



Installation, Startup, Operation and Maintenance Manual

Model FDR Burner

For Gas, Oil And Combination Burners
With And Without Low NOx IFGR



Manual Part No. 950093

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SAFETY PRECAUTIONS

Good safety practices must be used when working on burner equipment. The potential energy in the electrical supply, fuel and related equipment must be handled with extreme care to prevent equipment failures, injuries and potential death.

Throughout this manual, the following symbols are used to identify potential problems.

WARNING

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

CAUTION

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

The following general safety precautions apply to all equipment work.

WARNING

IF YOU SMELL GAS, OPEN WINDOW, EXTINGUISH ANY OPEN FLAMES, STAY AWAY FROM ELECTRICAL SWITCHES, EVACUATE THE BUILDING AND IMMEDIATELY CALL THE GAS COMPANY.

IN ACCORDANCE WITH OSHA STANDARDS, ALL EQUIPMENT, MACHINES AND PROCESSES SHALL BE LOCKED OUT PRIOR TO SERVICING.

IF THIS EQUIPMENT IS NOT INSTALLED, OPERATED AND MAINTAINED IN ACCORDANCE WITH THE MANUFACTURERS INSTRUCTIONS, THIS PRODUCT COULD EXPOSE YOU TO SUBSTANCES IN FUEL OR FROM FUEL COMBUSTION WHICH CAN CAUSE DEATH OR SERIOUS ILLNESS AND WHICH ARE KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM.

IMPROPER SERVICING OF THIS EQUIPMENT MAY CREATE A POTENTIAL HAZARD TO EQUIPMENT AND OPERATORS.

SERVICING MUST BE DONE BY A FULLY TRAINED AND QUALIFIED PERSONNEL.

BEFORE DISCONNECTING OR OPENING UP A FUEL LINE AND BEFORE CLEANING OR REPLACING PARTS OF ANY KIND:

- TURN OFF THE MAIN MANUAL FUEL SHUTOFF VALVES INCLUDING THE PILOT COCK, IF APPLICABLE. IF A MULTIPLE FUEL BURNER, SHUT OFF ALL FUELS.
- TURN OFF ALL ELECTRICAL DISCONNECTS TO THE BURNER AND ANY OTHER EQUIPMENT OR SYSTEMS ELECTRICALLY INTERLOCKED WITH THE BURNER.

TABLE OF CONTENTS

A. General	Page 4	E. Preliminary Adjustments	Page 25
1. Nameplate Information	Page 4	1. Visual Inspection	Page 25
2. Ratings	Page 4	2. Burner Drawer Set Up	Page 25
3. Product Offering	Page 4	3. Motor Rotation	Page 25
4. Your Complete Manual	Page 6	4. Fuel, FGR and Air Control	Page 25
5. Service and Parts	Page 6	5. Air Damper Adjustments	Page 25
B. Component Description	Page 7	6. Pilot and Scanner Set Up	Page 26
1. General	Page 8	7. Gas System Adjustments	Page 26
2. Combustion Air	Page 8	8. Oil System Adjustments.....	Page 26
3. Burner Drawer	Page 8	9. Air Proving Switch	Page 27
4. Gas Fuel Components	Page 9	10. Operating and Modulating Controls	Page 27
5. Oil Fuel Components	Page 10		
6. Flue Gas Recirculation (FGR).....	Page 11	F. Startup and Operating Adjustments	Page 28
7. Fuel-Air-Ratio Controls	Page 12	1. Pre-Start Check List	Page 28
8. Electrical Controls	Page 12	2. FGR Adjustments	Page 28
C. Installation	Page 14	3. Register Assembly Adjustments	Page 29
1. General Considerations	Page 14	4. Fuel Setups	Page 29
2. Gas Piping	Page 15	5. Combination Gas and Air Atomized #2 Oil	Page 30
3. General Oil Piping	Page 15	6. Gas Setup	Page 30
4. Air Atomized #2 Oil.....	Page 17	7. Air Atomized #2 Oil Setup	Page 31
5. Heavy Oil	Page 17	8. Heavy Oil Setup	Page 33
6. Gas Pilot.....	Page 17	9. Operating Control Adjustments.....	Page 34
7. FGR Duct System	Page 17	10. Limit Tests	Page 34
8. Draft and Stacks.....	Page 18	11. Pilot Test	Page 34
9. Electrical System	Page 19	12. Burner Shutdown	Page 35
D. Fuel and Electrical Systems	Page 20	H. Troubleshooting	Page 36
1. Gas Systems	Page 20		
2. Gas Pilot	Page 21		
3. Air Atomizing #2 Oil.....	Page 22		
4. Fuel-Air-Ratio Controls.....	Page 23		
5. Electrical Controls	Page 23		
6. Operating and Modulating Controls.....	Page 24		
7. Flame Safeguards.....	Page 24		

A. GENERAL

1. Nameplate Information
2. Ratings
3. Product Offering
4. Your Complete Manual
5. Service and Parts

This manual covers the Models FDR and FDRX burners offered by Webster Combustion. These burners are intended for industrial applications on watertube boilers. They can fire gas, oil or combinations of gas and oil.

READ AND SAVE THESE INSTRUCTIONS FOR REFERENCE

WARNING

DO NOT ATTEMPT TO START, ADJUST OR MAINTAIN THIS BURNER WITHOUT PROPER TRAINING OR EXPERIENCE. FAILURE TO USE KNOWLEDGEABLE TECHNICIANS CAN RESULT IN EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

The startup and maintenance of the FDR and FDRX burners requires the skills of an experienced and properly trained burner technician. Inexperienced individuals should not attempt to start or adjust this burner.

THE INSTALLATION OF THE EQUIPMENT SHALL BE IN ACCORDANCE WITH THE REGULATION OF AUTHORITIES HAVING JURISDICTION, INCLUDING THE NATIONAL ELECTRICAL CODE, CSA STANDARDS 139 AND 140, THE CANADIAN NATIONAL ELECTRIC CODE, PART I AND ALL LOCAL CODES.

Every attempt has been made to accurately reflect the burner construction, however, product upgrades and special order requirements may result in differences between the content of this manual and the actual equipment. These special components will be described in the information provided with the burner and should be used as the controlling document.

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

1. Nameplate Information

Each burner has a nameplate with important job details. The "X" in the FDRX refers to a low NOx burner, where FGR is used to reduce the NOx in the combustion gases. If the burner is not a low NOx burner, there is no "X" in the model.

The serial number represents the unique number for that burner and is a critical number that will be needed for any communications with Webster Combustion.

The input rates define the maximum and minimum inputs for that burner, given in MBH for gas and GPH for oil. Air atomized burners show both the oil pressure and air pressure. For gas firing, the gas manifold pressure is given in "psi" which is pounds per square inch.

The electrical ratings of the burner are given, with the voltage, current load, frequency and phase (this will either be single or 3-phase). For motors, the motor HP is listed.

2. Ratings

The ratings for each specific burner are given on the nameplate (Figure A-3). The general burner ratings are given in Figure A-3. The maximum and minimum inputs are given, based on the type of fuel. Other conditions, like the supply gas pressure or the combination of fuels, emission requirements and control systems may limit the turndown.

Turndown is defined as the ratio of the maximum input to the minimum input. For example, a burner with a maximum input of 120 GPH and a minimum input of 12 GPH has a 10:1 turndown.

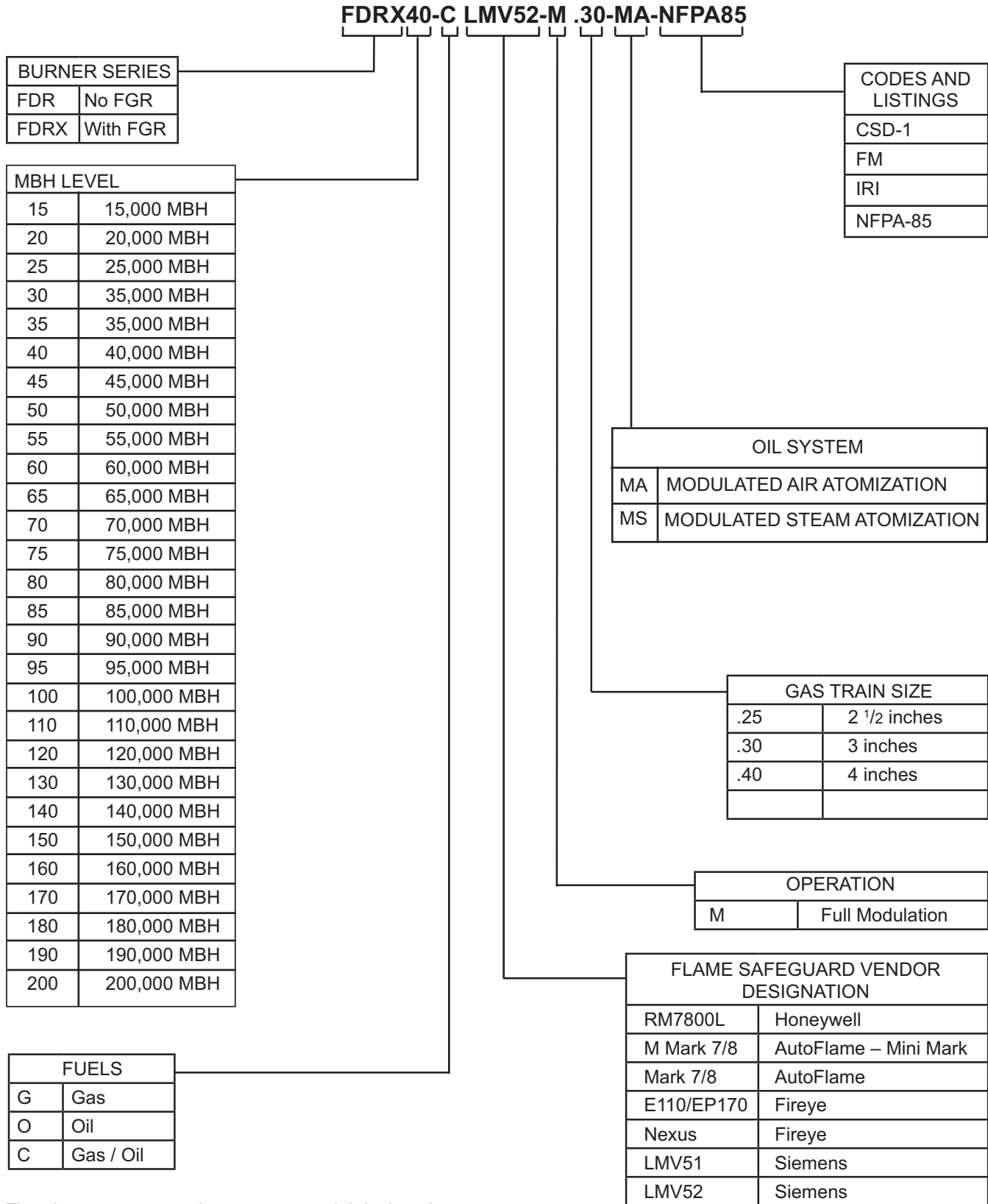
3. Product Offering

The FDR burner is intended for watertube boiler applications. The burner can fire natural gas, propane and digester gas as well as all grades of light and heavy oil (#2, #4, #5, and #6 oils as defined by ASTM D396).

DO NOT USE GASOLINE, CRANKCASE OIL OR ANY OIL CONTAINING GASOLINE.

This burner is also available as a low emission burner, and will have model designation FDRX. The "X" in the FDRX refers to a low NOx burner, where FGR is used to reduce the NOx in the combustion gases. If the burner is not a low NOx burner, there is no "X" in the model name.

MODEL FDR(X) BURNER MODEL CONFIGURATION FIGURE A-1



The above represents the common model designations.
Contact the factory for other options and special applications.

4. Your Complete Manual

In addition to this manual, there are several other documents that should be considered as part of the complete manual for the burner. All of these documents are needed to support the installation and startup of the unit. These additional items include:

- a. The wiring diagram, which shows the limits and interconnection of the burner and vessel controls.
- b. The gas and oil piping schematics, which show the components and their positions in the piping train.
- c. The unit material list which provides an overview of the burner requirements and a complete bill of material, including part numbers and description for each item.

d. The flame safeguard manual provides the operating sequence for the burner management system. This will be a critical document for troubleshooting any future problems.

e. Catalog cuts of the major components. These provide details on the installation, adjustment and maintenance of the components used on the burner.

5. Service, Parts And Other Information

Service and parts are available from your local Webster Representative. For a list of Webster Representatives, please visit the Webster web site at: www.webster-engineering.com or call 620-221-7464.

Figure A-2 General Ratings

Model	Gas MBH		#2 Oil (GPH)	
	Max.	Min.	Max.	Min.
FDR30	30,000	3,000	215	27
FDR45	45,000	4,000	320	40
FDR60	60,000	6,000	430	53
FDR75	75,000	7,500	535	67
FDR90	90,000	9,000	645	80
FDR110	110,000	11,000	785	98
FDR130	130,000	13,000	930	115
FDR150	150,000	15,000	1070	130
FDR170	170,000	17,000	1215	150
FDR190	190,000	19,000	1360	170
FDR200	200,000	20,000	1430	180

Figure A-3 Nameplate

MODEL NUMBER		SERIAL NUMBER			
FDRX60-C LMV52-M.30-MA-NFPA85		U237000A-01			
JOB LOCATION		DATE MFG			
BOULDER, CO		20-JUL-2001			
	GAS INPUT RATING		OIL INPUT RATING		
	MBTU/HR	PSI	GPH	PSI	
MAXIMUM	60,000	5.0	430	28/31	
MINIMUM	6,000	0.1	53	12/21	
FUEL	NATURAL GAS		#2 OIL/AIR		
	VOLTS	AMPS	HERTZ	PHASE	HP
CONTROL CIRCUIT	115	5	60	1	
BURNER MOTOR	460	20.1	60	3	40
OIL PUMP MOTOR	460	2.9	60	3	1.5

B. COMPONENT DESCRIPTION

1. General
2. Combustion Air
3. Burner Drawer
4. Gas Fuel Components

This section describes the components of the FDR and FDRX burner lines and provides some details on their application and operation. Other sections of this manual

5. Oil Fuel Components
6. Flue Gas Recirculation (FGR)
7. Fuel-Air-Ratio Controls
8. Electrical Controls

provide a more detailed review of how the components work as a system and explain the overall operation of the burner.

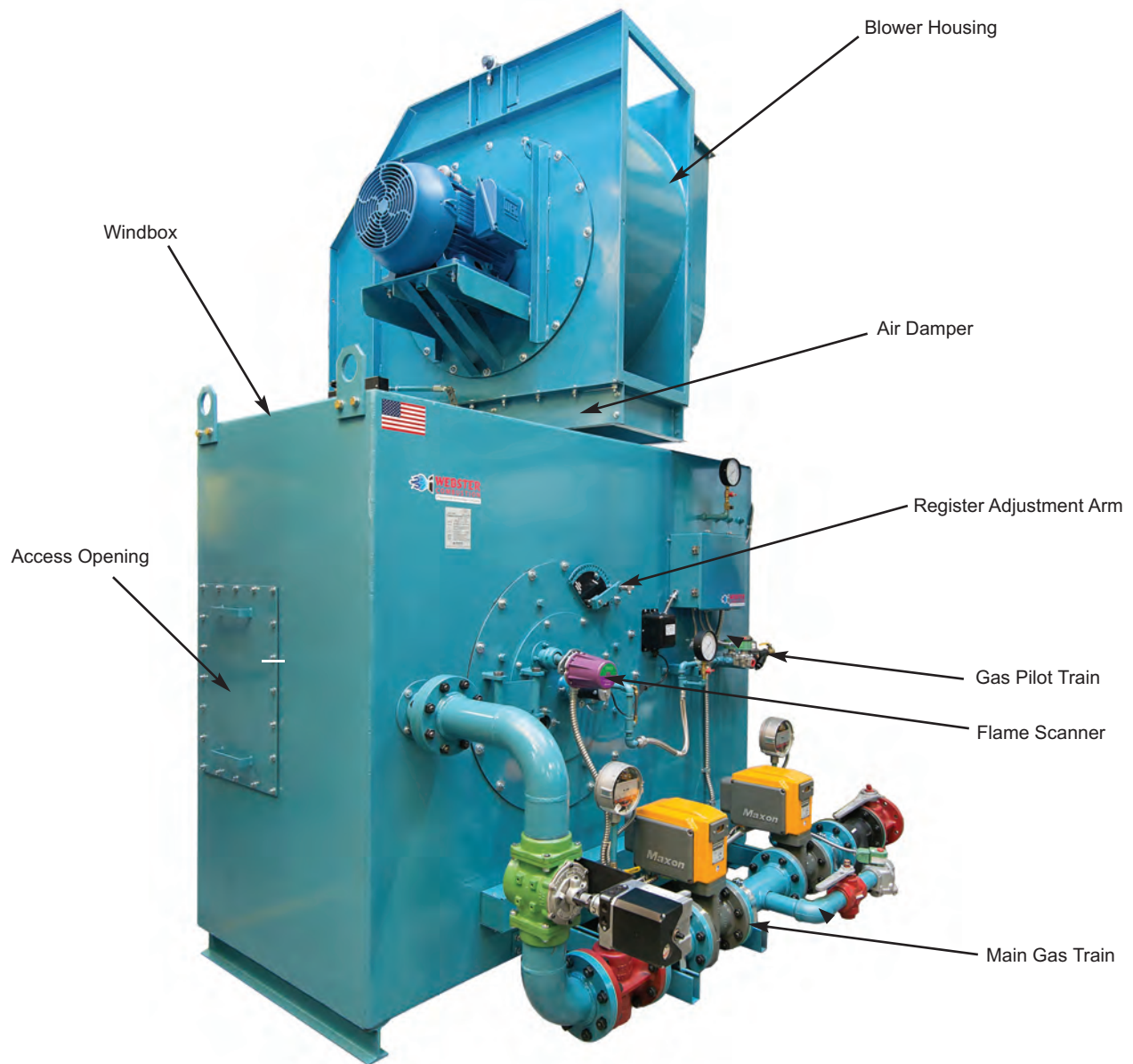


Figure B-1 FDR Burner

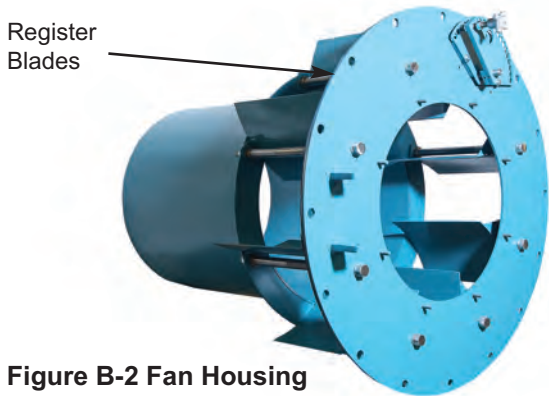


Figure B-2 Fan Housing

1. General

The FDR and FDRX burner lines (Fig. B-1) are configured from a common group of components that may vary in size and style depending on the capacity, NOx level, fuels and application. These common groups of components are described in this section, however the exact detail of any specific burner must be taken from the unit specific information provided with each burner. This would include the material list, wiring diagram, catalog cuts and fuel train drawings.

