

\$25.00 U.S

# **CLEAVER-BROOKS**

## ***ProFire™ Burner***

### **Operation, Maintenance, and Parts Manual**

#### **Addendum to:**

- **FLX Hot Water and Steam Boiler  
Operating Manual (750-145)**
- **FLX Hot Water and Steam Boiler  
Installation Manual (750-154)**
- **FLE Erectable Hot Water or Steam  
Boiler Assembly Instructions  
(750-155)**

## 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 heed 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. When setting up or operating the ProFire burner, be sure to reference the applicable flame safeguard control manual.

The following symbols are used throughout this manual:



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



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

### NOTICE

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 <sub>2</sub> O	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LE	Low Emission
LWCO	Low-Water Cut-Off
MM	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
UL	Underwriter's Laboratories
V	Volt
WC	Water Column
WSI	Watts Per Square Inch

# **CLEAVER-BROOKS**

## **ProFire™ Burner**

**Operation, Maintenance, and Parts Manual**  
**for**  
**Burners 1.5 to 9.0 MMBtu/hr**

**Fuel: Oil, Gas, or Combination**



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



**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.

The operation of this equipment by the owner and his 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

## Description

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 TO INSTALLER:** 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 FLX boilers.

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

This manual 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. The manual should be used in conjunction with the applicable boiler Operating and Maintenance manual.

### B. BURNER

The ProFire Burner is designed to operate with natural gas or light oil at input rates from 1.5 to 9.0 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:

GL(L) - W - X - Y - Z

Where:

GL (or GP) designates the burner orientation; either blower housing down (GP) or blower housing up (GL). The presence of the (L) suffix denotes inclusion of IFGR low NOx equipment.

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

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

Y designates burner capacity (MMBtu/hr).

Z designates the insurance underwriter.

For Example:

GL - 700 - 2 - 3.5 - IRI

indicates a blower housing “up” 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 (#1 & #2), as defined by ASTM D396 - 1978 specification.



**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.**

Burner Input (MMBtu's)		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	7.00	8.00	9.00
Gas Firing (1)	Dry scfh	16310	21750	27180	32620	38060	43500	48930	54370	59810	65240	76120	87000	97870
	Dry lb/hr	1248	1664	2080	2496	2912	3327	3743	4159	4575	4991	5823	6655	7487
Oil Firing (2)	Dry scfh	16680	22240	27800	33370	38930	44490	50050	55610	61170	66730	77860	98980	100100
	Dry lb/hr	1276	1702	2127	2553	2978	3403	3829	4254	4680	5105	5956	6807	7658

NOTES:

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

**Table 1-1. Combustion Air Flow Requirements**

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

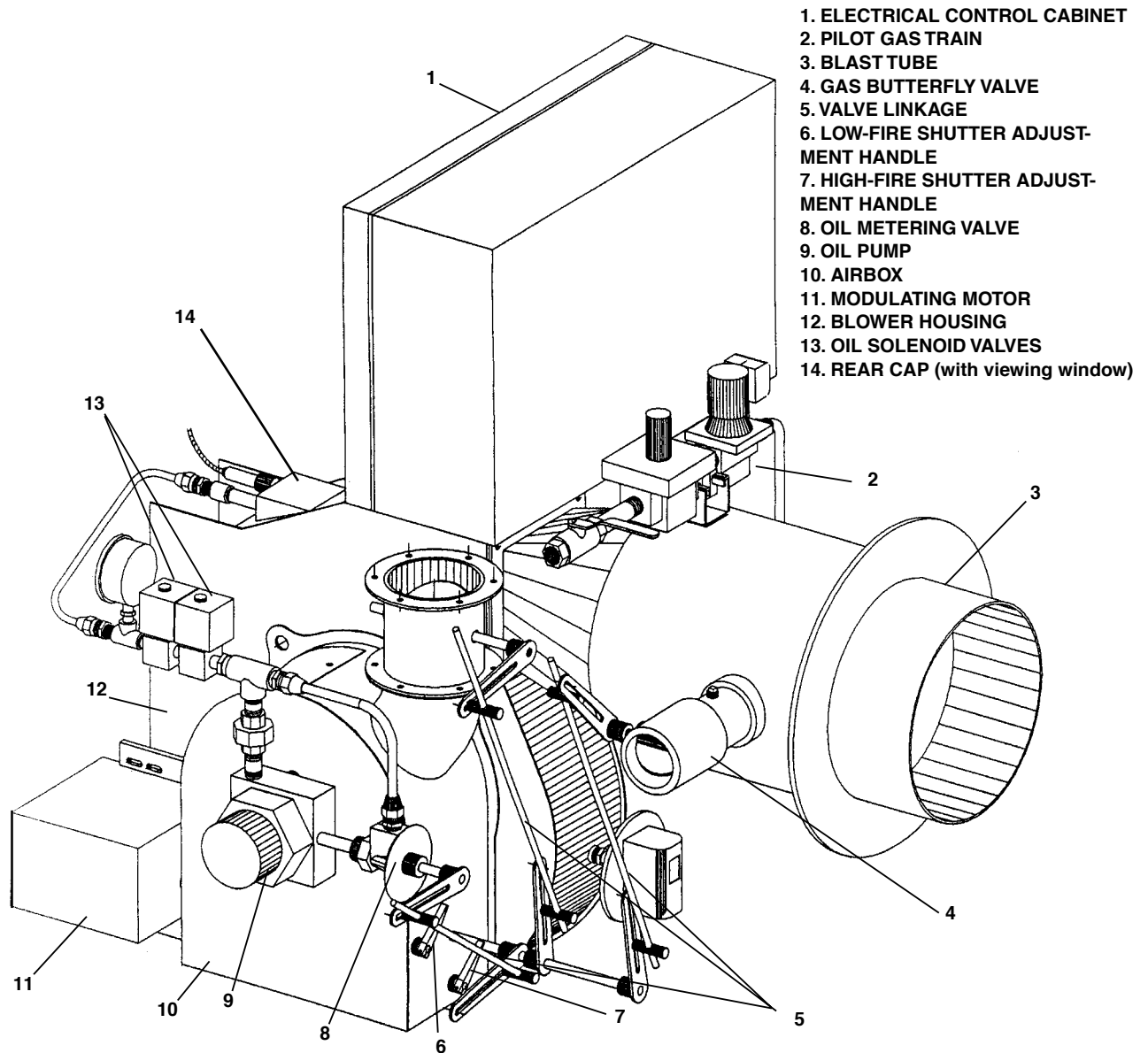
### D. CONTROLS AND COMPONENTS

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 1-1 and 1-2 for component locations. The following list describes components and basic functions of the burner.

1. Electrical Control Cabinet (Figure 1-1). The control cabinet houses many of the electrical control components and the flame safeguard. The operator control switches and indicator lights are located on the face of the control cabinet door (Figure 1-3). 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 be-

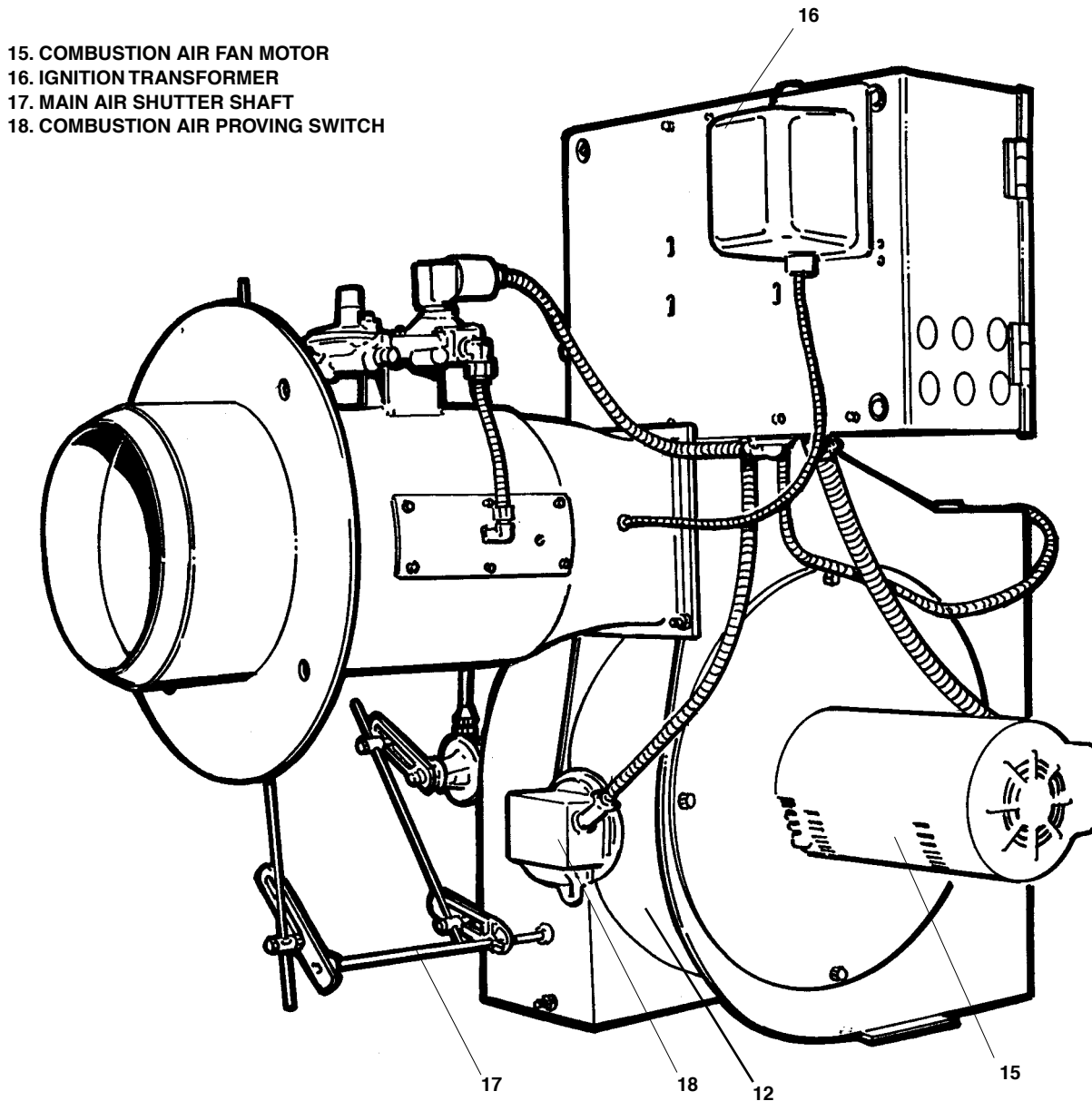
tween low-fire and high-fire operation.

- 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.
  - Fuel Selection Switch: Allows the operator to select either gas or oil as the active fuel on combination burners. (The switch is located inside the control cabinet.)
2. Pilot Gas Train (Figure 1-1). 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.
  3. Blast Tube (Figure 1-1). The blast tube functions as a duct for combustion air, and houses the fuel nozzle(s), gas pilot assembly, diffuser, and air baffle assemblies.
  4. Gas Butterfly Valve (Figure 1-1). 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.
  5. Valve Linkage (Figure 1-1). 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.



**Figure 1-1. ProFire Burner Combustion System**

- 6. Low-Fire Shutter (Figure 1-1). 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.
- 7. High-Fire Shutter (Figure 1-1). 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.
- 8. Oil Metering Valve (Figure 1-1). 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.
- 9. Oil Pump (Figure 1-1). The oil pump provided for oil burning is coupled to an extension of the combustion air fan shaft.
- 10. Airbox (Figure 1-1). 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.
- 11. Modulating Motor (Figure 1-1). The modulating motor is coupled to the jack shaft that operates the main air shutter



**Figure 1-2. ProFire Burner Combustion Air Motor Side**

- and the fuel valve linkages. The modulating motor produces the torque and rotary positioning required for firing rate control.
12. Blower Housing (Figure 1-1 & 1-2). The blower housing encloses the impeller. The fan drive motor is mounted directly to the blower housing.
13. Oil Solenoid Valves (Figure 1-1). 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.
14. Rear Cap (Figure 1-1). 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.
15. Combustion Air Fan Motor (Figure 1-2). The electric motor drives the combustion air fan and the oil pump (if so equipped).
16. Ignition Transformer (Figure 1-2). The ignition transformer produces the high voltage required for spark generation by the pilot electrode(s).

