RMB Ultra™* and FRMB™*

ULTRA LOW NOx BURNER

INSTRUCTION AND OPERATION MANUAL

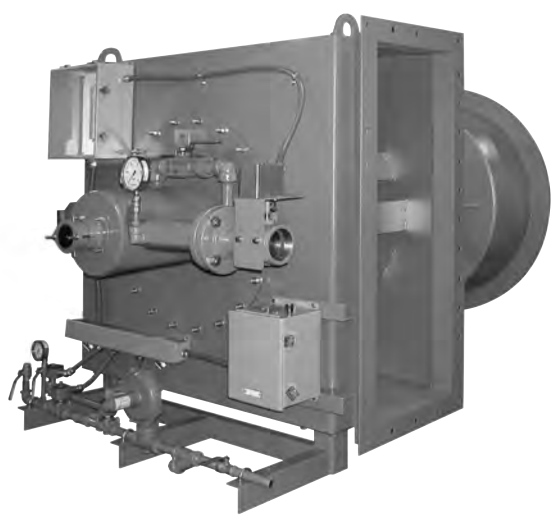
FOR GAS AND LIGHT OIL FUEL SYSTEMS

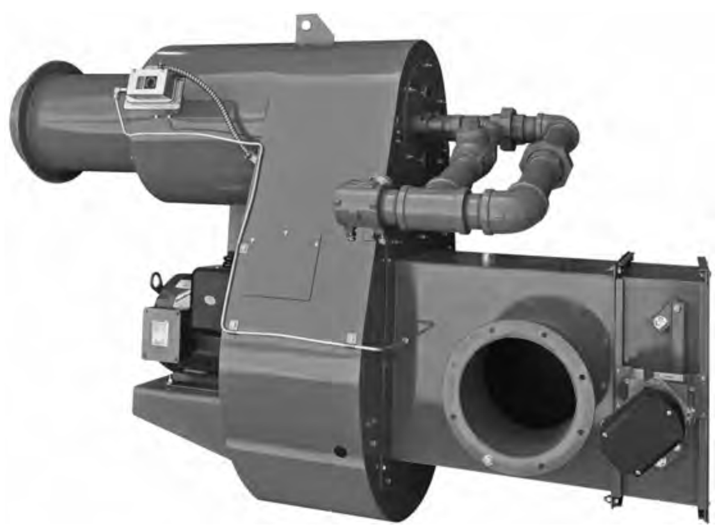
MANUFACTURED BY JOHN ZINK COMPANY, L.L.C.

NOTE: THIS MANUAL IS PROVIDED TO SUPPLY GENERAL INFORMATION ON THE OPERATION, AND MAINTENANCE OF THIS BURNER SYSTEM. HOWEVER, NOT EVERY CONTINGENCY OF INSTALLATION, OPERATION, AND MAINTENANCE CAN BE COVERED IN ANY MANUAL. THEREFORE, THE OWNER'S OPERATING AND MAINTENANCE PERSONNEL SHOULD ALSO BE GUIDED BY GENERALLY ACCEPTED INDUSTRY PRACTICE IN THE INSTALLATION, OPERATION, AND MAINTENANCE OF THIS BURNER SYSTEM.

WARNING!

BURNER MUST BE INSTALLED, MAINTAINED, AND OPERATED BY TRAINED PERSONNEL. DO NOT ATTEMPT TO OPERATE THE BURNER WITHOUT FIRST FAMILIARIZING YOURSELF WITH THESE OPERATING INSTRUCTIONS! IMPROPER INSTALLATION, OPERATION, OR MAINTENANCE OF THE EQUIPMENT MAY RESULT IN INJURY TO PERSONS, LOSS OF LIFE AND DAMAGE TO THE EQUIPMENT.





PRINCIPLES OF OPERATION

The model RMB burner is designed to produce ultra low NOx emissions levels firing gas fuels. The patented burner design utilizes rapid mixing of fuel and air at the burner outlet to suppress the formation of prompt NOx and uses induced flue gas recirculation to suppress thermal NOx formation. The burner is capable of operating with NOx emissions as low as sub-9ppm, while providing stable and reliable combustion.

*Covered by one or more of the following patents:
U.S. Patent Numbers 5407347; 5470224; 4785680; 4932274. CA Patent Number 1279632.

TABLE OF CONTENTS

WARNING!

If you smell gas:

1. Open windows.
2. Don't touch electrical switches.
3. Extinguish any open flame.
4. EVACUATE people from building.
5. Immediately call the gas supplier.

The use and storage of gasoline or other flammable liquids and vapors in open containers in the vicinity of this appliance is hazardous.

In accordance with OSHA standard 1910.147, all equipment, machines and processes shall be locked out prior to servicing.

If not installed, vented, operated and maintained in accordance with the manufacturer's 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.

BURNER COMMISSIONING AND SERVICING MUST BE DONE ONLY BY 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 manual fuel shutoff valves including pilot gas 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.

Do NOT use TEFLON TAPE or compounds with TEFLON content as an oil or gas pipe sealant. TEFLON can cause valves to fail creating a SAFETY HAZARD. Warranties are nullified and liability rests solely with the installer when evidence of TEFLON is found.

PART I

MINIMUM INSTALLATION INSPECTION CHECKLIST

GENERAL

- ❑ Is burner installed in accordance with applicable installation drawings?
- ❑ If a refractory combustion chamber is part of the installation, is it completely dry, cured, and ready for firing at full boiler input?
- ❑ Has the proper electrical voltage been connected to the burner control cabinet as shown on the burner material list?
- ❑ Has the burner wiring been checked for completeness and accuracy? Have 3-phase motors been properly wired and checked for correct rotation?
- ❑ Are the boiler mounted limit controls such as low water cutoffs, high limit controls, operating controls, modulating controls, etc., properly installed and wired?
- ❑ Are the boiler controls the right type and range for the installation?
- ❑ Is the boiler water supply, including feed pumps, properly connected and is boiler filled with water?
- ❑ Is sufficient load connected to the boiler so that it can be fired continuously at full rating?
- ❑ If boiler load is not connected, can steam be wasted so that boiler can be fired continuously at full rating without endangering personnel or equipment?
- ❑ If the installation is a hot water boiler, have the circulating pumps been completely installed, wired, and tested to assure proper operation so that the burner can be fired continuously at full rating?
- ❑ For new boiler installations, has the boiler been boiled out in accordance with the boiler manufacturer’s instructions?
- ❑ Have the boiler breeching connections to the stack been completed and are they open and unobstructed?
- ❑ Is draft control equipment required and, if so, installed?
- ❑ Have adequate provisions for combustion air been installed?
- ❑ Have the persons listed below been notified of the burner start-up date?
    - ❑ Owner’s Representative
    - ❑ Mechanical Contractor’s Representative
    - ❑ Electrical Contractor’s Representative
    - ❑ Service Organization’s Representative
    - ❑ Boiler Manufacturer’s Representative
- ❑ Is all specified auxiliary equipment mounted and wired? This may include outdoor temperature controls, oil flow switches, space thermostats, water flow switches, motorized combustion air louvers, etc.

PART I: MINIMUM INSTALLATION INSPECTION CHECKLIST CONTINUED

GAS FIRING

- ❑ Are all gas train components installed and have they been properly selected, sized and assembled?
- ❑ Have properly sized vent lines been installed on all gas train components which require venting? This includes such items as pressure regulators, normally open vent valves, diaphragm valves, low and high gas pressure switches, etc.
- ❑ Have gas train piping and components been tested and proven gas tight?
- ❑ Have the gas lines been purged?
- ❑ Is the proper gas pressure available at the inlet to the controls which meets the requirement shown on the burner material list?

OIL FIRING

- ❑ Is the oil tank installed and filled with the proper type and grade of fuel oil as required by the burner material list?
- ❑ Is the proper oil pressure, temperature and viscosity available at the inlet to the controls which meets the requirements shown on the burner material list and/or oil system sheet?
- ❑ Have oil supply and return lines been properly sized to meet the maximum pumping capacity of the pump and has the system been purged and proven leak proof?

SIGNATURE OF INSPECTOR(S)

Name: ______________________________ Date: ______________

Name: ______________________________ Date: ______________

Name: ______________________________ Date: ______________

PART II

GENERAL

NOTE

Installation requirements and instructions should always be covered in appropriate engineering drawings and specifications which detail the applicable building codes, etc. Information contained herein is to be used as a guide ONLY and not as the final authority.

NOTE

This inspection should be performed before the burner start-up specialist is called in. An incomplete or inadequate installation may require additional time and effort by start-up personnel and cause an untimely and costly delay.

- Starting a burner is an event which normally culminates the efforts of several different contractors, manufacturers, utility and engineering concerns, sales and factory representatives, and others.
- In order for the burner to operate safely and meet its design capabilities, the interfacing fuel, air, electrical, exhaust and plant heating control systems must be properly sized, selected, installed and tested. Additionally, all conditions must be such that the heat generated by the burner can be safely used or wasted without endangering personnel or equipment.
- It shall be the policy of John Zink Company, L.L.C. that no responsibility is assumed by the company nor any of its employees for any liability or damages caused by an inoperable, inadequate or unsafe burner condition which is the result, either directly or indirectly, of any of the improper or inadequate conditions described above.
- To insure that a safe and satisfactory installation has been made, a pre-start inspection is necessary. This inspection must be performed by an individual who is thoroughly familiar with all aspects of proper boiler/burner installation and how it interfaces with overall plant operation.
- Part I of this bulletin sets forth major inspection items that must be considered.
- The results of this inspection will often times identify corrections that must be made prior to start-up as well as point out potential or long range problems in plant operation if corrections are not made.
- Burner start-up is a serious matter and should not be viewed as a time for “crowd gathering” by unconcerned, uninformed or unauthorized personnel. The number of persons present should be held to an absolute minimum.
- Instruction of operating and other concerned personnel should be done after the burner has been successfully fired and adjusted by a qualified service agency or factory start-up specialist.

PART III

BURNER FAMILIARIZATION AND PRELIMINARY INSPECTION

BURNER FAMILIARIZATION

Study the following illustrations taking special note of the PART NAMES as shown in the call-outs.

Variations between systems are commonplace due to the many differences in job conditions and agency requirements.

This manual contains information applicable to a typical fuel system arrangement and is not intended to be representative of any specific agency or code criteria.