2. Combustion Air

Fan

A backward curved fan (Fig. B-2) is used to supply the combustion air to burn the fuel. If the burner is equipped with FGR for low NOx, the fan will also provide the recirculated flue gas. The fan diameter and width will vary to match the required combustion air flow rate, FGR rate, burner altitude and vessel backpressure. The fan can operate at either 1750 or 3550 rpm. Generally, smaller burners operate at 3550 rpm and larger units operate at 1750 rpm.

An inlet cone is used with the fan to provide a smooth air flow transition to the fan. Each fan has a matching inlet cone. In some cases, the inlet cone bolts directly to the housing and in other cases, it bolts to an adapter that bolts to the housing. The inlet cone should extend into the fan inlet about 1/4 inch.

Fan and Motor Assembly

The combustion air fan and motor are assembled together on a motor support plate that attaches to the blower housing. The fan can be adjusted on the shaft to provide the correct overlap between the fan and inlet cone (any fan adjustments or assembly must follow the installation procedures for that fan arrangement).

All combustion air motors are braced to minimize vibrations. Larger motors are mounted on a box which is secured to the floor. Smaller motors are braced with pipe brackets.

Several different motor styles can be used depending on the application. An Open-Drip-Proof style is most common and used in a typical enclosed, clean environment. A TEFC (Totally Enclosed Fan Cooled) would typically be used in a dirty or wet environment. Other styles are also available for special applications. The motor dimensions, including the shaft diameter can vary by motor type.

Fan Housing

The fan housing is an enclosure that routes the combustion air from the fan to the windbox. The combustion air fan and inlet cone are contained within the fan housing.

Windbox And Register

The burner windbox connects the fan housing to the firing head, and contains the register and mounting for the burner drawer.

The register is a multi-vane, circular assembly using curved louvers for precise distribution and control of combustion air. The position of the registers is manually adjusted to impart swirl to the air flow. By adjusting the register adjustment arm, the air can be rotated either in a clockwise or counter clockwise direction. This rotating combustion air creates a thorough mixing of the fuel and air before it enters the combustion zone, resulting in complete and efficient combustion.

Air Damper

The air damper (Fig. B-3) regulates the flow of air to the burner. It has multiple blades to control the air flow. The air damper is typically located on the inlet to the fan or at the outlet of the fan between the windbox and burner housing.

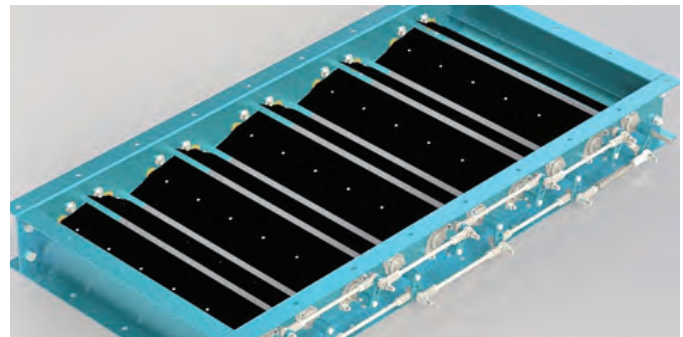
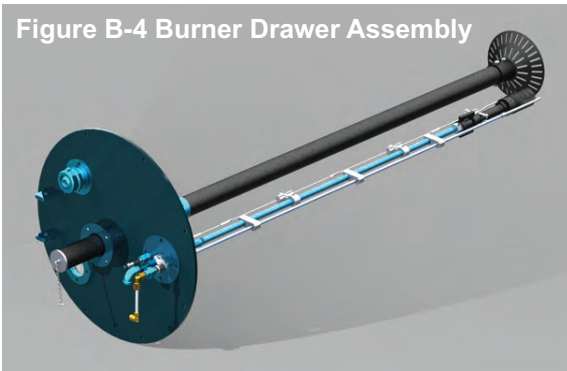


Figure B-3 Multi-blade damper

3. Burner Drawer

The burner drawer (Fig. B-4) contains the pilot, scanner, guide tube and oil gun. These components are all attached to the backplate. The burner drawer can be removed as a complete unit for adjustment and inspection. The burner drawer slides through the burner windbox and register and into the head. It is attached to the burner by bolting the backplate to the windbox.

Figure B-4 Burner Drawer Assembly



The oil gun position can be adjusted (in and out) by sliding the oil gun through the guide tube. Setscrews are used to lock these tubes into position. The oil gun can be removed for inspection or extended gas firing without removing the burner drawer. The scanner is adjustable by way of its ball and swivel mounting.

Diffuser

The diffuser (Fig. B-5) provides the directional control of the combustion air for mixing and combustion stability. The diffuser is mounted to the guide tube and can be adjusted by loosening the set screws on the drawer assembly and moving the guide tube.



Figure B-5 Diffuser

Scanner

The scanner is an electronic sensor that detects the flame and acts as a safety switch with the flame safeguard. It is aligned to see the end of the pilot flame and the main flame on both gas and oil. The scanner is mounted on an adjustable ball and views the flame through a pipe. This allows the scanner to be positioned to see the end of the pilot, which ignites the main flame.

Pilot

The pilot (Fig. B-6) uses a machined casting to provide a venturi to pull in air and mix the gas and air prior to burning. A perforated screen is used on the outlet of the venturi to shield the base of the pilot flame from high velocity air. A raw gas tube is used to provide additional gas to the pilot and generate the proper pilot flame size. The ignition electrode provides a spark within the perforated screen to ignite the pilot flame.

The pilot is positioned about 2 inches behind the diffuser, so that the pilot flame passes through the diffuser to ignite the main flame. The pilot should never be operated for longer than 60 seconds at a time as it can damage the diffuser.

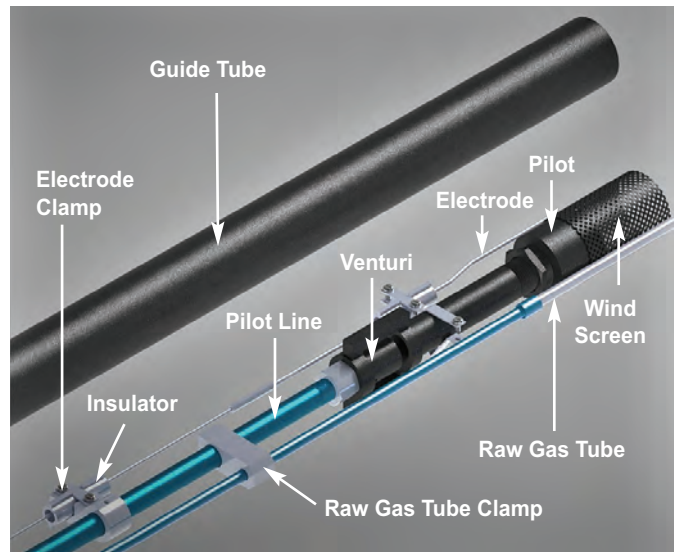


Figure B-6 Pilot

4. Gas Fuel Components

Gas Train

The gas train contains the safety shut-off valves, manual shut-off valves, pressure switches and other components that may be required for the specific installation, available gas pressure, insurance codes and local regulations. The details of the gas train can vary greatly from burner to burner. Gas trains tend to be designed for each application and a unit-specific gas train assembly drawing is provided for each unit, identifying the major components. Details are provided in the burner manual included with each burner.

The gas train shown in Figure B-7 uses a gas pressure regulator upstream of two safety shutoff valves.

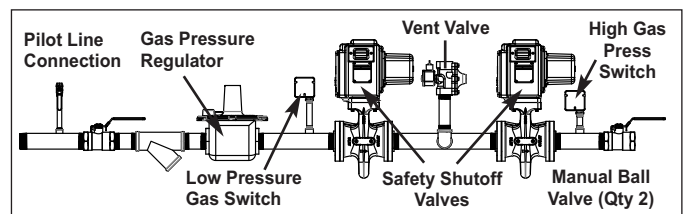


Figure B-7 Gas Train

Gas Safety Shutoff Valve

Each gas train has two shutoff valves in the gas train. These shutoff valves are usually motorized to open and spring return to close. They may contain a proof of closure switch to prove that the valve is in the closed position prior to starting the burner.

High Gas Pressure Switch

This switch is located after the last shutoff valve and before the gas flow control valve. It is set at a pressure that is greater than the highest gas pressure expected at this location. If the gas pressure rises above this level, it will trip the switch and cause the burner to shut down.

Low Gas Pressure Switch

This switch is located before the first shutoff valve. It is set to a pressure that is below the expected gas pressure at this location. If the gas pressure falls below this setting, the switch will trip and cause the burner to shut down.

Gas Pressure Regulator

Each gas train must have a gas pressure regulator. The regulator insures a consistent supply pressure to the burner. Often the gas pressure regulator is the first item in the gas train or can be integrated into the second shutoff valve.

Gas Control Valve

The gas control valve is used to modulate the flow of gas fuel to the burner. With a parallel positioning system (linkageless), an actuator is connected to the gas control valve and modulated by electronic control to the desired position. The gas control valve is located on the pipe that connects to the gas manifold.

Gas Manifold

The gas manifold, shown in Fig. B-1 of the FDR(X), is either an internal or external gas ring. The internal ring is standard unless conditions exist such as contaminated fuel, high combustion air temperatures, or use of multiple fuels. The precision drilled gas spuds are accessible on both internal and external designs.

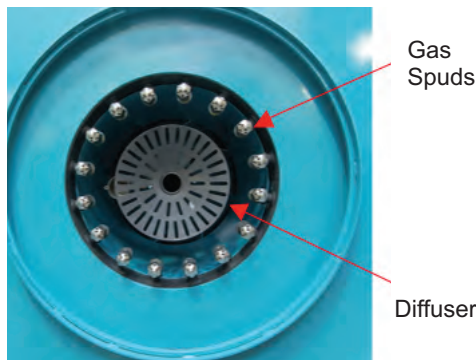


Figure B-8 Gas Spuds in Gas Manifold

Gas Spuds

A series of gas spuds are used to direct the gas into the air stream. These gas spuds are located around the circumference of the gas manifold. The gas spuds are arranged in a manner that gives good mixing of the air and fuel in conjunction with the diffuser.

5. Oil Fuel Components

The oil system uses air or steam to atomize the oil. An air compressor is typically used for atomization but plant air or steam can be used as an alternate. Any grade of oil can be fired from #2 through #6 oil.

Oil Pump (Optional)

The oil pump (Figure B-9) is used to supply the oil to the nozzle at sufficient flow and pressure for the nozzle. The oil pump is provided as a separate item that must be mounted, wired and piped. The assembly consists of the pump, motor, coupling, pump-motor bracket and oil pressure regulator. The motor base mount is used to secure the assembly.



Figure B-9 Oil Pump

Oil Pressure Regulator

An oil pressure regulator is used to maintain constant oil pressure to the burner. It is adjusted to provide the oil pressure needed at the nozzle.

Oil Supply Pressure Gauge

This indicates the oil supply pressure from the pump.

Oil Train

The oil train contains the safety shut-off valves, pressure switches and other components that may be required for the specific installation, insurance codes and local regulations and can vary greatly from burner to burner. Oil trains tend to be designed for each application and a unit specific oil train drawing is provided with each unit. Details of the actual components are provided with each burner.

Oil Safety Shutoff Valve

Each oil train has two shutoff valves. The valves can be either solenoid or motorized type and can have an optional POC (proof of closure) switch.

Low Oil Pressure Switch

This switch is set to a pressure below the expected oil pressure and will trip if the oil pressure drops below this level, shutting down the burner.

High Oil Pressure Switch

This optional switch is set to a pressure above the expected oil pressure and will trip if the oil pressure rises above this level, shutting down the burner.

Oil Heater Trim Heater (Heavy Oil Only)

This is an electric heater that is sized to increase the oil temperature by up to 30° F and provides final temperature adjustments close to the burner.

Low Oil Temperature Switch (Heavy Oil Only)

This switch is used on residual oil burners and set to a temperature that is below the expected oil temperature. If the oil temperature drops below this temperature, it will shut down the burner. If the burner is equipped with a trim heater, this switch is located on the trim heater.

High Oil Temperature Switch (Heavy Oil Only)

This switch is used on residual oil burners and set to a temperature above the expected oil temperature. If the oil temperature rises above this, the burner will shut down.

Manual Ball Valve

A manual valve is provided in the oil line to perform testing of the safety controls as part of normal startup procedures.

Oil Flow Control Valve

The oil flow control valve regulates the flow of oil to the nozzle. The oil flow control valve modulates with the air damper to provide different input rates. With a parallel positioning system (linkageless), an actuator is connected to the oil control valve and modulated by electronic control to the desired position.

Oil Nozzle

Several types of oil nozzles may be used depending on the oil system, burner size, turndown and application. They all share a common purpose of atomizing the oil into small droplets so that they will easily and quickly burn. The oil nozzles use either air or steam to atomize the oil. The nozzle is mounted to the end of the oil gun and is inserted into the support tube. The position of the nozzle can be adjusted by moving the gun in the tube. The oil nozzles and gun have a “top and bottom” position that is critical for correct operation. The end of the oil gun is marked with the word “TOP”.

Figure B-10 shows the components of typical air atomizing nozzles. The nozzle tip and swirler are lapped together to form a perfect fit and can only be used together as a matched set. Other air atomizing nozzles may have slightly different construction.

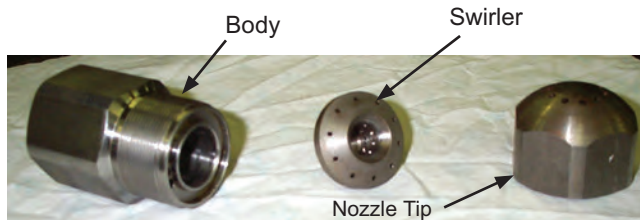


Figure B-10 Typical Large Air Atomizing Oil Nozzle

Oil Gun

The oil gun consists of the oil nozzle and pipe connections for the nozzle. The oil gun slides into the guide tube. Two blocks are used to keep the gun centered in the guide tube and lock the gun to the end of the guide tube.

The gun assembly must be mounted in the correct position, with the word “TOP” located on top of the gun assembly. This will allow for even oil distribution and prevent oil dripping out of the gun and lines after shutoff.

Nozzle Oil Pressure Gauge

This gauge indicates the oil pressure at the oil nozzle. This reading is important in determining proper operation of the nozzle for atomization at any given firing rate. There is a wide range of possible pressures, but typically it is in the range of 15 to 60 psi.

Nozzle Atomizing Air Pressure Gauge

This indicates the atomizing air (or steam) pressure at the nozzle. This reading is important in determining proper operation of the nozzle for atomizing the oil. The pressure can vary widely depending on the nozzle and rate, but typically it will be in the range of 15 psi at low fire to as high as 55 psi at high fire.