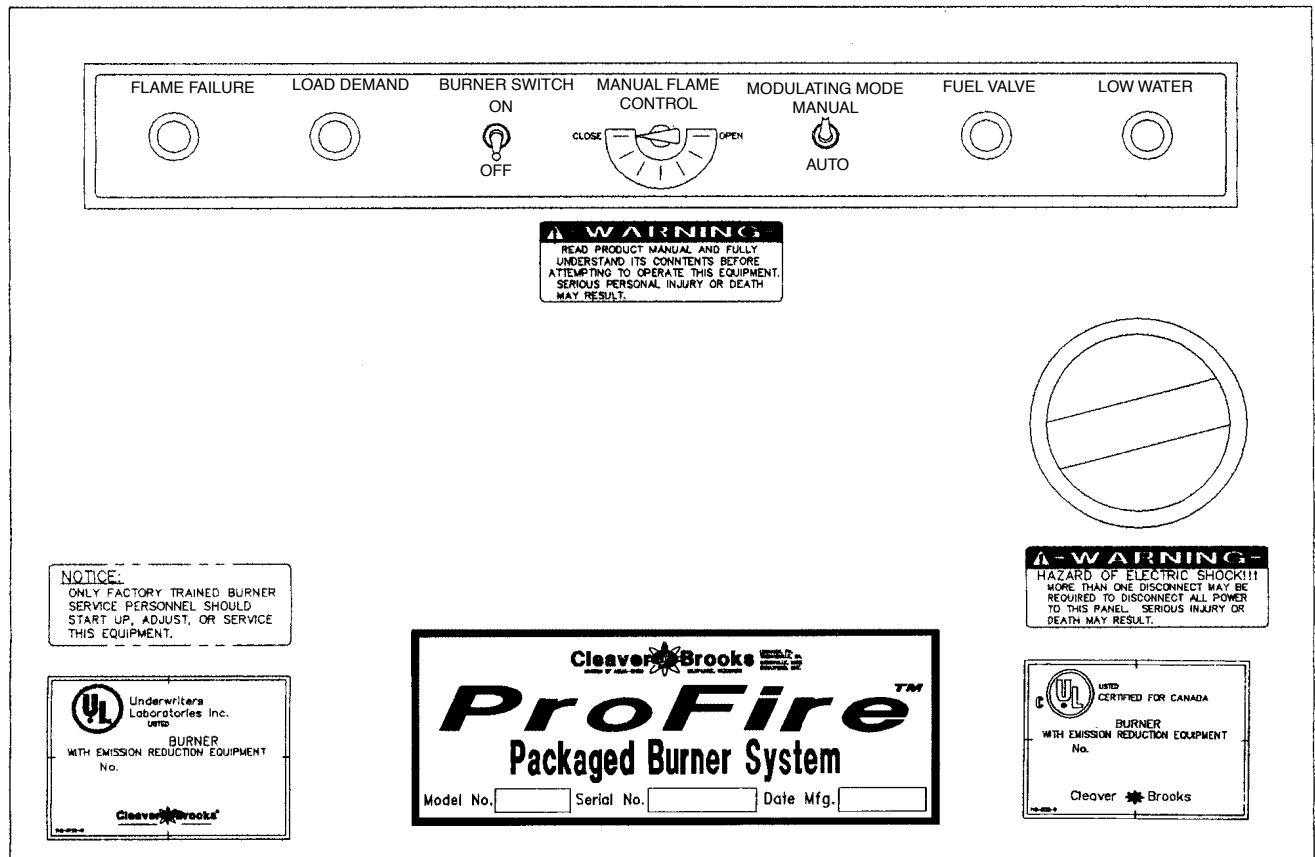


Figure 1-3. Control Cabinet Door

17. Main Air Shutter Shaft (Figure 1-2). The main air shutter modulates the combustion air between low fire and high fire conditions. The shaft connects the modulating motor to the main air shutter and to the fuel valve linkage assemblies.
18. Combustion Air Proving Switch (1-2). The combustion air proving switch provides confirmation to the flame safeguard that the combustion air fan is providing air flow. The fuel supply valves will not open if this switch does not sense adequate air pressure.
19. Impeller (not illustrated). 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.
20. Flame Safeguard (not illustrated). 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.

***NOTES***

# CHAPTER 2

## Preparation for Initial Startup

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

### A. 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 2-6 shows the configuration of the gas train for various insurance requirements). Figure 8-2 shows minimum and maximum gas pressure limits for the various burner configurations.

The pilot gas train is supplied with the burner, and is factory-installed. Figure 2-7 illustrates the pilot gas train configuration.

Fuel oil piping for oil-fired systems is shown pictorially in Figure 2-1 and 2-3. 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.

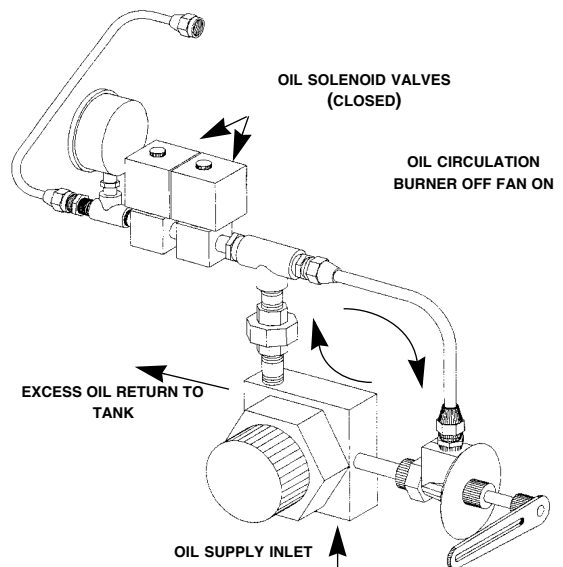
#### **CAUTION**

*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.

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.



**Figure 2-1 Oil Pump Circulation**

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.

### B. 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 1-3). 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.

### C. 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 3-2 and 3-4). Apply a lock-tight type compound to any fasteners after adjustment.

### D. 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 (Figure 2-2 and 2-4). 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.

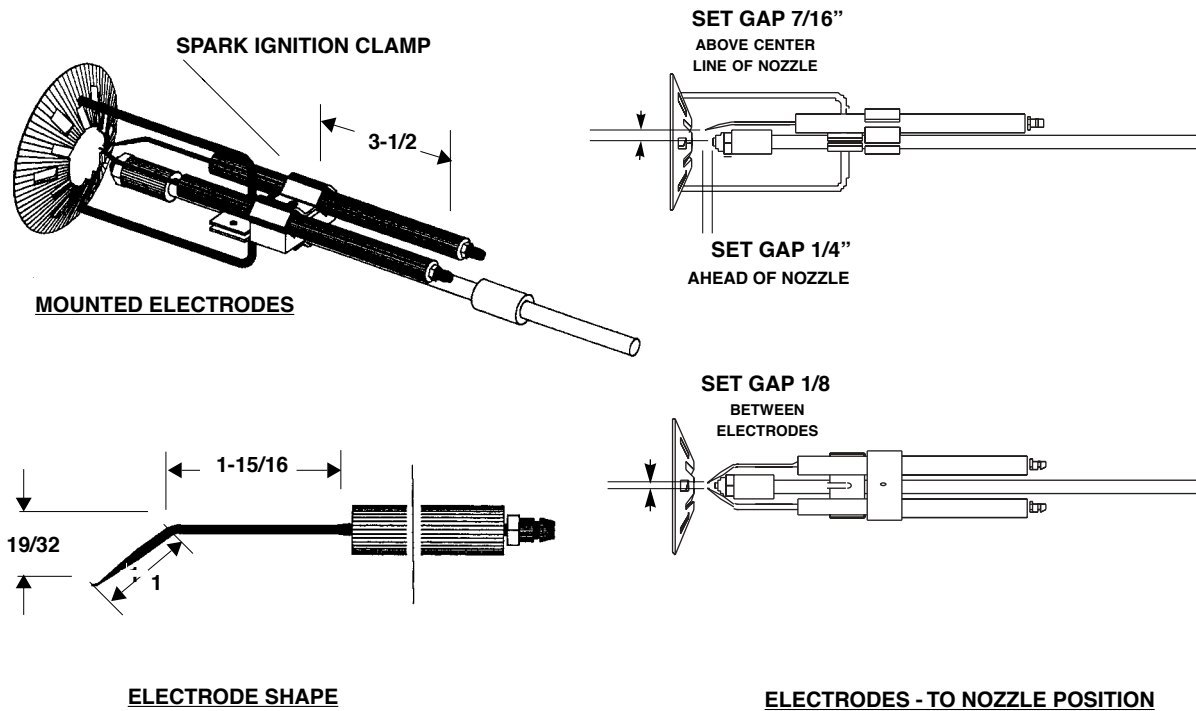
The nozzle/diffuser assembly must be removed from inside the burner to enable measurement and adjustment of the oil-spark-ignition electrodes (furnished only on oil burners) and the nozzle relative to the diffuser.

1. Remove the nozzle/diffuser assembly as follows:

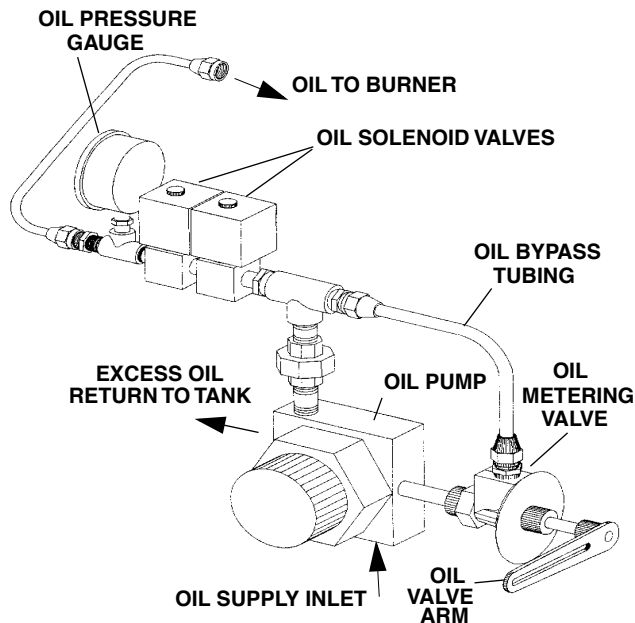
**⚠ WARNING**

**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.



**Figure 2-2 Direct Spark Ignition Electrode Adjustment Dimensions**

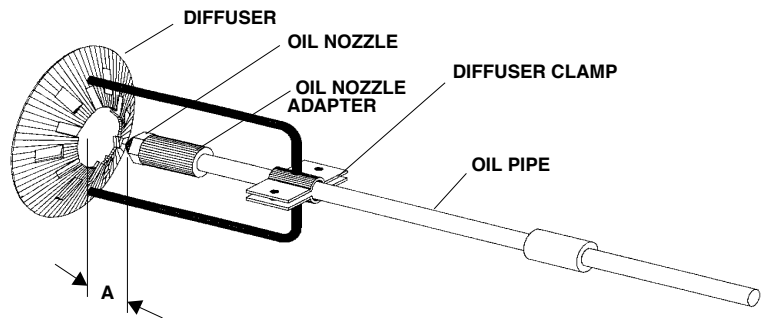


**Figure 2-3 Oil Piping Schematic**

- 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 2-2. 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 2-2).
  - B. Rotate and slide each electrode in the clamp, as necessary, to achieve the correct position relative to the burner tip.

- C. Tighten the locking screws securely to lock the electrodes in position. Apply a lock-tight type compound to the screws before tightening.
3. Refer to Figure 2-4 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 2-5 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.

ITEM	KEY	SIZE 1	SIZE 2	SIZE 3	SIZE 4
Nozzle To Diffuser	A	5/8	11/16	3/4	1-1/16



**Figure 2-4 Nozzle/Diffuser/Air Baffle Alignment**

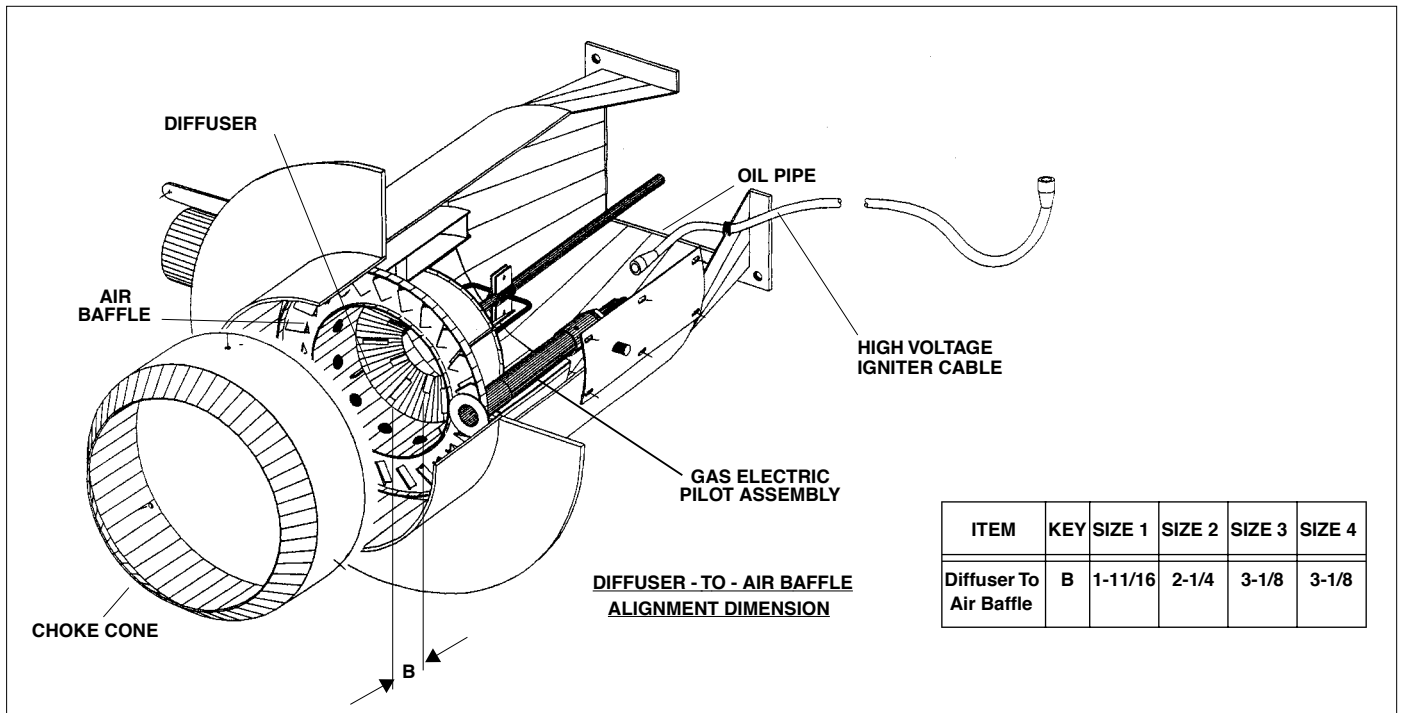
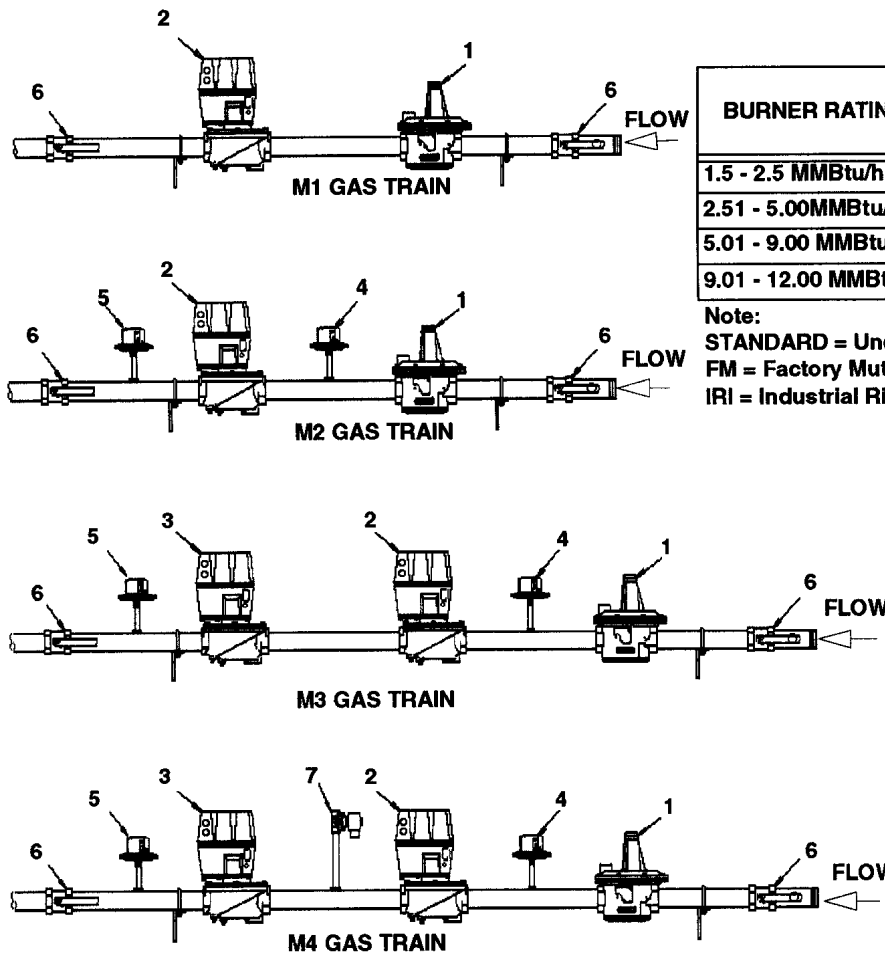