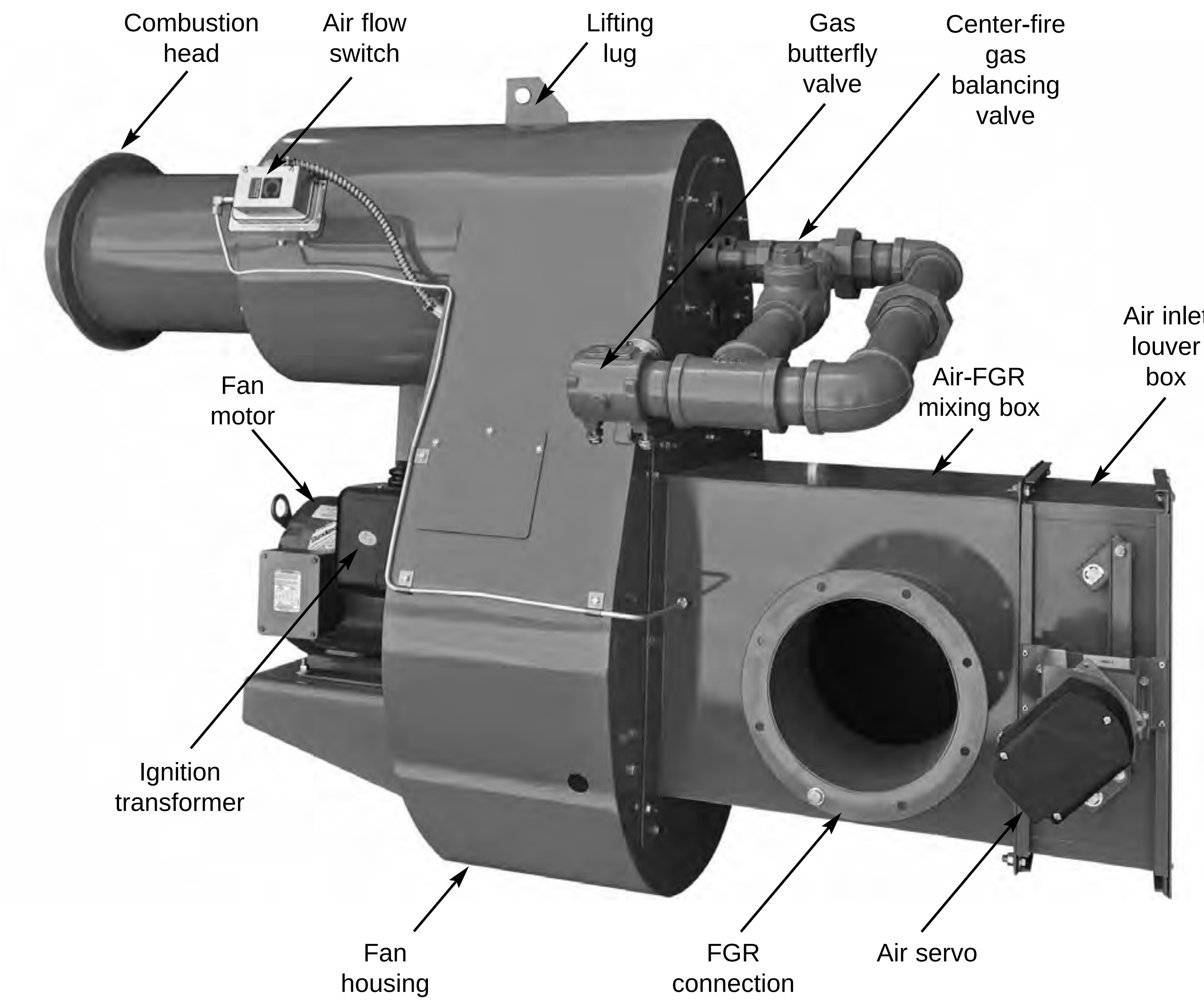
PRELIMINARY INSPECTION

The burner should be visually checked for damage and loose components as these conditions can occur during shipment, through improper handling, by tampering or through improper care and storage at the job site.

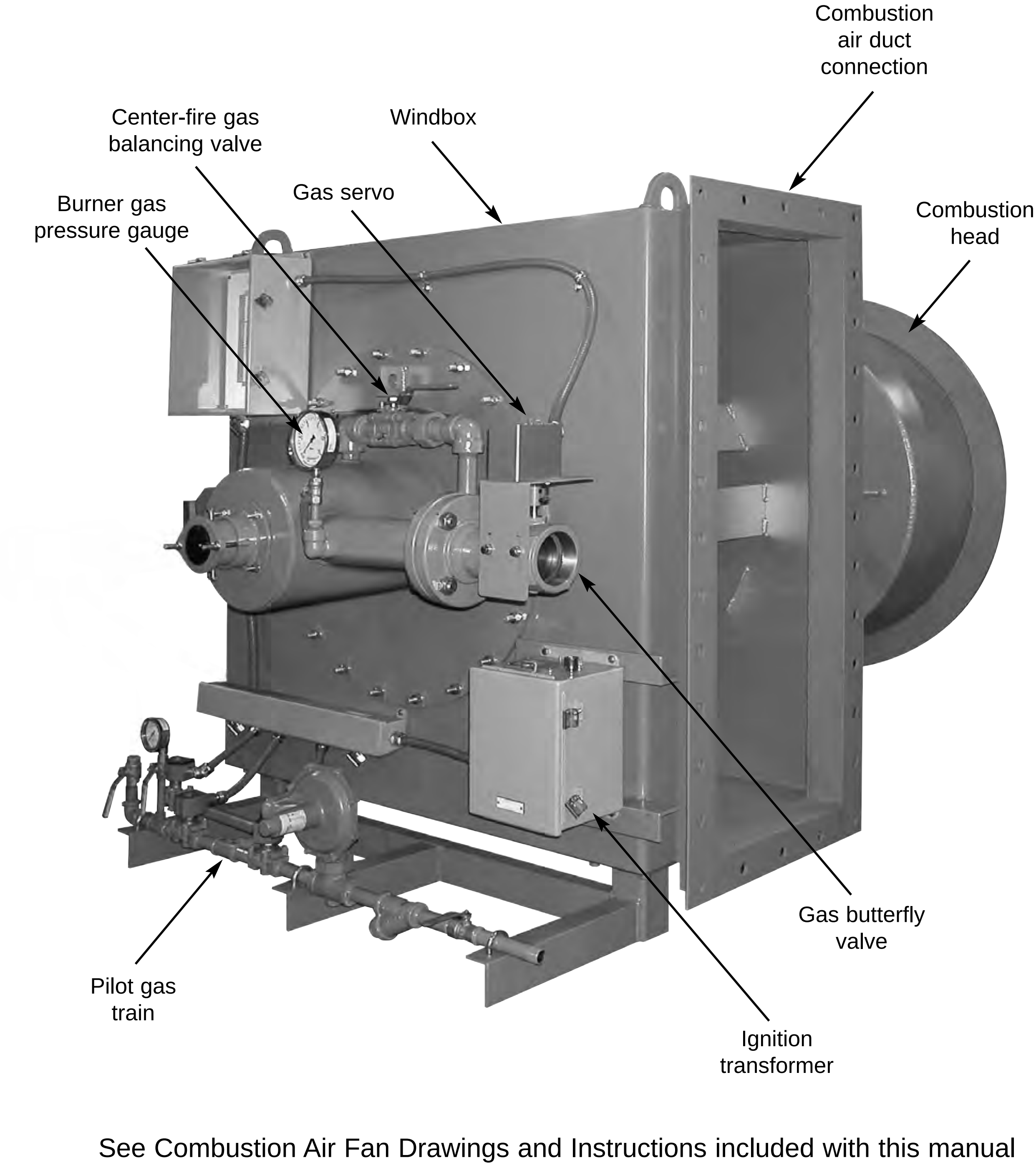
CHECK FOR:

- ❏ Obvious damage to housing, air inlet, and components mounted thereon.
- ❏ Tightness of fasteners, tube fittings, plugs, etc.
- ❏ Tightness of electrical terminals and connections.
- ❏ Tightness of adjustment mechanisms such as ball-joint swivel connectors and control arms.
- ❏ Accumulations of oil, dust, dirt, water or other foreign matter on, in, or near the burner.

FRMB (Integral Fan)



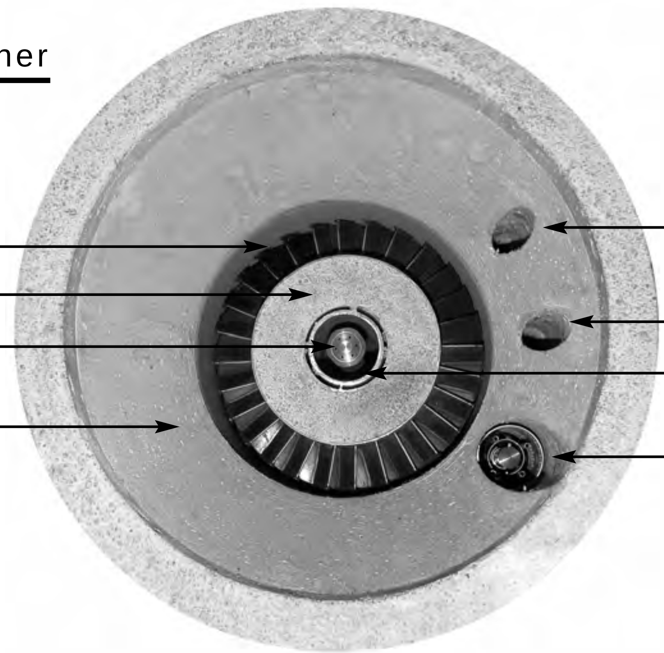
RMB Ultra (Remote Fan)



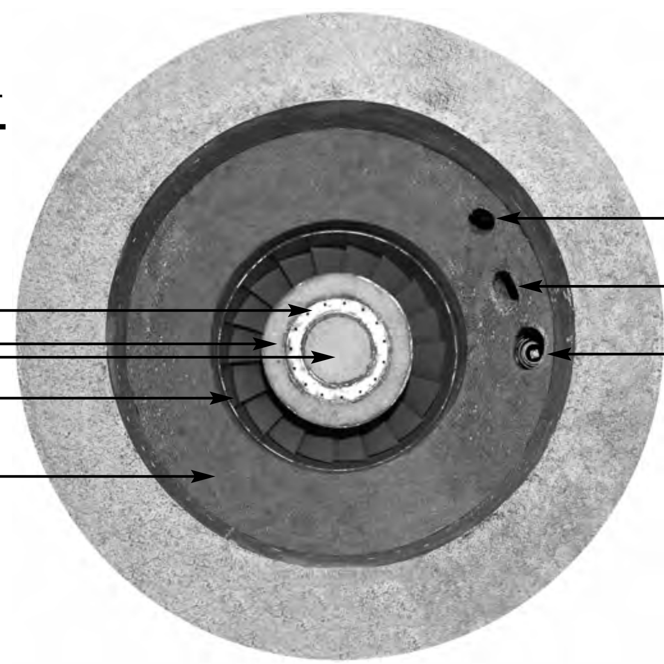
See Combustion Air Fan Drawings and Instructions included with this manual for remote fan assembly details.

Burner Front Views (RMB Ultra and FRMB)

Gas and Oil Burner



Gas Only Burner



PART IV

SYSTEM DESCRIPTION

NOTE

Please read through these instructions and refer to the separate data sheets before attempting to start the burner.

WARNING!

Do NOT use Teflon tape as an oil or gas pipe sealant. Teflon tape can cause valves to fail creating a safety hazard. Warranties are nullified and liability rests solely with the installer when Teflon tape is used. Use a pipe joint compound rather than Teflon tape.

GENERAL

The following data is pertinent to the burner start-up and should be carefully studied before any attempt to start the burner is made. This material is a part of the instructions manual which accompanies the burner.

- Burner Material List
- Burner Wiring Diagram
- Flame Safeguard Bulletin
- Gas System Schematic
  (Diagram 35-000204-40)

  Air System Schematic
  (Diagram 35-000205-40 or Diagram 35-000212-40)
- Combustion Air Fan Drawings and Instructions (if applicable)
- Oil System Sheet (if applicable)

  (1-gen-80.8 for air atomized oil systems or
  1-gen-80.9 for steam atomized oil systems)
- Manufacturer's Data Sheets on Controls, Valves, Regulators, etc.

The above cited manual is "One of a Kind" in that it contains material covering your specific burner. To replace it, considerable time, special handling, and significant costs are involved. Accordingly, it should be handled with care and kept in a location free of dust and moisture.

BURNER OPERATION

The Rapid Mix Burner (RMB) is a state-of-the-art low NOx burner developed to meet current and future regulatory emissions requirements.

Combustion air is premixed with recirculated flue gas and then rapidly mixed with gaseous fuel just upstream of the burner throat. The high degree of mixing combined with the advanced swirl burner geometry, achieves optimal combustion efficiency, low emissions, and a compact, stable flame. The burner's basic layout and principle of operation is shown in Figure 4-1.

WARNING!

Do NOT operate burner with FGR system disconnected or non functioning.

It is important to note that once your burner is set up, tuned, and the controls are locked, the correct balance of air and FGR has been achieved. Changing the tuning parameters by untrained personnel can result in pulsation, flame instability, high emissions, or explosions. Although the interchangeability of air and FGR gives the burner added flexibility in controlling NOx emissions, it also means that equally careful control must be maintained over the FGR and excess air level both during the steady state and transient conditions.

Because of the rapid and complete mixing of the fuel and the combustion air, NOx emissions can be effectively controlled using recirculated flue gases (FGR) and excess air levels. By designing in the proper FGR and excess air rate, NOx emissions can be reduced to extremely low levels. Because the burner operates with near ideal mixing, products of incomplete combustion such as CO and unburned hydrocarbons are virtually eliminated up to a 4:1 turndown range.

As shown in Figure 4-1, the RMB can be supplied as a dual fuel burner and fired on oil or other liquids. NOx control with oil fuels is obtained by adjusting the liquid spray angle and number of injection holes to delay fuel and air mixing and the use of FGR to control thermal NOx. Simultaneous firing of liquid and gas fuels is not permitted at any time.

The RMB offers simplicity of operation combined with superior performance, with the following main feature and advantages.