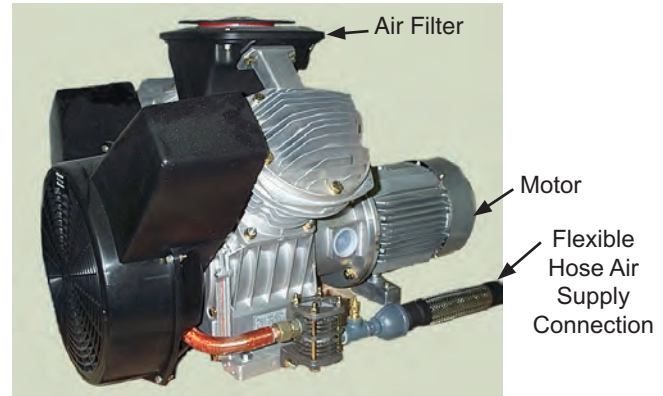


Figure B-11 Air Compressor

Air Compressor

The air compressor, if used, provides air to the oil nozzle to atomize the oil. The assembly includes the compressor motor, relief valve and flexible connection to isolate the vibration of the air compressor. The large air compressor (Figure B-11) is equipped with rubber mounts that must be used when mounting the compressor to a base.

Atomizing Media Control

The atomizing media can be controlled in different ways. House air and steam are controlled by a modulating flow control valve. If an air compressor is used, the flow will be controlled by bleeding some air off, with either a fixed valve or modulating valve. An air muffler is provided to reduce the noise from bleeding off air.

6. Flue Gas Recirculation (FGR)

The flue gas recirculation components in this section only apply to the FDRX model that uses recirculated flue gas to reduce the NOx emissions.

FGR Control Valve

The FGR control valve controls the flow of recirculated flue gas. The valve is connected to the FGR inlet tube at the combustion air inlet. The FGR inlet tube is in a negative pressure zone, which creates the pressure differential for FGR flow.

The FGR control valve modulates in conjunction with the fuel and air valves to provide different input rates. With a parallel positioning system (linkageless), an actuator is connected to the FGR control valve and modulated by electronic control to the desired position.

FGR Duct

The FGR duct provides the connection between the boiler outlet and the control or shut-off valve. The design of this duct is very important for proper operation and to prevent maintenance problems (see Section C).

7. Fuel-Air-Ratio Controls

The burner is equipped with a parallel positioning system (linkageless). This system provides the basic fuel-air-ratio control required for good combustion.

The Posi-Control system is a parallel positioning system (linkageless) that uses individual actuators for each control valve and a computer controller that directs each actuator to provide the input change from minimum to maximum capacity. The control provides more flexibility in setting each fuel rate.

8. Electrical Controls

Control Panel

The control panel (Figure B-12) contains a flame safeguard control, relays, terminal strips for electrical connections and other components required for the control of the unit. Other components may be included for the operation of the boiler, for example, a low water cutout relay.

Flame Safeguard

The flame safeguard provides operational control and safety sequencing for the burner. Safety limits are tied to the unit and it controls the operation of the fuel valves. The flame scanner is part of this control and can detect a flame failure causing a safety shutdown. There are several flame safeguard models available with different features and cost levels. They can provide fault annunciation and communication with other controls. The details of the control used in the burner are supplied with the unit.

On-Off Switch

This switch is used to start/stop the burner by opening or closing the limit circuit to the flame safeguard control.

Fuel Transfer Switch

This switch selects the proper fuel for firing. It has a center off position that prevents moving the switch from one position to the other, without momentarily stopping in the center off position.

Power On Light

Indicates power is applied to the control panel.

Call For Heat Light

Indicates the burner On-Off switch is closed and the boiler limits are closed.

Fuel On Light

Indicates the main fuel valve circuit has been energized.

Alarm Light

Indicates the flame safeguard control is in a safety shut-down and lockout condition. The flame safeguard control reset button must be pressed before the burner can operate again. On some burners the Alarm light may also be used to indicate other failure conditions such as low water, high limit, etc. See the burner wiring diagram for more details.

Control Transformer (Optional)

The control circuit transformer is used to reduce the main power input to 115 VAC for the control circuit. If this electrical supply could be provided as a separate input, this transformer would not be required. The transformer has two fuses located on the transformer box.

Alarm Bell

The alarm bell (or buzzer) provides an audible noise if the burner were to lock out due to an alarm condition.

Control Relays

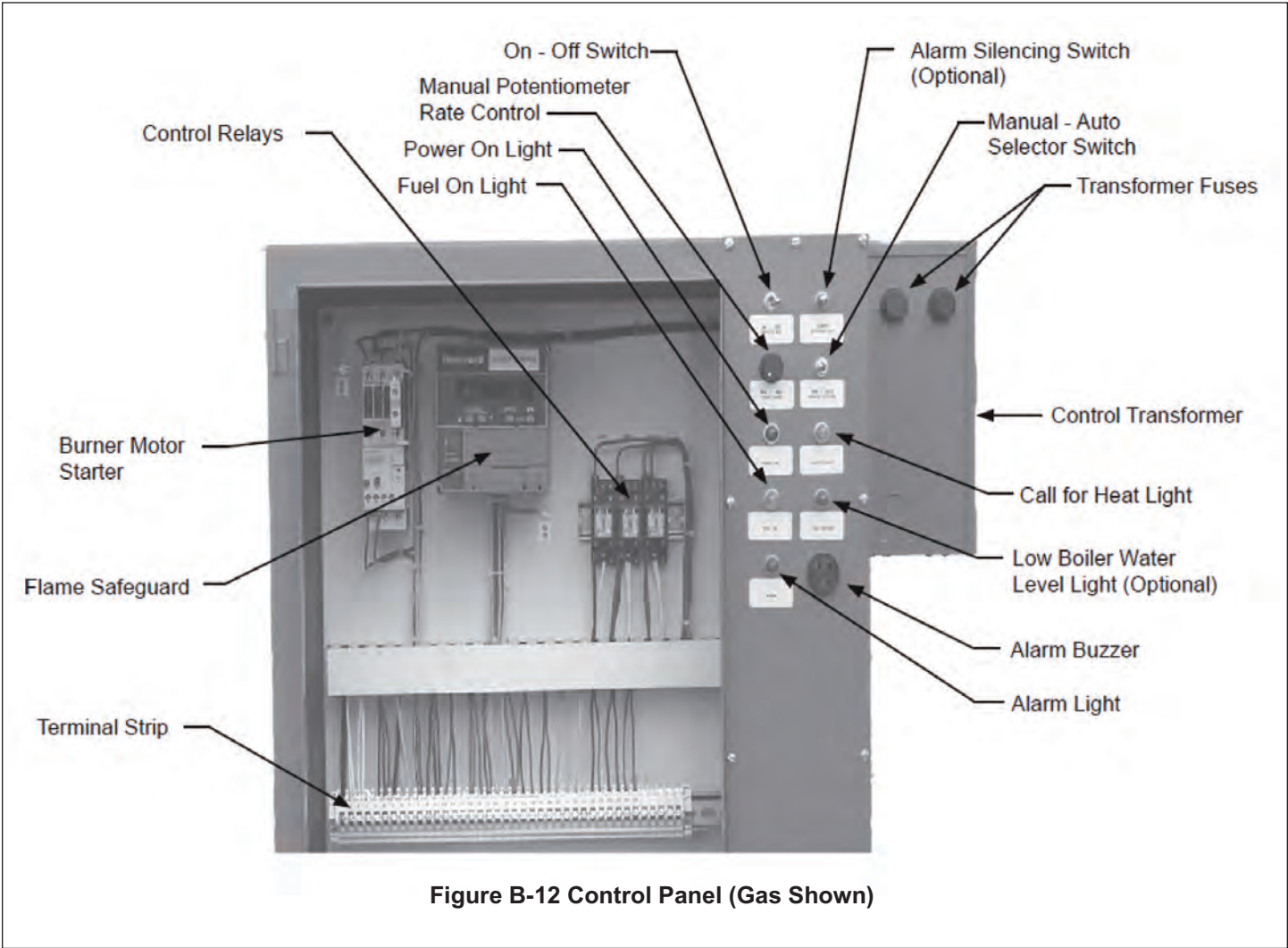
Relays are provided to support electrical options. The number and type of relays will vary with the equipment, and will be indicated on the wiring diagram/material list.

Motor Starters

At least one motor starter, for the combustion air fan, will be included in each control panel (unless a VFD is used). If other motors are used, for an oil pump or air compressor, these will also be located in the control panel.

Junction Box

The junction box contains the electrical connections that are required between the burner and control panel.



C. Installation

1. General Considerations
2. Gas Piping
3. General Oil Piping
4. Atomized #2 Oil
5. Heavy Oil

This section covers the installation procedures for each of the standard systems offered on the FDR (FDR and FDRX) burner line. Your specific burner will not have each of these systems and may be supplied to you as an installed system. If you receive the burner as part of a new boiler for example, the burner may be installed in the vessel with much of the piping already done. For this reason, a complete review of the installation is required to determine which tasks are complete and which need to be done.

THE INSTALLATION OF THE EQUIPMENT SHALL BE IN ACCORDANCE WITH THE REGULATION OF AUTHORITIES HAVING JURISDICTION, INCLUDING THE NATIONAL ELECTRICAL CODE, INSURANCE REGULATIONS, CSA STANDARDS 139 AND 140, THE CANADIAN NATIONAL ELECTRIC CODE AND ALL LOCAL CODES.

The equipment shall be installed in accordance with the state and local requirements and in Canada, in accordance with Provincial Installation Requirements, or in their absence, the CGA B149.1 and B149.2 codes shall prevail. Authorities having jurisdiction should be consulted before installations are made.

NOTE TO INSTALLER: The main power disconnect for this equipment must be conspicuously labeled and placed within sight of the operating system and equipped with lockout provisions.

1. General Considerations

In the initial planning of the installation, several items must be covered:

- a. Prior to starting the installation, all the technical literature should be collected and reviewed to identify requirements. As a minimum, these should include the Installation and Operating Manuals for the burner and vessel, the wiring diagrams, the fuel schematics and technical literature on supplied controls.
- b. A general overview of the equipment should be made prior to the installation. Check the location of access doors and insure that they will be able to function properly when all equipment is installed. The burner and control panel should have sufficient clearance for the operator to monitor, inspect and perform maintenance. A minimum clearance of 36 inches all around the burner should be provided for maintenance. The burner drawer and oil gun is pulled out from the front of the burner and there needs to be sufficient space for this activity.

6. Gas Pilot
7. FGR Duct System
8. Drafts & Stacks
9. Electrical System

c. A source of combustion air must be provided for the burner. Local codes often determine minimum requirements, and these must be followed. In absence of other codes, the following can be used.

Webster recommends two air sources be provided, one located high and one low. Each air source must be at least 1 ft². If there are multiple burners, the area must consider all burner requirements. Exhaust fans are not recommended as they create additional air flow requirements that must be included in the area calculation.

The quantity of air required for combustion and ventilation is 0.24 cfm/MBH. The maximum air velocity is 250 ft/min from the floor to 7 feet high, and 500 ft/min above 7 feet high. Outdoor louvers may restrict the open area, and if the exact restriction is unknown, a restriction of 20% can be used. Add 3.5% to the area for each 1000 ft above sea level. The calculations are,

$$\begin{aligned}\text{Total air required (cfm)} &= \text{MBH} * 0.24 \\ \text{Open area} &= \text{cfm} / \text{velocity} \\ \text{Louvered area} &= \text{open area} * 1.2 \text{ (or actual)} \\ \text{Area of opening} &= \text{louvered area} / 2\end{aligned}$$

For example, with duct located under 6' high for a 20,900 MBH boiler, what would the area need to be? The total air is (20,900 MBH * 0.24 cfm/MBH) = 5016 cfm. The maximum velocity is 250 ft/min, so the open area must be = (5016 cfm / 250 ft/min) = 20 ft². Since these opening will have louvers, the actual openings must be = (20 ft² x 1.2) = 24 ft². There will be two opening, so each will be = (24 ft² / 2) = 12 ft².

The location of the combustion air source must not create a condition where the burner or vessel comes in contact with very cold air (under 40°F) or causes large fluctuations in combustion air temperature. Cold air can cause condensation below 40°F in a standard burner and below 50°F when equipped with FGR.

There should be no large variations in combustion air temperature supplied to the burner. The burner can be adjusted to handle temperature variations of 30°F, but may not be able to handle temperature swings of 50°F without combustion deterioration. In conditions where this can occur, some conditioning of the combustion air must be done by location, baffling or pre-heating of the air. Seasonal tuneups can also help cover the larger temperature swings.

d. There are several people that should be notified before starting, including the owners representative, the mechanical contractor, the electrical contractor, the service organi-

2. Gas Piping

WARNING
DO NOT USE TEFLON TAPE OR COMPOUNDS CONTAINING TEFLON. THIS COULD DAMAGE THE VALVES CREATING AN UNSAFE OPERATION.

NOTE TO INSTALLER: The manual shutoff valve on the gas supply drop line to the burner must be clearly labeled.

Figure C-1 shows a typical gas piping schematic, although some components can vary based on size, insurance and other requirements. Consult the job specific gas train piping schematic (provided with the burner if train is supplied by Webster), along with a detailed list of components for specific details. This must be followed to properly locate the components in the gas train.

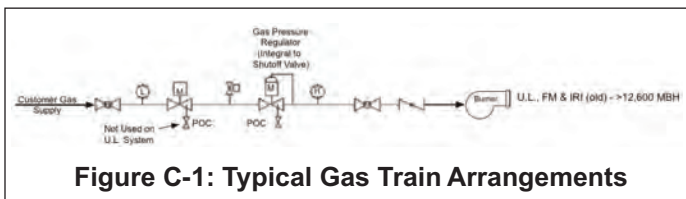


Figure C-1: Typical Gas Train Arrangements

The gas piping must comply with all local and state codes and must be in accordance with the local gas company and insurance requirements.

If the gas train has not been factory assembled, the components should be assembled as indicated on the gas piping schematic furnished with the burner. A drip leg should be provided upstream of the first manual valve to collect any moisture or contaminants. Some general considerations for this installation are:

- a. The piping to the burner must be sized to provide gas at the pressure and volume indicated on the order.
- b. The gas piping should be installed according to local regulations and any applicable insurance requirements.
- c. The gas pressure regulator usually requires a minimum straight length of pipe leading into and from the valve for proper operation. Also some regulating valves require a downstream pressure tap that must also be located at a certain dimension from the valve. These details are provided in the job specific details provided with the burner.
- d. The piping between the train and burner must be done in a manner that will minimize the pressure drop. The pipe size should be the larger of the two connection points (on the train or the burner connection) and must use a minimum amount of elbows.
- e. The gas piping should be cleaned to remove filings and other debris common in the construction process.
- f. The piping should be pressure tested with inert gas at two times normal operating pressure before use. Check main and pilot regulators for maximum inlet pressure.

3. General Oil Piping

WARNING
DO NOT USE TEFLON TAPE OR COMPOUNDS CONTAINING TEFLON. THIS COULD DAMAGE THE VALVES CREATING AN UNSAFE OPERATION.

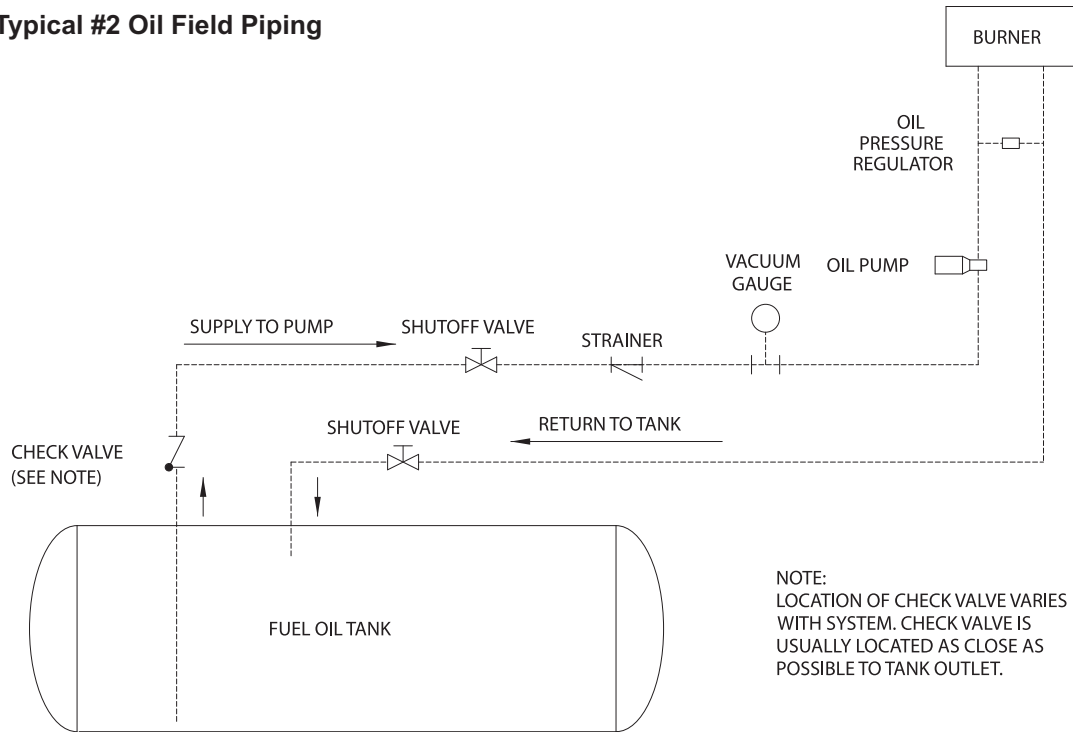
The amount of oil piping required in the field will depend on the type of system and how the burner was purchased. If the burner was factory mounted to the boiler, much of the installation work may already be complete. Units with heavy oil have more complexity built into them and will require more installation effort. The items identified in this manual assume that none of the installation work has been done by others.

