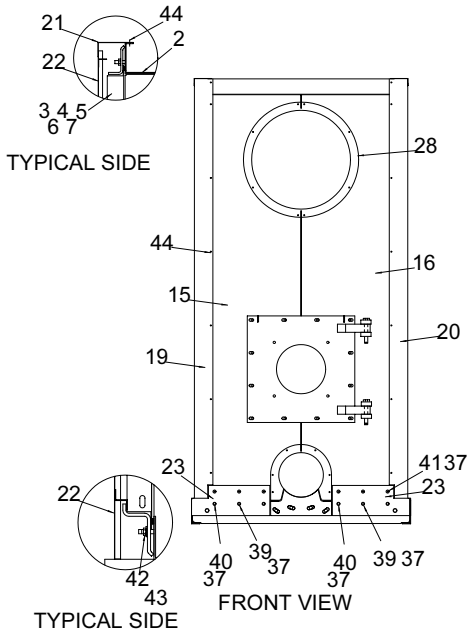
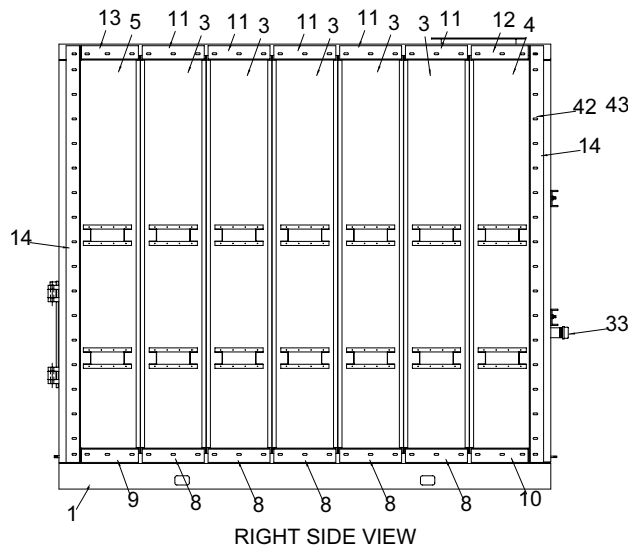
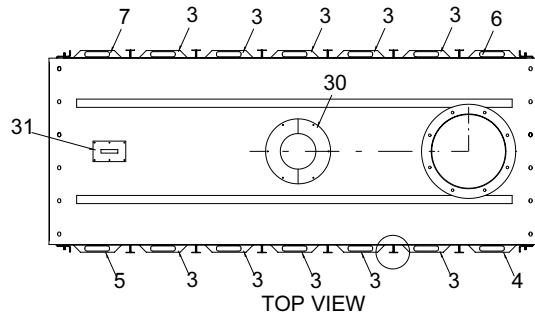
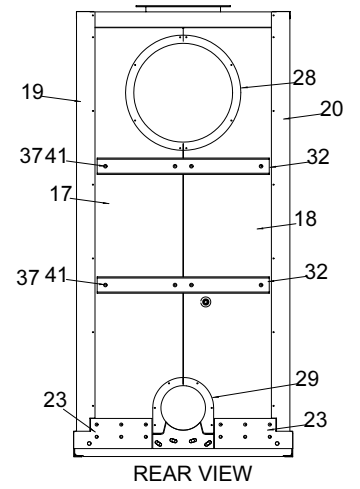
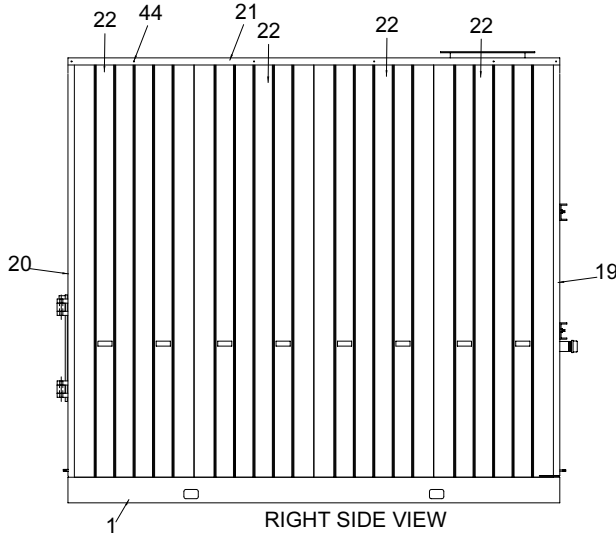
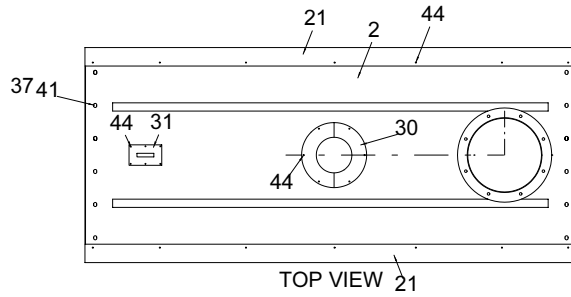
ITEM	REQ.	DESCRIPTION	500 STEAM PART NO.
1	1	Base	315-728
2	1	Roof	315-878
3	4	Inner casing - center	315-879
4	1	Inner casing - right rear	315-880
5	1	Inner casing - right front	315-881
6	1	Inner casing - left rear	315-882
7	1	Inner casing - left front	315-883
8	4	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-789
10	2	Inner casing bolt angles-lower end RR/LF	315-790
11	4	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-791
13	2	Inner casing bolt angles-upper end RF/LR	315-792
14	4	Inner casing bolt angles-end	315-884
15	1	Front wall-left	315-885
16	1	Front wall-right	315-886
17	1	Rear wall-left	315-887
18	1	Rear wall-right	315-888
19	2	Outer casing strips-lf/rr corner	315-889
20	2	Outer casing strips-lr/rf corner	315-890
21	2	Outer casing strips-top	315-801
22	6	Outer casing	315-892
23	4	Plate,base to wall	315-780
24	6	Inner casing bolting strips-upper w/bolts	315-893
25	6	Inner casing bolting strips-lower w/bolts	315-756
26	6	Inner casing bolting strips-upper w/o bolts	315-894
27	6	Inner casing bolting strips-lower w/o bolts	315-758
28	2	Sealing plate, upper drum	315-209
29	2	Sealing plate, lower drum	315-695
30	1	Sealing ring, Steam outlet	315-221/519
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-861
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	212	Washer, flat, 3/8"	952-298
43	212	Nut, hex hd., 3/8"	869-30
44	88	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188
46	8	Washer, flat, 5/8"	952-321