- Ultra-low NOx levels (as low as sub-9 ppm @ 3% O_2), using gaseous fuels;
- CO and hydrocarbon emissions typically less than 1 ppm;
- Compact flame minimizing the potential for flame impingement.

PRINCIPLES OF NOx FORMATION AND CONTROL

NOx emissions are one of the primary pollutant concerns from fossil-fuel fired boilers. The formation of NOx during the combustion of fossil fuels has been associated with three distinct mechanisms, generally referred to as “Thermal NOx,” “Fuel NOx,” and “Prompt NOx.” An understanding of the mechanisms involved in the formation of NOx can be used to control NOx emissions through combustion modifications. Combustion modifications can be implemented via the design of the combustion system and/or the selection of specific operating conditions. An understanding of the mechanisms of Thermal, Prompt, and Fuel NOx formation has also been used to develop correlations of NOx emissions for various burner types, boiler designs and different fuels. These correlations allow projections of NOx emissions to be developed for a given combustion system.

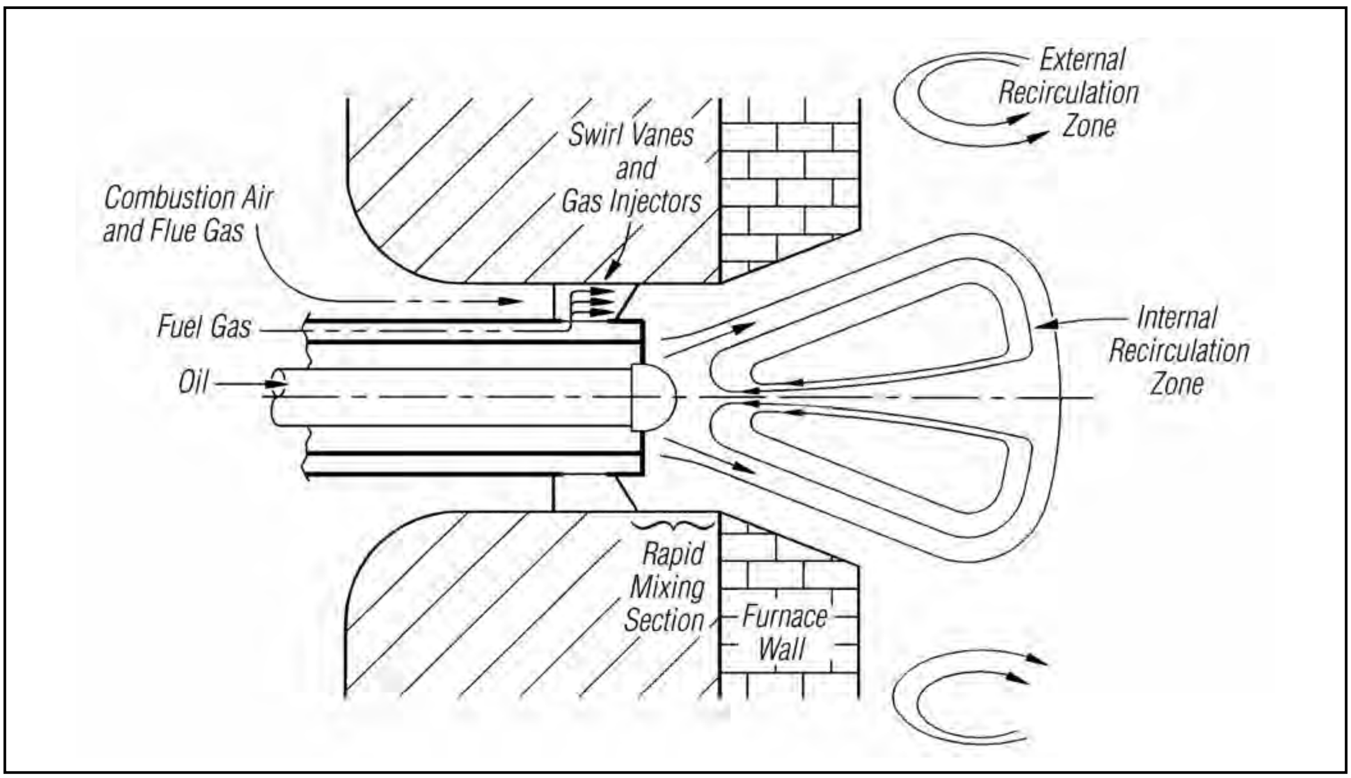


Figure 4-1

Thermal NOx refers to the NOx generated by the high temperature reaction of atmospheric nitrogen and oxygen present in the combustion air. The reaction rate is highly dependent on temperature, since high energy is required to break the nitrogen molecule's chemical bond: Thermal NOx formation is primarily controlled by temperature and by residence time of the nitrogen in the flame zone. The formation of thermal NOx is dependent to a lesser extent on the availability of oxygen in the flame zone. Because Thermal NOx formation is so highly dependent on temperature, the flame environment and the furnace geometry can dramatically affect its formation. Heat reflected back into the flame from refractory covered walls, or high heat release rates in the boiler (BTU's per cubic foot of furnace volume), will both tend to increase thermal NOx formation.

Fuel NOx is formed by the oxidation of organically bound nitrogen in the fuel during combustion. Fuel NOx formation is less sensitive to flame temperature than thermal NOx (since less energy is required to free up the nitrogen atom), but is strongly influenced by oxygen availability. Since Fuel NOx formation is directly related to the content of organically bound nitrogen in the fuel, the higher the fuel nitrogen content, the higher the fuel NOx generated. For combustion of fuel oil, both Fuel NOx and Thermal NOx mechanisms are important. For natural gas firing, however, only Thermal NOx and Prompt NOx are formed in any significant quantities, since natural gas contains negligible amounts of organic nitrogen. Some unusual gaseous fuels can contain chemically bound nitrogen, such as ammonia, that will form Fuel NOx.

Prompt NOx is formed during a two step process as a result of local sub-stoichiometric conditions within the flame. Conventional low NOx burners lower thermal NOx, in part, through creating local sub-stoichiometric zones within the flame, this is often referred to as fuel staging or air staging. Sub-stoichiometric combustion results in the formation of CO, OH, and other radicals including HCN. HCN and similar products of incomplete combustion include Nitrogen as part of the molecule. These compounds are later burned to completion as the air mixes with the flame; unfortunately, they readily burn to NOx. Concisely put, the flame forms fuel bound nitrogen within the flame and converts it to NOx. Prompt NOx forms at very low concentrations in the 10 to 20 ppm range. It is important because it prevents conventional low NOx burners from ever reaching NOx levels less than 10 ppm. The RMB burner eliminates the formation of prompt NOx because the rapid mixing does not allow sub-stoichiometric conditions to form.

Combustion techniques that are employed in this burner to reduce NOx emissions include:

(1) Rapid Mixing

(2) Flame temperature reduction through the use of flue gas recirculation

Rapid Mixing is a NOx reduction technique that is described fully under prompt NOx immediately preceding this section.

Thermal NOx can be controlled by reducing the overall flame temperature. One effective technique is the use of flue gas recirculation (FGR). The addition of flue gas from the boiler or economizer exit to the combustion air acts to decrease the flame temperature and lower the local oxygen concentration. FGR can have a relatively minor impact on boiler performance if properly designed, although the increased fan power required for the recirculation must be considered. FGR can also cause unstable flames if used improperly.

The RMB burner is stable with 40% FGR or more. Under certain circumstances, this can be increased. Other effective means of reducing the flame temperature are lowering the combustion air temperature and lowering the FGR temperature. Both methods directly reduce the flame temperature.

GAS PIPING INFORMATION – The "E2" gas system is used for modulation firing, and is provided in a single point positioning linkage configuration and a linkageless parallel positioning configuration. It is used on RMB burners with 5,250 MBH to 105,000 MBH capacity and is used in conjunction with the "F8" and "F9" oil systems for combination gas-oil models.

DESCRIPTION

The "E2" linkage gas system uses motorized gas valves and a single modulating motor to provide a low fire to high fire gas flow and simultaneously regulate the combustion air available to the burner. Gas pressure is adjusted and maintained by a pressure regulator, which may be integrated with the motorized gas valves in some cases. Head or orifice pressure is varied by a butterfly metering valve linked to the modulating motor. The gas butterfly metering valve is opened for high fire and gas is delivered to the orifices at the pressure setting of the pressure regulator. The air louvers are also linked to the modulating motor, thus combustion air is increased proportionately as the orifice pressure increases. At start-up the linkages are adjusted to provide the proper air-fuel ratio across the burner operating range.

The “E2” linkageless gas system uses motorized gas valves and a servo motor to provide a low fire to high fire gas flow. A separate servo motor is connected to the air louvers and simultaneously regulates the combustion air available to the burner. Gas pressure is adjusted and maintained by a pressure regulator, which may be integrated with the motorized gas valves in some cases. Head or orifice pressure is varied by a butterfly metering valve. The gas butterfly metering valve is opened for high fire and gas is delivered to the orifices at the pressure setting of the pressure regulator. The air louvers are controlled in parallel by the air-fuel ratio controller, thus combustion air is increased proportionately as the orifice pressure increases. At start-up the fuel-air control curve is characterized to provide the proper air-fuel ratio across the burner operating range.

Flue gas recirculation (FGR) is piped from the exhaust of the boiler to a mixing box attached to the inlet of the combustion air fan. Suction from the fan provides the motive force to draw FGR to the fan, where it is then mixed with the combustion air. An FGR damper with its own modulating motor, or servo, controls the amount of FGR delivered to the fan inlet. This damper is modulated along with the firing rate of the burner by the FGR controller. At start-up the FGR control curve is characterized to provide the proper FGR rate across the burner operating range to achieve the desired NOx emission levels.

OPERATING SEQUENCE

The blower motor starts on a call for heat by the operating control and the pre-purge cycle begins. **FGR valve should remain closed during purge cycle.** At the end of pre-purge, the air louver must be in the closed (low fire) position for the low fire guarantee switch to close and allow ignition. Also, at the end of pre-purge, the ignition transformer is energized and the pilot valves open, igniting the gas pilot.

The flame detector proves the flame and the main safety shutoff gas valves open, supplying gas to the orifices at the low fire setting of the butterfly metering valve and the burner ignites at the low fire rate.

The ignition transformer and pilot valve are de-energized.

After a short delay, the burner is released to modulate and the controller drives the fuel and air from the low fire position toward the high fire position to match the boiler load. At the same time the controller positions the FGR valve in parallel to control the NOx emissions.

As the boiler load is overcome, the controller drives the fuel, air and FGR back toward their low fire positions and the burner modulates over the range between low fire and high fire in response to the boiler load.

When the operating control is satisfied, the gas valves close and the blower motor is switched off, causing the burner to shut down and await the next call for heat.

The gas control equipment furnished and the minimum gas pressure required at the inlet to the controls are shown in the Burner Material List contained in the manual shipped with the burner.

Gas piping should be sized to provide the required minimum gas pressure at the main manual shutoff when operating at maximum input. Consult your local utility on any questions regarding gas pressure, piping pressure drops allowable and local piping requirements.

Gas piping should be installed in accordance with the American National Standard, ANSI Z223.1 and any other local codes which may apply. All gas piping should be tested after installation with air pressure or inert gas for at least three times the gas pressure that will be used.

The RMB burner uses very small gas orifices, which can be plugged by excessive dirt or debris in the gas system. To guard against this the piping ahead of the main manual shutoff shall include a 200 mesh strainer.

One of the most common oversights by an installer is failure to purge air, water, rust or other foreign matter from the fuel systems. DAMAGE TO BURNER, VALVES, PUMPS AND OTHER COMPONENTS CAUSED BY RUST, WATER OR FOREIGN PARTICLES IS NOT COVERED BY WARRANTY.

OIL SYSTEM PURGING

A standard method for purging oil systems is to remove the system pressure gauge (or plug where gauge would normally be installed) and temporarily install a piece of copper tubing long enough to drain into a bucket or other container. The pump motor starter contacts are then manually depressed with a piece of wood or other non-conductor device and the pump allowed to run until purging is complete. There must be no sign of air, water, rust or other foreign matter in the flow.

If flow is not established within 2 minutes, the pump should be primed through the suction line. Reinstall gauge or plug after purging is complete.