The oil piping must be constructed to provide the flow and maintain the pressure required for proper system operation. Refer to the previous section for details on each of the different types of oil systems and how they operate.

Some of the actions required for successful piping systems are:

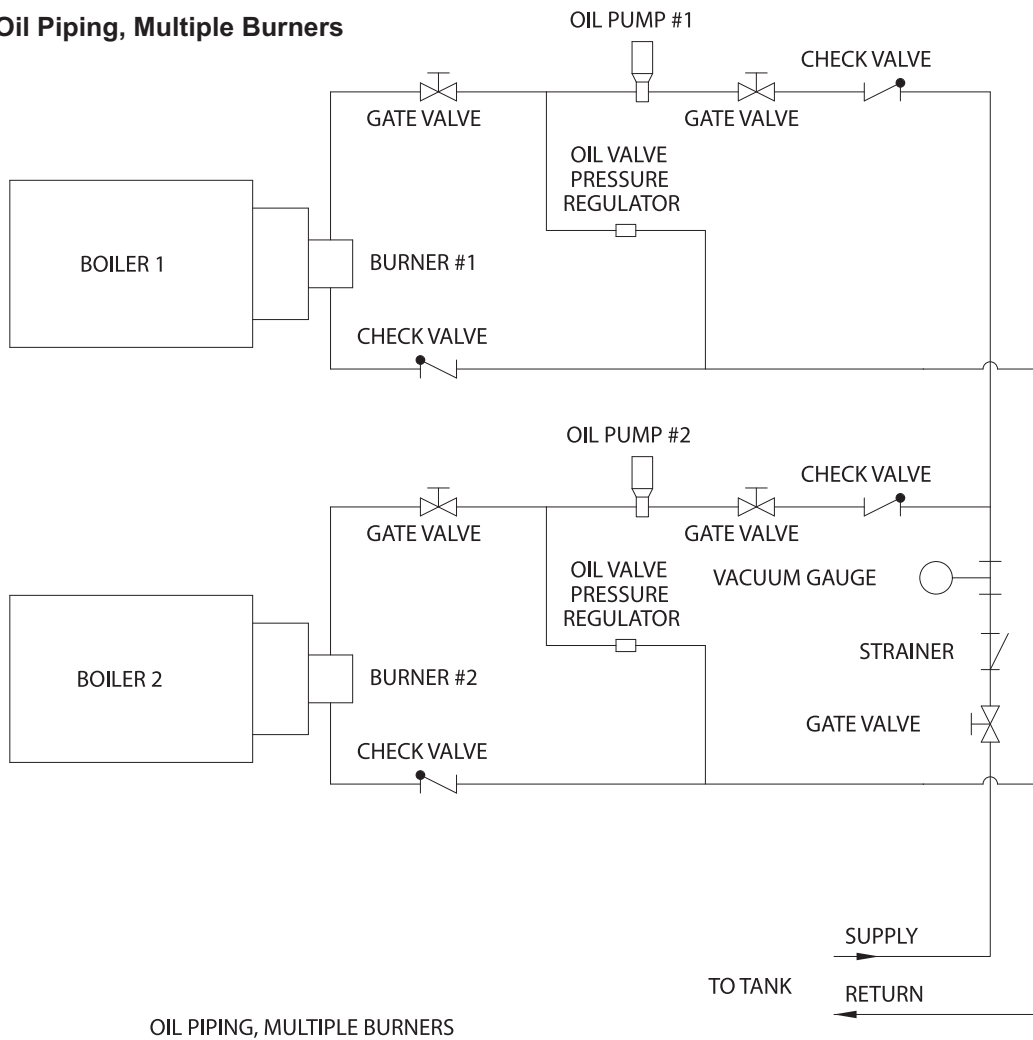
- a. Oil storage tanks and piping must conform to the National Fire Protection Association "Standard for the Installation of Oil Burning Equipment NFPA-31", local ordinances and EPA underground storage tank requirements.
- b. Oil lines shall be substantially supported and protected against physical damage. Buried lines shall also be protected against corrosion.
- c. After installation and before covering, buried lines should be pressure tested for leakage.
- d. Cast iron fittings should not be used.
- e. Aluminum tubing should not be used.
- f. Proper allowance should be made for expansion and contraction, jarring, vibration and tank settling.
- g. Always run full size lines.
- h. Suction and return lines shall be as short as possible.
- i. The oil lines must be cleaned to remove water, rust and foreign matter.
- j. The standard oil pumps supplied on the FDR(X) are Viking Model SG operating at 1750 rpm. These pumps can provide suction (vacuum) of 10 inch of Hg when used to pull from a tank. If a transfer pump is used, the maximum inlet pressure that the pump can tolerate is 15 PSIG, although most regulations require a maximum transfer loop pressure of 3 PSIG.

Figure C-2 Typical #2 Oil Field Piping



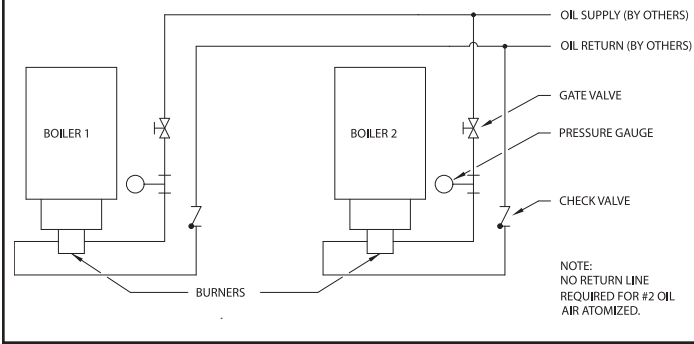
NOTE:
LOCATION OF CHECK VALVE VARIES
WITH SYSTEM. CHECK VALVE IS
USUALLY LOCATED AS CLOSE AS
POSSIBLE TO TANK OUTLET.

Figure C-3 Oil Piping, Multiple Burners



OIL PIPING, MULTIPLE BURNERS

Figure C-4 Oil Schematic, Multiple Burners with Remote Oil Pumps



k. A strainer is required to protect the pump, valves and oil nozzle. This strainer is not part of the standard equipment supplied by Webster, but is intended to be supplied and installed by others. The strainer should have a maximum filter opening of 0.027" for #2 oil and sized to handle the full flow rate of the pump. The strainer must also handle the pressure (max. 25" vacuum). Retain and follow the strainer instructions supplied by the manufacturer. It is essential that these instructions be followed to insure proper filtration to protect the pump, valves and nozzle.

l. In Canada, refer to CSA Standard B139, "Installation Code for Oil Burning Equipment" for recommended installation procedures.

m. The oil lines and most valves are sized to handle the full pump capacity. The pumps are selected for a capacity of at least 1.5 times the maximum nozzle rate.

The selection of the oil pipe line size is critical for proper operation of the system.

To determine the equivalent length of the oil piping, use the straight length of piping and add the equivalent length of straight pipe given for each fitting.

CAUTION: PUMP FAILURES CAUSED BY FOREIGN MATTER IN THE OIL LINES WILL NOT BE COVERED BY WARRANTY

4. Air Atomized #2 Oil

The standard FDR air atomized burner equipped for light oil may not include the optional oil pump. Oil is to be delivered to the burner at a constant 125 PSIG and with a flow capacity that is at least 50% higher than the rated nozzle capacity.

The oil supply and return lines must be piped to the burner, with the components installed as shown in the schematic. The oil pressure regulator must be located close to the burner to provide a constant oil supply pressure.

5. Heavy Oil

The standard FDR burner equipped for heavy oil will include a trim heater and controls, but not the pump or primary heater. Oil is to be delivered to the burner at 125 PSIG and at a temperature that is within 30°F of the final oil temperature. The pressure regulating valve must be capable of controlling the pressure anywhere in the range of 75 to 125 psi, as required for proper burner operation.

The primary oil heater (provided by others) may be required to reach the temperatures needed for good atomization. This can be accomplished with a heat exchanger that uses steam, hot water or electrical energy, or it could be done by simply heating the oil tank. In either case, the oil must be provided to the burner at a temperature that is within 30°F of the required atomization temperature.

A supply and return line connection are required. The lines must be sized correctly to provide the required flow with minimal pressure drop. The pressure in the return line should not exceed 3 PSIG.

The oil supply and return lines must be piped to the burner. The motor base of the oil pump and air compressor should be bolted securely to the floor or some rigid base.

6. Gas Pilot

The typical piping schematic for the gas pilot is shown in Figure C-5. The supply is connected upstream of the first manual gas valve. Actual gas pilot arrangement and construction may differ depending on agency listings and local building codes.

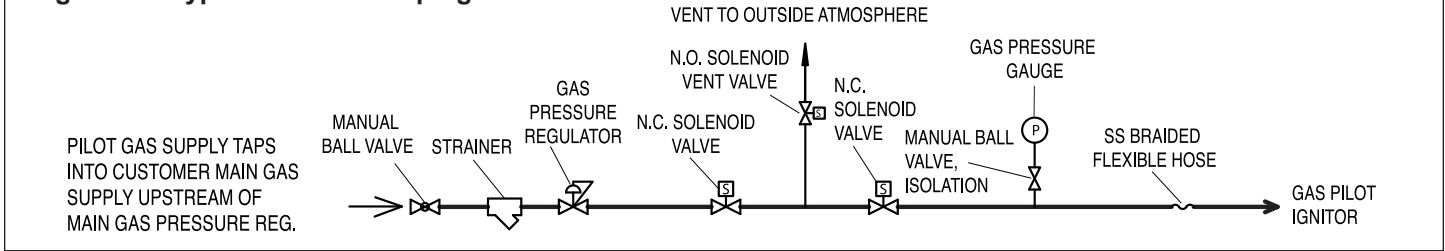
7. FGR Duct System

If the burner is equipped with Induced Flue Gas Recirculation (IFGR), it will require a duct connection between the stack outlet of the boiler and the air inlet of the burner. FGR is used to reduce NOx emissions.

There can be different levels of NOx emissions that require different quantities of flue gas and different FGR duct and valve sizes. Proper sizing and installation of the FGR duct must be done to provide the required emission control and burner performance.

The FGR control valve is already installed on the burner and the duct will connect to this point. A flange is supplied on the burner that the pipe can be welded to. Depending on the duct size required, a pipe reducer may be required to match the control valve to the duct. The control valve is usually a smaller pipe size.

Figure C-5 Typical Pilot Gas Piping Schematic



a. The duct should be routed in a manner that has the minimum number of elbows and provides for the normal expansion and contraction of the piping. Long duct runs can change length by over 1" and can put an extreme load on the connecting points that could cause component failures. The design must include offsets that will allow for the required movement of the piping without undue force on the burner or stack.

b. A condensation drip leg must be provided upstream of the FGR control valve. There must be sufficient condensate drip legs and catch space (volume of drip legs) to prevent the condensation from flowing through the control valves and into the fan. In cases of heavy condensation, a condensate drip leg may be required on the bottom of the housing, to remove condensate.

CAUTION: UNCONTROLLED CONDENSATION CAN CAUSE PREMATURE FAILURE OF THE CONTROL VALVES, FAN AND MOTOR. ADEQUATE MEANS MUST BE PROVIDED TO REMOVE CONDENSATION FROM THE SYSTEM. COLD STARTUP WILL GENERATE SIGNIFICANT AMOUNTS OF CONDENSATION.

c. Determine the duct size, as indicated above. Remember that changing the fitting type and number of elbows can have a large impact on the pressure drop. If the pressure drop is too high, the unit will not make the required NO_x or input due to the increased pressure drop. The burner capacity is reduced about 6% for each 1" of pressure drop.

d. Determine if pipe reducers are needed for the connection to the FGR control valve.

e. The duct must be properly supported, handling both the weight of the duct and to control the thermal expansion and contraction. The supports may need to be anchored to provide this stability in the FGR duct.

f. The FGR duct is normally made from schedule 40 pipe because it is easily obtainable and inexpensive. Schedule 20 pipe can also be used for this application.

g. The duct components must be seal welded, flanged or screwed together to provide an air tight duct. Air leakage into the duct will prevent the system from working properly. It is sufficient to only inspect the welds for a proper seal, they do not need to be leak tested.

8. Drafts And Stacks

Stacks and breechings must be designed to maintain a relatively constant draft at the boiler outlet without large variations. The draft at the boiler outlet should be maintained within +/- 0.1" wc. at low fire and up to +/- 0.25" at high fire, with intermediate draft proportional to firing rate. More important than the actual draft is the variation in draft at any given firing rate. For example, a tall stack or multiple units in a single stack may have different draft conditions depending on the outside temperature and the number of units running. The draft variation at any given firing rate should be controlled to within +/- 0.1" wc.

The stack should be designed to avoid wind influences from adjacent structures as well as preventing the flue products from entering inlet ducts, windows or other occupied areas. It should be of sufficient height to extend above the roof of the building or adjoining buildings to avoid down drafts in the stack or the possibility of carrying combustion gases to undesirable locations. Local codes should be checked for criteria on heights and exit velocities.

The breeching should be designed to be as straight and short as practical, to minimize pressure fluctuations. Smooth bends, gradual transitions, low velocities and tight construction are all important. Round breechings are preferred to square or rectangular ducts because they are more efficient and less likely to generate noise on the flat side due to resonance.

CAUTION: OIL BURNING EQUIPMENT SHALL BE CONNECTED TO FLUES HAVING SUFFICIENT DRAFT AT ALL TIMES, TO ASSURE SAFE AND PROPER OPERATION OF THE BURNER.

Circular elbows should be at least a four piece construction with a centerline radius that is at least double the duct diameter (use three times the duct width for square ducts). The breeching should have a slight upward elevation (about 1" per foot) towards the stack to help induce a draft.

The breeching connection to the stack or multiple boilers to a common breeching or stack must be done with care. The ducts should never be connected at a 90° angle, but rather a 45° angle where the flows will easily join each other. When connecting multiple boilers into a single breeching, the breeching size must be increased to accommodate the larger flow rates before the introduction of the added flow.

These breaching size changes must be gradual, with no more than a 10 degree slope change in the duct. When multiple breechings are connected into a common stack, their locations must be staggered to prevent the flow of one breaching interfering with another. Tall stacks can generate large drafts, and in fact the amount of the draft is related to the stack height. Also, systems with multiple boilers can have draft variations that are well beyond the desired level. These conditions must be corrected to allow the burner to work properly, or the draft variations will cause combustion problems. Controls can be added to compensate for this draft, and bring it back into the desired level. The barometric damper is the most common and least expensive control. Several barometric dampers can be added to provide the total correction to the system draft.

Draft controls are also available to regulate the draft by controlling an outlet damper. The speed of response is critical to allow these units to work correctly. If the draft control does not operate much quicker than the burner changes rate, the result may be large swings in draft as the control attempts to catch up with the burner. If there are large drafts due to tall buildings, special consideration must be given to the type of damper needed to regulate the draft, and the response of the control to maintain the proper draft.

Figure C-6 Maximum MBH in a Breaching

Breaching Dia. (in)	Total MBH
16	200
18	300
20	400
22	500
24	700
26	900
28	1100
30	1400
32	1600
34	1900
36	2200
38	2500
40	2900
42	3200

9. Electrical System

The burner is supplied as standard, with a remote control panel. The panel is either intended for floor or wall mounting. A proper location will allow the operator to see the burner operate while manning the controls. In some areas, there are local regulations that define where the control panel must be mounted in relation to the vessel.

The control panel must be securely attached to either the floor or wall with lag bolts.

The wiring diagram for the specific job should be followed for connections to the panels and external equipment. The National Electric Code, Canadian Electrical Code, Part 1 or similar code for other jurisdictions should be followed.

The following list covers the standard acronyms and abbreviations typically found on wiring diagrams.