ASSEMBLY, CASING (800) H.W., FLEXTUBE

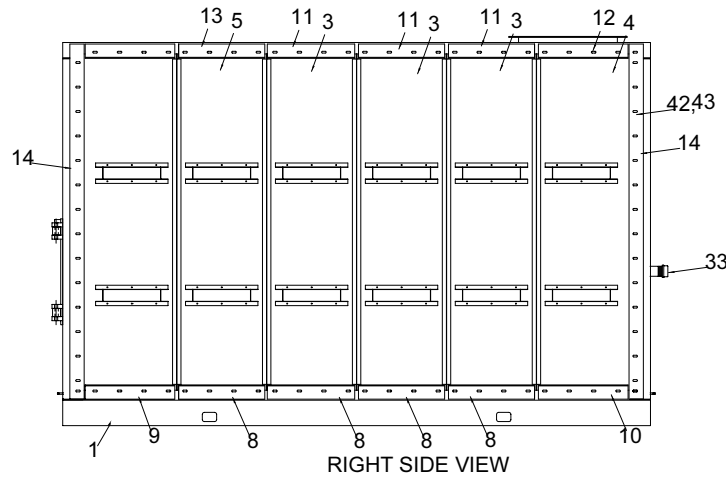
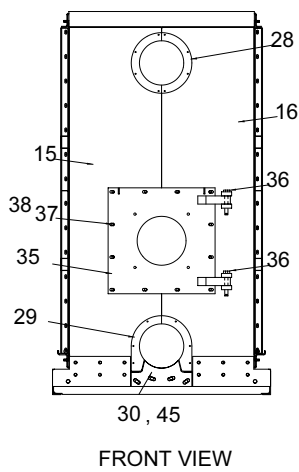
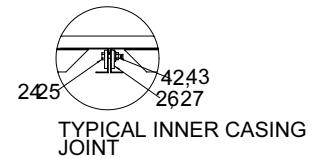
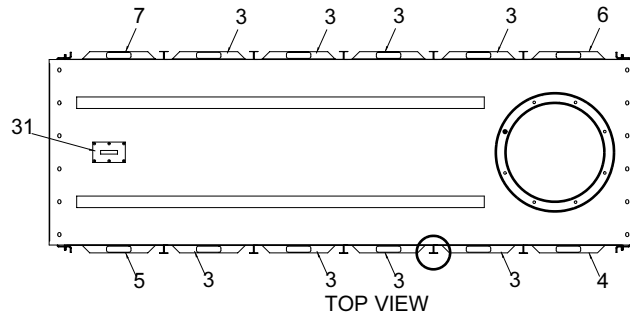
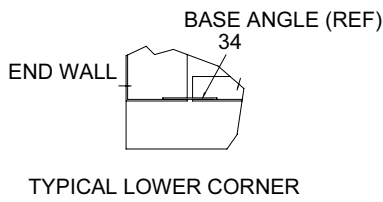
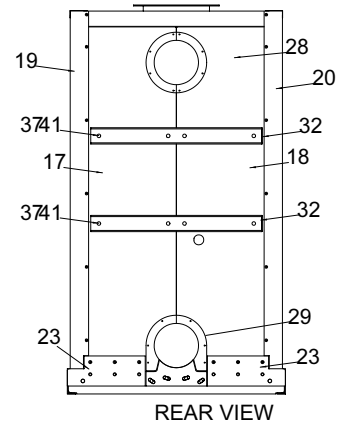
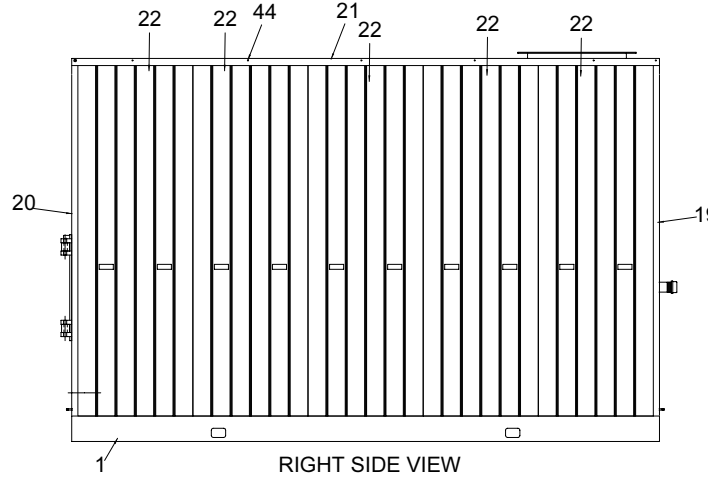
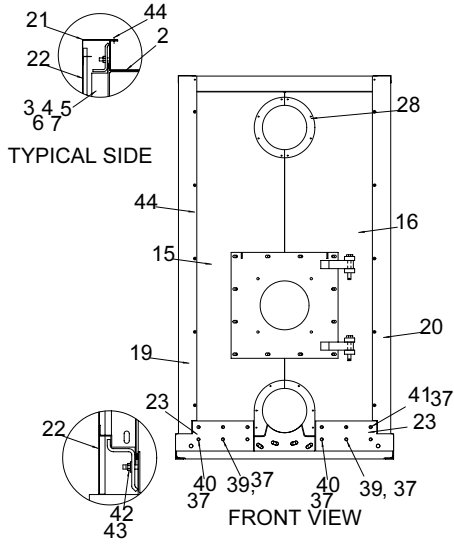
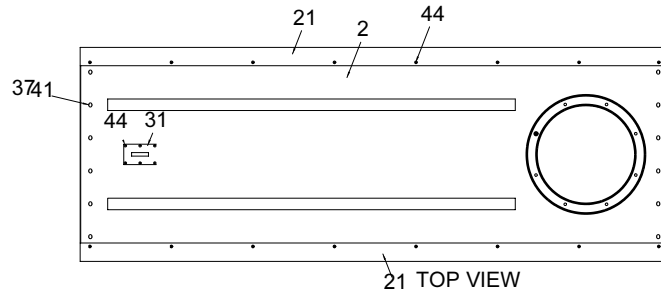
ITEM	REQ.	DESCRIPTION	800 HOT WATER PART NO.
1	1	Base	315-729
2	1	Roof	315-806
3	2	Inner casing - center	315-807
4	1	Inner casing - right rear	315-808
5	1	Inner casing - right front	315-809
6	1	Inner casing - left rear	315-810
7	1	Inner casing - left front	315-811
8	6	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-812
10	2	Inner casing bolt angles-lower end RR/LF	315-813
11	6	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-814
13	2	Inner casing bolt angles-upper end RF/LR	315-815
14	4	Inner casing bolt angles-end	315-816
15	1	Front wall-left	315-817
16	1	Front wall-right	315-818
17	1	Rear wall-left	315-819
18	1	Rear wall-right	315-820
19	2	Outer casing strips-lf/rr corner	315-821
20	2	Outer casing strips-lr/rf corner	315-822
21	2	Outer casing strips-top	315-824
22	8	Outer casing	315-825
23	4	Plate,base to wall	315-827
24	8	Inner casing bolting strips-upper w/bolts	315-828
25	8	Inner casing bolting strips-lower w/bolts	315-829
26	8	Inner casing bolting strips-upper w/o bolts	315-830
27	8	Inner casing bolting strips-lower w/o bolts	315-831
28	2	Sealing plate, upper drum	315-208
29	2	Sealing plate, lower drum	315-695
30	8	Washer, flat, 5/8"	952-321
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-862
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	256	Washer, flat, 3/8"	952-298
43	256	Nut, hex hd., 3/8"	869-30
44	84	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188