Back off the back pressure regulating valve and oil pump relief valve to allow circulation at a few pounds pressure with all oil being returned to the tank. Run this way until entrained air is expelled then slowly build up the oil pressure in the circulating loop to 100 PSIG by tightening up the springs in these same valves.

The oil pump relief valve should be set to start opening at 5 to 10# above the setting of the back pressure regulating valve.

OIL PIPING INFORMATION - The F8 and F9 Oil Systems are used for modulating control in firing No. 2 fuel oil on gas-oil fired RMB and FRMB burners. Refer to Oil System Sheet included in the burner manual for application, description, and operating sequence of the applicable oil system.

PART V

COMBUSTION SYSTEM ADJUSTMENTS

FACTORY ADJUSTMENTS - The burner is adjusted at the factory to meet "dry run" conditions. Adjustments and initial settings must be checked prior to initial light-off and settings must be verified by combustion tests.

Depending on the model and capacity of the burner, various adjustment mechanisms control the air, fuel and FGR available for combustion, while others control the safe and reliable function of the gas-electric ignitor.

ADJUSTMENT MECHANISMS – Illustrations which follow show the items which are subject to adjustment. Determine the applicability of each illustration to your burner, then proceed to familiarize yourself with the function of the item. Where a setting is indicated, verify the setting or make preliminary adjustments as necessary to facilitate initial start-up.

Adjustable air and fuel control mechanisms which modulate with the burner firing rate must be adjusted with the 0 to 90° actuator in the 0° position.

BURNER AIR AND FUEL ADJUSTMENTS

Items 1 through 11

ITEM 1
ADJUSTMENT OF AIR INLET LOUVER BOX

DESCRIPTION - The amount of air available for combustion is controlled by adjustable louvers located in the air box. The louvers are interconnected through a series of small linkage arms secured to a common drive rod.

HOW IT WORKS - See Figure 5-1. Louver opening and travel is controlled by adjusting the linkage mechanism from the actuator to obtain the desired opening and stroke. The actuator drives the louvers open or closed as the combustion control programs the burner firing rate to meet the boiler load.

ITEM 2
ADJUSTMENT OF GAS PILOT IGNITOR ASSEMBLY

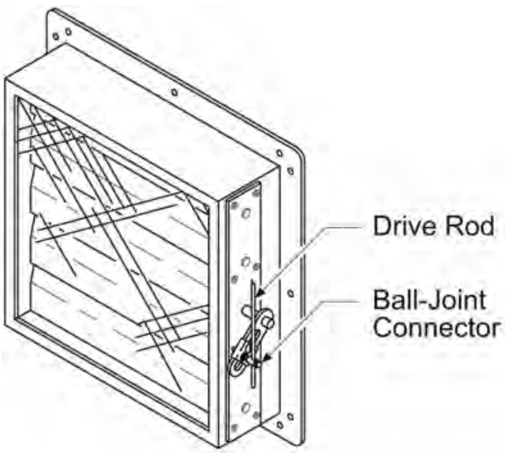
DESCRIPTION - The gas pilot ignitor is basically composed of:

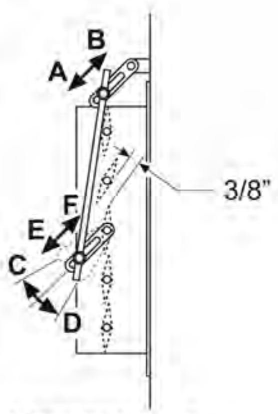
1. An ignition electrode with insulator which generates an arc between it and the adjacent ground.

2. A fuel tube through which the gas is directed to the point of the electrical arc.

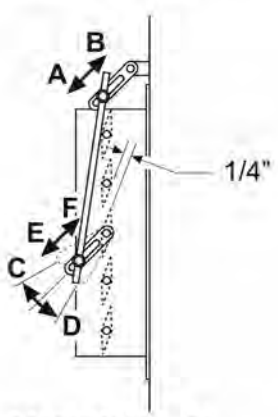
HOW IT WORKS - See Figures 5-2A and 5-2B. A charge from a high voltage transformer is routed to the ignition electrode causing an intense arc to ground. The electrode is then immersed in a concentration of gas as the pilot solenoid valve opens allowing flow to the pilot. The arc ignites the gas, the electrical discharge from the transformer terminates and the pilot stands ready to ignite the main burner flame. On initial startup, pilot flame should be established with raw gas manual valve closed. After main pilot flame is set, raw gas manual valve must be opened enough to provide adequately sized and stable pilot.

Air Inlet Louver Box





METHOD I



METHOD II

Adjustment Procedure

Method I (High Turndown)

1. Use box end or socket wrench to loosen ball-joint connector.
2. To adjust low fire (minimum) air setting, loosen ball-joint connector holding drive rod and manually close all louvers.
3. Re-tighten ball-joint connector.
4. With a 3/32" Allen wrench loosen the set screws on the second from the top louver. Set the louver 3/8" open and tighten set screws.

Method II (Medium Turndown)

1. Use box end or socket wrench to loosen ball-joint connector.
2. To adjust low fire (minimum) air setting, loosen ball-joint connector holding drive rod and manually position louvers to obtain the desired opening, then re-tighten connector.
3. For initial start-up; position air inlet louvers so they are approximately 1/4" open.

NOTE To adjust amount of travel (stroke), loosen base of ball-joint connector located in slotted (louver) actuator arm and reposition to desired setting, then re-tighten connector.

A= Increases louver opening
B= Reduces louver opening
C= Slows opening of louver first 1" of travel
D= Quickens opening of louver first 1" of travel
E= Reduces louver opening
F= Increases louver opening

Figure 5-1

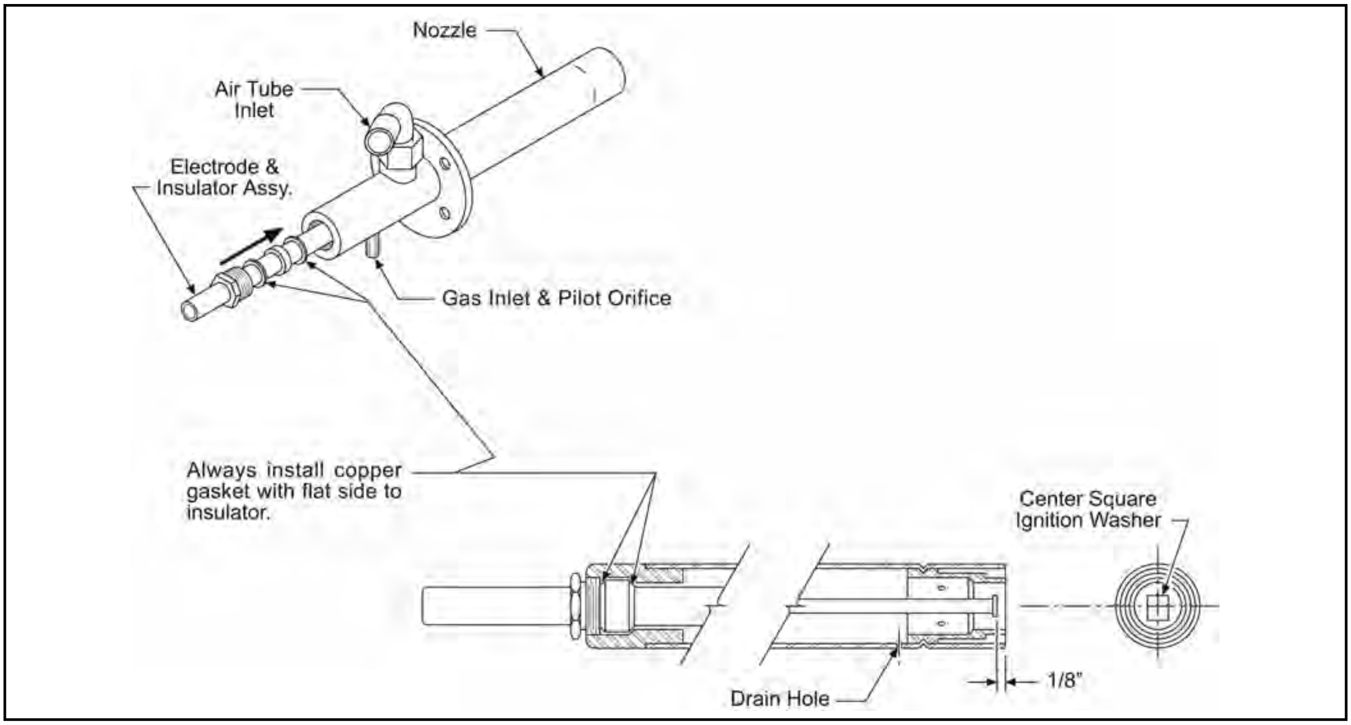


Figure 5-2A

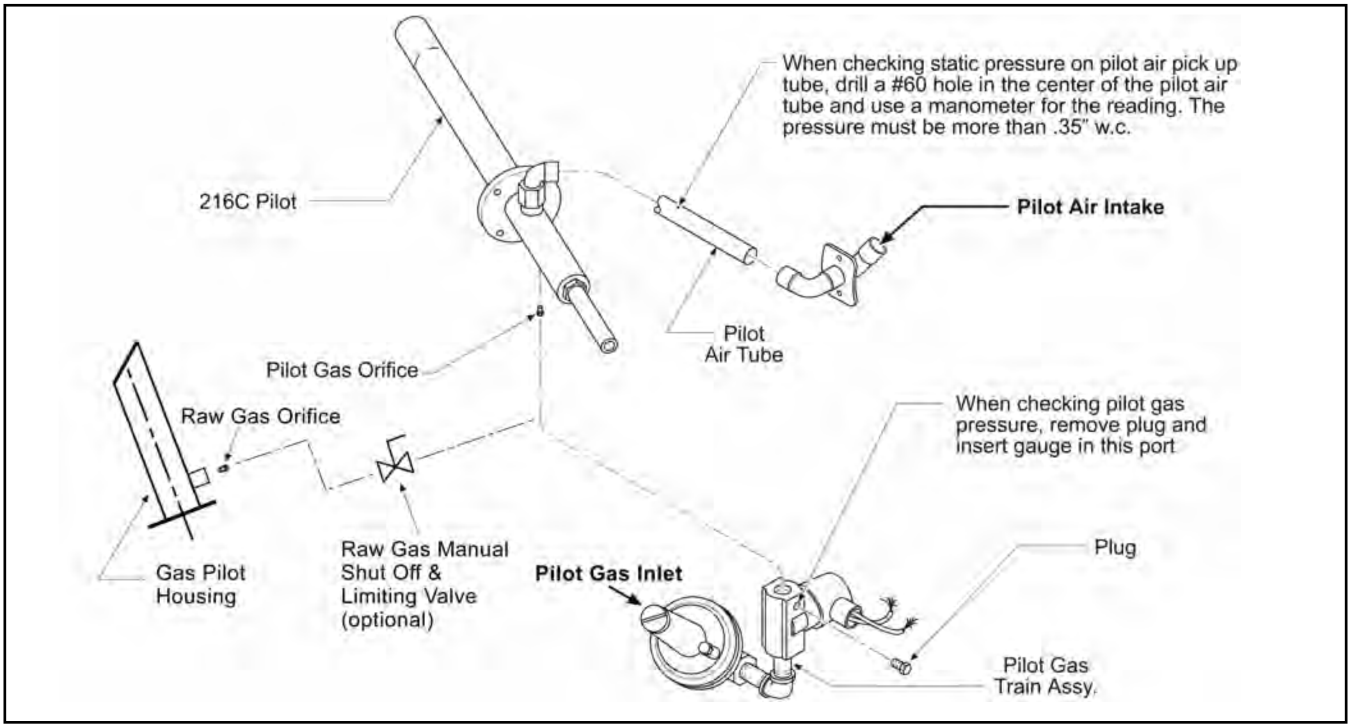


Figure 5-2B

ITEM 3
ADJUSTMENT OF BUTTERFLY GAS VALVE

DESCRIPTION - The butterfly gas valve is a fuel throttling device which proportions the gas in proper ratio to the combustion air. The valve is opened or closed by an actuator as the combustion control adjusts the burner firing rate to meet the boiler load.

HOW IT WORKS - See Figure 5-3. A centrally located disc turns within a cylindrical body which regulates the gas flow to the main burner flame. The butterfly valves used are the non-tight shutoff type.