Figure 2-5 Blast Tube



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 - 9.00 MMBtu/hr	M3	M3	M4
9.01 - 12.00 MMBtu/hr	M3	M3	M4

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

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

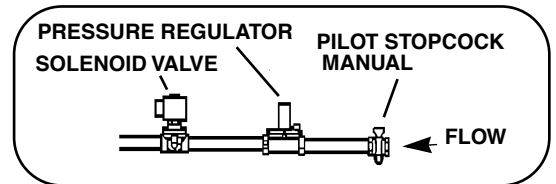


Figure 2-7 Pilot Gas Train

Figure 2-6 Burner Gas Train Configurations

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

# CHAPTER 3

## Startup Procedures

### A. 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.

**Note:** It is recommended that GPL and GLL units (equipped with an IFGR Low Emission Option) have been set up by a Cleaver-Brooks authorized representative to the local site conditions.

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 3-1) for minimum and maximum natural gas pressure requirements.
- 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.

- Verify that the prestart checklist for the boiler has been thoroughly completed.
- Provide the following test equipment on site:
  - 1). Combustion analyzer for O<sub>2</sub>.
  - 2). U-tube manometer, or pressure gauge, to measure gas pressures (main and pilot).
  - 3). Inclined manometer to measure draft pressures.
  - 4). Smoke spot tester for oil fired units. (CO analyzer for gas fired burners).
  - 5). Voltmeter.
  - 6). Thermometers and thermocouples.

#### CAUTION

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

The operator should be very familiar with the burner, boiler, all controls, components, and adjustments before attempting initial system startup. Familiarity can be gained by inspection of the installed equipment and through study of the manuals.

### B. 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

<b>Input Range</b> Gamme De Puissance						
	Gas (CFH) Gaz (PCH)	Press. (In. WC) (Po. col. d'eau)	Liquid (GPH) Fluide (GPH)	Press. (PSI) (LPC)		
Max.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>		
Min.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>		
<b>Fuel Type</b> Type de combustible		<b>Heating Value</b> Valeur calorifique				
<input type="text"/>		<input type="text"/>				
<input type="text"/>		<input type="text"/>				
Max. Overfire Draft Tirage maximum dans le foyer						
<input type="text"/> (In. W.C.) (Po. col. d'eau)						
<b>Current Characteristics</b> Caracteristiques Electriques						
<b>Load</b> Charge	HP	VOLTS	PH.	HZ.	AMPS.	FUSE
Main Circuit principal		<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Control Circuit Circuit de controle		<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Fan Motor Moteur du ventilateur	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Air Compressor Compresseur d'air	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Control Circuit Circuit de controle	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Transformer	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
	K.V.A.		PRIMARY			
			SECONDARY			
<b>CleaverBrooks</b> <small>MADE IN USA - 1981</small>						

SPECIFICATION PLATE

<b>CleaverBrooks</b> <small>MADE IN USA - 1981</small>			<small>WINDSOR, ONT. CANADA</small>
<h1>ProFire™</h1>			
<h2>Packaged Burner System</h2>			
Model No.	<input type="text"/>	Serial No.	<input type="text"/>
Date Mfg.	<input type="text"/>		

NAME PLATE

Figure 3-1. ProFire Burner Nameplate and Specification Plate

air for complete, efficient combustion.

A brief description of the induced flue gas recirculation (IFGR) system is provided in Chapter 4 of this manual. If the burner unit includes an IFGR system for control of NO<sub>x</sub> emissions, the system fuel and air adjustments must be done by a Cleaver-Brooks authorized representative.

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:

## 1. 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 (see Figure 1-1). Adjustment of these shutters is accomplished by loosening a setscrew that holds the shutter shaft within a stationary collar mounted on the airbox.

## 2. 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<sub>x</sub> 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 #1 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 discussed in Chapters 2 and 3 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment, specified in Chapter 2, should be available on site and installed.

### CAUTION

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

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

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

**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 3-2.

2. Place the burner switch to the OFF position (see Figure 1-3).

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

tem 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.

STARTUP. Proceed with startup of the natural gas-fired sys-

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	
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
2	Main Gas Valve Arm (Combination)	54	65	52	72	70	70	60	45	45	45	45	45	46
1	Main Shaft Gas Valve Arm (Gas Only)	31	30	30	32	35	25	25	20	23	23	25	25	22
2	Main Gas Valve Arm (Gas Only)	50	55	55	65	65	70	55	40	38	40	40	40	40
3	Butterfly Valve Setting (Combination)	34	25	22	25	30	25	25	25	25	25	27	25	24
3	Butterfly Valve Setting (Gas Only)	28	18	25	20	25	20	20	20	20	25	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	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
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	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

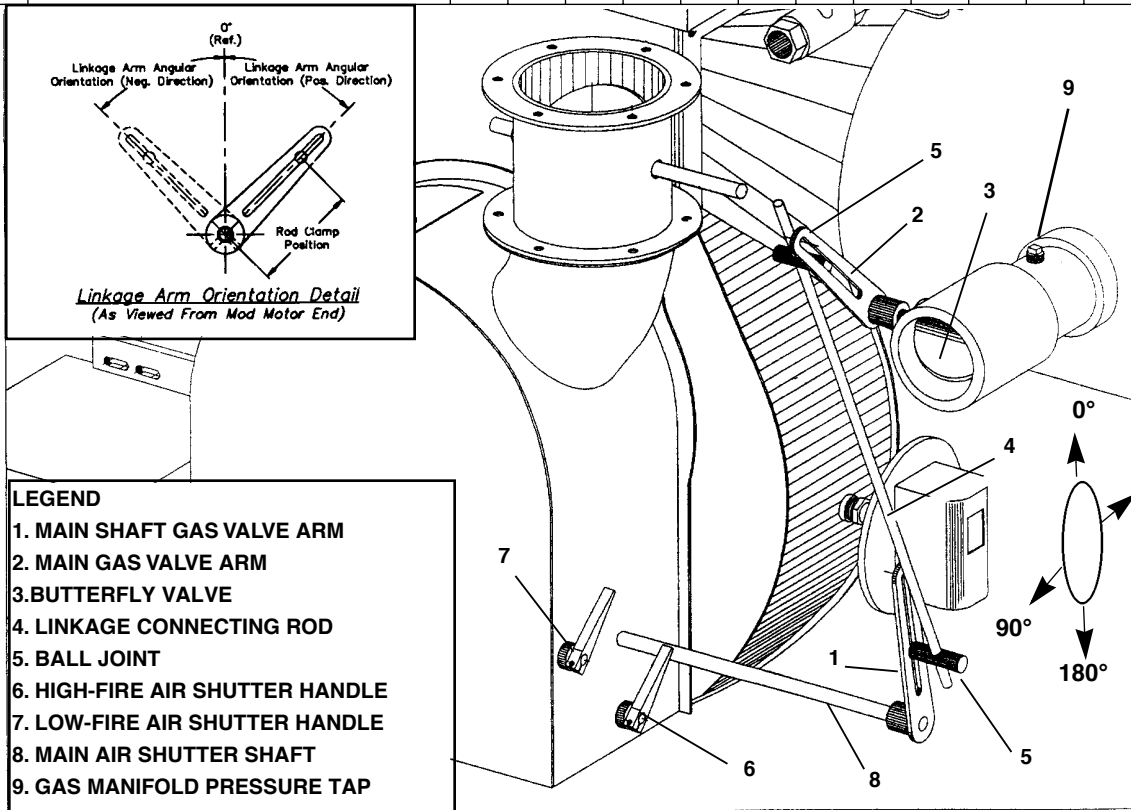


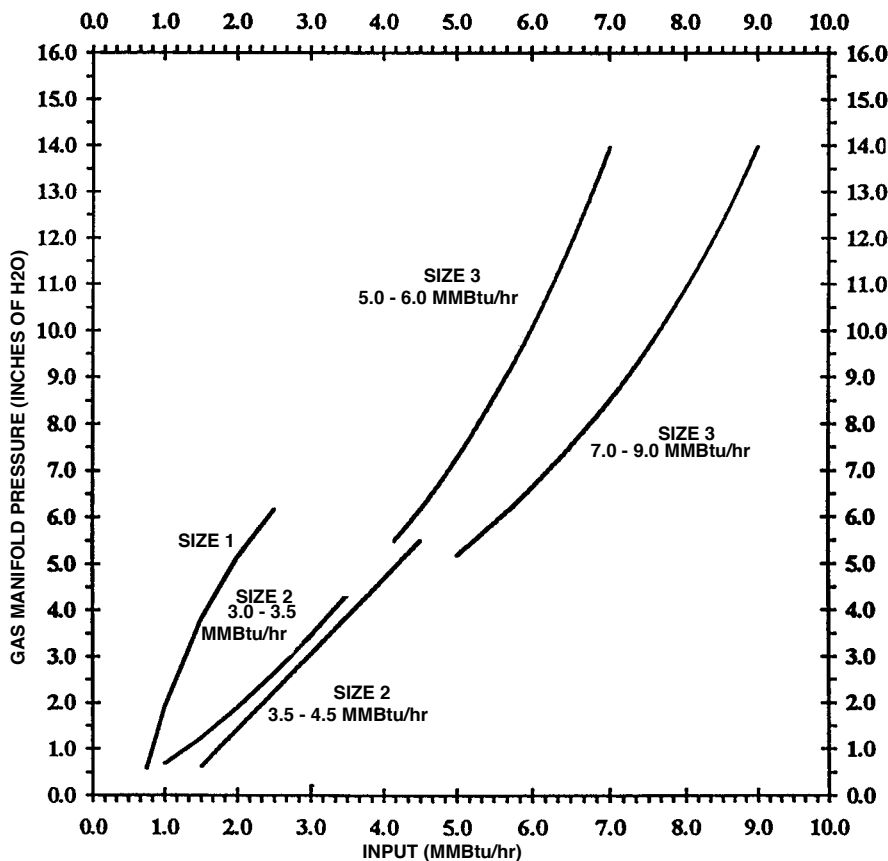
Figure 3-2. Natural Gas System Control Linkage

3. Place the upstream manual gas valve in the on position, allowing natural gas to enter the gas train. (furthest from the burner)
4. Verify that the gas metering valve is nearly closed.
5. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.
6. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
7. When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by observing the stem move from the CLOSED to the OPEN position.
8. After the main flame has been established, the gas manifold pressure entering the burner should be read

**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.

(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 3-3. 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 3-3, and select the temporary firing rate. This rate for startup is not critical, but merely an acceptable starting point to begin the high fire adjustment procedures.

9. After a few seconds, the O<sub>2</sub> analyzer should have an accurate reading of the O<sub>2</sub> present in the flue gas. Table 3-1 shows the acceptable O<sub>2</sub> range for the gas burner. Normally, O<sub>2</sub> levels are set between 4 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).
10. Operate the boiler at low fire until it is up to operating pressure (steam) or Temperature (hot water). Then increase the fuel input to the boiler by turning the manual flame control potentiometer towards OPEN in small increments. This will cause the butterfly valve to open, allowing more gas into the burner. While increasing the input, observe that the O<sub>2</sub> levels remain within the range listed in Table 3-1. Adjust the gas pressure regulator, as necessary, to correct this situation. Continue to do this



**NOTES:**  
 1. The excess air setting should be sufficient to allow normal variations in air and fuel without abnormal excess air levels, per Table 3-1.  
 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 3-1.

Figure 3-3. Natural Gas Input Pressure Curves

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. 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.

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

**NOTE:** Some meters may require 6.0 IN. H<sub>2</sub>O correction to P<sub>gas</sub>. Consult meter calibration data.

Where:

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

P<sub>atm</sub> = Atmospheric pressure in inches of mercury.

P<sub>gas</sub> = Gas pressure ahead of the volumetric flow meter in inches of mercury.

T<sub>gas</sub> = Gas temperature at the volumetric flow meter in °F.

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

S = Seconds.

- Adjust the high fire excess air rate using the high-fire shutter adjustment (see Figure 3-2 for location).
- Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel flow at the low-fire position in accordance with the burner data plate minimum gas-pressure rating.
- Adjust the low-fire (see Figure 3-2) damper again to obtain the correct low-fire excess air level within the range of 4-5% O<sub>2</sub>.

INPUT (MMBtu/hr)	MINIMUM O <sub>2</sub> (%)	MAXIMUM O <sub>2</sub> (%)
<b>SIZE 1</b>		
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
<b>SIZE 2</b>		
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
<b>SIZE 3</b>		
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
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 3-1. Recommended Stack Gas O<sub>2</sub> Concentration at Various Rates (Natural Gas) for Non-IFGR Burners**

### 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 discussed in Chapters 2 and 3 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment specified in Chapter 2 should be available on site.