Note : Varies on burner



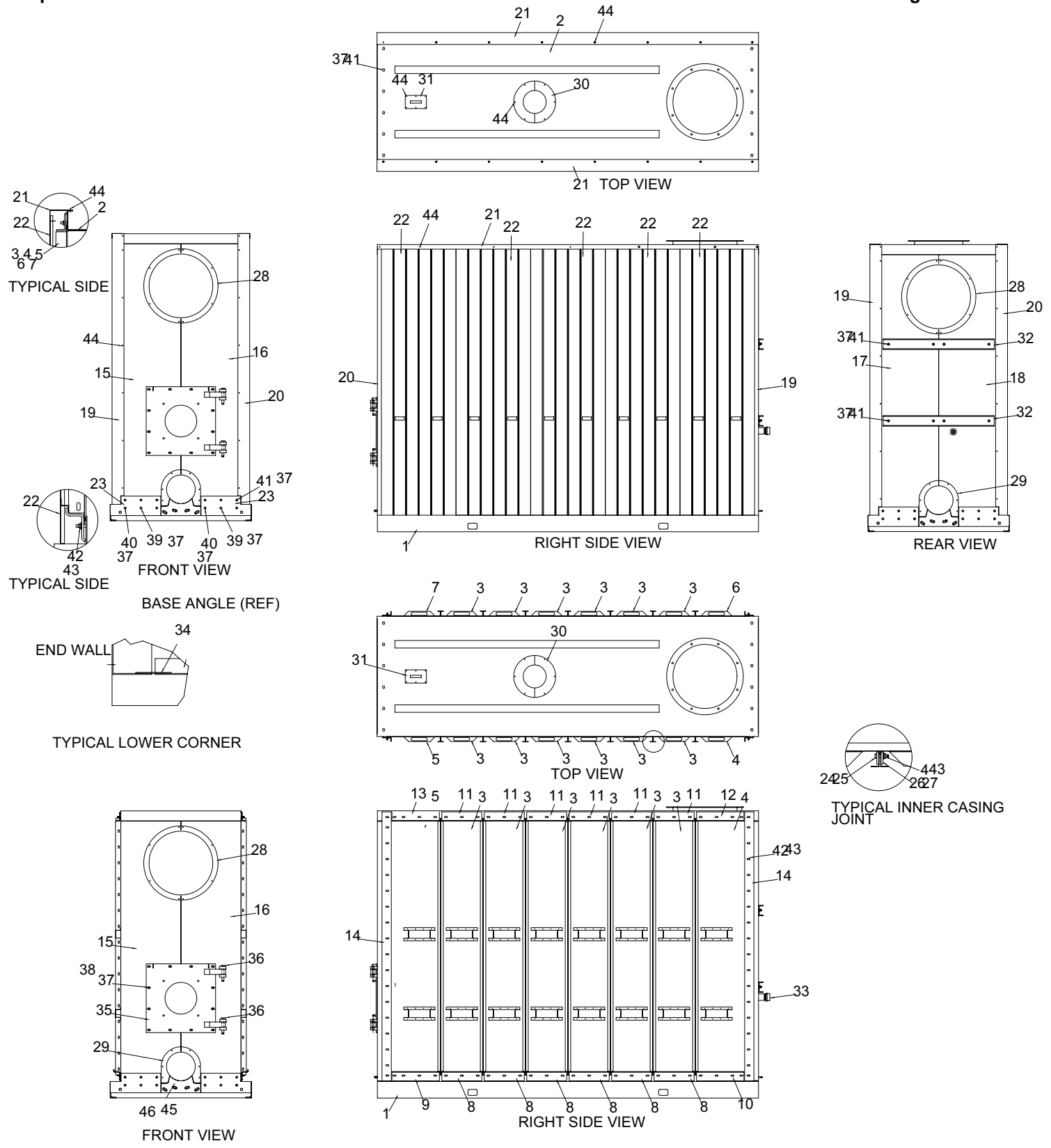
ASSEMBLY, CASING (800) STEAM, FLEXTUBE

ITEM	REQ.	DESCRIPTION	800 STEAM PART NO.
1	1	Base	315-928
2	1	Roof	315-895
3	10	Inner casing - center	315-896
4	1	Inner casing - right rear	315-897
5	1	Inner casing - right front	315-898
6	1	Inner casing - left rear	315-899
7	1	Inner casing - left front	315-900
8	10	Inner casing bolt angles-lower center	315-901
9	2	Inner casing bolt angles-lower RF/LR	315-902
10	2	Inner casing bolt angles-lower end RR/LF	315-903
11	10	Inner casing bolt angles-upper center	315-904
12	2	Inner casing bolt angles-upper end RR/LF	315-905
13	2	Inner casing bolt angles-upper end RF/LR	315-906
14	4	Inner casing bolt angles-end	315-907
15	1	Front wall-left	315-908
16	1	Front wall-right	315-909
17	1	Rear wall-left	315-910
18	1	Rear wall-right	315-911
19	2	Outer casing strips-lf/rr corner	315-912
20	2	Outer casing strips-lr/rf corner	315-913
21	2	Outer casing strips-top	315-938
22	8	Outer casing	315-915
23	4	Plate,base to wall	315-827
24	12	Inner casing bolting strips-upper w/bolts	315-916
25	12	Inner casing bolting strips-lower w/bolts	315-829
26	12	Inner casing bolting strips-upper w/o bolts	315-917
27	12	Inner casing bolting strips-lower w/o bolts	315-831
28	2	Sealing plate, upper drum	315-210
29	2	Sealing plate, lower drum	315-695
30	1	Sealing ring, Steam outlet	315-222/550
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-862
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	348	Washer, flat, 3/8"	952-298
43	348	Nut, hex hd., 3/8"	869-30
44	94	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188
46	8	Washer, flat, 5/8"	952-321



ASSEMBLY, CASING (1100) H.W., FLEXTUBE

ITEM	REQ.	DESCRIPTION	1100 HOT WATER PART NO.
1	1	Base	315-730
2	1	Roof	315-832
3	8	Inner casing - center	315-807
4	1	Inner casing - right rear	315-833
5	1	Inner casing - right front	315-834
6	1	Inner casing - left rear	315-835
7	1	Inner casing - left front	315-836
8	8	Inner casing bolt angles-lower center	315-737
9	2	Inner casing bolt angles-lower RF/LR	315-837
10	2	Inner casing bolt angles-lower end RR/LF	315-838
11	8	Inner casing bolt angles-upper center	315-740
12	2	Inner casing bolt angles-upper end RR/LF	315-839
13	2	Inner casing bolt angles-upper end RF/LR	315-840
14	4	Inner casing bolt angles-end	315-816
15	1	Front wall-left	315-817
16	1	Front wall-right	315-818
17	1	Rear wall-left	315-819
18	1	Rear wall-right	315-820
19	2	Outer casing strips-lf/rr corner	315-821
20	2	Outer casing strips-lr/rf corner	315-822
21	2	Outer casing strips-top	315-841
22	10	Outer casing	315-842
23	4	Plate,base to wall	315-827
24	10	Inner casing bolting strips-upper w/bolts	315-828
25	10	Inner casing bolting strips-lower w/bolts	315-829
26	10	Inner casing bolting strips-upper w/o bolts	315-830
27	10	Inner casing bolting strips-lower w/o bolts	315-831
28	2	Sealing plate, upper drum	315-208
29	2	Sealing plate, lower drum	315-695
30	8	Washer, flat, 5/8"	952-321
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-862
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	300	Washer, flat, 3/8"	952-298
43	300	Nut, hex hd., 3/8"	869-30
44	88	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188



ASSEMBLY, CASING (1100) STEAM, FLEXTUBE

ITEM	REQ.	DESCRIPTION	1100 STEAM PART NO.
1	1	Base	315-929
2	1	Roof	315-918
3	12	Inner casing - center	315-896
4	1	Inner casing - right rear	315-919
5	1	Inner casing - right front	315-920
6	1	Inner casing - left rear	315-921
7	1	Inner casing - left front	315-922
8	12	Inner casing bolt angles-lower center	315-901
9	2	Inner casing bolt angles-lower RF/LR	315-923
10	2	Inner casing bolt angles-lower end RR/LF	315-924
11	12	Inner casing bolt angles-upper center	315-904
12	2	Inner casing bolt angles-upper end RR/LF	315-925
13	2	Inner casing bolt angles-upper end RF/LR	315-926
14	4	Inner casing bolt angles-end	315-907
15	1	Front wall-left	315-908
16	1	Front wall-right	315-909
17	1	Rear wall-left	315-910
18	1	Rear wall-right	315-911
19	2	Outer casing strips-lf/rr corner	315-912
20	2	Outer casing strips-lr/rf corner	315-913
21	2	Outer casing strips-top	315-939
22	10	Outer casing	315-927
23	4	Plate,base to wall	315-827
24	14	Inner casing bolting strips-upper w/bolts	315-916
25	14	Inner casing bolting strips-lower w/bolts	315-829
26	14	Inner casing bolting strips-upper w/o bolts	315-917
27	14	Inner casing bolting strips-lower w/o bolts	315-831
28	2	Sealing plate, upper drum	315-210
29	2	Sealing plate, lower drum	315-695
30	1	Sealing ring, Steam outlet	315-575/221
31	1	Sealing plate, Lifting lug	315-262
32	2	Rear wall stiffener	149-862
33	1	Cap, sight	550-42
34	4	Sealing plate	125-304
35	1	Burner plate	See Notes
36	2	Capscrew, hex hd. 3/4" - 10 x 6" lg	868-600
37	56	Washer, flat, 1/2"	952-286
38	12	Nut, hex hd., 1/2" brass	869-27
39	4	Capscrew, hex hd. 1/2" - 13 x 4" lg	868-182
40	8	Capscrew, hex hd. 1/2" - 13 x 1-1/2" lg	868-102
41	32	Nut, hex hd., 1/2"	869-144
42	400	Washer, flat, 3/8"	952-298
43	400	Nut, hex hd., 3/8"	869-30
44	98	Screw,self tapping, 1/4" x 1" lg	841-423
45	8	Capscrew, hex hd. 5/8" - 11 x 1-1/2" lg	868-188
46	8	Washer, flat, 5/8"	952-321