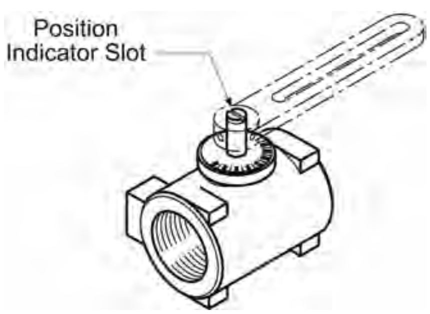


Figure 5-3

Through a linkage system, or using a linkageless servo motor and air-fuel ratio controller, an actuator drives the valve open or closed in response to electrical signals from the combustion control.

ITEM 4
ADJUSTMENT OF GAS PRESSURE REGULATORS

DESCRIPTION - Gas burners have two gas pressure regulators, one to regulate the pressure to the main flame and the other to regulate the gas pilot ignitor.

HOW IT WORKS - See Figure 5-4. Simply stated, gas flow is controlled by a spring of known load range which works against the supply (from the meter) gas pressure. Accordingly, each regulator must be fitted with the right spring for it to function properly. Additionally, the tension on the regulator spring must be adjusted to obtain the exact gas pressure required at the inlet to the controls.

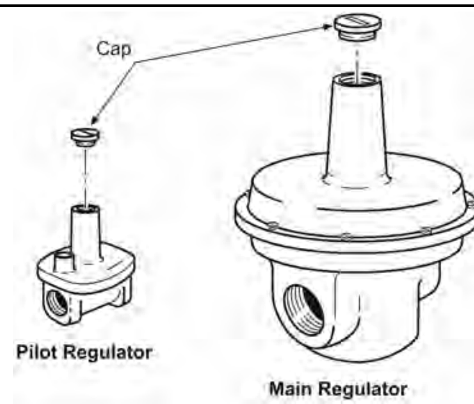


Figure 5-4

ITEM 5
ADJUSTMENT OF GAS PRESSURE SWITCHES

DESCRIPTION - Gas pressure switches are pressure-actuated electrical switching devices designed for safety shutoff when gas pressures are either too low or too high.

HOW IT WORKS - See Figure 5-5. The pressure switch senses any change in gas pressure and, if properly adjusted, will transmit an electrical signal to the automatic shutoff valve and/or other interlocking devices when an unsafe condition exists. The burner will then re-cycle or completely shut down depending upon the flame safeguard used. Gas pressure switches are designed to operate over a specified pressure range; therefore, each switch must be selected to be compatible with the burner operating gas pressure and also to obtain the desired electrical features.

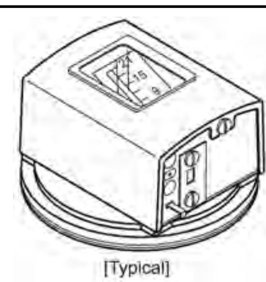


Figure 5-5

ITEM 6 ADJUSTMENT OF OIL DRAWER ASSEMBLY

DESCRIPTION - Oil burners have an assembly made up of vital oil and air handling components known as the "Oil Drawer Assembly". Basically, this assembly contains the oil tubes, the atomizing nozzle(s), and backplate which secures the unit to the burner housing.

HOW IT WORKS - See Figure 5-6. The oil and air are delivered to the nozzle through a tube-within-a-tube arrangement. The outer tube carries the air while the inner tube carries the oil.

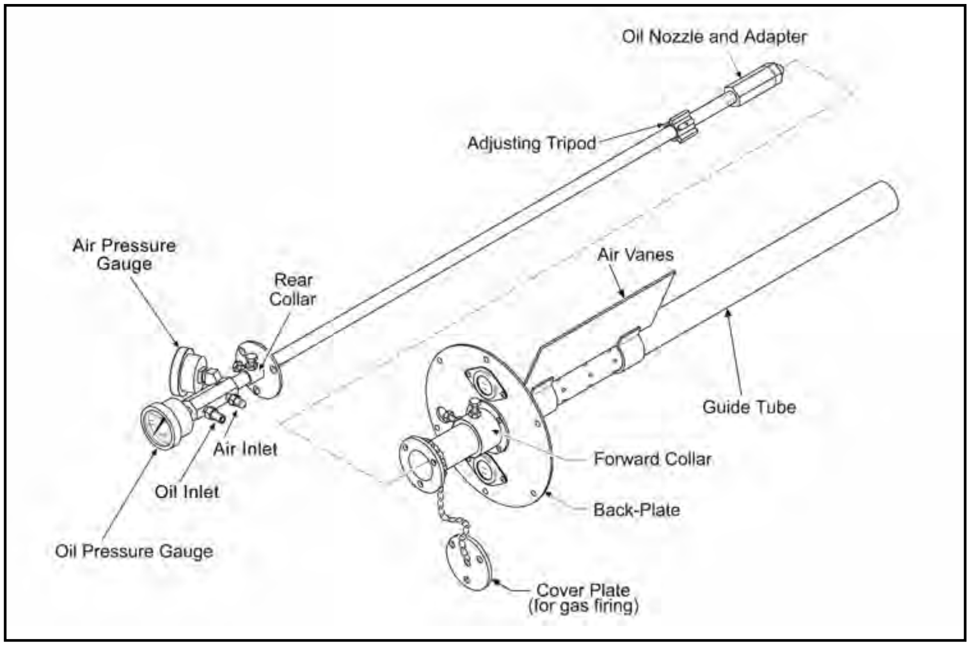


Figure 5-6

Oil and air pressures are indicated by gauges located in the air/oil distributor block.

The air and oil enter the mixing chamber of the nozzle, then the atomized oil is forced out the nozzle into the stream of combustion air.

The burner distributes the combustion air through the atomized oil which is then ignited by the gas pilot ignitor.

ADJUSTMENT PROCEDURE

WARNING!

Oil gun must be removed from the burner before firing gas and cover plate installed. If the oil gun is left installed durning gas firing, damage to the oil nozzle will occur.

REMOVAL:

1. Tighten set screws to hold guide tube and oil gun securely in position.
2. Disengage fittings on oil supply and air lines.
3. Loosen set screws and remove oil gun through burner back plate.
4. Install cover plate provided onto guidetube end.

CAUTION

In the following step, do not permit front end of drawer assembly to fall as the oil gun slides out of the guide tube. Nozzle may be damaged requiring repair or possible replacement.

To re-install the oil gun, reverse the order of the steps outlined above.

ITEM 7
ADJUSTMENT OF OIL METERING VALVE

DESCRIPTION - See Figure 5-7. Oil burner fuel control systems must deliver oil to the nozzle at reduced pressure for low fire. This is normally accomplished by diverting a portion of the oil pump delivery thru a bypass return line to the tank.

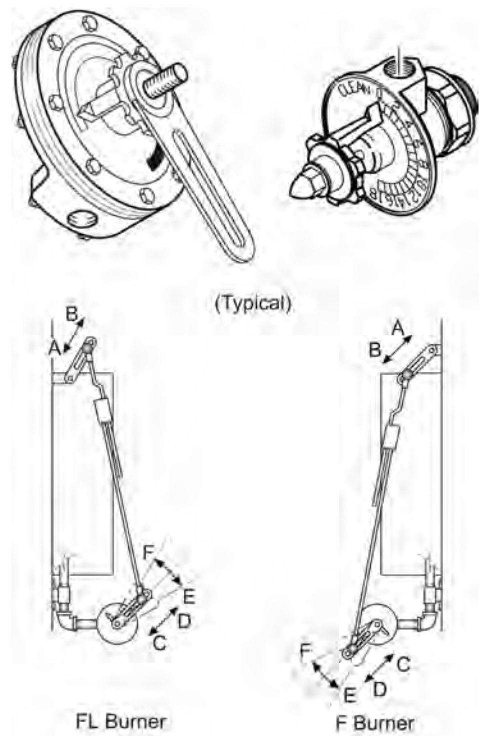
The amount of oil delivered to the nozzle versus that returned to the tank is controlled by a device which limits or meters flow, thus an oil metering valve is commonly used for this purpose.

HOW IT WORKS - Most oil metering devices work on the principle of limiting flow by constricting the area thru which the oil must pass. In order to vary the orifice area, mechanical movement must take place, thus the oil metering valve requires an actuator to do its job. By interconnecting a common actuator to the combustion air control and the oil metering valve, or using a linkageless parallel positioning controller, this allows the fuel (oil) to be proportioned in precise ratio to the amount of air available for combustion, This feature is essential on modulating type fuel control systems.

ITEM 8
ADJUSTMENT OF OIL SUPPLY PRESSURE REGULATOR VALVE

DESCRIPTION - See Figure 5-8. Oil burners require a close regulation of the pressure at which oil is delivered to the nozzle. RMB/FRMB burners normally use an oil pump which has a separate pressure regulating valve.

HOW IT WORKS - Burner oil pumps are generally identified by the rate at which they can deliver (GPH), the pressure of the delivery (PSI) and the speed of rotation (RPM). The pump is usually capable of delivering more fuel than is required to meet firing requirements; therefore, the amount of oil delivered to the nozzle must be controlled. This control is accomplished through use of an adjustable pressure regulating valve which reduces flow to the nozzle by causing more oil to be returned to the tank. Like most regulators, flow is controlled by an adjustable spring and each regulator has a pressure range over which it will reliably operate.



See item 1 for adjustment notes.

Figure 5-7

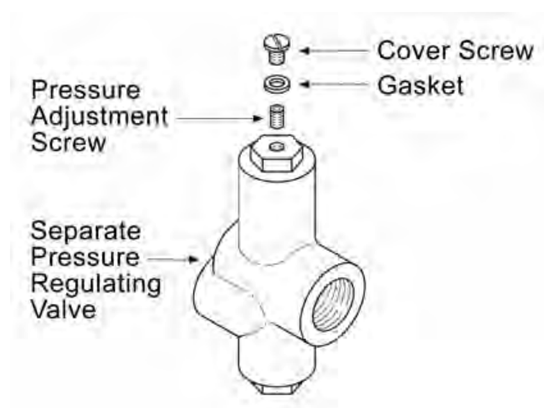


Figure 5-8

ITEM 9
ADJUSTMENT OF LOW OIL PRESSURE SWITCH

DESCRIPTION - See Figure 5-9. Low oil pressure switches are often times used to insure the oil pressure at the nozzle is adequate for proper atomization of the oil.

HOW IT WORKS - A pressure sensing device within the switch controls an electrical circuit normally interlocked with the flame safeguard causing the burner to recycle or shut down when the pressure sensed falls below the setting.

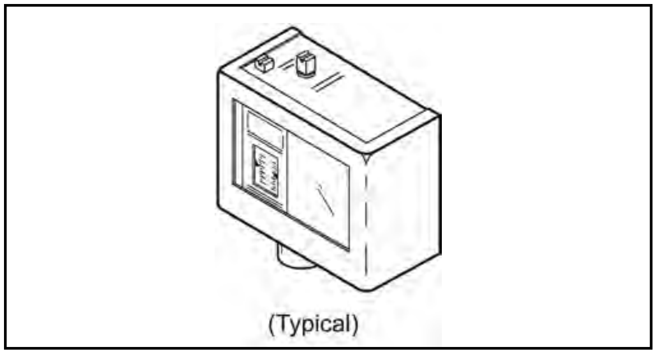


Figure 5-9

ITEM 10
ADJUSTMENT OF CHARACTERIZED LINKAGE

DESCRIPTION - See Figure 5-10. Characterized linkage provides the mechanical means to fine tune the fuel input (flow) to the burner in order to achieve maximum fuel efficiency and reduce harmful stack emissions.

HOW IT WORKS - There are nine (9) adjustment screws which control the contour of a flexible metal track upon which a roller and plunger mechanism travel. This mechanism in turn controls the linkage to the fuel valve, providing the precise amount of travel to dispense the right amount of fuel to the burner as it modulates to meet load demand. The objective is to shape the flexible metal track into what amounts to a “combustion efficiency profile.”