**CAUTION**

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

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	
LINKAGE ARM ANGULAR ORIENTATION (IN DEGREES)														
1	Main Shaft Oil Controller Arm	88	94	106	110	110	115	115	125	120	120	120	120	120
2	Oil Controller Arm	80	66	52	65	45	75	75	140	95	90	90	55	55
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
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
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

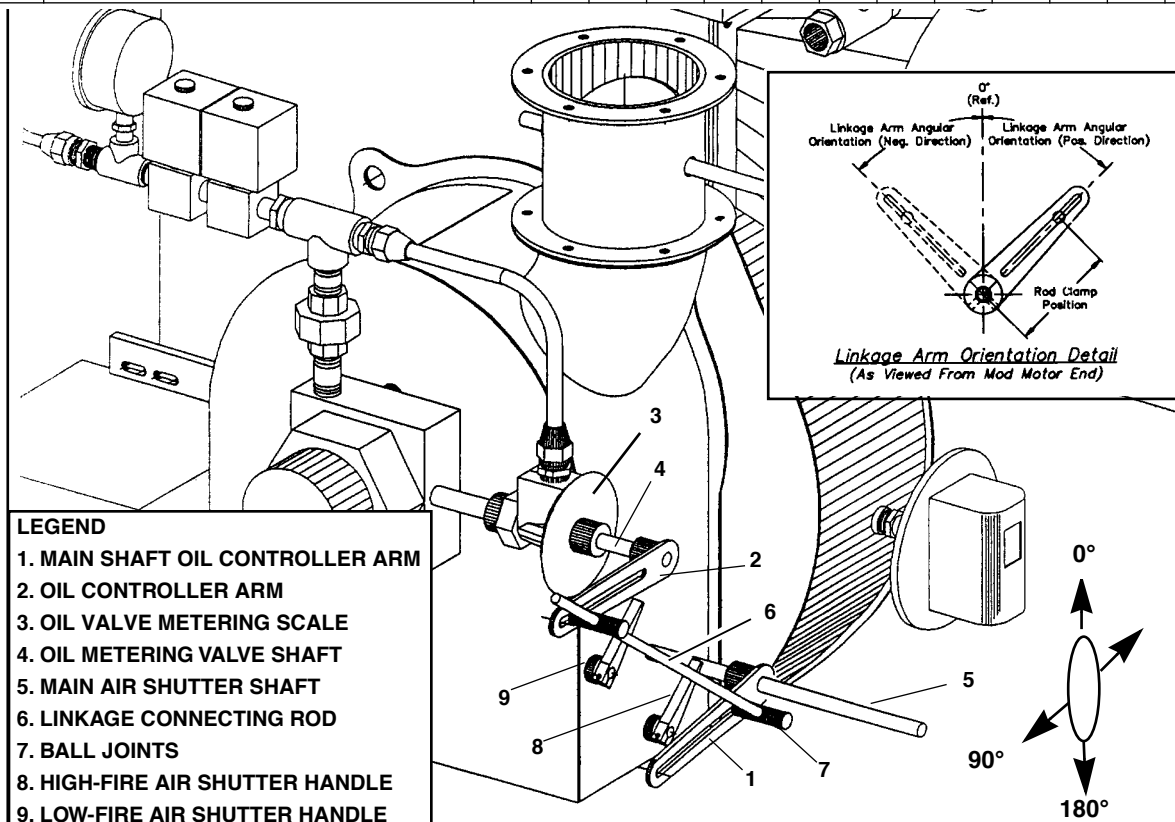


Figure 3-4. Oil-Fired System Control Linkage

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 3-4).

**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 3-4.

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

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

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

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

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

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

5. After the main flame has been established, the oil pressure entering the burner nozzle should be read (by reading the oil pressure gauge downstream of the oil solenoid valves) to get an initial estimate of the fuel oil input rate. Oil pressure should be about 80 psi when operating at low-fire. Adjust the oil metering valve if the actual pressure is not within the range of 80 to 90 psi.
6. Operate the boiler at low fire until it is thoroughly warmed. Then, modulate to high fire by turning the manual flame potentiometer to the OPEN position. This will cause the oil metering valve to close, resulting in an increase in the oil pressure feeding the burner nozzle. Check the excess air in the flue gas (see Table 3-2 for

INPUT (MMBtu/hr)	MINIMUM O2 (%)	MAXIMUM O2 (%)
<b>SIZE 1</b>		
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
<b>SIZE 2</b>		
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
<b>SIZE 3</b>		
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
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 3-2. Recommended Stack Gas O<sub>2</sub> Concentration At Various Rates (Light Oil) for Non-IFGR Burners**

acceptable excess O<sub>2</sub> levels), while modulating to high-fire. Adjust the oil pressure if needed.

7. Set the high-fire fuel input pressure to match the maximum oil pressure specification on the burner data plate by adjusting the fuel input. The oil metering valve should be in the fully closed position and the fuel pressure should be about 300 psi.

**NOTE:** Refer to the curves of burner input rate versus oil pressure (Figures 3-5A, 3-5B, and 3-5C) 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.

NOTE: Select the appropriate burner nozzle size curve based on the burner size and capacity stamped on the burner nameplate (see Chapter 1).

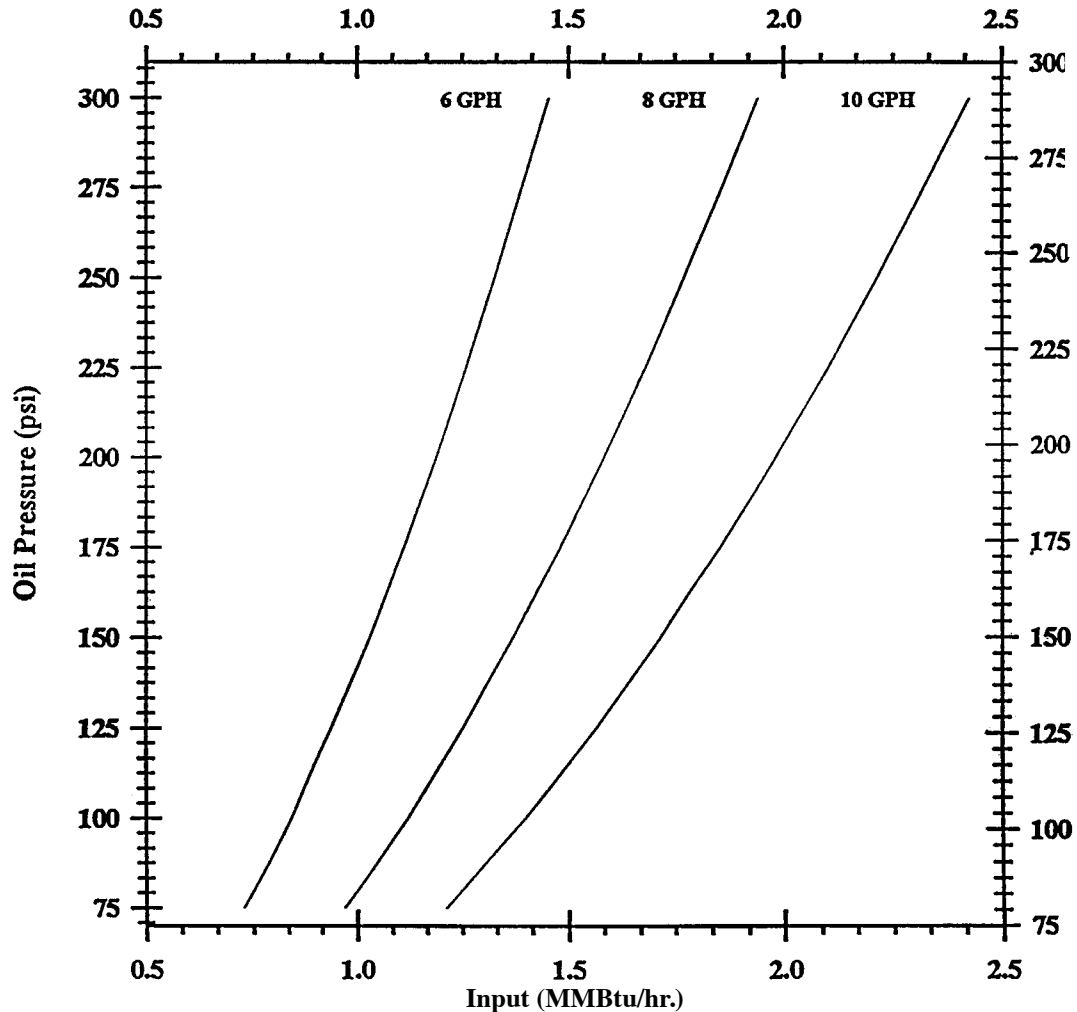


Figure 3-5A. Burner Input vs Oil Pressure and Nozzle Size (Size 1 Burners)

8. Adjust the high-fire shutter to obtain the correct excess air level (see Figure 3-4 for the adjustment location).
9. Modulate to low fire using the manual flame control in accordance with Table 3-2.
10. Set the proper fuel input for low fire by adjusting the linkage to drive the oil metering valve to the proper position (see Figure 3-6 for oil metering valve linkage adjustments).
11. Check intermediate positions for proper combustion. Adjust the linkage, as required, to match the fuel and air rates indicated in Table 3-2.
12. 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

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.*

NOTE: Select the appropriate burner nozzle size curve based on the burner size and capacity stamped on the burner nameplate (see Chapter 1).

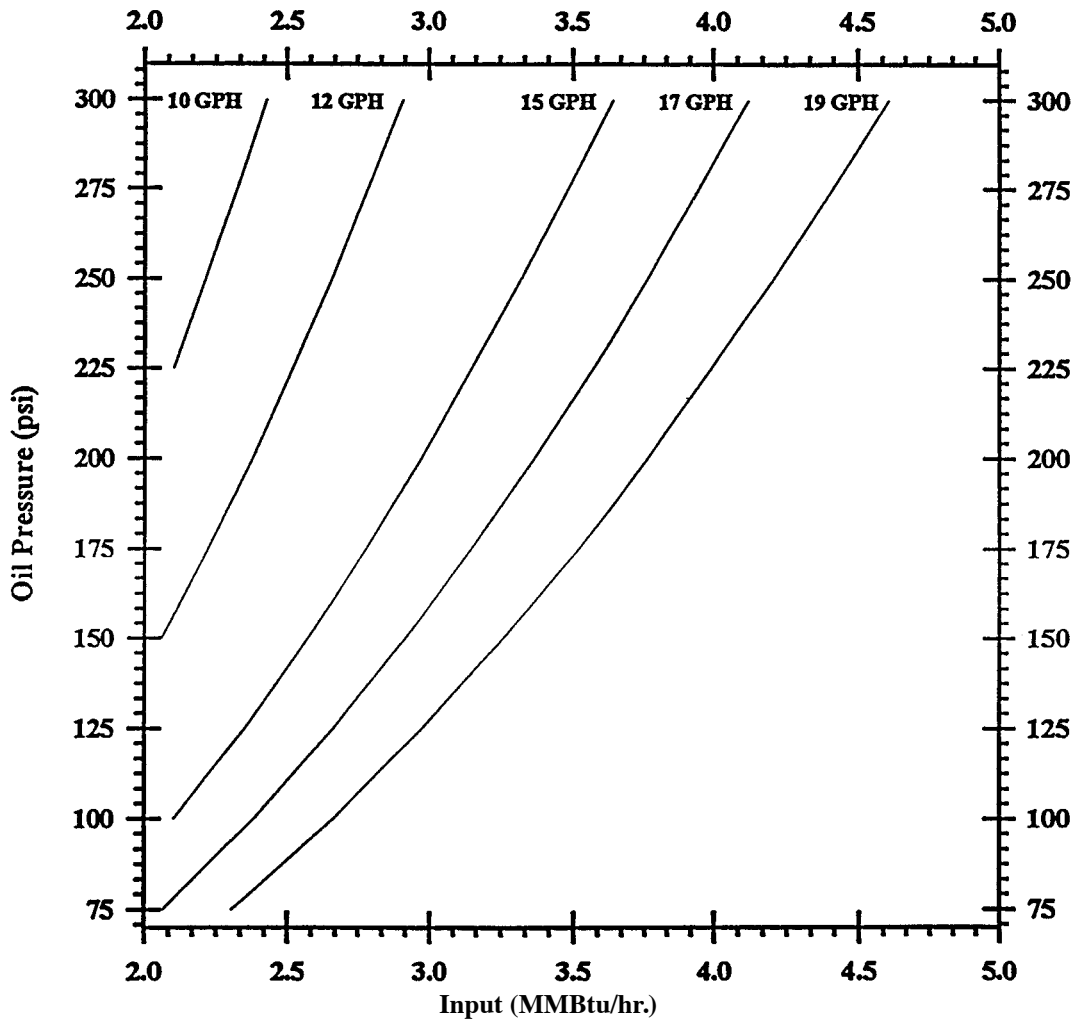


Figure 3-5B. Burner Input vs Oil Pressure and Nozzle Size (Size 2 Burners)

These procedures assume that the pre-startup tasks, checklists, and adjustments discussed in Chapters 2 and 3 have been completed, and that the boiler system is prepared for initial startup. All necessary test equipment specified in Chapter 2 should be available on site.

In general, the combination fueled system is to be started first using oil, because, as a fuel, oil has a greater combustion air requirement than natural gas. After being completely adjusted for oil combustion, the burner is re-started and adjusted using natural gas as fuel. Combustion adjustment of the combination burner for natural gas involves balancing the input gas rates only against the existing flow of combustion air, as established initially for oil-firing. Do not readjust the air shutters when tuning the combination burner for combustion of natural gas.