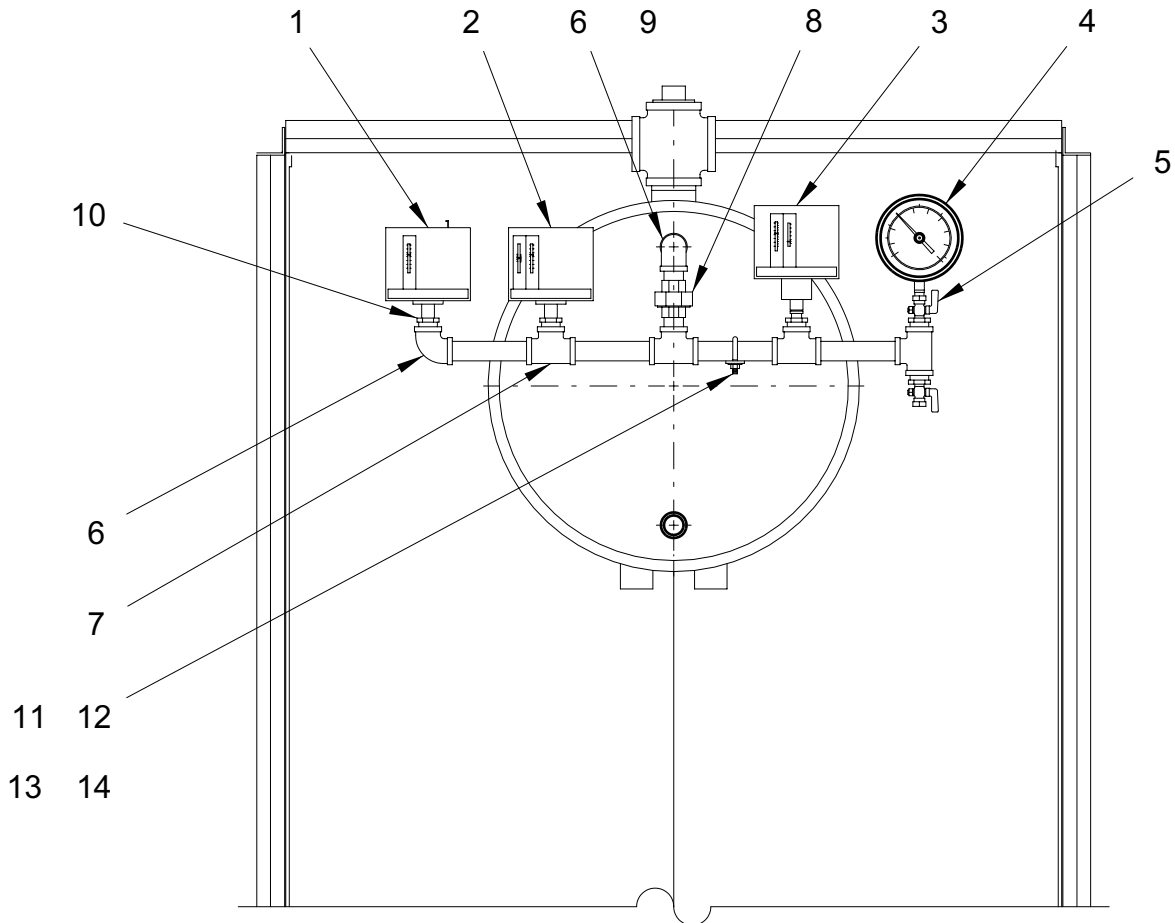
Notes

CHAPTER 9

Section 3: Controls

Pressure Controls	9-38
Level Controls	9-39
Water Column 15# Steam	9-41
Water Column 150# Steam	9-43

ITEM	QTY	15#	150#	DESCRIPTION
1	1	817-415	817-109	CONTROL, PRESSURE,HIGH LIMIT MANUAL RESET
2	1	817-16	817-110	CONTROL, PRESSURE, OPERATING AUTO RESET
3	1	817-229	817-244	CONTROL, PRESSURE, MODULATING
4	1	850-243	850-122	GAUGE, PRESSURE
5	2	825-31	825-31	COCK, 1/4"
6	2	859-81	859-81	ELBOW, 3/4"
7	3	859-25	859-25	TEE, 3/4"
8	1	858-165	858-165	UNION, 3/4"
9		-	-	-
10	5	847-464	847-464	BUSHING, REDUCING, 3/4" TO 1/4"
11	1	8-3183	8-3183	BRACKET, PRESSURETROLS
12	1	841-1120	841-1120	U-BOLT, 3/4" PIPE
13	1	952-294	952-294	WASHER, FLAT, 1/4"
14	1	869-234	869-234	NUT, HEX., 1/4"

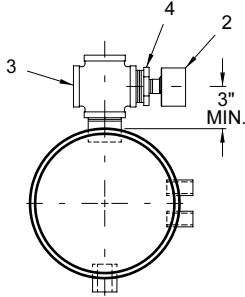


FRONT VIEW
INSTALL, PIPING & CONTROLS
PRESSURE (STEAM), FLX.

Controls

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817-2349	LOW WATER CUTOFF, MCM&M 750-T-120, AR
	1	817-2305	LOW WATER CUTOFF, MCM&M 750-MT-120, MR
2	1	817-2351	PROBE, REMOTE, MCM&M RS-1-LP
3	1	859-267	CROSS, 2"
4	1	847-440	BUSHING, REDUCING, 2" X 3/4"

MAXIMUM DESIGN PRESSURE - 160 P.S.I. H.W.



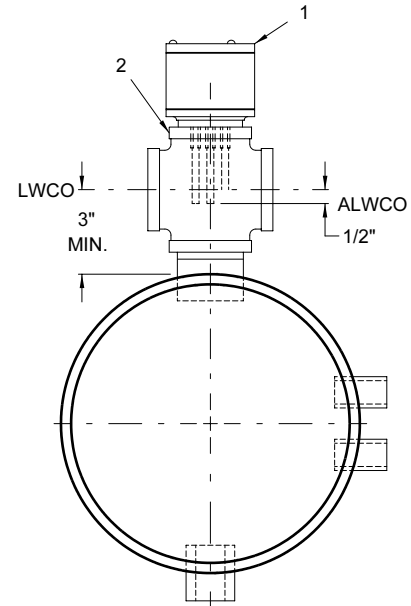
NOTES:

- 1.) DO NOT ATTACH ANY ROD FOR PROBE LENGTH TO ITEM #2.
- 2.) INSURE MINIMUM CLEARANCE OF 1/4" BETWEEN PROBE END AND PIPING.