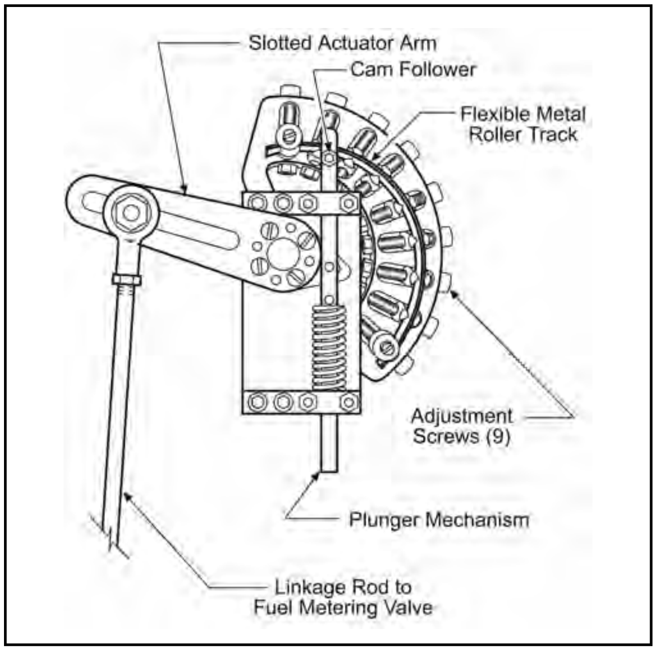


Figure 5-10

ITEM 11
ADJUSTMENT OF AIR FLOW SWITCH [DIAPHRAGM]

DESCRIPTION - See Figure 5-11. The air flow switch is used to prove the flow of combustion air from the blower assembly. It causes the fuel valve to close or fail to open upon loss of or inadequate combustion air.

HOW IT WORKS - The air flow switch is wired in series with the flame safeguard. When the blower starts, creating an air flow through the burner housing, the switch closes delivering electricity to the flame safeguard.

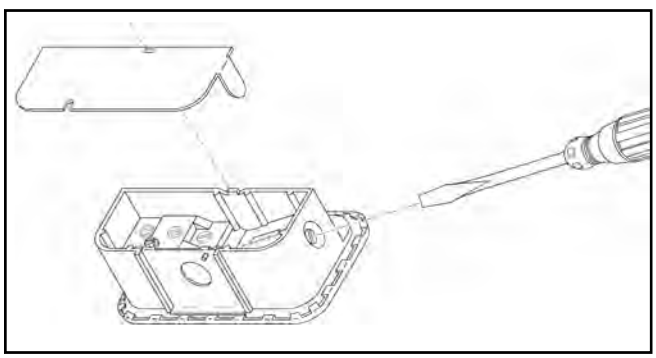


Figure 5-11

PART VI

BURNER START-UP

WARNING!

Start-up and initial tuning of an RMB should only be performed by a trained John Zink service person and/or factory approved personnel.

CAUTION

This bulletin has been prepared as a guide in burner start-up operations. It is written for the start-up specialist who is thoroughly qualified both by training and experience.

Due to wide variations in engineering specifications, state and local codes, utility and insurance underwriters requirements, etc., the contents herein are of a general nature. If additional information is required or if questions arise concerning specific requirements, please contact your local representative or the factory.

FLAME SAFEGUARD INSTALLATION - Assure flame safeguard is properly installed in its sub-base.

IDENTIFICATION OF CONTROLS - Review the burner operating sequence and wiring diagram in the instructions manual. Study these items and identify the various controls.

NOTE

The burner flame safeguard is often times packaged and shipped in a separate carton; however, the control cabinet will contain the mounting sub-base which is installed and pre-wired at the factory. See separate instructions on flame safeguard for mounting the unit in the sub-base.

RECOMMENDED PRE-FIRING CHECKLIST		
	RMB ULTRA	FRMB
Correct Ignitor Location		
Adequate Ignitor Air Supply		
Purge Air to Scanner		
Fan Outlet Damper Present		N/A
Oil Gun Removed		
Outer Refractory Quarl Correctly Installed		
Gas Line Cleaned		
Gas Strainer Present		
Min. and Max. RDL Properly Set		
FGR Line and Valve Correctly Installed		

Table 6-1

IGNITOR

Before firing the boiler, several installation details of the ignitor must be checked. These features include:

1. The ignitor should be recessed about 2 inches back inside the refractory quarl. If any portion of the ignitor sticks out into the furnace, it will be destroyed.
2. Because the ignitor is positioned inside the burner, air must be piped to the ignitor from a clean, external source.

FLAME SCANNER

It is recommended that the flame scanner be equipped with purge air (2 to 3 SCFM).

AIR POSITIONERS, DAMPERS AND LINKAGE

Depending on the turndown required, the stroke on the positioners and dampers should be set prior to starting the burner. Table 6-2 lists good starting estimates for the minimum and maximum register draft losses (RDL) (windbox to furnace pressure drops) for various applications. The information in Table 6-2 also shows maximum turndown allowable for ranges of operating conditions. The table should be viewed as a guide only, and if the guaranteed turndown is less than the maximum turndown listed, then the minimum RDL value should be adjusted accordingly.

The maximum turndowns listed here are determined on the basis of a minimum air flow to prevent burner overheating. In no cases should the burner be fired with a lower RDL than listed in Table 6-2, unless it is carefully confirmed that no overheating is occurring. FGR should be set to provide windbox O_2 levels per Figure 6-3.

There is no major problem in setting the maximum RDL higher than listed in Table 6-2. If the maximum RDL is set significantly higher than shown in the table, less than full stroke of the positioner will be used. Effectively, this would result in a minor loss of accuracy in setting the air flow.

DUAL FUEL BURNERS

If the burner is a dual fuel burner, the oil gun must be removed before firing gas. Additionally, the core air supply (the air pipe which comes out of the windbox and into the annulus surrounding the oil gun) should be fully closed. If the core air annulus appears to be overheating when the burner is in operation on gas, a small amount of core air can be used for cooling.

If the burner is a combination gas-oil unit, it is recommended that the burner be fired on gas first so the correct input rate in BTU's per hour may be determined by reading the gas meter.

NOTE

Do not proceed with start-up unless all applicable checklist items in Table 6-1 and preliminary adjustment requirements in Part V have been satisfied.

REQUIRED NOx	REQUIRED CO	MAXIMUM TURNDOWN	MINIMUM RDL INCHES WC	MAXIMUM RDL INCHES WC
<9ppm	<50ppm	3:1	1.0	9.0
<9ppm	<100ppm	4:1	0.5	9.0
<12ppm	<50ppm	4:1	0.5	9.0
<12ppm	<100ppm	5:1	0.35	9.0

Table 6-2

START-UP SETTINGS OF BURNER CONTROLS

During initial start-up, the operator must be on constant alert for emergency conditions such as fuel leaks, electrical malfunctions, etc. The location of all manual shutoff valves and disconnect switches should be clearly in mind so the burner can be quickly shut down if necessary.

WARNING!

Should the burner fail to ignite, never manually manipulate the flame safeguard sequence which provides for purging of the combustion chamber.

Using the Manufacturer's Instructions Bulletin on the flame safeguard, proceed with checkout to insure proper function of the safeguard under burner operational conditions.

NOTE

While performing these checks, certain adjustments and readings must be made at the appropriate time. These include, but are not limited to:

(1) Burner Combustion Air

(2) Gas Pressure (at control inlet and orifice)

(3) Boiler Limit Controls

(4) Draft Controls

(5) Other Controls Electrically Interlocked with the Burner Control System.

(6) Gas Flow through Utility Meter (CFH)

(7) O_2, NOx and CO in stack

(8) Stack Temperature

(9) O_2 in Windbox

(10) FGR

(11) Furnace Pressure

WARNING!

Be certain combustion chamber, flues and surrounding areas are free of gas accumulations, oil or oil vapor and other combustibles such as paint thinners, cleaning solutions, etc. An explosimeter (Mine Safety Appliances Co., Model No. 2A, or equivalent) should be used to make this determination.

GAS FIRING

REVIEW BURNER MATERIAL LIST IN THE INSTRUCTIONS MANUAL AND ANNOTATE THE FOLLOWING INFORMATION:

(1) Firing Rate (MBH)

(2) Cubic Feet of Gas per Hour (CFH)

(3) BTU per Cubic Foot (BTU/CF)

(4) Required Gas Pressure at Control Inlet (inches w.c.)

(5) Required Gas Pressure at Orifices taken at burner manifold (inches w.c.)

The above information is pertinent to starting up the burner.

The Rapid Mix Burner system you have purchased is a highly engineered, state of the art, combustion device. The RMB system is highly automated, and typically will require only routine maintenance. This section describes the operation of a typical boiler system after it is set up by John Zink service engineers. If the operation of the RMB system installed at your plant differs from the automatic operation described in this section, John Zink should be immediately contacted to ensure that your system is properly set-up. Adjustment of the burner or controls should only be performed by John Zink trained personnel. Adjustment by non-qualified personnel can result in unsafe operating conditions, damage to equipment and/or injury to personnel.

Additional maintenance items, other than those listed here, may be required by equipment vendors, company policy or insurance requirements.

Operation of this equipment should always be performed in a manner consistent with plant and operating rules and the requirements of other system components (furnace, boiler, etc.).

Note that before starting the burner on gas, the oil gun must be removed or withdrawn inside the guide tube. If a gaseous flame is started with the oil gun inserted, the oil gun will be damaged.

Operation on gas firing is completely automatic. To start the burner, the appropriate switches on the burner management panel should be placed in the "on" position. Typically this entails ensuing the fan is running (either in the automatic or manual position) and the burner switch is turned on or the burner start push button is depressed. If the burner is a dual fuel burner, set the fuel switch to the gas position. Depending on how the burner was shut down previously, the reset button may have to be pushed. If all start interlocks are satisfied, the burner purge will begin automatically. Following the burner purge, the combustion controls will go to the light-off position and if the correct low fire interlocks are made, the pilot ignition trial will begin. If a pilot flame is detected, the main flame ignition trial will begin and upon successful ignition of the main flame the pilot is turned off and the combustion controls will be released to modulate.

Once the main flame has been started, the control loops should transition to automatic with the only loop remaining in manual being the burner firing rate demand controller. The air, fuel, and FGR loops should go into full automatic without any operator intervention required.

The burner should remain at low fire until the boiler reaches operating pressure and/or temperature. The boiler operating instructions should be consulted to determine the maximum heat up rate for the equipment. If a slower rate is desired than obtained with the burner at low fire, the burner can be cycled on and off to yield a reduced rate. When the furnace reaches the operating temperature or pressure the firing rate demand can then be placed in automatic. The control system will then maintain the proper process set point.

TUNING ON GAS

Once the refractory has been properly cured, the fuel, air and FGR inputs can be set up over the load range. Initially, it is desirable to start the burner at minimum load to ensure proper operation. Do not operate the RMB with less than the RDL shown in Table 6-2, unless you are sure that the flame is maintained in the refractory portion of the burner. Normally, the RMB would be started with the FGR on and then set approximately to the desired rate for NOx control. At minimum load, tune the boiler to the desired excess air rate, FGR, and NOx level.

Slowly increase the load, and again set the excess air and FGR rate to the desired levels. The FGR rate can be calculated by measuring the windbox O_2 and using Figure 6-3. Repeat this procedure until the correct settings are obtained over the load range. Decrease the load in steps to minimum and readjust the excess air and FGR at any points in the load curve where required.