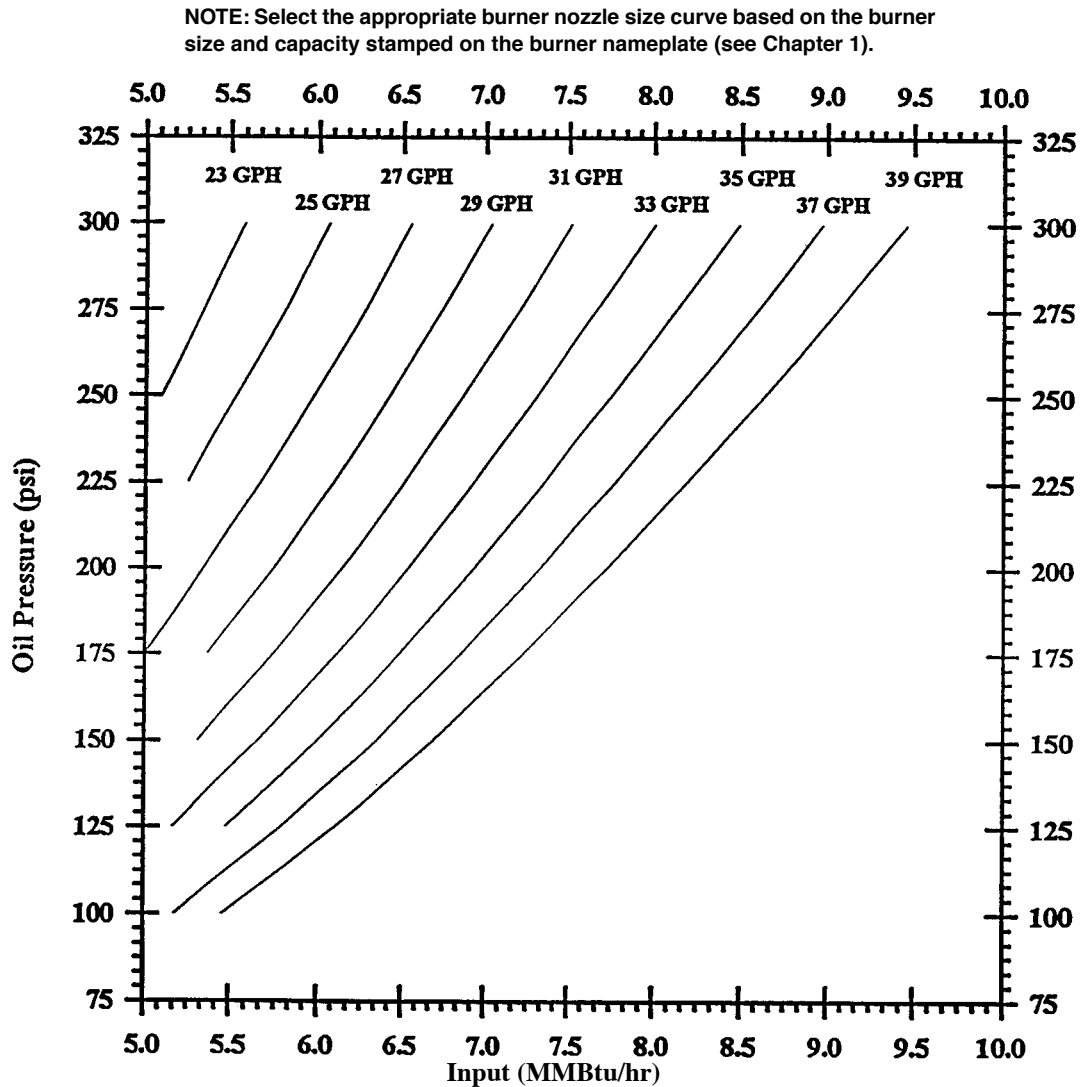
### CAUTION

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

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

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



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

- place, or if the setting has been lost, install the linkage in accordance with Figures 3-2 and 3-4.
  2. Place the burner switch in the OFF position (see Figure 1-3).
  3. Place the Modulating Mode switch in the MANUAL position.
  4. Place the manual flame potentiometer in the CLOSE (low-fire) position.
  5. Open the low-fire and high-fire shutters completely.
- STARTUP. Proceed with initial startup using oil as follows:
1. Position the fuel selector switch (located inside the control panel) to OIL.
  2. Proceed with startup and combustion adjustments using the same procedures defined for oil-fired burner initial startup.
  3. After the system has been completely adjusted for oil-firing, place the burner switch to the off position, and position the fuel selector switch to GAS.
  4. Place the Manual/Auto mode switch to the MANUAL position.
  5. Place the manual flame control potentiometer to the CLOSE (low-fire) position.
  6. Close the downstream manual shutoff valve on the burner gas train (closest to the burner).
  7. Admit natural gas to the gas train.
  8. Verify that the butterfly valve is in a position that is nearly closed.

9. Turn the burner switch on. This will start the blower motor and initiate the prepurge sequence.
10. When the prepurge sequence ends, the pilot valve will open. The pilot flame should be visible from the viewing window.
11. When the pilot is established, the flame safeguard will energize the main gas valve (this is accompanied by fuel valve activity and illumination of the FUEL VALVE light). The main gas valve should be visually checked by observing the stem move from the CLOSED to the OPEN position.
 

**NOTE:** The downstream manual gas shutoff valve should be in the closed position, for initial boiler startup, to ensure proper operation of the automatic gas valves. This valve can then be slowly opened when the pilot is established and proven.
12. After the main flame has been established, the gas pressure entering the burner should be read (using the pressure tap between the butterfly valve and the blast tube) to determine an initial estimate of the gas input rate. By doing so, and referring to Figure 3-3, 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 3-3 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 O<sub>2</sub> analyzer should have an accurate reading of the O<sub>2</sub> present in the flue gas. Table 3-1 provides a representation of the acceptable O<sub>2</sub> range

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

for the gas burner. Normally, the O<sub>2</sub> levels are set between 3 and 5 percent at low fire, depending on the application and burner size (see the burner specification plate for the minimum firing rate).

14. Operate the boiler at low fire until it is thoroughly warmed. Then increase the fuel input to the boiler by turning the manual flame potentiometer towards open in small increments. This will cause the butterfly valve to open farther, allowing more gas into the burner. While increasing the input, observe that the O<sub>2</sub> levels remain within the range shown in Table 3-1. Adjust the gas pressure regulator, as necessary, to correct this situation. Continue to do this until the burner reaches high fire (the potentiometer is at the open position).
15. Adjust the high fire gas input to match the maximum rating. At high fire, the butterfly valve should be near the

full open position (readjust linkage if required). Adjust the gas pressure to obtain the correct fuel input. (Maximum pressure specified on the burner specification plate.)

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

**NOTE:** Some meters may require 6.0 IN. H<sub>2</sub>O correction to P<sub>gas</sub>. Consult meter calibration data.

Where:

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

P<sub>atm</sub> = Atmospheric pressure in inches of mercury.

P<sub>gas</sub> = Gas pressure ahead of the volumetric flow meter in inches of mercury.

T<sub>gas</sub> = Gas temperature at the volumetric flow meter in °F.

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

S = Seconds.

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

16. Modulate the burner to low fire. The butterfly valve should be adjusted to provide the correct fuel pressure at the low-fire position in accordance with the burner data plate minimum gas-pressure rating.

**FUEL FLOW ADJUSTMENTS.** Fuel flow rates are adjusted to provide the design-rated heat inputs into the burner at both high-fire (maximum rate) and low-fire (minimum rate) operating conditions. The maximum and minimum fuel input flow rates for the burner are identified on the data plate (see Figure 3-1). Natural gas flow rates are specified in cfh (cubic feet per hour), and fuel oil flow rates are specified in gph (gallons per hour).

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

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

1. Maximum flow rate is established by operating the burner at high-fire with the butterfly valve (Figure 1-1) fully open, then adjusting the manifold pressure to the

maximum as specified on the data plate (Figure 3-1). Maximum manifold pressure is obtained by adjusting the main gas pressure regulator on the gas train while operating the burner at high-fire.

2. Gas flow modulation for turndown is accomplished by throttling the flow rate with the butterfly valve. The flow restriction of the partially closed butterfly valve reduces the flow of gas through the burner nozzle. The butterfly valve throttling position is controlled by linkage from the main air shutter shaft, which is operated by the modulating motor.

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

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

1. Maximum flow rate is established by operating the burner at high-fire with the oil metering valve (Figures 1-1 and 2-3) 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 3-1).

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 3-1).

## **NOTES**

***NOTES***

# CHAPTER 4

## Induced Flue Gas Recirculation

### A. GENERAL

Induced Flue Gas Recirculation (IFGR) is an option available on the ProFire Burner that is used to reduce NO<sub>x</sub> emissions (Figure 4-1). The low emission option is available on systems ranging in capacity from 1.5 to 9.0 MMBtu/hr firing natural gas or light oil.

### B. PRINCIPLES OF OPERATION

The IFGR system lowers NO<sub>x</sub> emissions when firing natural gas or light oil by recirculating and mixing a portion of the flue gas with the combustion air at the blower fan inlet. The oxygen depleted flue gas reduces the flame temperature, which results in lower NO<sub>x</sub> emissions.

Larger quantities of recirculated flue gases will result in progressively lower flame temperatures and NO<sub>x</sub> levels. (As the flue gas quantities increase, the size of the impeller and motor must be increased to handle the larger volume.)

The flue gasses are “induced” from the boiler stack outlet into the combustion air blower through a duct, which connects the stack outlet to the impeller inlet. A damper located in the duct controls the flow rate of the flue gas, relative to the burner firing rate.

Major components and their function are as follows:

- A metal flue gas duct, typically between 2" and 6" in diameter, provides a path for the flue gas to recirculate from the stack outlet to the blower inlet.
- The combination of the flue gas control damper and main air shutter controls the amount of flue gas being recirculated. The damper modulates with the burner, to provide the correct flow at all input rates. Dual fuel systems have a linkage arm for each fuel.
- The combustion air impeller and motor provide the suction necessary to draw the flue gas in with the combustion air. Larger impellers and motors are often required with IFGR. The actual size depends on the amount of emission reduction that is required.

- The IFGR burner details will vary with the emission requirements, and may not be the same as depicted on the standard burner. In addition, the ratings for IFGR burner may be less than that of standard burner. Use the information provided with your specific unit to determine components and ratings.

### C. SETUP AND ADJUSTMENT

IFGR setup and adjustment must be accomplished by a Cleaver-Brooks authorized representative. **DO NOT** attempt to alter factory settings of IFGR linkage components!

Initial IFGR linkage settings and adjustments must be established by a Cleaver-Brooks authorized representative to fit your particular requirements and conditions. Set up of the LE Option requires simultaneous consideration of air-to-fuel ratios and NO<sub>x</sub> levels. This can only be accomplished with proper combustion emissions monitoring equipment with NO<sub>x</sub>, O<sub>2</sub>, and CO measuring capability.

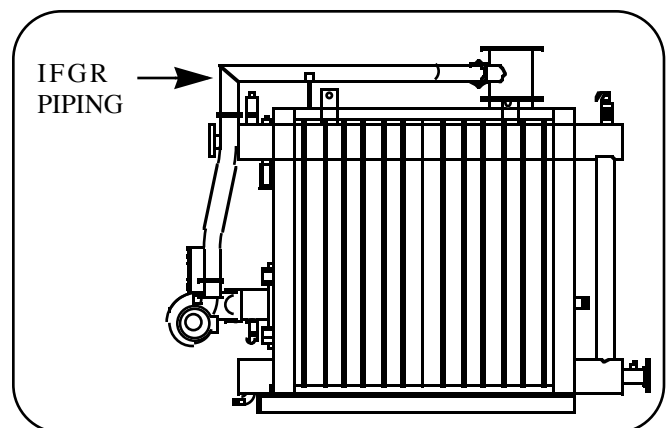


Figure 4-1 IFGR Piping

***NOTES***

# CHAPTER 5

## GENERAL BOILER OPERATING CONTROLS

**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.

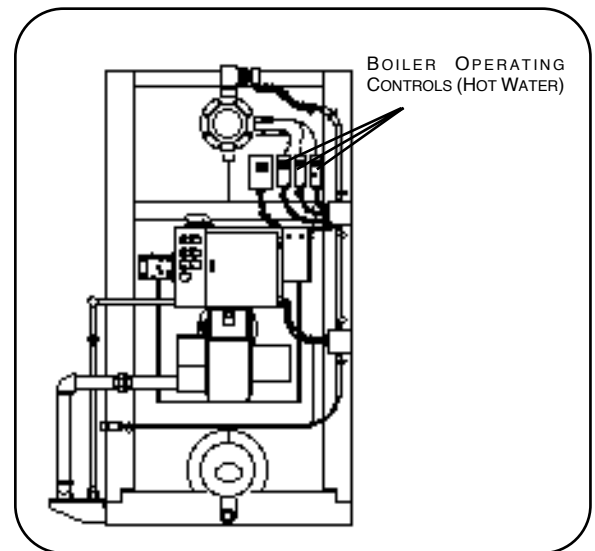
The High Limit Control senses the hot water temperature or steam pressure. It is used as a safety limit to turn the burner off in the event the Operating Limit Control fails. The High limit control should be set sufficiently above the Operating Limit control to avoid nuisance shutdowns.

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. This control must be set to initiate startup only at the low fire position.