- | | |
|------------------------------|------------------------------------|
| AUX. - Auxiliary | L.F.H. - Low Fire Hold Switch |
| C.B. - Circuit Breaker | L.W.C.O. - Low Water Cut Off |
| C.C.W. - Counter Clock-Wise | MR - Manual Reset |
| C.W. - Clock-Wise | N. - 120 V Neutral |
| CR() - Control Relay | N.C. - Normally Closed |
| FGR - Flue Gas Recirculation | N.O. - Normally Open |
| FTS - Fuel Transfer Switch | P.L.F.S. - Proven Low Fire Start |
| GND - Ground Terminal | |
| H.W.C.O. - High Water Cutoff | P.O.C.S. - Proof Of Closure Switch |
| INT - Interlock | SW. - Switch |
| L - 120V Line | |
| TDR - Time Delay Relay | |

Figure C-7 Pressure Drop per 100 Feet of Duct (in wc)									
MBH	Max Inlet Press.	4"	5"	6"	8"	10"	12"	14"	16"
Pressure Drop for 60ppm NOx – Natural Gas Firing									
8,400	1.00	1.4	0.4	0.1					
10,500	1.00	2.1	0.6	0.2					
12,600	1.25	3.1	0.9	0.3					
14,700	1.25	4.2	1.2	0.5					
16,800	1.25	5.5	1.6	0.6					
18,900	1.25	7.0	2.0	0.8	0.2				
21,000	1.50		2.5	0.9	0.2				
23,100	1.50		3.0	1.1	0.2				
25,200	1.50		3.6	1.3	0.3				
29,400	1.50		4.9	1.8	0.4				
31,500	1.50		5.6	2.1	0.5				
33,600	1.50		6.4	2.4	0.5	0.2			
33,600	2.00		8.1	3.0	0.7	0.2			
42,000	2.00			3.7	0.8	0.2			
46,200	2.00			4.5	1.0	0.3			
50,400	2.00			5.4	1.2	0.3			
Pressure Drop for 30ppm NOx – Natural Gas Firing									
8,400	1.00			1.9	0.4	0.1			
10,500	1.00			2.9	0.6	0.2			
12,600	1.25			4.2	0.9	0.3			
14,700	1.25			5.8	1.3	0.4			
16,800	1.25			7.5	1.7	0.5	0.2		
18,900	1.25				2.1	0.6	0.3	0.1	
21,000	1.50				2.6	0.8	0.3	0.2	
23,100	1.50				3.1	0.9	0.4	0.2	
25,200	1.50				3.7	1.1	0.5	0.2	
29,400	1.50				5.1	1.5	0.7	0.3	
31,500	1.50				5.8	1.7	0.8	0.3	
33,600	1.50				6.6	2.0	0.9	0.4	
33,600	2.00				8.4	2.5	1.1	0.5	
42,000	2.00					3.1	1.3	0.6	
46,200	2.00					3.7	1.6	0.7	
50,400	2.00					4.4	1.9	0.9	
Pressure Drop for 20ppm NOx – Natural Gas Firing									
8,400	1.00			4.6	1.0	0.3			
10,500	1.00			7.2	1.6	0.5	0.2		
12,600	1.25				2.3	0.7	0.3		
14,700	1.25				3.1	0.9	0.4		
16,800	1.25				4.0	1.2	0.5	0.2	
18,900	1.25				5.1	1.5	0.7	0.3	
21,000	1.50				6.3	1.9	0.8	0.4	0.2
23,100	1.50				7.6	2.3	1.0	0.5	0.2
25,200	1.50					2.7	1.2	0.5	0.2
29,400	1.50					3.7	1.6	0.7	0.4
31,500	1.50					4.2	1.8	0.8	0.4
33,600	1.50					4.8	2.1	1.0	0.5
33,600	2.00					6.1	2.7	1.2	0.6
42,000	2.00					7.5	3.3	1.5	0.8
46,200	2.00						4.0	1.8	0.9
50,400	2.00						4.7	2.2	1.1

D. Fuel and Electrical Systems

1. Gas Systems
2. Gas Pilot
3. Air Atomized #2 Oil
4. Fuel-Air-Ratio Controls

5. Electrical Controls
6. Operating and Modulating Controls
7. Flame Safeguards

The burner can be equipped with a variety of fuel and operating systems to control the fuel, air, modulation and safety. This section describes how these systems operate.

Each of the applicable systems must be completely understood prior to operating any equipment. In addition to the basic principles defined here, the component details and specific combination of components on your specific unit must be fully studied and understood. The fuel diagrams, wiring diagram, component manuals and bill of materials for the unit must be included in the study.

1. Gas Systems

All gas fuel systems have a common group of components, including the pressure regulator, shutoff valves, gas control valve and pressure switches. In addition, some systems use a vent valve, pressure switches and proof of closure switches. The type and location of these components can vary with the different applicable regulations, insurance and component supplier.

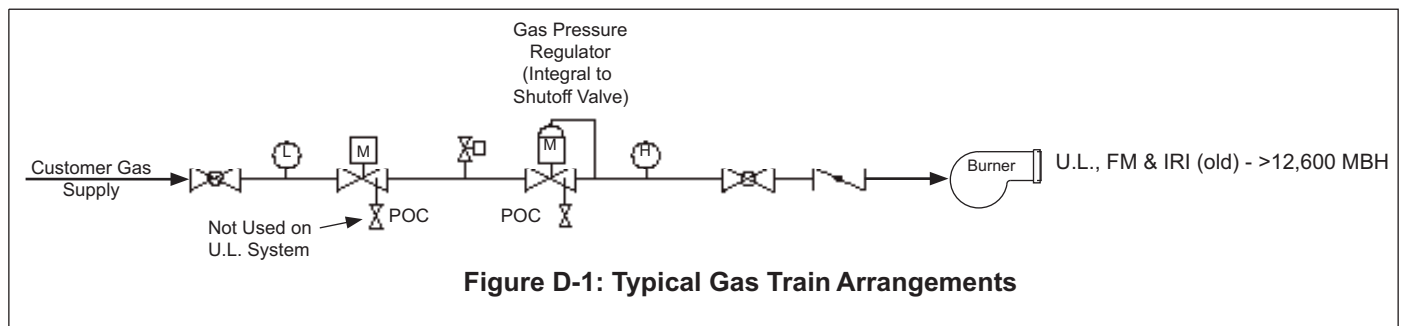


Figure D-1 shows a typical gas train arrangement used on the FDR(X) burner line. There may be other local or job site requirements that can alter the components in addition to those outlined in this summary.

All gas and oil systems for the FDR(X) burner are full modulating. The two gas safety shutoff valves are motorized and are controlled by the flame safeguard to provide safe control of the fuel flow.

The gas control valve is a butterfly valve used to control the flow of gas from the low fire to the high fire input.

The butterfly valve is driven by a fuel cam (linkage system) or a direct coupled actuator. There are different types of gas control valves used, which may use mechanical low fire stops and may be internally ported as a smaller size.

A vent valve is provided in some applications to allow gas that may leak past the first valve to escape to a safe point of discharge. **Vent valves are not used on propane fuels that are heavier than air or fuels that could be toxic.**

A gas pressure regulator is used to provide a constant supply pressure to the gas train and butterfly control valve. This constant pressure through a variable orifice in the gas control valve obtains consistent gas flow rates. The regulator must be capable of operating through the full range of flows and pressure with consistent and steady pressures. The regulator may be located upstream of the safety shutoff valves or integral with the second safety shutoff valve. The high and low gas pressure switches are used to detect an improper gas pressure situation and will prevent the burner from firing under these conditions. The low gas pressure switch is located near the supply of gas to the gas train, to detect a loss of supply pressure. The high gas pressure switch is located before the metering valve to detect a surge in pressure to the burner.

The gas train is designed to work with the pressure available at the job site. This supply pressure generally refers to the pressure available at the entrance to the gas train, which is the pressure supplied to the gas trains shown in Figure D-1. The supply pressure may vary depending on the operation of the unit, in which case a minimum and maximum pressure are needed to define the supply pressure. The maximum pressure is the static pressure, or the pressure in the line when there is no flow. The leading components of the gas train are selected to operate up to these pressures. The minimum, or dynamic pressure is that pressure available when the unit is operating a full rate, or the reduced pressure due to the flow in the line. The gas train is sized to this pressure, so that it can deliver the required flow to the burner with this available pressure. The job site supply pressures must be consistent with the pressures listed on the burner material list.

The regulated gas pressure is that pressure required to overcome the pressure drops in the piping, firing head and furnace pressure to deliver the required flow at high fire.

Usually, one of the first steps in setting up gas combustion is to adjust the regulator to get rated capacity. This regulator is usually at the beginning of the train, but in some cases, it can be integral to the second shutoff valve. The pressure drops and regulated pressures will be different in these two designs.

The manual valves lock out the fuel flow during off times and during initial startup checkout. They provide an added level of safety and simplify maintenance.

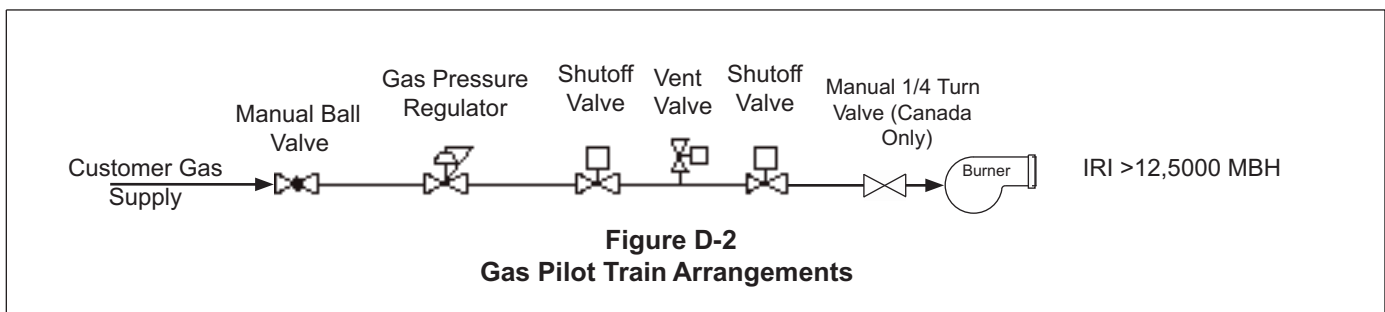
The gas piping can play a critical role in the operation of the system. Throughout the system, the piping must carry the required flow without significant loss of pressure. If the drop is too high, there may not be enough pressure to operate the burner at full capacity. This is especially true between the gas train and the burner, where the pressure is lowest. The piping between the train and burner should have a minimum number of elbows and / or turns to prevent high pressure drops.

2. Gas Pilot

Figure D-2 show the typical gas pilot systems. Like the gas trains above, they have the common components of a pressure regulator and shutoff valve. The gas line connects upstream of the pressure regulator in the gas train.

The gas pilot is positioned behind the diffuser, with the pilot flame passing through the diffuser. The flame must be large enough to pass in front of the scanner tube for the Flame Safeguard to detect the pilot flame and allow the burner to start. This also insures that there is sufficient pilot flame to ignite the main fuel.

The gas pilot can operate with either natural gas or propane. Different internal orifices are used to regulate the gas flow and maintain the same pilot size with the two different fuels.



3. Air Atomizing #2 Oil

An air atomizing system uses compressed air to atomize the oil. The oil pump and oil pressure regulating valve are optional and may be provided by others.

Figure D-3 shows a schematic of the air atomizing #2 oil system. The oil nozzle has two inputs, oil and air. Oil is supplied to the system at 125 PSIG. An optional remote pump assembly may be used, or it can be provided by other systems. In either case, a backpressure regulator is required to provide a constant pressure to the system.

The oil metering valve regulates the flow of oil to the nozzle and is used to vary the oil flow rate from low to high fire. Modulation is obtained by a fuel cam (linkage system) or by a direct drive actuator.

An air compressor is used to supply air for atomization. The air compressor is provided as a separate assembly and is field piped to the burner. The compressor should be located as close as possible to the burner to prevent loss of airflow. Also, the piping should be done to minimize the use of elbows and turns that result in pressure loss. The following chart should be used to determine the minimum size (Figure D-4).

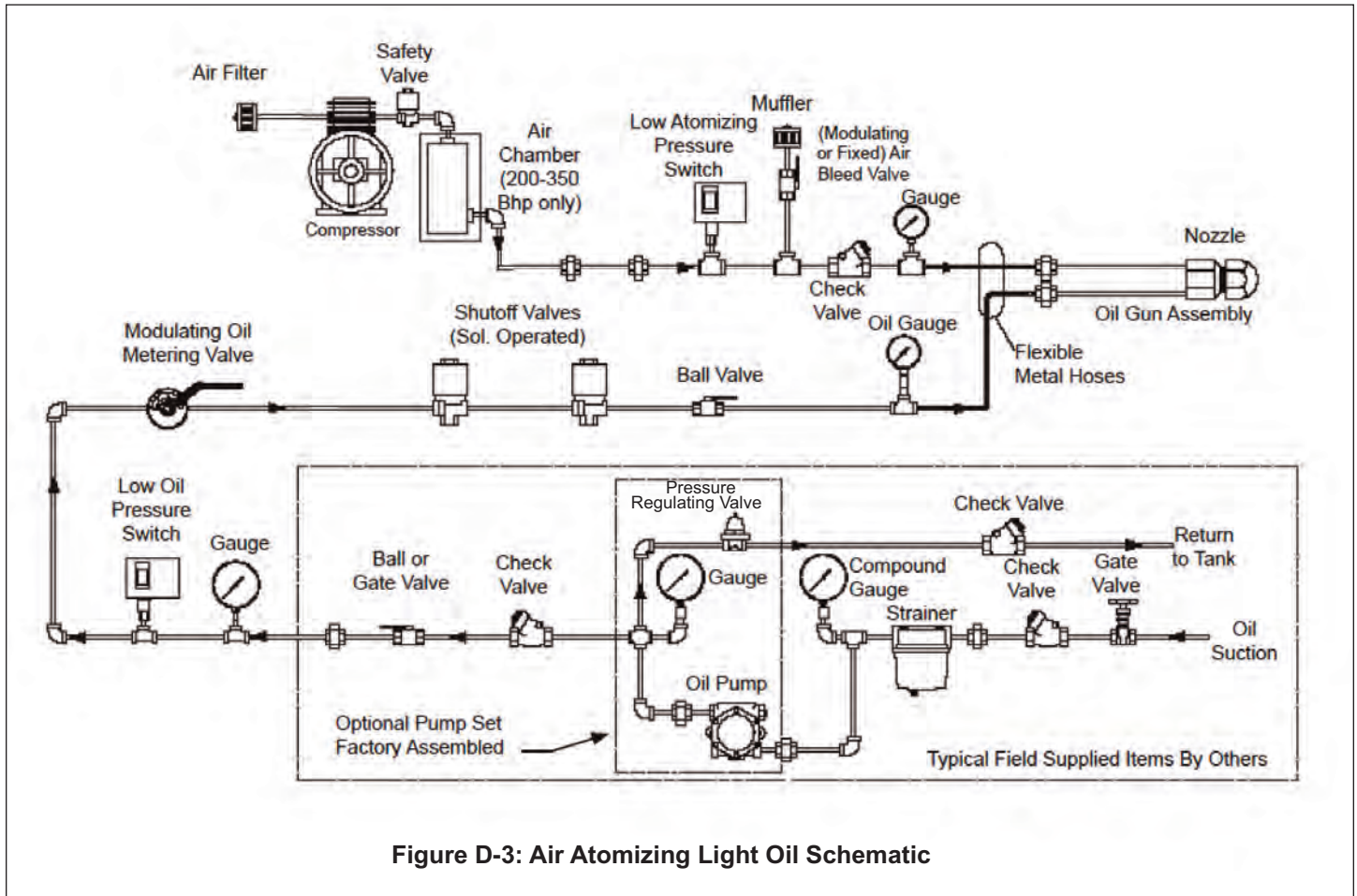


Figure D-3: Air Atomizing Light Oil Schematic

Atomizing Air Line Minimum Pipe Size		
MBH	Piping Length (feet)	
	0 - 100 feet	100 - 200 feet
8400-14700	1 inch	1 1/4 inch
16800-25200	1 1/2 inch	2 inch
25200-50400	1 1/2 inch	2 inch

Figure D-4 Air Atomizing Pipe Size

The atomizing airflow rate is regulated by the bleed valve, which can bleed off the excess air not required for good atomization. In some systems, especially with lower turn-down rates, the bleed valve is set manually and does not vary. In other systems, especially with higher turndowns, the bleed valve is modulated with firing rate, by connection to the jackshaft or by a direct drive actuator.

4. Fuel-Air-Ratio Controls

All FDR(X) burners are full modulation. That means that they can modulate from a lower input to a higher input, based on a measured need for more or less input. The system that adjusts the fuel and air flow is called fuel-air-ratio controls and is covered in this section.

For proper operation, the rate of fuel and air flow must be closely matched for clean and efficient combustion. Too little combustion air and not all of the fuel will be burned, wasting fuel and increasing emissions. Too much air and the energy is wasted in heating this excess air to a relatively high stack temperature.

There are two common types of fuel-air-ratio controls, single point positioning (linkage) and parallel positioning (linkageless). The linkage system uses mechanical shafts and connection links to physically tie the air and fuel control valves together. A modulating motor is used to modulate the valves from low to high fire by providing a 90 degree rotation that matches the firing rate required.