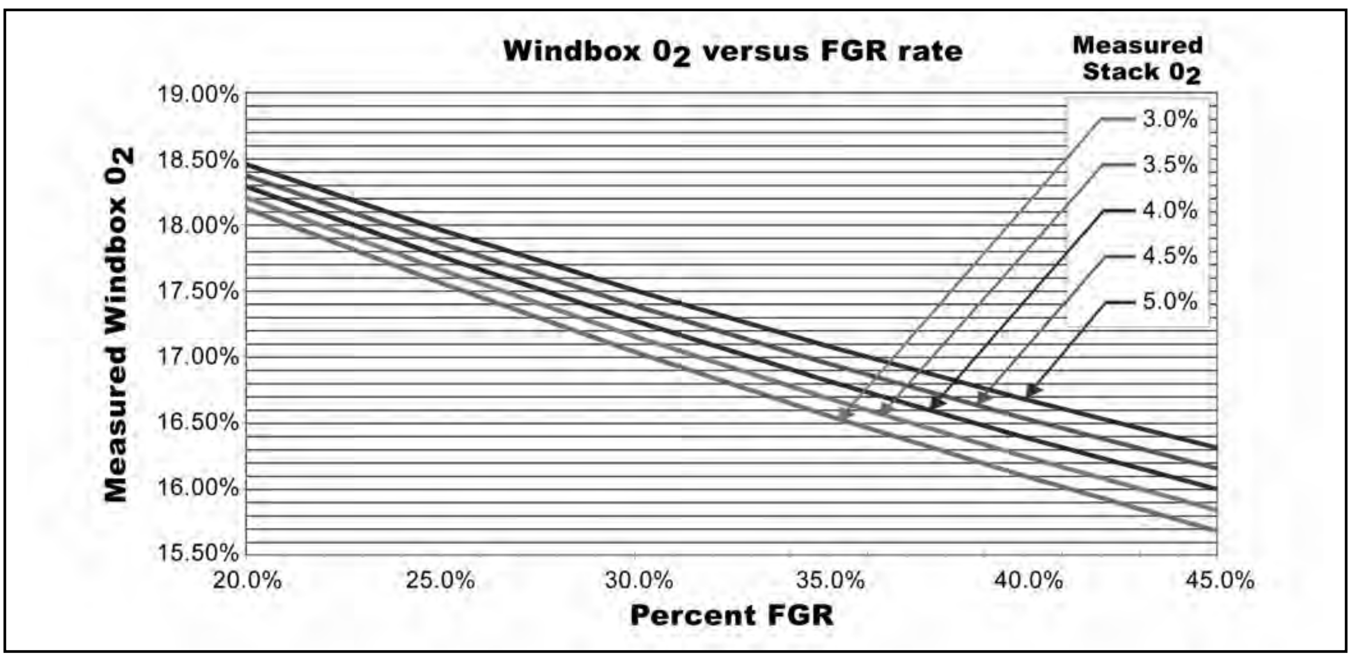


Figure 6-3

AUTOMATIC OPERATION ON GAS

When the controls are put into automatic, ensure that the control system is maintaining the proper stoichiometry over the load range, especially when operating at the maximum rate of load changes. Typically, the excess air should be maintained within +/- 5% of the setpoint (+/- 1% O_2) and the FGR rate should also be maintained within 5 percent. If the excess air or FGR is allowed to exceed this range, flame stability may be lost, while if the O_2 is too low, vibration problems may result.

FLAME CONSIDERATIONS FOR GAS FIRING

The flames of a burner allow the operator a method of judging the efficiency and proper operation of the burner. They can be used to judge operation of the burner but cannot be used to tune the burner.

A principle feature of the burners is that an extremely stable primary flame is formed, and it is difficult to extinguish the flame with high combustion airflow. However, the fact the flame does not blow out does not mean that optimum air volumes are being used. High excess air levels may result in a proper flame appearance even though excessive amounts of CO are been produced. If a continuous flame is not obtained, but rather one that is broken into several different sections at different lengths from the burner, the airflow should be reduced to reestablish the correct flame shape.

The RMB flame consists of a blue ring stabilized between the beginning of the expansion and the bend in the quarl to the straight section. Another property is “whiskers” of flame extending from the quarl. Typically, the inner refractory of the gas gun glows red hot, while the outer refractory is relatively cool. The vanes should not be glowing red hot. This can indicate high excess air at low load without FGR. The glowing is caused by flame stabilization in the vanes which causes them to overheat. The burner must not be operated without the FGR system intact and functional.

LOW AND HIGH GAS PRESSURE SWITCHES

If burner is equipped with low and high gas pressure switches, perform the following steps:

LOW GAS PRESSURE SWITCH ADJUSTMENT

Close the main manual gas shutoff valve and install a manometer or gas gauge in the upstream test port of the safety gas shutoff valve.

Open the main manual gas shutoff valve.

Cycle the burner to high fire and take gas pressure reading on manometer. Using the main manual gas shutoff valve, throttle down the gas flow to a point where the burner just starts to become unstable, makes noise or the CO level goes above 400ppm but in no case should the gas pressure go below 50% of the initial pressure reading. Increase gas pressure by opening main manual gas valve until gas pressure increases midway between last reading and the initial reading. Adjust the low gas pressure switch downward until it breaks and shuts down the burner. Restore main manual gas shutoff valve to full open.

To insure the switch is functionally sound and properly installed, recycle the burner to high fire and again use the main manual gas shutoff valve to throttle the gas flow. The low gas pressure switch should immediately break and shut down the burner at the reduced pressure setting.

Turn main manual gas shutoff valve to off, then remove manometer and reinstall test plug in gas safety shutoff valve. Restore main manual gas shutoff valve to full open.

Cycle the burner on-off several times to assure the switch will not cause nuisance shutdowns as the burner ignites.

HIGH GAS PRESSURE SWITCH ADJUSTMENT

Cycle the burner to high fire. Slowly adjust the switch downward until the switch breaks and shuts down the burner, then reverse the adjustment so the setting is approximately 10-20% greater than the reading at which the switch broke.

EXAMPLE:

If the switch broke and shut down the burner at 4.0” w.c., then set the switch at 4.5” w.c.

Cycle the burner on-off several times to assure the switch will not cause nuisance shutdowns as the burner ignites.

FINAL O_2 AND CO ANALYSIS ON GAS

With gas input rate established, perform a final O_2 analysis and make air adjustments as necessary. The final air settings should produce a flue gas analysis of between 3-1/2% and 5% O_2 with minimal CO. CO should be in the range listed in Table 6-2, but not over 400 ppm air free.

WARNING!

Do not set fire visually on forced draft burners. Calibrated instruments are the only safe and reliable means to determine the proper adjustments.

MOTOR RUNNING CURRENT AND VOLTAGE CHECK

Measure motor running current after final air adjustments have been made. Current should not exceed motor service factor amps shown on motor nameplate.

Check control voltage on terminals 1 and 2 as motor starts. Voltage should not drop below 102 volts (even momentarily) or difficulty may occur in control operation. Extreme voltage drop indicates inadequate service wire size to the burner.

BURNER SAFETY CHECK ON GAS

Start and stop the burner several times to insure proper operation. Check for proper functioning of low-water cutoff, high limit and/or operating control.

Check operation of flame safeguard by simulating a flame failure, making certain the burner locks out on safety within the time limits of the control.

Using burner operating sequence, start the burner in accordance with the step-by-step operating sequence procedure. As the burner enters the flame safeguard sequence, verify each burner function at the timing indicated.

NORMAL OPERATION ON GAS - Providing the setup and checkout operations outlined above have been properly completed and all tests have been found to be satisfactory, the burner is now ready for normal gas firing operations.

OIL FIRING

REVIEW BURNER MATERIAL LIST IN THE INSTRUCTIONS MANUAL AND ANNOTATE THE FOLLOWING INFORMATION:

(1) Oil Firing Rate (GPH)

(2) Oil Pressure at Nozzle (PSIG)

(3) Atomizing Air or Steam Pressure at Nozzle (PSIG)

The above information is pertinent to setting up the burner.

To start the burner on the oil standby fuel, the following procedure should be followed. First check to make sure the oil gun has the correct oil tip correctly installed. Insert the oil gun into the oil guide tube and lock gun into position. Set the fuel switch to the oil position. Ensure that core air supply is fully opened. As is the case with a gaseous fuel, the start procedure for an oil fuel is fully automatic and can be initiated using the same procedure as for gas.

TUNING ON OIL

During initial start-up, the operator must be on constant alert for emergency conditions such as fuel leaks, electrical malfunctions, etc. The location of all manual shutoff valves and disconnect switches should be clearly in mind so the burner can be quickly shut down if necessary.

WARNING!

Should the burner fail to ignite, never manually manipulate the flame safeguard sequence which provides for purging of the combustion chamber.

Using the manufacturer’s instructions bulletin on the flame safeguard, proceed with those tests which verify pilot and flame signal characteristics.

After pilot characteristics and flame signal have been proven satisfactory, permit the flame safeguard to cycle through to main burner ignition.

Make low fire input, fuel-air ratio and FGR adjustments. Observe oil spray through sight glasses and determine if spray is impinging on refractory throat. If so, loosen collar set screws and slide the drawer assembly forward until impingement ceases; then re-tighten set screws.

After proper boiler warm-up, run burner to high fire and make fuel-air ratio and FGR adjustments. Observe base of flame through back-plate sight glasses.

Set screws or clamp screws must be re-tightened after each adjustment.

If flame exhibits signs of instability, move nozzle to the rear a little at a time, until stability is obtained.

Manually run the burner to low fire and visually determine if there is any oil spray impingement on refractory throat. If so, re-check nozzle pressure and atomizing media adjustments and re-adjust as required.

If impingement persists, move oil nozzle forward until impingement ceases.

After oil drawer adjustments have been made, run burner through several ignitions and low fire to high fire cycles to check for proper performance.

REMOVAL OF OIL GUN FOR EXTENDED GAS FIRING

If this operation is going to be done while the burner is firing on gas, the burner must be manually run to its lowest firing rate and held there until completed. Follow instructions in section V for oil gun removal.

Cover plate must be installed when the burner is fired on gas with the oil gun removed.

FLAME CONSIDERATIONS FOR OIL FIRING

Optimum air velocities and proper atomization pressures are required to produce the turbulence and droplet size necessary to correct air and oil mixing, flame shape, and stability. If insufficient air is being used, or if the atomization pressure is insufficient, black smoke will form and the boiler may tend to pulsate or flutter. Under these conditions, the flame will be seen to swell and assume a dark orange to red color.

An excess of air will cause the formation of white or brown smoke, and when the flame is viewed, it will appear to be cloudy and ragged. In particularly bad cases of high excess air, unburned oil droplets will be torn away from the main flame and deposited on the furnace lining and boiler surfaces. The white or brown smoke is normally the result of a “chilling” or “quenching” of the flame by the high levels of excess air. The large mass of relatively cold air actually cools the fire and halts the combustion process. It may also be the result of flame impingement on the walls of the boiler, which similarly results in “chilling” of the flame. A flame that, in general appears to have the proper geometry and color, but which exhibits a high level of sparklers or oil droplets is likely the result of inadequate atomization, or when steam atomizing media is “wet.”

When a burner is operated below the lower end of an application’s turndown range, the flame will also be ragged in appearance and will lose its normally well-defined shape. White smoke will be produced as a result of the chilling of the flame by the high excess air, but black smoke may also be present due to the poor mixing of the oil droplets and the air. Increasing the atomizing media pressure may help in correcting this condition, but a turndown level will be reached where no further change in operating conditions will be successful. At this level, the minimum turndown has been reached for that particular burner/boiler configuration. Increasing the air-flow will further chill the flame; decreasing the air-flow until acceptable conditions are met may be necessary. Many times the actual minimum turndown of the system is not limited by the burner’s capabilities but rather the fan’s ability to turndown the air flow to the burner.

On first igniting an oil fire, it will generally be necessary to input fuel at a rate in excess of the aforementioned turndown minimum. This is true because the limits of flammability for igniting a fuel are much narrower than when the flame has already been established. Burner management and combustion control systems must be designed, if needed, to allow discrimination between these “low-fire light off” and “minimum fire” requirements.

Under normal operating conditions when burning fuel oil there should be no difficulty in obtaining a very good flame over a fairly wide range of atomizing media pressures. To obtain the best combustion conditions at normal operating loads while maintaining proper flame supervision, the following steps should be performed:

1. View the flame in the furnace. It should not be continuously touching or impacting any of the boiler walls or tubes, and it should be symmetrical around the burner. If the flame can be viewed appropriately, make sure that it is attached to the atomizer nozzle within a distance corresponding to the swirler diameter, and that is not pulsing. If any of the above conditions are not met, the burner manufacturer should be contacted.

2. If all of the conditions in (1) above are met, and black smoke is still present, raise the burner atomizing media flow (i.e., increase absolute or differential pressure supply at the burner) until no smoke is visible. If this is unsuccessful, raise the burner airflow until the black smoke disappears. If white smoke is present, reduce the burner air flow until the smoke disappears. Monitoring CO levels in the flue gas should also be done. CO levels are a direct indication of combustion quality.