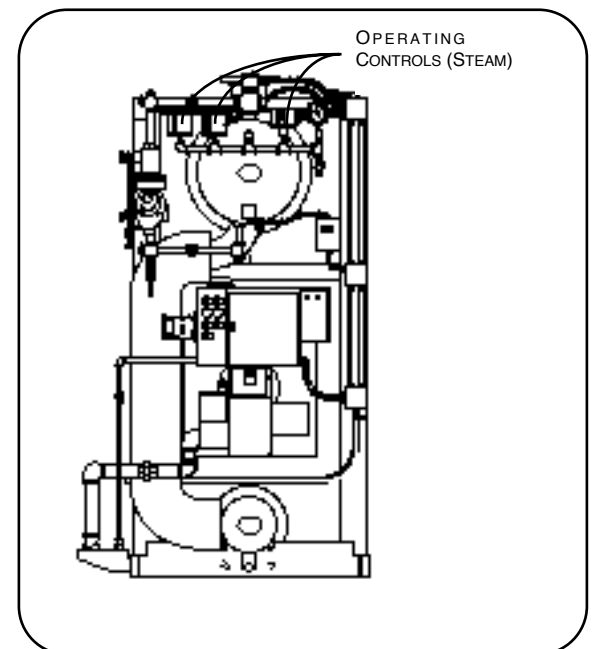
The Modulating Control senses changes in the hot water temperature or steam pressure and signals the modulating motor to control the flow of fuel and air to the burner. With either steam or hot water boilers, the Modulating control must be set to ensure the burner is at its minimum low fire position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



**Figure 5-1 Operating Controls (Hot Water)**



**Figure 5-2 Operating Controls (Steam)**

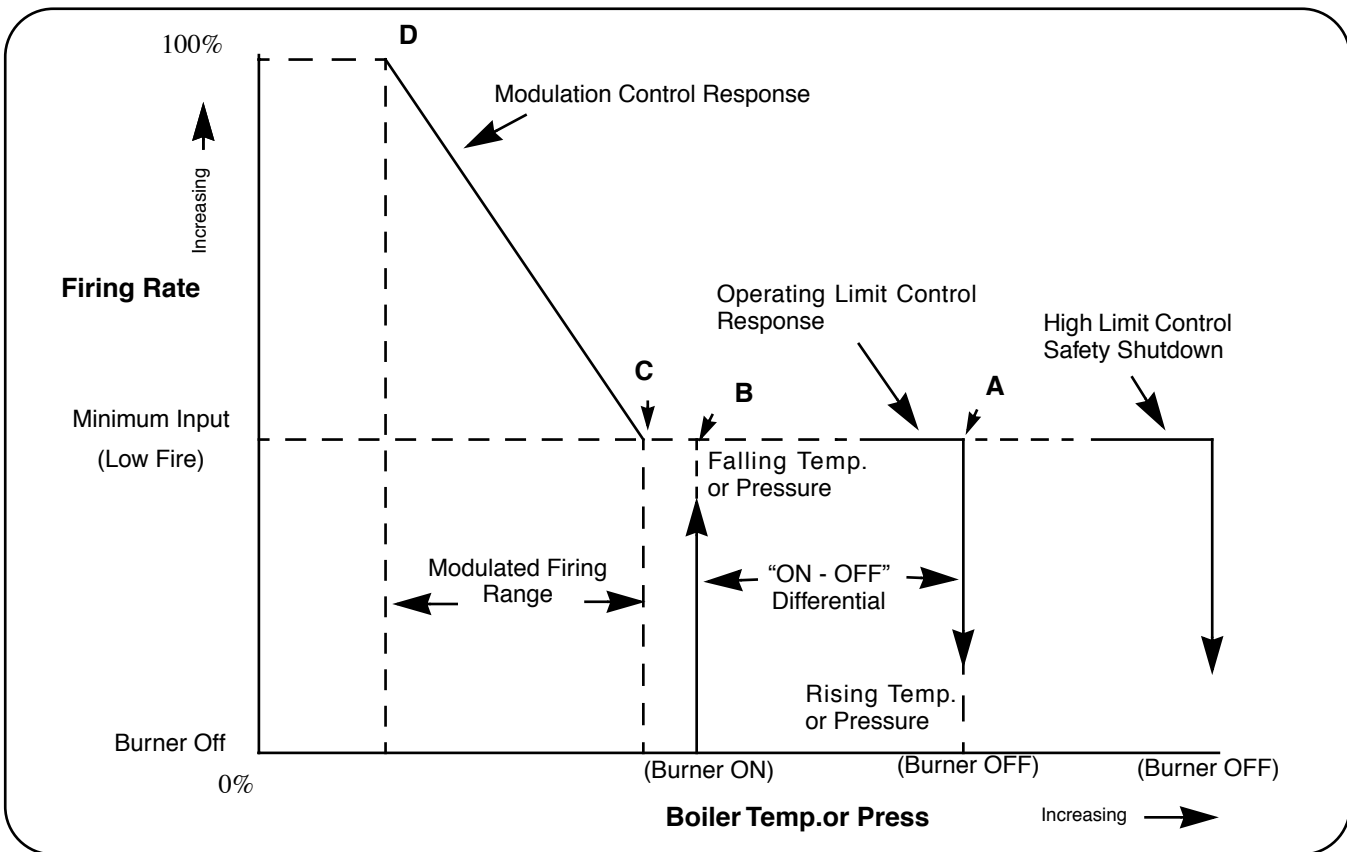


Figure 5-3 Firing Graph

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 effect modulated firing and burner on-off cycling. Figure 5-3 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. This is referred to as **modulated firing**

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

The firing graph (Figure 5-3) shows that point **B** and point **C** do not coincide. Extreme load conditions could require these points be closely matched.

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

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

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

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

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

Do not operate 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. Often, especially on new construction, 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 this, 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 this adjustable differential (Figure 5-3 A to B) should be set as wide as conditions permit, since this 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 this 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 these 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 the proving the pilot and main flame. This, plus approximately one-half minute required for the damper motor to travel from low to high fire. This time lag may allow pressure or temperature to drop below desirable limits.

*Notes*

# CHAPTER 6

## Troubleshooting

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

**Table 6-1. Troubleshooting**

***NOTES***

3. If the burner operates in a damp environment, cover it with plastic to protect all electrical components from moisture.

MAINTENANCE SCHEDULE. Refer to the following check list (Table 6-1) for recommended periodic testing of the combustion system components:

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

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

Monthly:

1. Remove, inspect and clean the flame scanner for soot buildup.
2. Check and clean the diffuser for soot buildup.
3. Check and clean the air baffle for soot buildup.

ITEM	ACCOMPLISHED BY	REMARKS
<b>Daily</b>		
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.
<b>Weekly</b>		
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.
<b>Monthly</b>		
Low Fan Pressure, Interlock	Operator	Manually adjust until switch opens.
High & Low Gas Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.

**Table 7-1. Recommended Test Schedule**

ITEM	ACCOMPLISHED BY	REMARKS
High & Low Oil Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
<b>Semi- Annually</b>		
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.
Inspect Burner Components	Service Technician	Refer to instructions.
<b>Annually</b>		
High Limit Safety Control	Service Technician	Manually adjust until switch opens.
Firing Rate Control	Service Technician	Check with combustion test.
Pilot and Main Gas or Main Oil Fuel Valves	Service Technician	Perform leakage tests. Refer to instructions
Operating Control	Service Technician	Manually adjust until switch opens.
Fuel Valve Interlock Switch (POC)	Service Technician	Refer to instructions. Disconnect POC wire at valve.
Burner Position Interlock	Service Technician	Refer to instructions. Disconnect wire at valve.
Low Fire Start Interlock	Service Technician	Refer to instructions.
Automatic ChangeOver Control (Dual Fuel)	Service Technician	Under supervision of gas utility.
Pilot Turndown Tests	Service Technician	Required after any adjustments to flame scanner mount or pilot burner. Verify annually. Refer to instructions.
Refractory Hold-In Controls	Service Technician	See "Pilot turndown tests."
<b>As Required</b>		
High & Low Oil Pressure Interlocks	Operator	Refer to instructions. Manually adjust until switch opens.
Pilot Turndown Tests	Service Technician	Required after any adjustments to flame scanner mount or pilot burner. Verify annually. Refer to instructions.

**Table 7-1. Recommended Test Schedule (Continued)**

***NOTES***

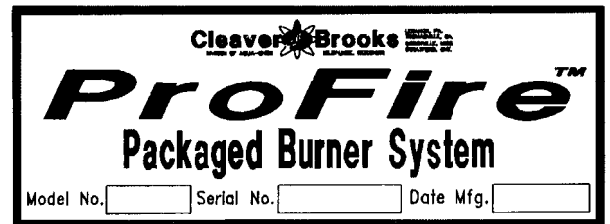
# CHAPTER 8

## Customer Service and 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 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
8-1	Control Panels	8-2
8-2	Main Gas Train	8-5
8-3	Pilot Gas Train	8-7
8-4	Starter Gas Train	8-8
8-5	Oil Train Assembly	8-9
8-6	Oil Gun Assembly	8-10
8-7	Fan Drive Assembly	8-10
8-8	Blower Motor	8-11
8-9	Blast Tube Assembly	8-12
8-10	Airbox Assembly	8-13
8-11	Input Dependent Parts	8-14

ITEM	DESCRIPTION	QTY	PART #
1	CABINET, 20W X 13H X 7D W/SUB-BASE	1	848-1128
	CABINET, 25W X 13H X 7D W/SUB-BASE	1	-
2	TERMINAL BLOCK, 30 TERMS	1	434-80
3	FUSE BLOCK	1	848-223
4	FUSE FRN 5.6	1	832-421
5	GROUND LUG	1	884-78
6	NAMEPLATE	1	118-3135
7	PILOT LIGHT, RED	2	881-225
8	PILOT LIGHT, WHITE	2	881-226
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	836-675
14	GAS-OIL NAMEPLATE	1	118-196
15	PROGRAMMER CHASSIS	1	TABLE 8-1A
16	PROGRAMMER MODULE	1	TABLE 8-1A
16a	PROGRAMMER DISPLAY	1	TABLE 8-1A
17	PROGRAMMER AMPLIFIER	1	TABLE 8-1A
18	PROGRAMMER BASE	1	TABLE 8-1A
19	FLAME DETECTOR	1	TABLE 8-1A
20	CONTACTOR	1	TABLES 8-1B & 8-1C
21	OVERLOAD	1	TABLES 8-1B & 8-1D
22	BLOWER MOTOR FUSES	1	TABLE 8-1E
23	BLOWER MOTOR FUSE MODULE	1	832-1892
24	CONT. CIRCUIT XFMR (1/2 KVA)	1	832-1801
	CONT. CIRCUIT XFMR (1/2 KVA)	1	832-1802
25	CCF-1 FUSES	2	TABLE 8-1F
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
31	WARRICK E-3 (NEED ITEM 30 ALSO)	1	833-1944

TABLE 8-1A. PROGRAMMERS						
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 (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 8-1. Control Panels (page 1 of 3)

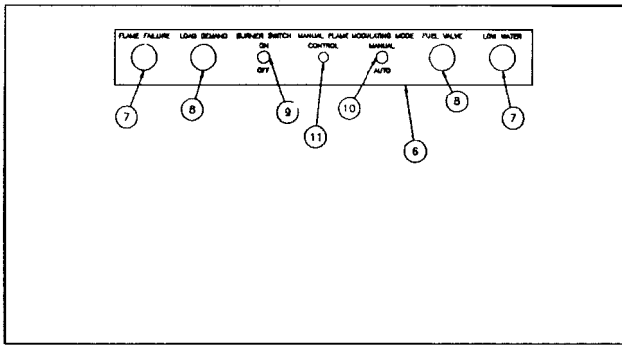
TABLE 8-1B. SIZING CHART												
MOTOR HP	SINGLE-PHASE				THREE-PHASE							
	115		230		200		230		460		600	
	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD	CONT CODE	OVER LOAD
1/4	8	-	8	-	1	-	1	-	1	-	1	-
1/3	8	-	8	-	1	-	1	-	1	-	1	-
1/2	8	-	8	-	1	E	1	D	1	B	1	B
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 8-1C. 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

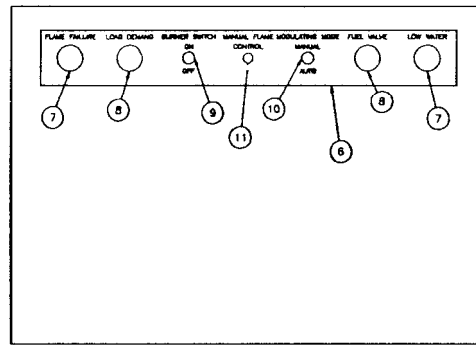
TABLE 8-1D. OVERLOAD		
AMP RATING	TABLE 2 CODE	PART #
.63-1	A	833-2672
1-1.6	B	833-2673
1.25-2	C	833-2674
1.6-2.5	D	833-2675
2.5-4	E	833-2676
4-6	F	833-2677
5.5-8	G	833-2678
7-10	H	833-2579
9-13	I	833-2680
12-18	J	833-2681
17-25	K	833-2782
23-32	L	833-2683
23-32	M	833-2684
30-40	N	833-2685
37-50	O	833-2686
48-65	P	833-2687

Figure 8-1. Control Panels (page 2 of 3)

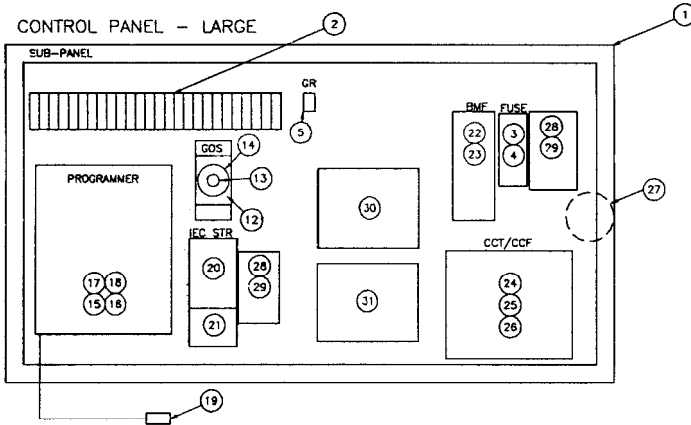
CONTROL PANEL DOOR (FRONT VIEW)



CONTROL PANEL DOOR (FRONT VIEW)