A long jackshaft is used to distribute this 90° rotation to each valve. Linkage arms are connected from the jackshaft to the valve. By adjusting the positioning of the linkage, the air and fuel valves can be set to match each other. A fuel cam is used to provide some improved flexibility in adjusting the intermediate fuel rates, to match the air damper settings. If the unit has FGR, the FGR control valve will be tied together with the other valves to provide the correct flow at each firing rate.

The linkageless system uses independent electric actuators for each fuel, air and FGR valve. These are driven by a controller, which is programmed to set the correct position of each valve at multiple firing rates. The linkageless system offers more flexibility in adjusting the valves, including low and high fire positions and different FGR rates for each fuel.

5. Electrical Controls

The burner is provided with a junction box on the burner and free standing control panel as standard. An integral control panel is provided as an option. The unit specific wiring diagram shows the wiring details of all these components, including the interconnecting wiring that may be required in the field. The motor starters for the oil pump and air compressor are also included inside the control panel. In some cases, the burner wiring diagram shows the interconnection of all the vessel safety and operating controls, like the low water cutoff. In other cases, these are shown on a separate diagram supplied by the vessel manufacturer. In all cases, these controls are integrated.

6. Operating and Modulating Control

Burner operations for on-off cycling and modulation are controlled by the boiler steam pressure or hot water temperature variation from set point. Parallel positioning systems use sensors to measure temperature or pressure and are programmed by a unique method, not covered in this manual. Refer to the control manual, provided with the burner, for complete details on setting the controls.

The standard equipment will include a high limit control, an operating control and a modulating control (not supplied with the burner). All of these controls are piped to the steam or hot water piping connected to the vessel. These three controls must be adjusted to function together or the burner will operate inefficiently and provide poor system response. If excessive on-off cycling occurs, the components will wear out prematurely. D-5 shows the relationship between the temperature or pressure and burner firing rates.

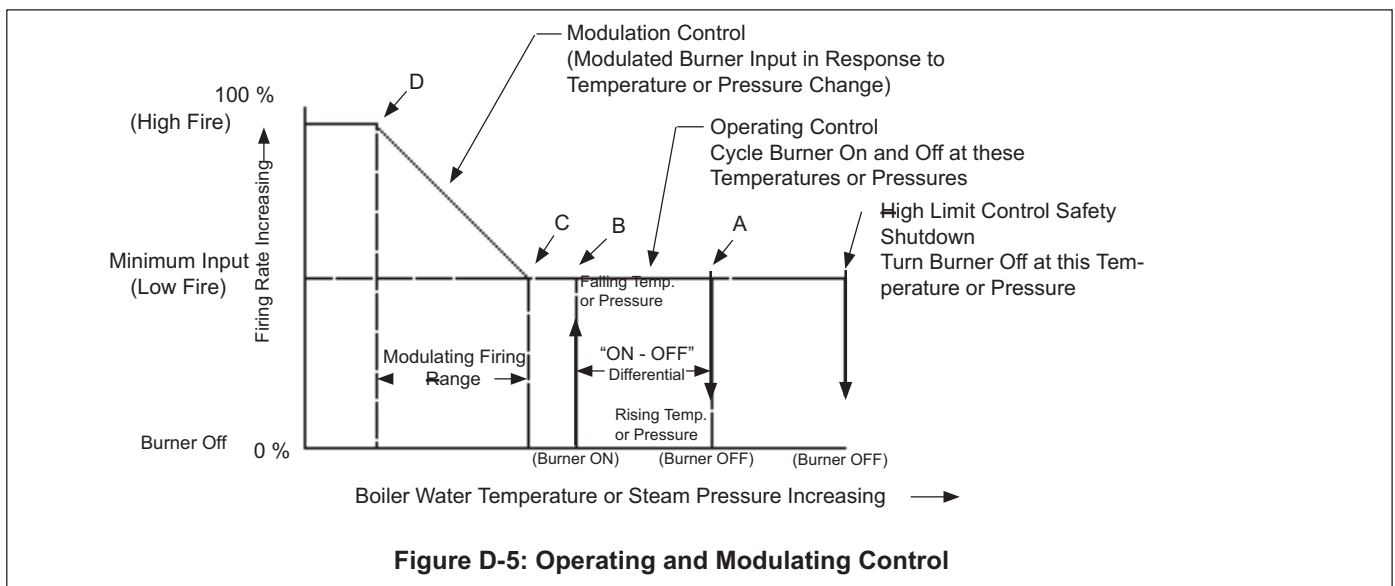
The high limit control senses the hot water temperature (vessel outlet) or steam pressure. It is used as a safety limit to turn the burner off if the operating control fails. If this limit is tripped, the burner will remain off and will have to be manually reset. The high limit control should be set sufficiently above the operating control (pressure or temperature) to avoid nuisance shutdowns. The high limit control cannot be set above the temperature rating of the vessel or connected piping. This point is indicated on the far right of Figure D-5 and represents the highest temperature or pressure available.

The operating control senses the temperature or pressure and automatically turns the burner on to initiate the startup sequence when the temperature or pressure drops

below the “Burner On” point (“B” on Figure D-5) and initiates the shut down sequence when the load is satisfied and the temperature or pressure rises above the “Burner Off” point (“A” on Figure D-5). The modulating control senses the temperature or pressure and signals the modulating motor to set the fuel and air input rates at a level consistent with the indicated temperature or pressure. An increasing load will cause the temperature or pressure to drop and the modulating motor will sense this lower level and increase the fuel and air input accordingly, starting modulation from low fire at point “C” and arriving at high fire at point “D” (Figure D-5). This control must be set to allow normal shutdown at low fire. As Figure D-5 shows, there should be clear separation between each of the control points for the system to work properly. If the controls are positioned too close to each other, or even overlapping, the burner will have excessive ON-OFF cycling that reduces efficiency, increases wear and can cause premature failure of the components. Standard burner motors in the FDR size range should not cycle on and off any more than 2 to 4 times per hour.

7. Flame Safeguards

Several different Flame Safeguards are offered for the FDR(X). They all perform the common function of controlling the process of pre-purge, pilot trial for ignition, main trial for ignition and flame safety as well as monitoring limit switches and sensors. The actual details of operation can vary. The manual for the specific Flame Safeguard is included with the burner and should be studied carefully prior to installation, startup or operation. The operating sequence, especially the sequence when the limit switches are checked will be important in troubleshooting the burner.



E. PRELIMINARY ADJUSTMENTS

1. Visual Inspection
2. Burner Drawer Setup
3. Motor Rotation
4. Fuel, FGR and Air Control
5. Air Damper Adjustments
6. Pilot and Scanner Adjustments

The burner combustion settings are not set at the factory. The burner will need to be adjusted for the specific application. In addition, several checks and adjustments are required prior to startup. This section covers these preliminary checks and adjustments.

WARNING: ADJUSTMENTS DEFINED IN THIS SECTION ARE ONLY INTENDED TO COVER THE INITIAL BURNER STARTUP. FINAL ADJUSTMENTS AS DEFINED IN SECTION F MUST BE DONE TO PROVIDE THE FULL SAFETY OF THE SYSTEM. FAILURE TO PROPERLY ADJUST THE CONTROLS COULD RESULT IN INJURY OR DEATH.

CAUTION: BURNER ADJUSTMENTS SHOULD ONLY BE PERFORMED BY TECHNICIANS TRAINED AND EXPERIENCED IN THIS WORK. FAILURE TO USE PROPERLY TRAINED AND EXPERIENCED TECHNICIANS COULD RESULT IN EQUIPMENT DAMAGE, PERSONNEL INJURY OR DEATH.

1. Visual Inspection

The shipment and installation of the burner can result in loose connections, bent arms and other changes. The burner should be visually inspected for any unusual conditions before operating.

- All wiring connections are tight. Test pulls on wire show them to be tight.
- All fuel lines are tight.
- Burner is securely mounted to vessel and floor.
- The air damper, FGR line and control valves are tight.
- The oil lines are tight.

2. Burner Drawer Set Up

The burner drawer must be inspected to insure that the components have not shifted or come loose during transit or installation. The following is a list of checks that should be done.

- The scanner tube should be aimed above the pilot and towards the main flame. It must not be able to see a small pilot flame that would not ignite the main flame. A pilot turndown test must be performed to insure this safe operation.
- The diffuser should not be crooked and must have the same spacing to the gas spuds throughout its circumference.

7. Gas System Adjustments
8. Oil System Adjustments
9. Air Proving Switch
10. Operating and Modulating Controls

3. Motor Rotation

The combustion air fan and pump motors must be checked for proper rotation.

The combustion air fan rotation is marked with an arrow on the blower housing. The rotation can be observed within the motor to verify correct rotation. The oil pump has a slot between the motor and pump where the rotation can be observed. An arrow on the pump shows the correct rotation. The direct drive air compressor can rotate in either direction, but belt driven compressor must rotate as the arrow indicates.

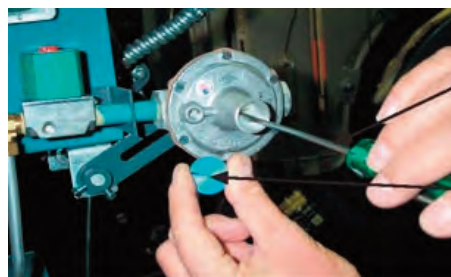
4. Fuel, FGR and Air Control

The fuel and air valves have initial positions set at the factory. Differences in air density, fuel properties and supply pressure will require tuning of the burner. The initial positions of the air damper, FGR valve, gas valve and oil valve should be adequate for initial startup, but must be checked so that movement did not occur during shipment or installation.

If the burner is equipped with FGR, the FGR valve will modulate with the fuel and air valves and it should travel from the near closed low fire position to a position that is about 45° to 90° open at high fire.

5. Air Damper Adjustments

Low fire is set at the factory to a near closed position. High fire position is typically 60° to 85° open, depending on the application. The combustion settings will determine final position.



Use screwdriver to adjust regulation

Removable cover

Figure E-1 Gas Pilot Regulator Adjustment

6. Pilot and Scanner Set Up

The pilot assembly is located on the end of a gas pipe that is inserted through the burner drawer assembly (Figure E-1). A bracket mounted to the guide tube is used to hold the pilot end in the correct position. A separate gas tube and ignition wire runs parallel to the pilot pipe, with brackets and insulators throughout the length.

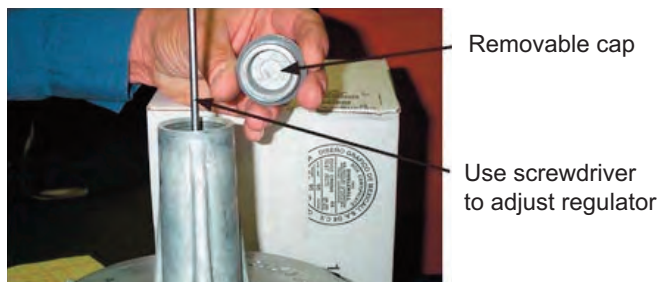


Figure E-2 Main Gas Pressure Regulator Adjustment

The electrode is positioned 1/16" from the end of the gas nozzle of the pilot, to generate the spark to ignite the pilot. The wind screen protects the pilot flame base from air turbulence, and the raw gas tube provide extra gas for a larger pilot flame.

The venturi is adjustable to allow air to mix with the gas in the pilot prior to ignition. The venturi is normally set for a 1/8" air gap, but is adjustable to more or less air.

The gas pilot regulator should be adjusted for gas pressure. The pilot flame should be large enough to easily pass through the diffuser and rise above the pilot.

The scanner is mounted to a pipe that is attached to a rotating ball. The scanner can be positioned to see the swirl flame from the pilot, but to drop out if the pilot flame is too small.

7. Gas System Adjustments

The gas pressure regulator should be set to the required gas pressure. If this value is not known, a value of approximately 50% over the high fire gas manifold pressure (given on burner nameplate) can be used for the initial setting. It will be adjusted at startup to obtain the rated capacity during setup (Figure E-2).

The low gas pressure switch (if provided) should be set for an initial value of 50% below the lowest expected gas pressure.

The high gas pressure switch (if provided) should be initially set at 50% above the highest valve expected at that point.

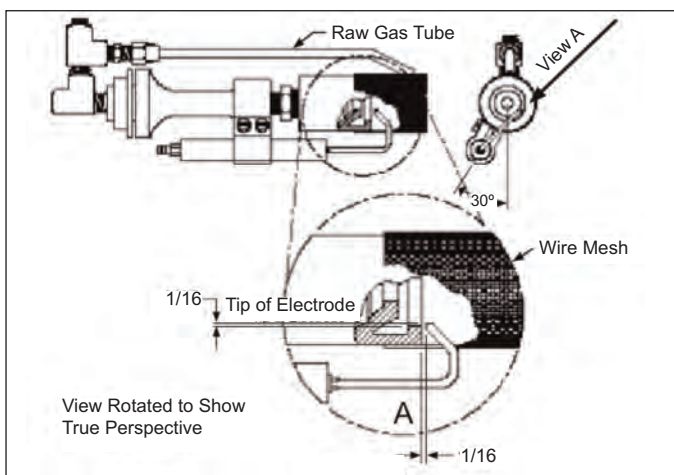


Figure E-3 Pilot Assembly



Figure E-4 Gas Pressure Switch Adjustment

8. Oil System Adjustments

The oil pressure supply to the burner should be set at 100 PSIG initially, and final adjustments made to support the high fire oil input, similar to the gas pressure regulator. The regulator is adjusted by removing the cap and turning the regulator screw clockwise (cw) to increase pressure and counter-clockwise (ccw) to decrease pressure (Figure E-5). The low oil pressure switch (Figure E-6) should be set for a pressure of about 25 PSIG lower than the regulated pressure.

#4 oil 150°F, #5 oil 180°F, #6 oil 200°F

The low oil temperature switch (Figure E-7) should initially be adjusted to 25°F below the value listed and the high oil temperature switch should be set at 25°F above the values listed.

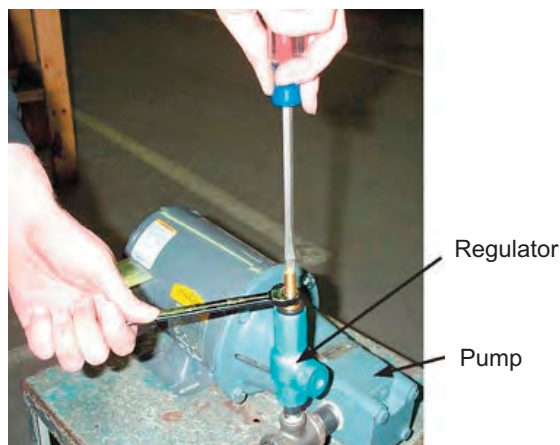


Figure E-5 Oil Pressure Regulator Adjustment

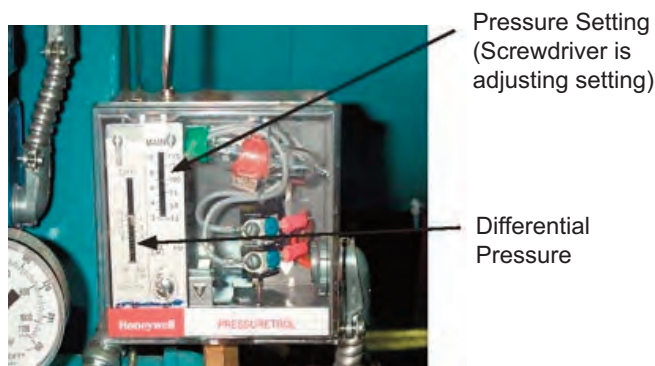
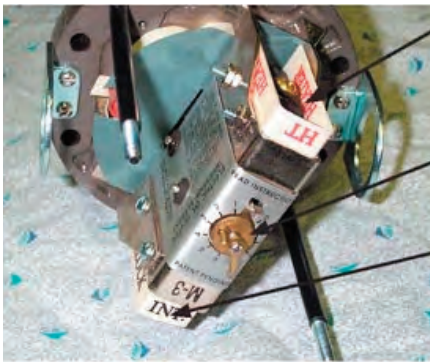


Figure E-6 Low Oil Pressure Switch



Oil Heater
Temperature
Control Contacts

Low Oil Temperature
Adjustment

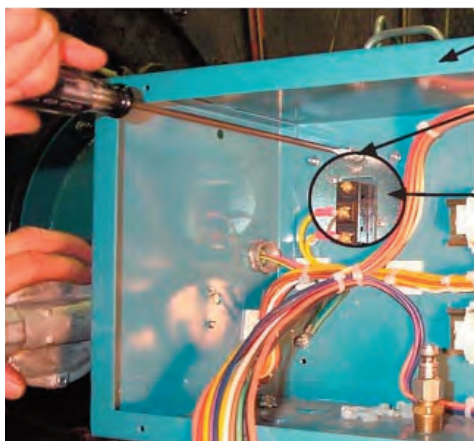
Temperature
Contacts

Figure E-7 Low Oil Temperature Switch

9. Air Proving Switch

The air proving switch has been adjusted at the factory for an initial setting. If this switch trips during initial startup, turn the adjustment screw CCW two full turns to reduce the trip pressure setting (Figure E-8).