Chapter 9

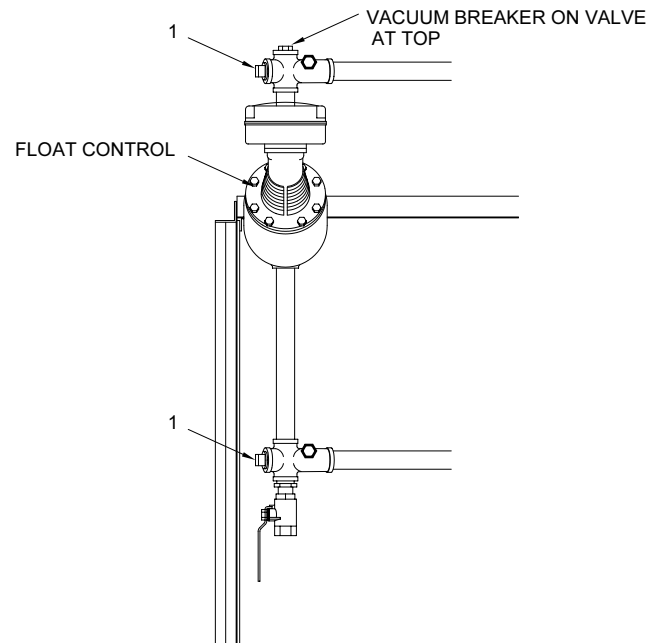
ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817-740	CONTROL, LIQUID LEVEL, WARRICK 3E2B
	1	817-1020	CONTROL, LIQUID LEVEL, WARRICK 3E3B
2	3	67-536	1/4" BRASS ROD X 4 1/8" LG.
3	1	859-267	CROSS, 2"

MAXIMUM DESIGN PRESSURE - 250 P.S.I. H.W.



ITEM	REQ.	PART NO.	DESCRIPTION
1	1	941-2223	McD-M TEST-N-CHECK VALVES #TC-4 CONSIST OF VALVES #317350 & #317353

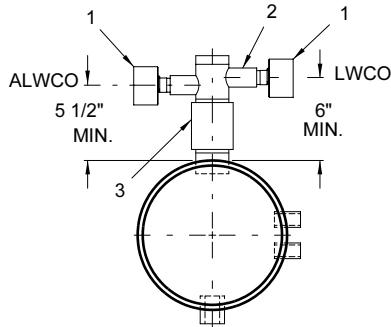
MAXIMUM DESIGN PRESSURE - 50 P.S.I. H.W.



OPTIONAL TEST-N-CHECK

ITEM	REQ.	PART NO.	DESCRIPTION
1	1	817-2351	PROBE, REMOTE, MCM&M RS-1-LP
2	1	157-1628	NIPPLE, SIDE OUTLET, 2" X 6" X 3/4"
3	1	858-56	COUPLING, FULL, 2"

MAXIMUM DESIGN PRESSURE - 160 P.S.I. H.W.



NOTES:

- 1.) DO NOT ATTACH ANY ROD FOR PROBE LENGTH TO ITEM #1.
- 2.) INSURE MINIMUM CLEARANCE OF 1/4" BETWEEN PROBE END AND PIPING.

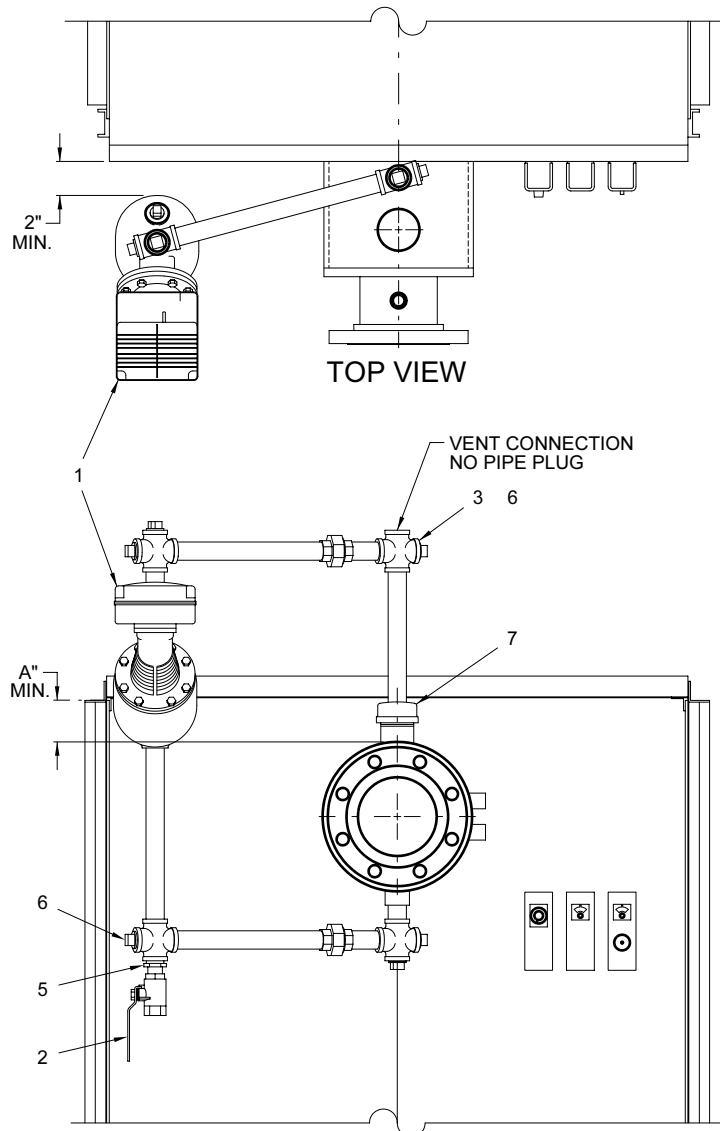
LEVEL CONTROLS HOT WATER

ITEM	PART NO.	DESCRIPTION	MAX. D.P.
1	SEE NOTE 2	McDONNELL & MILLER 63B LWCO CONTROL	50#
	SEE NOTE 2	McDONNELL & MILLER 64B LWCO CONTROL	50#
	SEE NOTE 2	McDONNELL & MILLER 150B LWCO CONTROL	150#
	SEE NOTE 2	MAGNETROL B24 LIQUID LEVEL CONTROL	250#
	SEE NOTE 2	MAGNETROL B29 LIQUID LEVEL CONTROL	250#
	SEE NOTE 2	MAGNETROL B73 LIQUID LEVEL CONTROL	250#
2	941-1790	VALVE, BALL, 3/4"	
3	859-264	CROSS, 1"	
4	858-166	UNION, FEMALE, 1"	
5	847-426	BUSHING, REDUCING, 1" TO 3/4"	
6	858-93	PLUG, 1"	
7	858-66	CAP, PIPE, 2"	

DIM. "A"	LWCO & ALWCO CONFIGURATIONS
3"	SINGLE FLOAT STYLE LWCO
3 1/2"	FLOAT STYLE LWCO & PROBE ALWCO
2 1/2"	PROBE STYLE LWCO & FLOAT STYLE ALWCO

NOTES:

- 1.) USE 1" MIN. PIPE SIZE & PLUG ALL UNUSED CROSS OPENINGS.
- 2.) FOR PART NO., SEE PROCESS SHEET.