CONTROL PANEL - LARGE



CONTROL PANEL

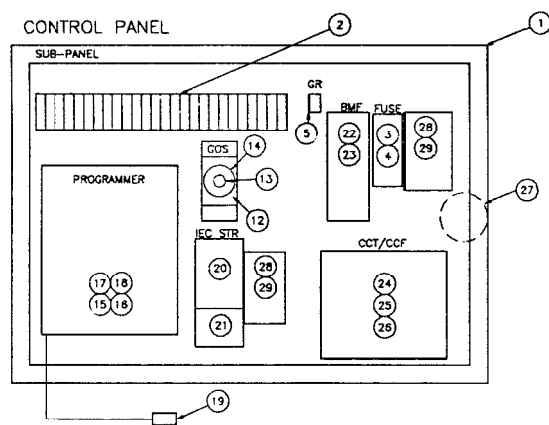


TABLE 8-1E. BLOWER MOTOR FUSES

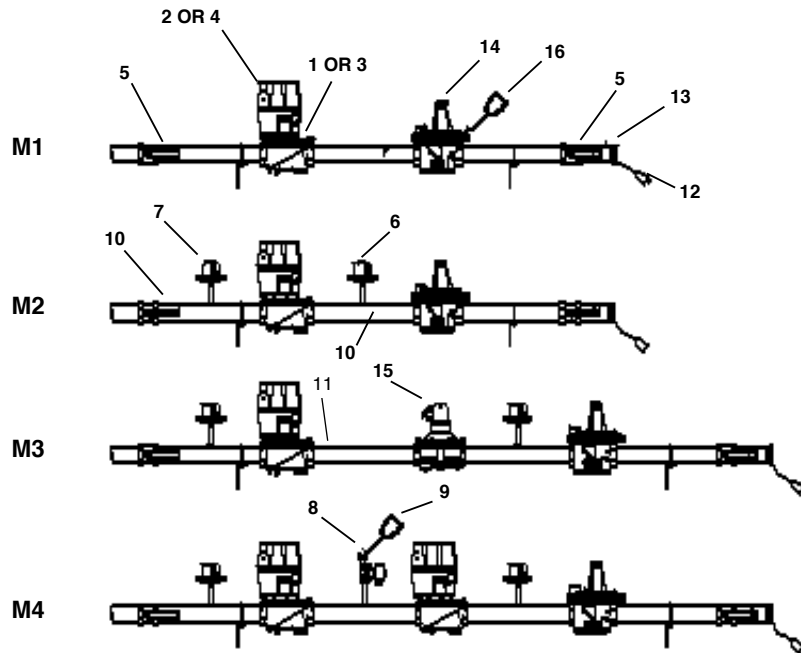
MOTOR HP	SINGLE PHASE						THREE PHASE								
	115			230			200 - 230			460			600		
	LP-CC-	QTY	PART#	LP-CC-	QTY	PART#	LP-CC-	QTY	PART#	LP-CC-	QTY	PART#	LP-CC-	QTY	PART#
1/4	8	1	832-884	5	2	832-879	1.8	3	832-870	1.6	3	832-869	1	3	832-866
1/3	10	1	832-886	5	2	832-879	1.8	3	832-870	1.6	3	832-869	1.6	3	832-869
1/2	12	1	832-887	8	2	832-884	3	3	832-874	1.6	3	832-869	1.6	3	832-869
3/4	20	1	832-889	10	2	832-886	5	3	832-879	1.8	3	832-870	1.8	3	832-869
1	20	1	832-889	10	2	832-886	5	3	832-879	3	3	832-874	1.8	3	832-870
1-1/2	25	1	832-890	12	2	832-887	7	3	832-883	4	3	832-877	3	3	832-874
2	30	1	832-891	15	2	832-888	10	3	832-886	5	3	832-879	4	3	832-877
3	40SP*	1	832-845	20	2	832-889	12	3	832-887	6	3	832-881	5	3	832-879
5	-	-	-	-	-	-	20	3	832-889	10	3	832-886	8	3	832-884
7-1/2	-	-	-	-	-	-	30	3	832-891	15	3	832-888	12	3	832-887
10	-	-	-	-	-	-	40SP*	3	832-845	20	3	832-889	15	3	832-888

\* USE 848-1150 FUSE BLOCK

TABLE 8-1F. CCF-1 FUSES

THREE PHASE				
KVA	200	230	460	600
	FNQ-R-6	FNQ-R-5	FNQ-R-5	FNQ-R-5
1/2	832-1812	832-1811	832-1811	832-1811

Figure 8-1. Control Panels (page 3 of 3)



ITEM NO.	DESCRIPTION	QTY	PART NO.			
			1 - 1/2"	2"	2 - 1/2"	3"
1	VALVE (STD)	TABLE 8-2B	940-4538	940-4539	940-4540	940-4541
2	ACTUATOR (STD)	TABLE 8-2B	945-139	945-139	945-139	945-139
3	VALVE (POC)	TABLE 8-2B	940-4543	940-4544	940-4545	940-4546
4	ACTUATOR (POC)	TABLE 8-2B	945-143	945-143	945-143	945-143
5	MANUAL SHUT-OFF VALVE <sup>A</sup>	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	948-2	948-2	948-2
	MAIN VENT VALVE (1")	1	948-53	948-53	948-53	948-53
	MAIN VENT VALVE (1 - 1/2")	1	948-54	948-54	948-54	948-54
9	VENT VALVE NAMEPLATE	1	118-492	118-492	118-492	118-492
10	S.O. NIPPLE (GPS)	1	157-444	157-606	157-1038	157-1039
11	S.O. NIPPLE (MGVV 3/4")	1	157-445	157-450	157-455	157-461
	S.O. NIPPLE (MGVV 1")	1	157-446	157-1043	—	—
	S.O. NIPPLE (MGVV 1 - 1/2")	1	—	—	157-1042	157-1041
12	PRESSURE REQUIRED NAMEPLATE	1	118-3139	118-3139	118-3139	118-3139
13	CAPLUG	1	919-169	919-104	919-105	919-99
14	MAIN REGULATOR <sup>B</sup>	1	SEE TABLE 8-2A			
15	SOLENOID VALVE	1	940-1075	940-1054	940-1025	940-1418
16	REGULATOR VENT TAG	2	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.  
 B. CANADIAN DESTINATION REQUIRES REGULATOR PER TABLE 2.

Figure 8-2. Main Gas Train (page 1 of 3)

**Table 8-2A**

INPUT MMBtu	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	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
	2-1/2	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
2.0	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	6.5	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
	2-1/2	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
2.5	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	210E	4-8	918-282
	2-1/2	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
3.0	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
	2-1/2	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
3.5	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	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
4.0	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	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-
4.5	1-1/2	15.6	21.5	-	-	-	-	-	29.7	36	210-D	10-22	918-610
	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
	3	-	-	-	-	-	-	-	-	-	-	-	-
5.0	1-1/2	19.9	27.3	-	-	-	-	-	37.3	44.7	210-D	15-30	918-540
	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	918-707	-	-	-	-	-
5.5	1-1/2	N/A	31.9	N/A	-	-	-	-	N/A	52.9	210-D	20-42	918-654
	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	918-707	N/A	-	-	-	-
6.0	1-1/2	N/A	32.5	N/A	-	-	-	-	N/A	57.5	210-D	20-42	918-654
	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	918-707	N/A	-	-	-	-
7.0	1-1/2	N/A	-	N/A	-	-	-	-	N/A	-	-	-	-
	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	1-1/2	N/A	-	N/A	-	-	-	-	N/A	-	-	-	-
	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	-	N/A	-	-	-	-
9.0	1-1/2	N/A	-	N/A	-	-	-	-	N/A	-	-	-	-
	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	-	N/A	-	-	-	-	

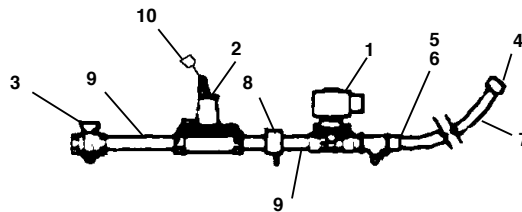
NOTES:

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.

**Figure 8-2. Main Gas Train (page 2 of 3)**

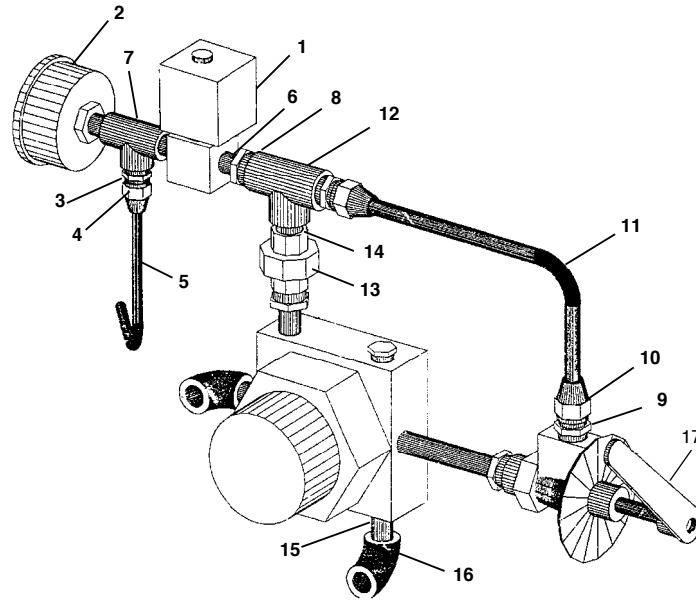
BURNER INPUT MMBtu	MAIN GAS TRAIN							VALVE TYPE						OVERALL LENGTH	
	TRAIN SIZE (STD)	VENT VALVE SIZE		MAIN TRAIN			STARTER TRAIN	S=SOLENOID M=MOTORIZED						MAIN GAS TRAIN	
		STD & FM	IRI	STD	FM	IRI		STD		FM		IRI		M1, M2 (APPROX)	M3, M4 (APPROX)
								UL	STD	POC	STD	POC	STD		
1.5-2.5	2	-	1	M1	M2	M4	S1	-	1M	-	1M	2M	-	60"	80"
2.51-4.99	2	-	1	M2	M2	M4	S1	-	1M	-	1M	2M	-	60"	80"
5	2.5	-	1-1/4	M2	M2	M4	S1	-	1M	-	1M	2M	-	63"	83"
5.01-9	2.5	-	1-1/4	M3	M3	M4	S2	1S	1M	1S	1M	1M	1M	63"	83"
9.01-12	3	-	1-1/4	M3	M3	M4	S2	1S	1M	1S	1M	1M	1M	63"	83"

Figure 8-2. Main Gas Train (page 3 of 3)



ITEM NO.	DESCRIPTION	QTY	PART NO.			
			1 – 1/2"	2"	2 – 1/2"	3"
1	PILOT VALVE	1	948-82	948-82	948-82	948-82
2	PILOT REG (2 - 6") [SIZES 1 & 2]	1	918-356	918-356	918-356	918-356
	PILOT REG (4 - 12") [SIZES 3 & 4]	1	918-717	918-717	918-717	918-717
3	PILOT GAS COCK	1	825-30	825-30	825-30	825-30
4	PILOT TUBE ELBOW CONNECTOR	1	845-662	845-662	845-662	845-662
5	PILOT TUBE CONNECTOR	1	845-314	845-314	845-314	845-314
6	PILOT TUBE UNION NUT	1	845-43	845-43	845-43	845-43
7	PILOT TUBING	1	939-413	939-413	939-413	939-413
8	PILOT MOUNTING CLAMP	1	928-169	928-169	928-169	928-169
9	PILOT NIPPLE (1/2")	2	857-154	857-154	857-154	857-154
10	TAG – REGULATOR VENT	2	118-2062	118-2062	118-2062	118-2062

Figure 8-3. 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	845-662	2	845-662
3	OIL LINE CONNECTOR	1	845-7	1	845-7	-	NOT USED	-	NOT USED
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	939-25	1	939-25
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	857-881	2	857-881	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	945-206	1	945-206
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: OIL STRAINER  
REQUIRED ON UNITS  
DESIGNATED FOR CANADA  
AND UNITS SHIPPED WITH  
FGR