The air proving switch may be located on the burner. In some cases, a pressure sensor may be used in place of the switch, depending on the type of controls used.



Panel

Adjusting
Screw

Air Proving
Switch

Figure E-8 Air Proving Switch

10. Operating and Modulating Controls

The operating controls will not be used during the burner setup, except that the high limit and operating controls can cycle the burner off and should be set for the highest allowable pressure for the application.

The high limit control should be set at the maximum temperature or pressure allowed for the boiler vessel or piping. The operating control should be set at a high enough pressure to prevent this control from turning the burner off unless the operating temperature or pressure is at the maximum value. The modulating control should be set at a value below the operating control to prevent the unit from modulating immediately after starting.

On heavy oil units, the electric trim heater should be set for a temperature that corresponds to the grade of fuel being burned.

F. STARTUP AND OPERATING ADJUSTMENTS

1. Pre-Start Check List
2. FGR Adjustment
3. Register Assembly Adjustments
4. Fuel Setups
5. Combination Gas and Air Atomized #2 Oil
6. Gas Setup
7. Air Atomized #2 Oil Setup
8. Heavy Oil Setup
9. Operating Control Adjustments
10. Limit Tests
11. Pilot Test
12. Burner Shutdown

This section covers the startup and operating adjustments of the Webster Models FDR burners.

WARNING

BURNER STARTUP, COMBUSTION ADJUSTMENTS AND LIMIT CONTROLS ADJUSTMENTS SHOULD ONLY BE PERFORMED BY TRAINED AND EXPERIENCED SERVICE TECHNICIANS. ATTEMPTING TO PERFORM THESE FUNCTIONS WITHOUT THE PROPER TRAINING AND EXPERIENCE CAN RESULT IN EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

Before proceeding with the startup and adjustment, be sure that the overall installation is complete. Review the boiler operating and installation manual, as well as all control manuals to verify that all equipment is ready for operation. These manuals must be read and understood prior to starting the equipment.

If you are not qualified to service this equipment, DO NOT TAMPER WITH THE UNIT OR CONTROLS - CALL YOUR SERVICEMAN.

At the conclusion of the startup, document valve, pressures and settings for future reference.

READ AND SAVE THESE INSTRUCTIONS FOR FUTURE REFERENCE.

1. Pre-Start Check List

Before starting the burner, a complete review of the installation, wiring and piping of the burner, boiler and all supporting equipment must be complete and all of these items must be ready for operation prior to starting. The following is a general review:

- _____ All wiring is connected. Test pulls on wire show them to be tight.
- _____ All fuel lines are connected and tight.
- _____ Pilot gas is connected.

_____ Burner is mounted to vessel and floor, with all bolts secured.

_____ The stack is connected and routed to the outside. Draft controls are installed and operational.

_____ Gas vent lines are connected and routed to outside.

_____ All cleanout doors are in place and secured.

_____ The vessel is completely installed, filled with water and operating controls checked.

_____ Support equipment is in place and ready (feed pumps, draft controls, steam/hot water systems, boiler limits and controls and feedwater systems).

_____ A load must be available for the burner startup and adjustment process. The burner must be operated at high rates for extended periods of time and the load must be capable of using this energy.

_____ A combustion analyzer with O₂ and CO (for gas) must be available to tune combustion. A smoke spot tester must be available for oil firing. If this is a low NO_x burner, a NO_x analyzer must be available. All of these analyzers must be recently calibrated and able to provide accurate readings.

_____ Other test equipment, including manometers, gauges and volt meter shall be available.

_____ Manometer or gauge on the gas manifold.

_____ Manometer or gauge before and after gas pressure regulator.

_____ Draft gauge or manometer (at stack outlet).

_____ Draft gauge or manometer for furnace pressure.

2. FGR Adjustments

Flue gas is recirculated back into the burner to reduce the flame temperature, which reduces the NO_x level. High quantities of flue gas result in lower NO_x levels, but can also result in flame instability if there is too much FGR. Generally, the NO_x levels only apply to gas firing and oil firing is not adjusted for NO_x levels. There may be exceptions to this, and the order details should be reviewed to identify any special combustion requirements.

The quantity of recirculated flue gas can be adjusted with the FGR valve, the relationship of the settings of the air louver, air register and FGR valve will also change the amount of FGR.

The quantity of recirculated flue gas can be adjusted with the inlet tube on the FGR line. To reduce the quantity of FGR, push the tube into the FGR line (loosen the two set screws to adjust the position of the tube, and tighten when done). Moving the tube into the air stream will increase the quantity of FGR. An access cover is provided opposite the FGR line for this adjustment.

On a dual fuel unit, the natural gas should be done first to properly set the FGR inlet tube. Once gas is setup, oil can be set.

3. Register Assembly Adjustments

The register is a multi-vane, circular assembly using curvature designed louvers for precision distribution and control of combustion air. By adjusting the register door positioner, the air can be rotated either in a clockwise or counter-clockwise direction. In addition, the amount of spin to the air can be adjusted by how far the register louvers are opened. The more open the louvers are positioned the flame produced will be longer and narrower. Conversely, the less the louver is opened the flame produced will be shorter and wider. This rotating combustion air creates a thorough mixing of the fuel and air before it enters the combustion zone, resulting in complete and efficient low excess air combustion that maximizes furnace geometry.

a. To adjust the diffuser to gas spud dimension, loosen the two screws on the center guide tube. The diffuser can now be moved in or out. Tighten the screws and nuts before operating the unit.

b. To adjust the oil nozzle to diffuser position:

- Loosen the two setscrews locking the oil gun lines to the aluminum end cap of the oil gun.
- Adjust the oil nozzle to obtain the best combustion.
- Watch for spray back on the diffuser when the gun is pulled too far back. The flame may appear good but carbon will quickly develop on the diffuser.
- Tighten the two setscrews on the oil tubes locking it into position.

4. Fuel Setups

Single fuel or combination fuel burners can be adjusted following the procedures outlined in Section 8 for gas firing; Section 9 for air atomized oil #2, and Section 10 for heavy oil firing.

The procedures for each of the systems must be completely understood and followed as part of the setup process.

5. Combination Gas and Air Atomized #2 Oil

Parallel positioning (linkageless) systems allow for flexibility in the fuel, air and FGR settings on each fuel, and can be tuned to match each fuel's needs. Each fuel curve is independent of the other fuel curves.

6. Gas Setup

- a. Place the burner switch in the "OFF" position
- b. If this is a combination fuel burner, make sure the fuel selector switch is on "GAS".
- c. Close the downstream manual shutoff valve (closest to the modulating valve) on the gas train.
- d. Turn the electrical power on for the burner, boiler and related components.
- e. Verify that the gas metering valve is nearly closed, the vent valve (if equipped) is operating and the gas pilot valve is not open.
- f. If equipped with FGR, verify that the FGR control valve is in the near closed position.
- g. Turn the burner switch on and follow the parallel positioning controls instructions on commissioning the burner. This will start the blower motor and initiate the prepurge cycle.
- h. When the prepurge sequence is complete and the low fire start switch is made, the pilot valve and ignition transformer will be energized and the pilot flame should be visible through the sight port. The flame signal should be strong and steady.
- i. When the pilot flame is established, the flame safeguard will energize the main gas valve (indicated with the Fuel On Light). This operation of the main fuel valves must be visually checked by observing the valve stem operation.
- j. After the timer has completed the trial for main flame, the burner will go out on alarm (the closed manual gas valve prevented the burner from lighting). At this time, the gas valves must be visually checked to verify that they have closed. This test sequence proves the proper operation of the primary control.
- k. Press the reset button and restart the burner. When the pilot has started, open the manual gas valve to allow the main flame to start.
- l. The control valve of the linkageless system should move from closed to a low flow position after the light off or golden start has timed out.

NOTE: If the burner is not operating as indicated, follow the troubleshooting guide steps to determine the problem and corrections required.

m. After a few seconds, the combustion analyzer should have an accurate reading of the O₂ in the stack. Figure F-2 shows the typical range of O₂ at different firing rates, and the burner should be adjusted to be within this range.

Rough settings for low and mid fire combustion settings are adequate at this time. Once the high fire is set, the other settings can be fine tuned.

- Operate the burner until the boiler is warmed up, and near the operating pressure or temperature. Follow the Parallel positioning controls instructions to commission the burner, while monitoring and adjusting the O₂ level. Adjust the gas pressure regulator as needed to reach the high fire input.
- n. If equipped with FGR, adjust the FGR valve as needed to obtain the approximate NOx level.
- o. Adjust the high fire input to match the maximum input listed on the rating label. At high fire, the gas butterfly valve should be at least 70 degrees open (more if available gas pressure is low), and the gas pressure regulator adjusted to obtain the rating. The input should be measured using the following equation:

Calculating Natural Gas Input

$$\text{Gas MBH} = \text{HHV} \times [(\text{Patm} + \text{Pgas})/29.92] \times [520/(\text{Tgas} + 460)] \times [\text{measured ft}^3/\text{sec}] \times [3600 \text{ sec/hr}]$$

Where: MBH = 1000's of BTU/M input HHV = Higher heating value of gas, BTU/cubic feet Patm = Atmospheric pressure in inches Hg Pgas = Gas pressure before gas meter in inches Hg

(inches HG = PSIG x 2.04) Tgas = Gas temperature at the flow meter, in degrees F Measured ft³ = volume of gas measured by meter sec = Time for measured ft³ to flow through meter

NOTE: Some gas meters require a 6 inch wc correction to Pgas. Consult your meter calibration data.

NOTE: THE LISTED MANIFOLD PRESSURE IS ONLY AN APPROXIMATE VALUE AND CAN VARY WITH OPERATING CONDITIONS AND NORMAL TOLERANCES. THE FUEL FLOW RATE MUST BE MEASURED TO OBTAIN AN ACCURATE INPUT VALUE.

- p. Adjust the air damper to obtain the correct O₂ level.
 - q. If equipped with FGR, adjust the NOx level to be about 10% below any guaranteed NOx performance. A balance of the FGR control valve and air damper are required to obtain the final result, as each can impact the other. Modulate the burner to low fire, adjusting the O₂ level as the burner modulates.
 - r. Adjust the low fire point for proper combustion.
 - v. Re-adjust the midfire points for the correct O₂ level.
 - w. If equipped with FGR, adjust the NOx levels at low and midfire rates to be about 10% under the guaranteed levels.
 - x. Adjust the low gas pressure switch to be 10% below the lowest expected gas pressure.
- With a gauge or manometer at the same location as the low gas pressure switch, modulate the burner to determine the firing rate with the lowest gas pressure.

- At the lowest gas pressure, adjust the low gas pressure setting up until the switch breaks and causes the burner to shutdown.
- From the scale reading of the switch, adjust the setting to a pressure that is 10% lower than the shutdown pressure. For example, if the switch opened at 10 inches as indicated on the low gas pressure switch, the switch should be adjusted to a reading of 9 inches.
- Remove the gauge or manometer and plug the opening. Cycle the burner on and off to determine if the limit works properly.
- If the limit causes nuisance shutdowns because of small pressure drops during startup, reduce the pressure setting an additional 5%. Note, the pressure cannot be set lower than 50% below the expected gas pressure.
- Adjust the high gas pressure switch to be 10% above the highest expected gas pressure.
- With a gauge or manometer at the same location as the high gas pressure switch, modulate the burner to determine the firing rate with the highest gas pressure.
- At the highest gas pressure, adjust the high gas pressure setting down until the switch opens and causes the burner to shutdown.
- From the scale reading of the switch, adjust the setting to a pressure that is 10% higher than the shutdown pressure. For example, if the switch opened at 10 inches as indicated on the high gas pressure switch, the switch should be adjusted to a reading of 11 inches.
- Remove the gauge or manometer and plug the opening.
- Cycle the burner on and off to determine if the limit works properly.
- If the limit causes nuisance shutdowns because of small pressure changes during startup, increase the pressure setting an additional 5%. Note, the pressure cannot be set lower than 50% above the expected gas pressure.
- The burner should be operating at low fire to adjust the air proving switch. Turn the adjusting screw cw (in) until the burner trips out (shutdown caused by the air flow switch). Turn the adjustment screw ccw (out) 1 1/2 turns from the point of shutdown. Check the operation at higher rates.

7. Air Atomized, #2 Oil Setup

The air atomized oil system has the potential for a large turndown range similar to gas and has the potential to be adjusted to different low fire rates. See the burner nameplate for details on actual rates for this burner.

- Place the burner switch in the "OFF" position.
- If this is a combination fuel burner, make sure the fuel selector switch is on "OIL".
- Turn the electrical power for the burner, boiler and related components on.
- Verify that the oil metering valve is at the nearly closed position.
- Turn the burner switch on and follow the parallel positioning controls instructions on commissioning the burner. This will start the blower motor and initiate the purge cycle.
- When the prepurge sequence is complete and the low fire start switch is made, the pilot valve and ignition transformer will be energized and the pilot flame should be visible through the burner sight port. The flame signal should be strong and steady.
- When the pilot flame is established, the flame safeguard will energize the main oil valves (indicated with the Fuel On Light), and the burner should ignite at low fire. This operation of the main fuel valves must be visually checked by observing the valve stem moving up with a motorized valve or hearing the clicking noise from a solenoid valve.
- If equipped with FGR, the control valve of the linkageless system should move from closed to a low flow/low fire position after the light off or golden start timing is over.

NOTE: If the burner is not operating as indicated, follow the troubleshooting steps to determine the problem and corrective action.

WARNING: DO NOT ATTEMPT TO START THE BURNER WHEN EXCESS OIL HAS ACCUMULATED, WHEN THE UNIT IS FULL OF VAPOR, OR WHEN THE COMBUSTION CHAMBER IS HOT.

**Figure F-2
O₂ levels**

% Rate	Natural Gas With FGR		Natural Gas No FGR		Oil	
	Min % O ₂	Max % O ₂	Min %O ₂	Max %O ₂	Min %O ₂	Max %O ₂
8	5.0	9.0	7.0	13	NA	NA
10	5.0	9.0	5.5	12	6.0	10.0
15	4.0	8.0	4.5	10	5.0	9.0
20	3.0	8.0	3.0	9	3.5	8.0
30	2.0	7.0	3.0	8	3.5	7.5
40	2.0	7.0	2.5	7	3.0	7.0
50	2.0	6.0	2.5	6	3.0	7.0
100	2.0	6.0	2.5	6	3.0	6.5

i. After a few seconds, the combustion analyzer should have an accurate reading of the O₂ in the stack. The O₂ level should be between 4% and 8% (see Figure F-2 for O₂ rates), and the nozzle oil press should be between 5 and 15 PSIG. Do not attempt to fine tune combustion until the high fire input has been set. If the burner is equipped with FGR, the FGR control valve should be set for the approximate NOx level required.

- The air damper should be positioned for the correct low fire settings.
- The atomizing air pressure can be adjusted using the air bleed valve.
- Operate the burner until the boiler is warmed up, and near the operating pressure or temperature (Figure F-3).
- Follow the Parallel positioning controls instructions to commission the burner, while monitoring and adjusting the O₂ level. Adjust the oil pressure and atomizing air pressure as needed to reach the high fire input.
- If the burner is equipped with FGR, adjust the FGR control valve as required to maintain the NOx level.
- At high fire adjust the high fire input to match the maximum input listed on the rating label. Using a flow meter, the fuel input may be measured using the following equation,

$$\text{Oil GPH} = \frac{[\text{Gal end} - \text{Gal start}] \times [3600 \text{ sec/hr}]}{[\text{measured sec}]}$$

Where Gal end = meter gallons at end of test
Gal start = gallons at start of the test
Measured sec = measured time of test
GPH = Gallons of oil per hour

n. If equipped with FGR, adjust the NOx level to be about 10% below any guaranteed NOx performance or if no performance guarantee exists adjust the FGR to provide some added turbulence but not high enough to impact flame stability. A balance of the FGR control valve and air damper are required to obtain the final result, as each can impact the other.

o. Modulate the burner to low fire, adjusting the O₂ level as the burner modulates.

p. Adjust the low fire input, following the parallel positioning controls instructions.

q. If the burner is equipped with FGR, adjust the NOx level according to the required level.

r. Re-adjust the midfire points for the correct O₂ levels.

s. If equipped with FGR, adjust the NOx levels at low and midfire rates to be about 10% under the guaranteed levels.

t. The burner should be operating at low fire to adjust the air proving switch. Turn the adjusting screw cw (in) until the burner trips out (shutdown caused by the air flow switch). Turn the adjustment screw ccw (out) 1 ½ turns from the point of shutdown. Check the operation at higher rates.