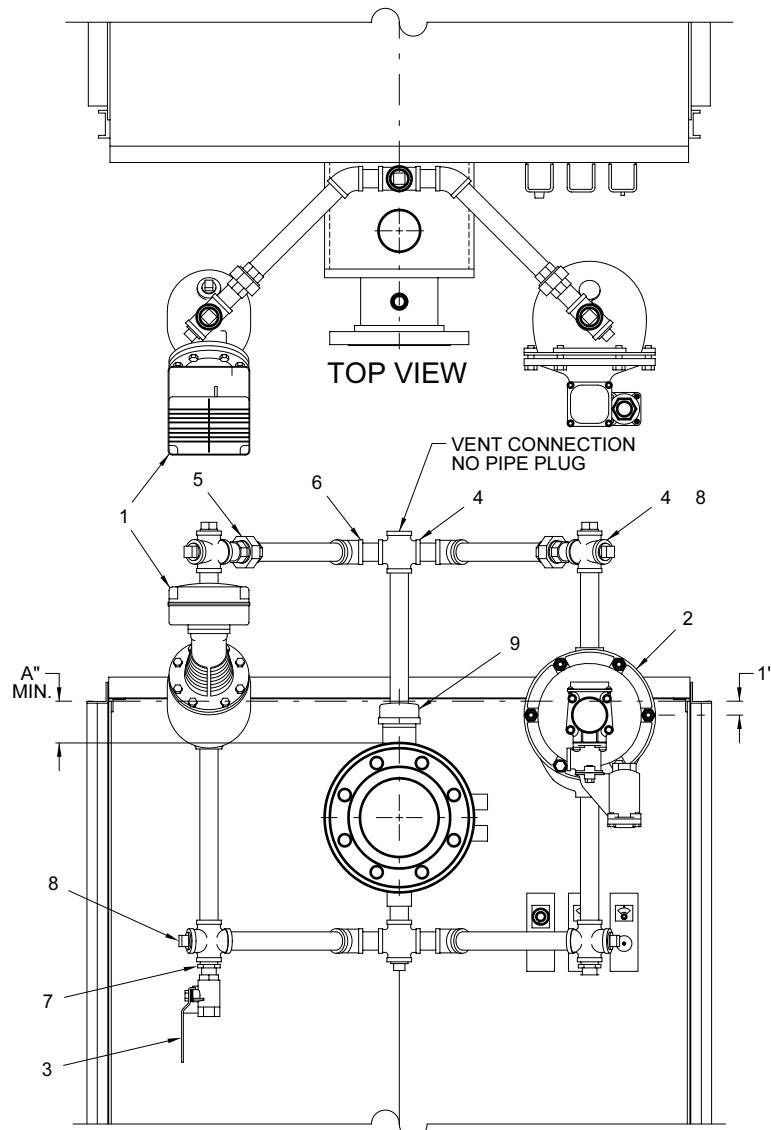
**LEVEL CONTROLS
HOT WATER**

ITEM	PART NO.	DESCRIPTION	MAX. D.P.
1	SEE NOTE #2	McDONNELL & MILLER 63B LWCO CONTROL	50#
	SEE NOTE #2	McDONNELL & MILLER 64B LWCO CONTROL	50#
	SEE NOTE #2	McDONNELL & MILLER 150B LWCO CONTROL	150#
	SEE NOTE #2	MAGNETROL B24 LIQUID LEVEL CONTROL	250#
	SEE NOTE #2	MAGNETROL B29 LIQUID LEVEL CONTROL	250#
	SEE NOTE #2	MAGNETROL B73 LIQUID LEVEL CONTROL	250#
2	SEE NOTE #2	McDONNELL & MILLER 53B WATER FEEDER	
3	941-1790	VALVE, BALL, 3/4"	
4	859-264	CROSS, 1"	
5	858-166	UNION, FEMALE, 1"	
6	859-96	ELBOW, 45°, 1"	
7	847-426	BUSHING, REDUCING, 1" TO 3/4"	
8	858-93	PLUG, 1"	
9	858-66	CAP, PIPE, 2"	

NOTES:

- 1.) USE 1" MIN. PIPE SIZE & PLUG ALL UNUSED CROSS OPENINGS.
- 2.) FOR PART NO., SEE PROCESS SHEET.

DIM. "A"	LWCO & ALWCO CONFIGURATIONS
3"	SINGLE FLOAT STYLE LWCO
3 1/2"	FLOAT STYLE LWCO & PROBE ALWCO
2 1/2"	PROBE STYLE LWCO & FLOAT STYLE ALWCO



LEVEL CONTROLS HOT WATER

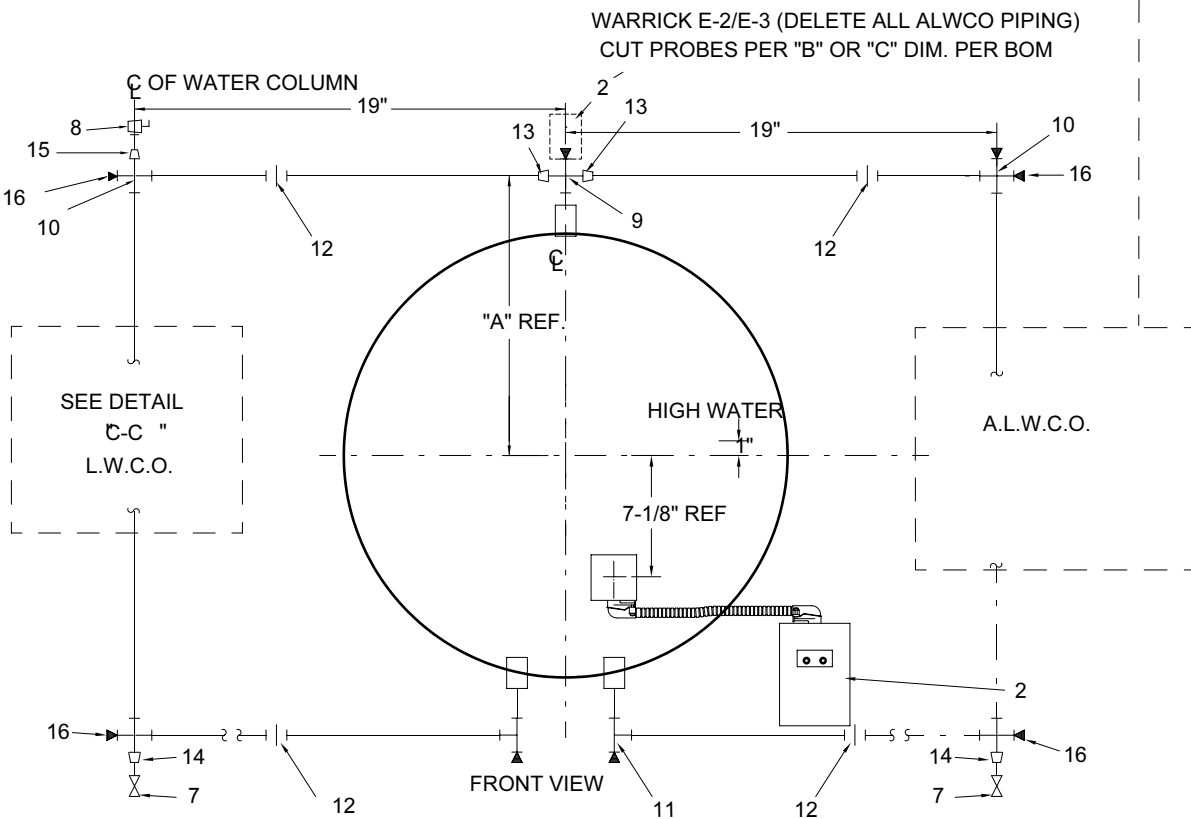
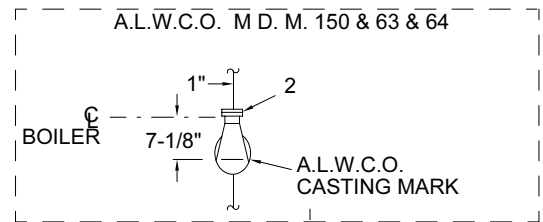
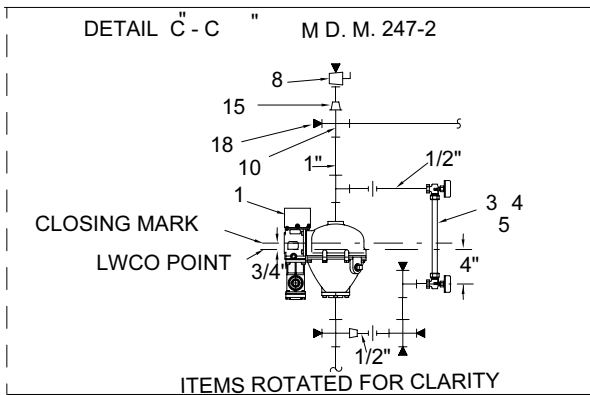
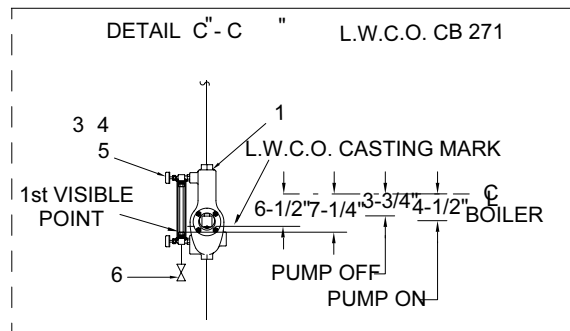
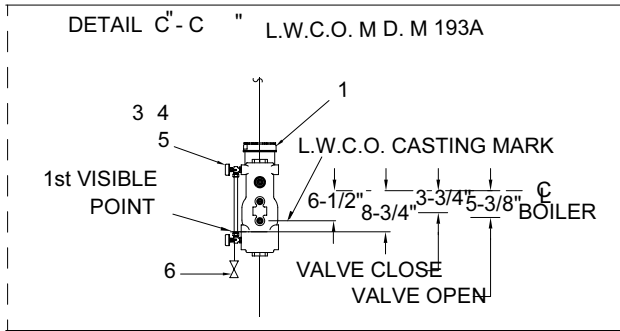
ITEM	QTY	PART NO.	DESCRIPTION	USED ON
1	1	100-271	LOW WATER CUT-OFF W/PUMP CONTROL (CB271)	STANDARD
	1	817-620	LOW WATER CUT-OFF W/FEEDVALVE CONTROL(McDM 193A)	OPTIONAL
	1	817-371	LOW WATER CUT-OFF W/FEEDER (McDM 247-2)	OPTIONAL
2	1	817-2305	McDM #750-MR CONTROL BOX	STANDARD
	1	817-2351	PROBE FOR McDM #750	
	1	817-740	AUX. LOW WATER CUT-OFF (WARRICK E2) * *	OPTIONAL
	2	067-868	PROBES FOR WARRICK (TRIM PER "B" DIM.)	
	1	817-1020	AUX. LWCO (WARRICK E3 W/HIGH ALARM) * *	OPTIONAL
	3	067-868	PROBES FOR WARRICK (TRIM 2 PER "B", 1 PER "C")	
	1	817-312	AUX. LOW WATER CUT-OFF (McDM 63-BM)	OPTIONAL
	1	817-777	AUX. LOW WATER CUT-OFF (McDM 64-B) *	OPTIONAL
1	817-2407	AUX. LOW WATER CUT-OFF (McDM 150S-BM)	OPTIONAL	