Figure 8-4. Oil Train Assembly

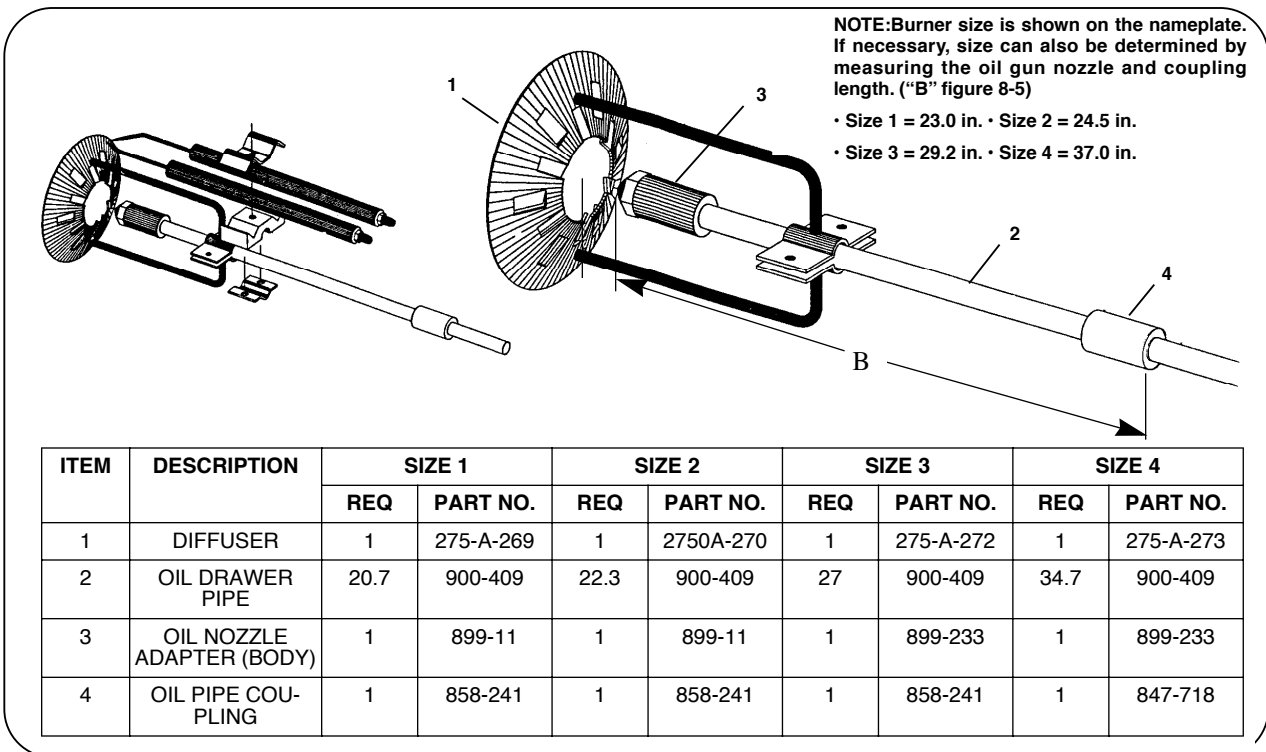


Figure 8-5. Oil Gun Assembly

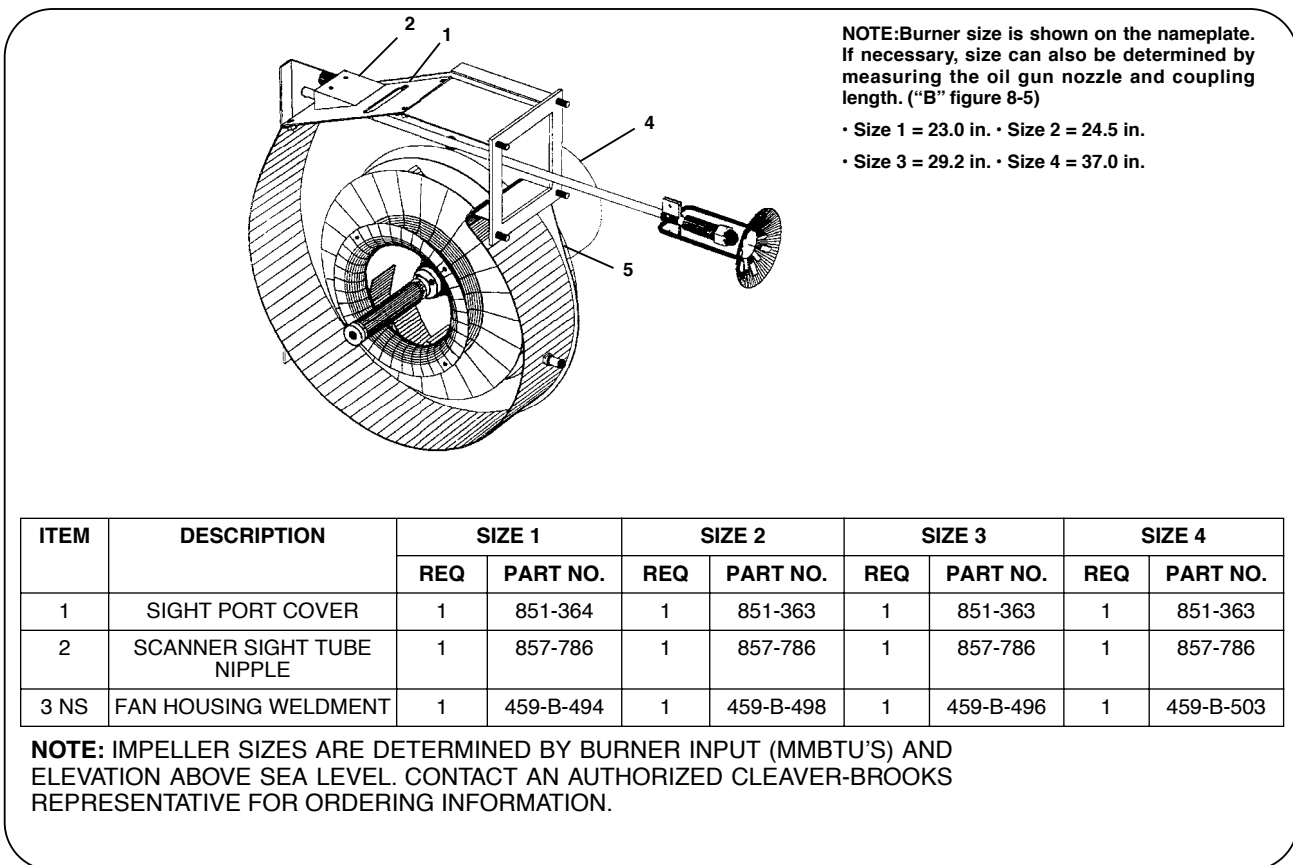
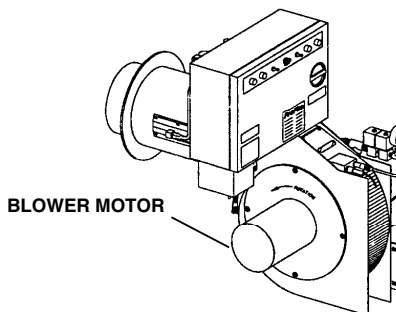


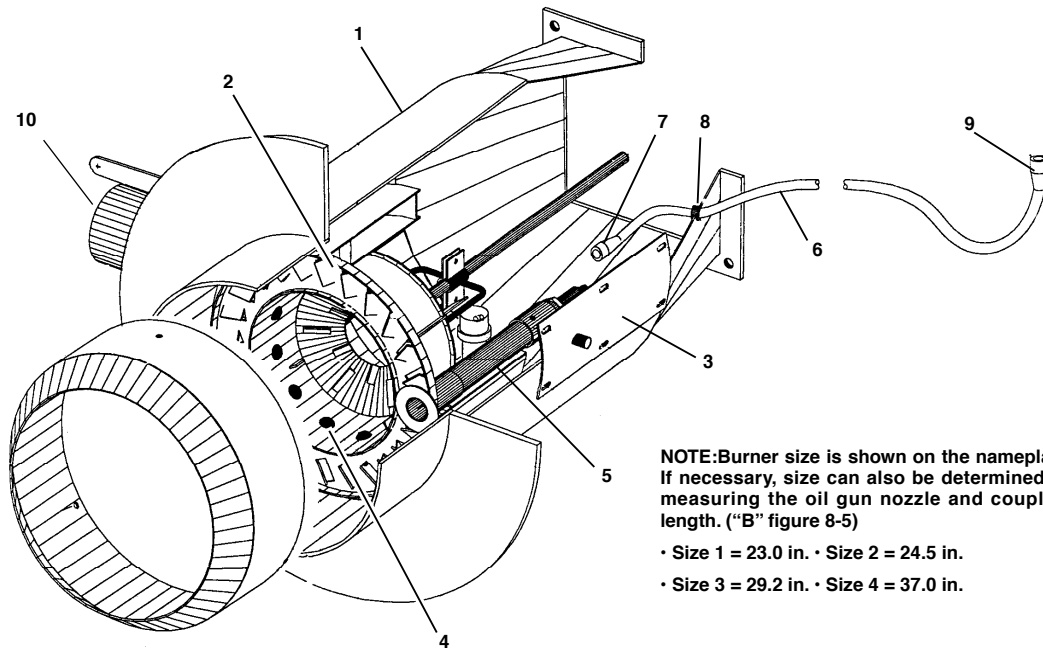
Figure 8-6. Fan Drive



MOTOR HP	OPEN DRIP PROOF (O.D.P.)			TOTALLY ENCLOSED (T.E.F.C.)		
	200/230/460	600	115/230	200/230/460	600	115/230
1/4	894-3579	894-3597	894-3589 *	894-3607	894-3625	894-3617
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	-

\* Standard Voltage

**Figure 8-7. 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 (19-B-1326)	1	19-1325 (19-B-1327)	1	19-1331 (19-B-1330)	1	19-1337 (19-B-1337)
4	RADIAL ORIFICE SPUD	6	42-A-11	10	42-A-11	12	42-A-11	12	42-A-12
5	PILOT ASSEMBLY	1	503-68	1	503-68	1	284-A-159	1	284-A-159
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	940-5319
NS	IGNITION TRANSFORMER	1	832-107	1	832-107	1	832-107	1	832-107

**Figure 8-8. Blast Tube Assembly**

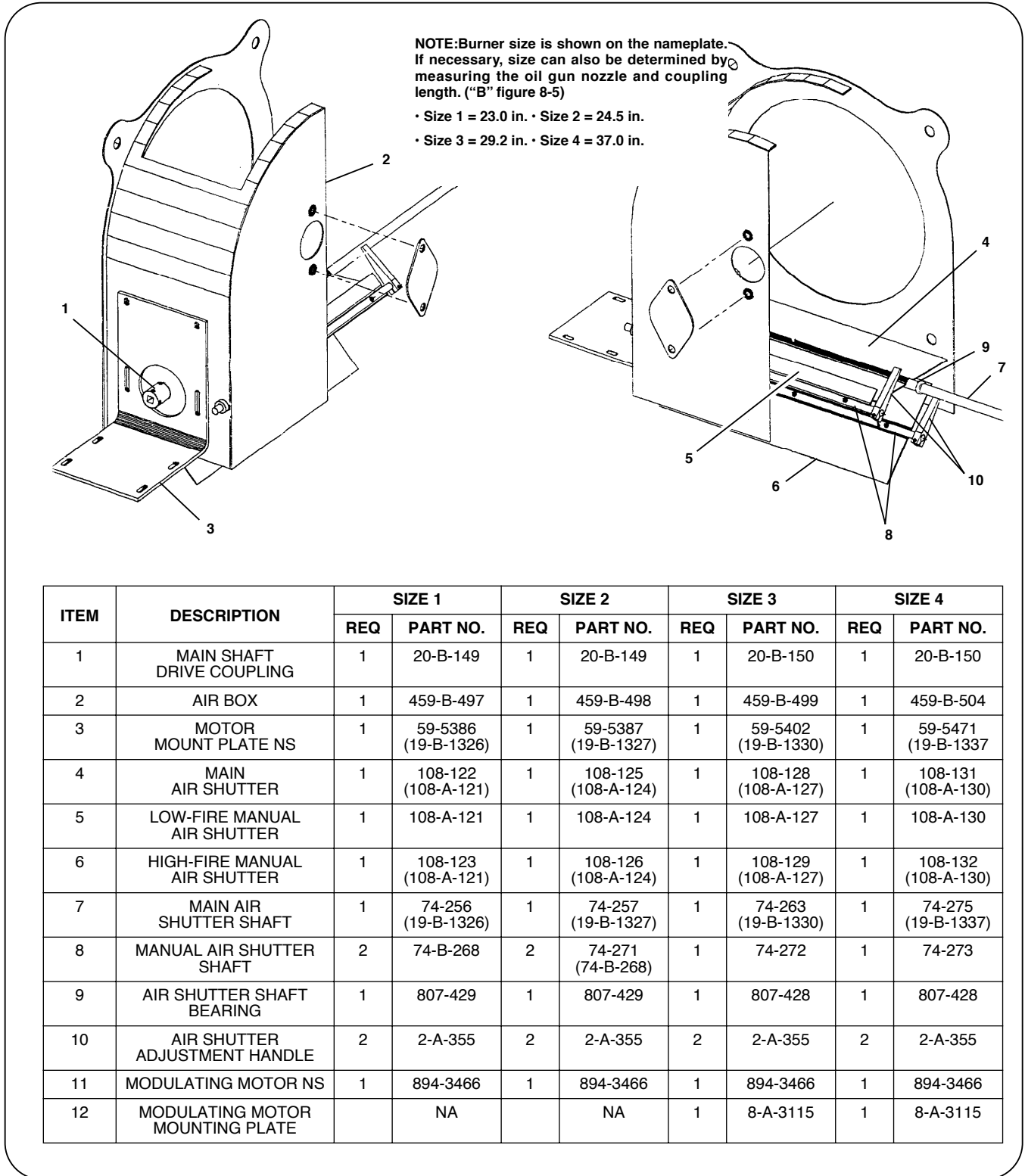
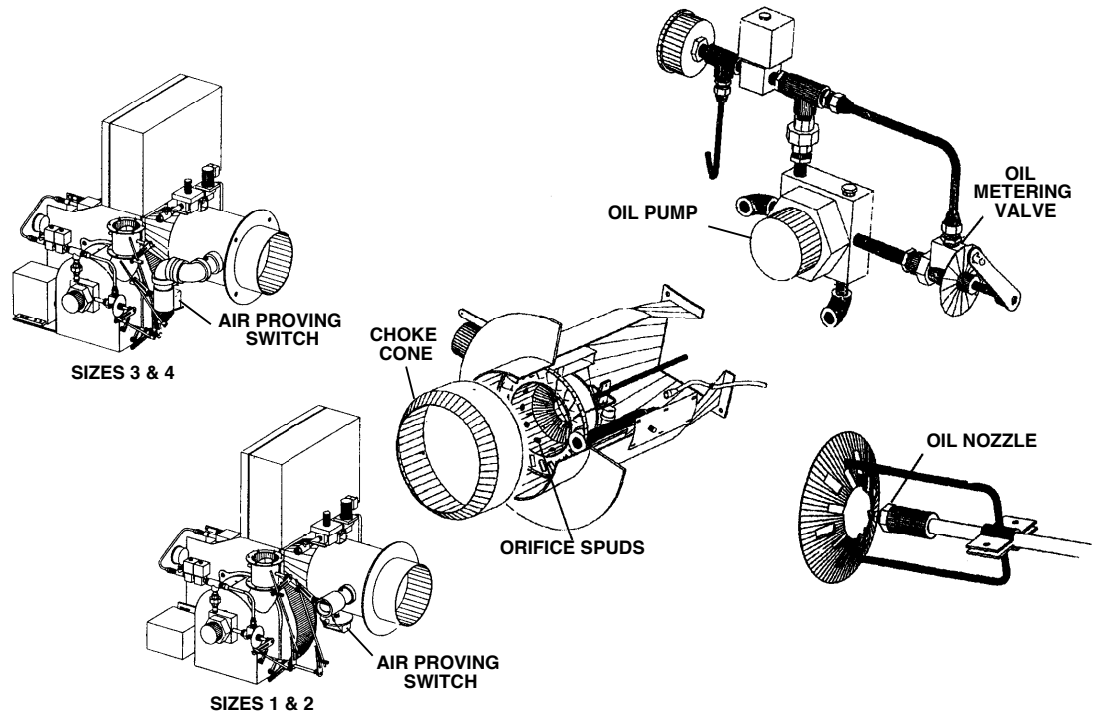


Figure 8-9. Airbox Assembly



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	817-1994	(14) 42-A-10	1-A-825	819-242	901-1436	899-220	940-5303
2	97-B-248	817-1994	(14) 42-A-10	1-A-825	819-242	901-1436	899-222	940-5303
2.5	97-B-248	817-1994	-	1-A-825	819-242	901-1436	899-225	940-5303
3	97-251 (97-B-249)	817-1994	(18) 42-A-10	1-A-825	819-242	901-1436	899-226	940-5328
3.5	97-251 (97-B-249)	817-1994	(18) 42-A-10	1-A-825	819-242	901-1436	899-228	940-5328
4	97-251 (97-B-249)	817-436	-	1-A-825	819-242	901-1437	899-230	940-5328
4.5	97-251 (97-B-249)	817-436	-	1-A-825	819-242	901-1437	899-231	940-5328
5	97-B-253	817-436	(22) 42-A-10	1-A-825	819-243	901-1437	899-22 899-223	940-5318
5.5	97-B-253	817-436	(22) 42-A-10	1-A-825	819-243	901-1437	899-223 899-224	940-5318
6	97-B-253	817-436	-	1-A-825	819-243	901-1544	899-224 899-226	940-5318
7	97-B-252	817-436	-	1-A-826	819-241	901-1544	899-227 899-228	940-5318
8	97-B-252	817-436	-	1-A-826	819-241	901-1544	899-229 899-229	940-5318
9	97-B-252	817-436	-	1-A-826	819-241	901-1545	899-231 899-231	940-5635

\* Ignore these items when using remote oil pump option

Figure 8-10. Input Dependent Parts

# ***NOTES***

# ***NOTES***

**CLEAVER**  **BROOKS**<sup>®</sup>