% Rate	Air Pressure
10	5 - 15
15	7 - 20
20	10 - 25
30	12 - 30
40	15 - 35
50	20 - 40
100	25 - 60

Figure F-3 Typical Atomizing Air Pressure

- a. Prior to startup, the oil system must be operating with the oil temperature to the burner (before the trim heater) within 20°F of the final temperature.
- b. Place the burner switch in the “OFF” position. If this is a combination fuel burner, make sure the fuel selector switch is on “OIL” and that the oil pump is running.
- e. Turn the electrical power on for the burner, boiler and related components.
- f. The oil may take some time to get up to temperature. If the oil is cool, the ball valve downstream of the N.O. oil return valve (Figure F-4) can be opened to make it easier for the oil to circulate and reach operating temperature.
- g. Verify that the oil metering valve is at the closed position.

WARNING DO NOT ATTEMPT TO START THE BURNER WHEN EXCESS OIL HAS ACCUMULATED, WHEN THE UNIT IS FULL OF VAPOR, OR WHEN THE COMBUSTION CHAMBER IS HOT.

- h. Turn the burner switch on and follow the parallel positioning controls instructions on commissioning the burner. This will start the blower motor and initiate the purge cycle.

CAUTION WHEN WORKING WITH HEATED OIL, PROTECTIVE CLOTHING, INCLUDING GLOVES, SHOULD BE WORN TO PROTECT FROM BURNS.

8. Heavy Oil Setup

The air atomized heavy oil system requires the additional adjustment of oil temperature in the burner setup. The temperature is adjusted to improve the viscosity for good atomization. Typically, this will be about 150°F for #4 oil, 180°F for #5 oil and 200°F for # 6 oil.

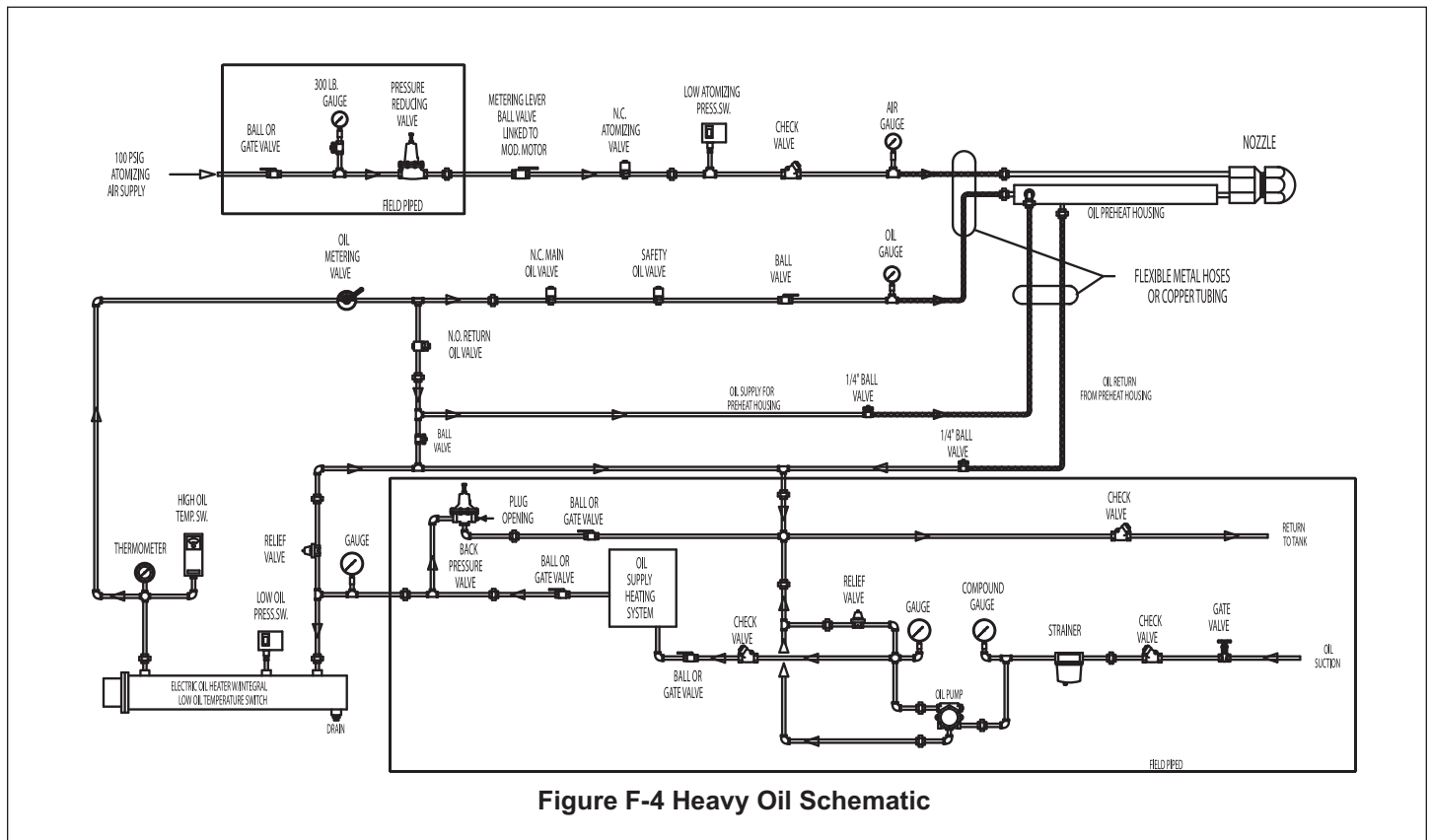


Figure F-4 Heavy Oil Schematic

i. When the prepurge sequence is complete and the low fire start switch is made, the pilot valve and ignition transformer will be energized and the pilot flame should be visible through the burner sight port. The flame signal should be strong and steady.

j. When the pilot flame is established, the main oil valves will be energized (indicated with the Fuel On Light), and the burner should ignite at low fire. This operation of the main fuel valves must be visually checked by observing the valve stem moving up with a motorized valve or hearing the clicking noise from a solenoid valve.

k. After a few seconds, the combustion analyzer should have an accurate reading of the O₂ in the stack. The O₂ level should be between 4% and 8% (See Figure F-2 for O₂ rates) and the nozzle oil press should be between 10 and 20 PSIG. Do not attempt to fine tune combustion until the high fire input has been set.

- The air damper should be positioned for the correct low fire settings.
- The atomizing air pressure can be adjusted using the air bleed valve (Figure F-3).
- Oil temperature can be adjusted to obtain best atomization.
- Operate the burner until the boiler is warmed up and near the operating pressure or temperature.
- Follow the Parallel positioning controls instructions to commission the burner, while monitoring and adjusting the O₂ level. Adjust the oil pressure and atomizing air pressure as needed to reach the high fire input.
- At high fire, adjust the high fire input to match the max. input listed on the rating label. Using a flow meter, the fuel input may be measured with the following equation,

$$\text{Oil GPH} = \frac{[\text{Gal end} - \text{Gal start}] \times [3600 \text{ sec/hr}]}{[\text{measured sec}]}$$

Where Gal end = meter gallons at end of test
Gal start = gallons at start of the test
Measured sec = measured time of test
GPH = Gallons per hour

- o. Modulate the burner to low fire, adjusting the O₂ level as the burner modulates.
- p. Readjust the low fire input.
- q. Re-adjust the midfire points for the correct O₂ levels.
- r. The burner should be operating at low fire to adjust the air proving switch. Turn the adjusting screw cw(in) until the burner trips out (shutdown caused by the air flow switch). Turn the adjustment screw ccw (out) 1 ½ turns from the point of shutdown. Check the operation at higher rates.

9. Operating Control Adjustments

The operating controls must be adjusted to properly cycle the burner "ON and OFF" and provide modulation. See Section D-6 & E-19 for details. The controls should not force the burner into rapid "ON-OFF" cycles, as this will cause premature failure of the motor and operating equipment.

The operating control must be adjusted to provide the "ON" pressure or temperature desired. It must allow the burner to come on and start before the temperature or pressure drops into the modulating range. The "OFF" pressure or temperature must be sufficiently above the "ON" point to allow a reasonable run time. The modulating control must be adjusted to start modulation at some reasonable point below the "ON" temperature or pressure and provide modulation to high fire at the lowest temperature or pressure.

10. Limit Tests

Once the burner has been started and the operating pressures and temperatures have been set, the limit switches need to be adjusted so that they will trip if the pressure or temperature exceeds the operating value, but will not trip with normal variations. The switch should be checked for proper operation by allowing the temperature or pressure to vary below (or above) the recommended level to insure that they provide safe shutdown before the burner operation is affected. In some high pressure or temperature switches, where the temperature or pressure cannot be set high enough to trip the switch, the switch can be checked by lowering the set point to prove that the switch will provide a safe shutdown.

The limit switches would include the air proving switch on the burner. Limits for gas operation could include the high and low gas pressure switches and for oil firing, the high and low oil pressure switches, high and low oil temperature switches and the atomizing air pressure switch. If in doubt about which limits are on a burner, refer to the wiring diagram that will show each item.

Limit switches need to be checked at regular intervals to ensure they are operating properly. See the maintenance section for details.

11. Pilot Test

Once the burner has been set for the firing rates intended for the burner, the pilot must be checked for proper operation and safety.

The minimum pilot test is done to insure that a pilot which can be seen by the scanner will light the main flame.

a. During a startup sequence, measure the time required to light the main flame after the fuel valves have been energized. This will be used to monitor the test with reduced pilot.

b. Lock the flame safeguard into the pilot position (refer to the manual for the flame safeguard for this setting)

- c. Adjust the gas pressure regulator to the pilot for a minimum value while still holding the minimum signal strength for the scanner.
- d. Release the flame safeguard from the pilot position and allow it to cycle through the main flame proving sequence.
- e. This reduced pilot must reliably light the main flame. Monitor the time from the main fuel valve opening and do not allow the burner to continue if the time is more than an additional two to three seconds from the initial time measured above.
- f. Run through two or three cycles.
- g. If this is a combination fuel burner, repeat the test on the other fuel.
- h. Failures due to reduced scanner signal are acceptable.

WARNING: THE MINIMUM PILOT TEST REQUIRES CLOSE SUPERVISION OF THE COMBUSTION PROCESS. FAILURE TO CLOSELY MONITOR THE MAIN FLAME TEST TIME COULD RESULT IN DAMAGE, INJURY OR DEATH.

- i. If the pilot does not light the main flame under these test conditions, check and adjust the pilot as shown in Figure E-1.

The scanner must be tested for hot refractory pickup. This test is performed to make sure that the scanner does not see hot refractory that could be mistaken for a flame.

- a. After the burner has been operating for some time at high input levels and the refractory in the vessel is hot, the burner should be cycled off while monitoring the scanner signal.
- b. The flame signal should drop off quickly as the flame goes out and should be well below the minimum level (indicating a flame) at the end of the post purge cycle.
- c. If the flame signal does not drop out as required, check the location of the pilot and scanner. This may also indicate a faulty scanner or amplifier.

12. Burner Shutdown

Normal operation of the burner will allow the operating controls to shut the burner down when the load demand is satisfied. If the burner needs to be shut down for any reason, the "ON-OFF" switch can be used to quickly turn the burner off. This will instantly cause the fuel valves to close and start a post purge cycle to remove any unburned fuel from the vessel.

In an emergency shutdown, all fuel and electrical power should be de-energized or turned off to secure the burner. This would include the main power disconnect, the manual gas shutoff valve at the drop down line and if equipped, the manual oil valve to the nozzle.

H. TROUBLESHOOTING

No.	System	Cause	Correction
1	No Ignition (lack of spark)	Electrode is grounded. Porcelain is cracked.	Replace
		Improperly positioned electrode	Recheck dimensions
		Loose ignition wire connection	Reconnect or tighten
		Defective ignition transformer	Check transformer, replace
2	No Ignition (spark, no flame)	Lack of fuel, no gas pressure, closed fuel valve	Check fuel supply and valves
		No voltage to pilot solenoid	Check electrical connections
		Defective pilot solenoid valve	Replace
		Incorrect location of pilot	Check location of pilot
		Improper raw gas tube position	Check location of raw gas tube
		Improperly positioned electrodes	Recheck dimensions
		Too much combustion air flow	Check air damper position
3	Pilot not detected (flame present)	Scanner tube not positioned correctly	Check location of scanner tube
		Scanner tube dirty	Clean scanner tube
		Scanner or amplifier faulty	Replace
		Pilot improperly positioned	Check pilot position
		Incorrect gas pressure to pilot	Readjust pressure
		Combustion air flow rate too high	Readjust damper
4	No main gas flame (pilot OK)	Weak scanner signal	Clean scanner lens and tube
		Damper or fuel control valve setting incorrect	Readjust
		Fuel valve(s) not opening	Check wiring to valves
5	No main oil flame (pilot OK)	Weak scanner signal	Clean scanner lense and tube
		Damper or fuel control valve setting incorrect	Readjust
		Fuel valve(s) not opening	Check wiring to valves
		Oil nozzle or line obstructed	Check nozzle and lines, clean
		No atomizing air pressure	Check compressor wiring
		Compressor pressure too low or high	Readjust
		Burner not level, oil is draining into vessel	Check level, adjust as required.
6	Burner stays at low fire	Manual pot in low fire position (low fire hold)	Readjust to high fire position
		Manual-auto switch in wrong position	Change position of switch
		Modulating Control	Check wiring or replace
		Loose linkage	Readjust and tighten
		Binding linkage or valve	Readjust or replace
7	Burner shuts down during operation	Loose electrical connection	Check and tighten connections
		Loss of fuel supply	Replenish fuel supply
		Limit switch breaks (opens)	Readjust limit switch
8	Burner does not start	Main disconnect switch is open	Close switch
		Loose electrical connection	Check electrical connections
		Operating controls are tripped	Check and reset operating limits
		High or low fuel pressure	Check fuel supply - reset switches
9	High CO at low fire (firing gas)	Improper excess air level	Readjust excess air
		Input too low for burner components	Check input, compare to rating label

No.	System	Cause	Correction
	High CO at low fire (con't)	High stack draft (especially at low fire)	Stabalize draft
	(firing gas)	Poor air flow distribution (off center flame)	Adjust air straightener blade
		Diffuser not in optimum position	Adjust diffuser position in or out
		Flucuating gas pressure (regulator not holding pressure)	Check regulator pressure, sensing line and supply pressure: sized properly
10	Gas combustion noise	Input too low for burner components	Check input, compare to rating label
	(rumbling)	Improper excess air	Readjust excess air
		Fluxuating gas pressure (regulator not holding pressure)	Check regulator pressure and supply
		High stack draft (especially at low fire)	Stabalize draft
		Diffuser not in optimum position	Adjust diffuser position in or out
		Poor air flow distribution (off center flame)	Adjust air straightner blade
11	Oil combustion smoking	Oil nozzle dirty or plugged	Clean oil nozzle
		Improper excess air	Readjust excess air
		Input too low for burner components	Check input, compare to rating label
		High stack draft (especially at low fire)	Stabalize draft
		Incorrect nozzle position	Adjust the nozzle to diffuser position
		Fluxuating oil pressures (regulator not holding)	Check regulator pressure and oil supply
		Poor air flow distribution (off center flame)	Adjust air straightner blade
		Too much FGR (if equipped)	Reduce FGR rate
12	Fuel-Air-Ratios are	Servo coupling loose or worn	Check/replace couplers
	not consistent	Fuel line plugged	Check and clean lines, stariners & filters
		Fuel supply pressure changing	Check and/or replace pressure regulator
		Combustion air temperature changed	Retune burner
		Draft condition changed	Check draft and outlet damper
		Plugged or leaky FGR line	Clean / repair
		Gas control valve - low fire stop not set	Adjust low fire stop
13	Fuel-Air-Ratios have changed	Air damper seal worn	Replace air damper seals
	over time	Fuel lines plugged	Check and clean lines, strainers & filters
		Fuel control valve worn	Replace fuel control valve
		Gas orifices or gas manifold plugged	Clean and/or replace
		Combustion air temperature changed	Retune burner
		Draft condition changed	Check draft and outlet damper
		Vessel plugged	Clean vessel
		Plugged or leaky FGR valve	Clean / repair
14	Cannot obtain capacity on	Wrong spring range in regulator	Install higher spring range
	gas	Too many elbows before control valve	Rework piping to reduce elbows
		Gas line too small, high pressure drop	Use larger pipe size
		Supply pressure lower then stated	Increase supply pressure
		Supply pressure drops too low at high fire	Use larger gas line sizes / orifice in service regulator
		Regulator too small for flow and pressure	Change regulator

No.	System	Cause	Correction
15	Cannot obtain rated input on oil firing (air atomized)	Oil nozzles plugged	Replace nozzles
		Air pressure too low	Replace nozzles
		Oil pressure too low	Increase oil pressure
		Flow valve set too low	Adjust oil control valve
16	Cannot obtain NOx levels on gas	Inlet tube in wrong position	Adjust inlet tube to center of fan inlet
		" "	Taper FGR valve to be full open
		FGR valve not full open	Adjust FGR valve to full open
		FGR valve full of condensate	Clean duct and add drains
		FGR duct not directed to flue stream	Add angle cut in center of stack
		FGR line too small	Check sizing, use fittings with less drop
		Operating on propane, not natural gas	Resize FGR for propane operation
Shutoff valve is not full open	Check FGR shutoff valve position		

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