- * NOTE: WHEN USING McD-M 64, WIRE AS MANUAL RESET THROUGH FLAME SAFEGAURD.
- * * NOTE: ADD APPROPRIATE WARRICK RELAYS TO BURNER CONTROL PANEL.

ITEM	QTY	PART NO.	DESCRIPTION	USED ON
3	1	825-281	SET WATER GAUGE	ALL
4	1	851-56	GAUGE, GLASS	ALL
5	2	912-51	ROD, GAUGE GLASS	ALL
6	1	941-55	VALVE, BALL 1/4"	ALL
7	1	941-1790	VALVE, BALL 3/4"	ALL
8	1	825-31	COCK, UNION, 1/4", BRASS	ALL
9	1	859-267	CROSS 2"	ALL
10	2	859-264	CROSS 1"	ALL
11	1	859-4	TEE 1"	ALL
12	2	858-166	UNION, 1" FEMALE	ALL
13	1	847-441	BUSHING, REDUCING, 2" X 1"	ALL
14	1	847-426	BUSHING, REDUCING, 1" X 3/4"	ALL
15	1	859-36	BUSHING, 1" X 1/4"	ALL
16	4	858-105	PLUG, PIPE, 1"	ALL
17	2	858-108	PLUG, PIPE, 2"	ALL

SIZE	A.L.W.C.O. PROBE LENGTHS		H.W. PROBE LENGTHS
	"A"	"B"	"C"
250	13-3/4"	22-3/8"	14-1/4"
350	13-3/4"	22-3/8"	14-1/4"
500	13-3/4"	22-3/8"	14-1/4"
800	15-3/4"	24-3/8"	16-1/4"
1100	15-3/4"	24-3/8"	16-1/4"

WATER COLUMN, MAIN & AUX FLEXTUBE, 15# STEAM



WATER COLUMN, MAIN & AUX FLEXTUBE, 15# STEAM

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ITEM	QTY	PART NO.	DESCRIPTION	USED ON VESSEL SIZE
1	1	817-2411	LOW WATER CUT-OFF W/PUMP CONTROL(McDM 157S-RD-MD)	250/350/500
	1	817-2406	LOW WATER CUT-OFF (McDM 157S-R)	800/1100
	1	817-620	LOW WATER CUT-OFF W/FEEDVALVE CONTROL(McDM 193A)	OPTIONAL
	1	817-163	LOW WATER CUT-OFF W/PUMP CONTROL (Mag. W25)	OPTIONAL
2	1	817-2305	McDM #750-MR CONTROL BOX - A.L.W.C.O.	250/350/500
	1	817-2306	McDM SENSOR HEAD, RS-1-BR-1	
	1	817-2307	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "B" LGTH)	
	1	817-2305	McDM #750-MR CONTROL BOX - A.L.W.C.O.	800/1100
	1	817-2307	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "B" LGTH)	
	1	817-2397	McDM CONTROL BOX, PCH-G-M-3 - PUMP CONTROL	
	1	817-2387	McDM SENSOR HEAD, RS-3-BR-1	
	1	817-2388	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "C" LGTH)	
	1	817-2388	PROBE FOR McDM ,P-2-SS(TRIM PER DETAIL & "D" LGTH)	
	1	100-A-402	BODY,ALWCO FLEXTUBE 800, 150#	
	1	817-740	AUX. LOW WATER CUT-OFF (WARRICK E2) *	OPTIONAL
	2	067-868	PROBES FOR WARRICK (TRIM PER "B" DIM.)	OPTIONAL
	1	817-1020	AUX. LWCO (WARRICK E3 W/HIGH ALARM) *	OPTIONAL
	3	067-868	PROBES FOR WARRICK (TRIM 2 PER "B", 1 PER "E")	OPTIONAL
1	817-97	AUX. LOW WATER CUT-OFF (McDM 150 M)	OPTIONAL	
1	817-93	AUX. LOW WATER CUT-OFF (MAG. B24)	OPTIONAL	

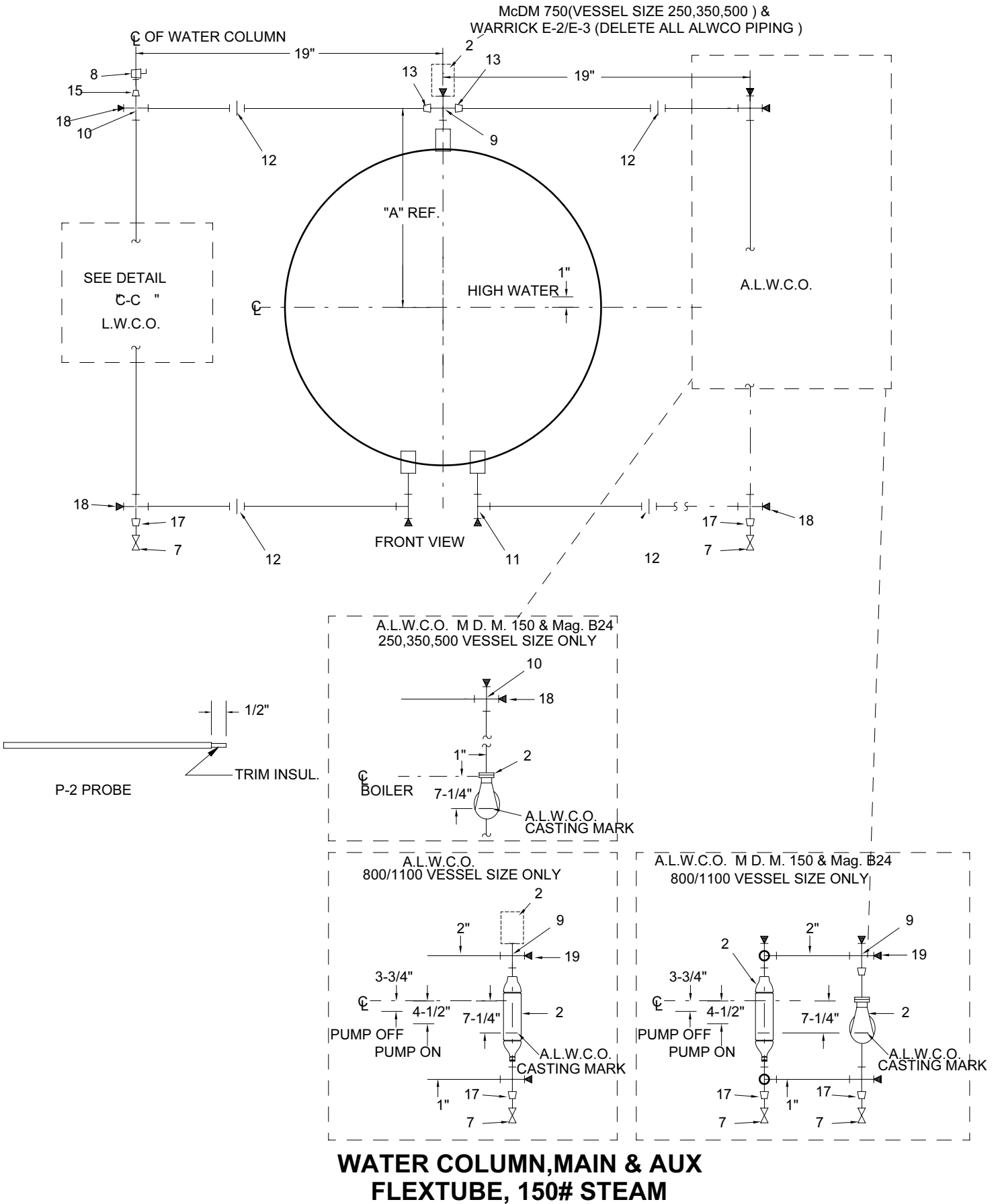
* - ADD APPROPRIATE WARRICK RELAYS TO BURNER CONTROL PANEL.

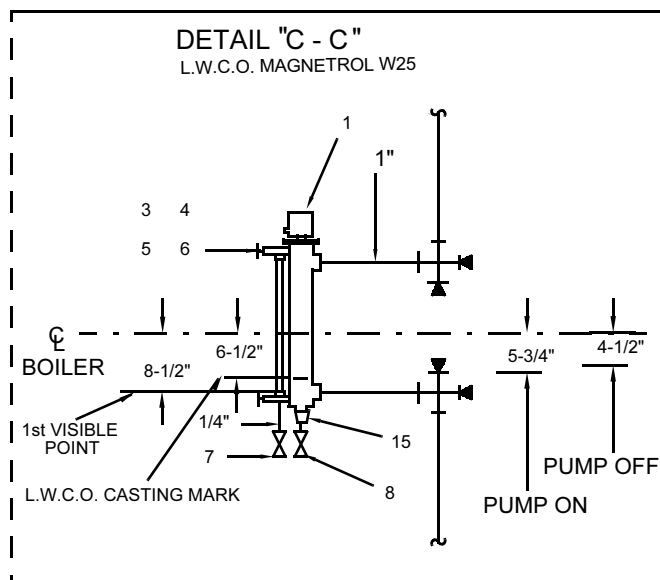
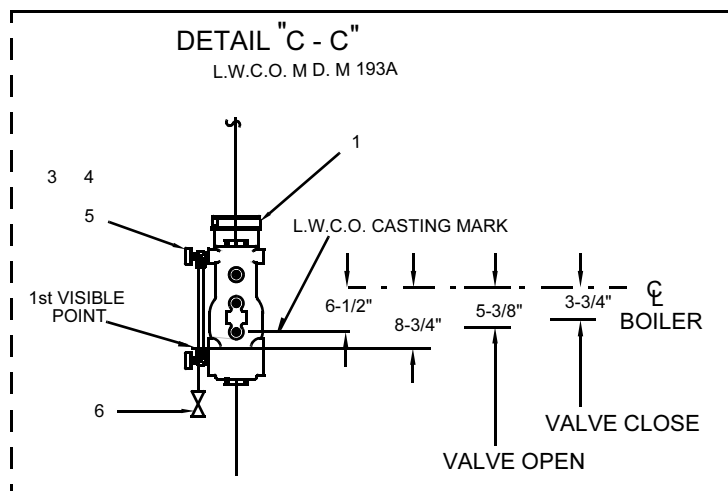
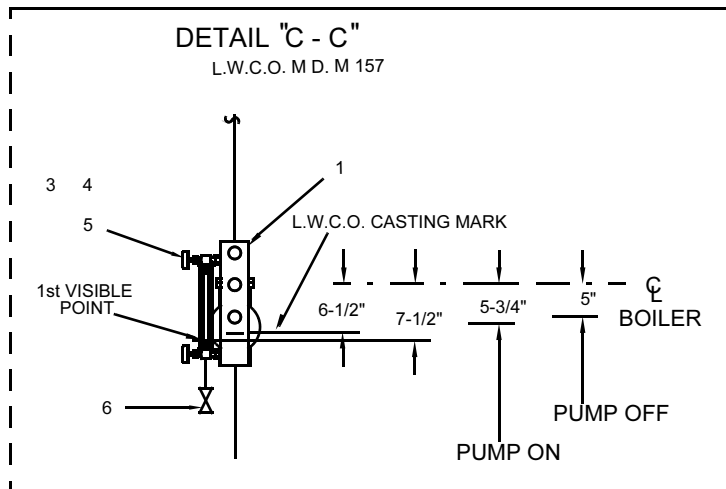
WATER COLUMN,MAIN & AUX FLEXTUBE, 150# STEAM

SIZE	PROBE LENGTHS				
	"A"	A.L.W.C.O. "B"	PUMP ON "C"	PUMP OFF "D"	H.W. "E"
250	13-3/4"	22-1/2"	-	-	14-1/4"
350	13-3/4"	22-1/2"	-	-	14-1/4"
500	13-3/4"	22-1/2"	-	-	14-1/4"
800	15-3/4"	24-1/2"	21-3/4"	21"	16-1/4"
1100	15-3/4"	24-1/2"	-	-	16-1/4"

ITEM	QTY	PART NO.	DESCRIPTION	USED ON VESSEL SIZE
3	1	825-132	SET WATER GAUGE	ALL
4	1	851-44	GAUGE, GLASS	STANDARD
	1	851-38	GAUGE, GLASS	MAG. W25
5	2	912-146	ROD, GAUGE GLASS	STANDARD
	2	912-38	ROD, GAUGE GLASS	MAG. W25
6	1	941-55	VALVE, BALL 1/4"	ALL
7	1	941-1790	VALVE, BALL 3/4"	ALL
8	1	825-31	COCK, UNION, 1/4", BRASS	ALL
9	1	859-267	CROSS 2"	250/350/500 & 1100
	2	859-267	CROSS 2"	800
10	3	859-264	CROSS 1"	250/350/500 & 1100
	2	859-264	CROSS 1"	800
11	1	859-4	TEE 1"	ALL
12	4	858-166	UNION, 1" FEMALE	ALL
13	2	847-441	BUSHING, REDUCING, 2" X 1"	ALL
	1	847-441	BUSHING, REDUCING, 2" X 1"	800
14	1	847-426	BUSHING, REDUCING, 1" X 3/4"	ALL
15	1	859-36	BUSHING, 1" X 1/4"	ALL
16	-	858-105	PLUG, PIPE, 1"	ALL
17	-	858-108	PLUG, PIPE, 2"	ALL

**WATER COLUMN, MAIN & AUX
FLEXTUBE, 150# STEAM**





**WATER COLUMN, MAIN & AUX
FLEXTUBE, 150# STEAM**

NOTES



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