3. View the flame in the furnace – it should be of a bright white to orange color.

4. From minimum fire to maximum fire, the flame appearance will generally have the following characteristics:

   a) Minimum Fire to 30% Load

   The fire will be a bright yellow with distinct spokes corresponding in number to the number of atomizer nozzle orifices. The center of the fire may be clean, and it may be possible to view the primary combustion zone swirl. The fire will be short and of a diameter slightly larger than the quarl opening.

   b) 30% to 60% Firing Rate

   Though it will still be possible to distinguish individual atomizer jets, the center of the fire will have dirty wisps, and the central area will fill in and lengthen considerably. The diameter will also increase somewhat, but not as significantly as the length. The color of the fire will tend more towards orange, except for the central area which will appear brownish.

   c) 60% to 100% Firing Rate

   The outer region of the flame will bend significantly and envelop the center region. For this reason, the brownish center will no longer be apparent. The flame length at high fire will be only slightly longer than that viewed at the 60% firing rate range. The color will remain a yellowish orange.

LOW OIL PRESSURE SWITCH

If burner is equipped with a low oil pressure switch, the switch should be set 10 to 15% below the final adjusted high fire “supply” oil pressure. Perform the following steps:

Annotate the “supply” oil pressure (PSIG) while the burner is at high fire.

Adjust the switch 10 to 15% below this pressure.

With the burner at low fire, slowly adjust the oil pressure regulator to obtain a reduced “supply” pressure making sure the switch cuts off the burner flame as the oil pressure drops past the PSI setting.

Adjust the oil pressure regulator to a higher pressure to allow the burner to be recycled to high fire. Then restore the high fire “supply” oil pressure annotated above.

FINAL O_2, CO AND SMOKE ANALYSIS ON OIL

Using the manual potentiometer, bring the burner up to the high fire position.

Adjust the nozzle oil pressure to the PSIG shown on the burner material list.

The high fire oil nozzle pressure is set by adjusting the oil pressure regulating valve while the oil metering valve may be used for trim purposes.

If possible, use 90° rotation of the oil metering valve between low and high fire.

Adjust air inlet louver for proper O_2, CO and smoke readings at full firing rate.

After obtaining the proper combustion on high fire, drive the burner back to low fire.

If necessary, reset low fire for proper combustion and check burner at 25%, 50% and 75% for rich or lean spots in the firing rate.

CLEANING OF OIL SYSTEM COMPONENTS AFTER START-UP

It is not uncommon for the oil system components to become dirty or clogged during initial start-up as foreign matter from the oil lines is pumped through the system.

Turn OFF the main manual fuel shutoff valves including pilot gas cock, if applicable.

Turn OFF all electrical disconnects to the burner and any other equipment or systems electrically interlocked with the burner.

Remove oil gun and/or oil drawer assembly, disassemble oil nozzle and clean using solvent and wooden toothpick to avoid damage to the finely machined surfaces.

Reassemble oil nozzle and replace oil drawer assembly.

Restore valves and electrical disconnects to ON.

BURNER SAFETY CHECK ON OIL

Start and stop the burner several times to insure proper operation. Check for proper functioning of low-water cutoff, high limit and/or operating control.

Check operation of flame safeguard by simulating a flame failure, making certain the burner locks out on safety within the time limits of the control.

Using burner operating sequence, start the burner in accordance with the step by step operating sequence procedure. As the burner enters the flame safeguard sequence, verify each burner function at the timing indicated.

NORMAL OPERATION ON OIL

Providing the set-up and checkout operations outlined above have been properly completed and all tests have been found to be satisfactory, the burner is now ready for normal oil firing operations.

PART VII

TROUBLE SHOOTING

The following is a list of possible problems and conditions that may exist on startup and the corrective measures to be taken. This deals only with combustion problems. Please refer to your flame safeguard manual and/or John Zink Company, L.L.C. wiring diagram for any electrical problems.

GAS IGNITOR

If the ignitor fails to light during a normal start cycles (the controller cycles through the pilot ignition trail), the following steps should be taken before the ignitor is removed for maintenance.

Ensure the pilot gas is turned on and the pressure is normal.

Ensure that the pilot solenoids are opening during the pilot ignition trial and that the gas pressure at the ignitor is normal.

Verify, if a suitable sight port is available, if a spark is obtained during the pilot ignition trial. If a spark is obtained and a pilot flame is established the problem is probably improper sighting of the scanner or a scanner failure.

If a spark is not obtained, probable causes of the failure are:

- The electrode is grounded.
- The electrode is worn out or misaligned.
- The high voltage transformer is not operating satisfactorily.

If a spark is obtained but the pilot does not light, possible causes are:

- The air supply to the ignitor is closed off.
- The gas holes in the ignitor are plugged.

If the problem with the ignitor cannot be determined, the ignitor assembly can be removed for cleaning and/or repair.

- Ensure that both the gas supply and electric supplies are turned off.
- Disconnect the gas supply line.
- Disconnect the high voltage cable at the electrode.
- Disconnect the ignitor by removing the four screws holding it to the air tube.
- Withdraw the ignitor internals from the carrier tube, making sure that personnel are not exposed to hot gases which may escape through the guide tube.

MAIN FLAME IGNITION FAILURE

If the pilot lights, but the flame fails during the main flame ignition period, the following steps can be taken to determine the problem.

First, the main shut off valves should be checked to ensure that they are opening at the proper time. If the main fuel valves are opening, but there is still a main flame ignition failure the air and fuel flow rates at light off should be determined.

The windbox pressure and burner gas pressure can be compared versus the last tune up data to assess any changes. Accurate static pressure measurement devices (manometers, test gauges or transducers) must be used.

If the problem is determined to be either the air or gas flow has changed during light off, the flow rates must be set back to the original light off values. This adjustment should only be performed by a properly trained service engineer.

GAS FIRING

1. VANE OVERHEATING

If vane overheating is observed visually, there are two methods of correcting the problem. The first method is to increase the FGR rate or by raising the excess air level by reducing the gas rate. The second method is to increase the minimum RDL until an acceptable low load fire is achieved.

2. VIBRATION

In a properly engineered and installed RMB, having good air flow distribution, vibration problems should be minimal. However, if the air distribution is poor, vibration can occur. Another cause that has been found to lead to vibration is low excess air levels (depending on the installation the problem can occur from 2% to 4% O_2).

If the vibration occurs because of low excess air, then the excess air should be increased. This is particularly true at the low end of the load range where air distribution tends to be worse. If the vibration appears to result from poor air distribution at low fire, increase the minimum load to the point where acceptable air distribution is obtained.

Additionally, vibration problems have been observed during load swings when the controls allow the excess air to fall below the vibration point. If this behavior is observed, then the excess air level at the point where the vibration occurs should be set higher. This may also require slowing down the ramp rate of the controller to allow air and fuel to ramp together.

3. PULSATION

A low frequency pulsation can also be encountered with the RMB. Typically, this is due to either a high excess air level or excessive FGR, or both, resulting in a very low NOx level. When this pulsation is observed, the NOx is typically less than 5 ppm. The pulsation can typically be eliminated by decreasing the excess air or FGR, or both, and raising the NOx level above 5 ppm.

4. FLAME FAILURES DURING LOAD SWINGS

During load swings, loss of either sufficient flame signal or actual flame failure can result if the excess air and/or FGR rate are not carefully controlled.

5. HIGH NOx

High NOx is typically caused by insufficient FGR. Check O_2 level in burner housing and compare to commissioning data. Other causes of high NOx can be poor airflow distribution, typically caused by movement or deterioration of air flow straightening baffles in the burner housing or air duct work. Since good air flow distribution is harder to achieve at reduced firing rates, the minimum achievable firing rate while maintaining NOx emissions will typically be higher than the minimum firing rate for stable burner operation.

6. HIGH CO

High CO emissions can caused by:

1. Operating with too much FGR, and consequently too low NOx
2. Operating with insufficient excess air
3. Operation with too much excess air
4. Poor airflow distribution

Since good air flow distribution is harder to achieve at reduced firing rates, the minimum achievable firing rate while maintaining CO emissions will typically be higher than the minimum firing rate for stable burner operation.

Cross leakage through a tangent tube furnace wall can also create CO problems and may require welding or sealing of the tangent tube walls.

OIL FIRING

1. Oil burner does not light, goes out on flame failure in main flame position:

a. Main oil valve not energized.

b. Oil metering valve not open far enough.

c. Oil strainer plugged.

d. Air louver open too far.

2. Oil burner lights but flame does not retain to burner head:

a. Drawer assembly not positioned properly. Move forward or backward.

b. Oil supply pressure at nozzle too low.

c. Atomizing media pressure at nozzle too low or high.

d. Air louver too far open.

If the oil fire is not retaining to the combustion head, the burner will build carbon on the head and fireside surfaces of the boiler. This can best be seen through the rear peep sight on the burner. Look for rivulets of oil running down the burner refractory throat and/or a wetting of oil on the inner walls of the boiler. Looking at the flame from the rear or the burner, the color of the flame should be the same all across the head. A darker color at the center usually means it is blowing off the head.

Look at the flame from the rear of the boiler. If it is retaining to the head, it will have a definite shape. If it is blowing off the head, the center of the fire will appear dark and it will be scattered over the boiler with no apparent shape or pattern. There will also be pulsation of the burner flame.

3. Burner flame retains to head on low-fire but blows off while modulating to hi-fire and/or blows out resulting in a flame failure: (Also See Item 2a - 2b previously)

   a. Louver box may be opening too fast, causing a lean spot at about 25% or 50% of range.

      The only sure way to check for the above mentioned lean spot is with proper O_2 test equipment. O_2 reading should range from approximately 6-7% O_2 on low-fire to 4-5% on hi-fire without any dips down to less than 3% O_2.

   b. If it is determined the air louver is set properly, the same linkage arm adjustments can be made on the oil metering valve to open it faster or slower, just off low-fire.

   c. Check oil strainers for possible blockage. On low-fire, there may not be enough oil flow. As unit modulates to high-fire, the burner is starved for oil.

> **NOTE**
>
> On new burner start-up, it is not uncommon to plug up the strainers with weld slag, dirt, etc. These should be checked after start-up is complete.

   c. Check nozzle. It may also have a partial blockage.

4. Burner rumbles when modulating to hi-fire:

   a. Burner is too lean. Check O_2. Reset air or oil linkage.

   b. Air louver is opening too fast.

   c. Drawer assembly not set properly.

   d. Flame is blowing off head.

5. Smoky flame:

   a. Check O_2. Flame may be too “rich” caused by not enough combustion air. Open louver box.

   b. Check for proper combustion air opening into boiler room. The outside air opening must not be less than 35 square inches of free area per gallon of oil input.

   c. “O” Ring in back block assembly leaking by.

   d. Dirty nozzle, causing poor atomization of the oil.

   e. Burner combustion air inlet blower dirty.

   f. Faulty nozzle seal. Replace.

> **NOTE**
>
> In some rare cases, it is possible to get the burner so lean or have so much excess air that the burner will produce white smoke or light grey colored smoke. This white smoke can also be caused by raw oil impinging on hot boiler surfaces.

6. Sparklers in the oil flame:

   a. Worn oil nozzle.

   b. Oil impingement on the combustion head caused by:

   (1) Drawer assembly too far to rear, impinging oil on inner fire cylinder of swirler.

   (2) Nozzle tip is too far in back of centerhole of air diffuser, causing impingement of oil on the diffuser.

   (3) Dirty nozzle.

   (4) Oil flame not retaining to the head.

   (5) Atomizing media contains water droplets (i.e. wet steam).

7. Carbon buildup on the fireside of the boiler:

   a. Dirty nozzle.

   b. Oil flame not retaining to head.

   c. Spray angle of the nozzle too wide; consult factory.

   d. Oil spray impinging on burner head, causing raw oil to deposit on boiler.

8. Flame length too long:

   a. Drawer assembly too far back; move forward slowly.

   b. Spray angle of nozzle too narrow; consult factory.

PART VIII

SAFETY MEASURES

ALL MEASURES AFFECTING OPERATOR SAFETY ARE OF EQUAL IMPORTANCE AT ALL TIMES

Attention is drawn to the specific WARNING OR PRECAUTION pages which follow:

TITLE	PURPOSE
General	WARNING
Explosions	WARNING
Boiler Purge	WARNING
Hazards of Sub-Stoichiometric Combustion	WARNING
Danger of Visual Sighting to Correct Air/Fuel Ratio	WARNING
Wiring Firing on Gas or Gas/Oil Combinations	WARNING
High Energy Ignitor Unit	WARNING
Gas Ignitor	WARNING
Ultra-Violet Flame Monitoring Head	WARNING
Safety Interlocks – Routine Checks	PRECAUTION
Infra Red Scanner Hot Refractory Hold In	WARNING
High FGR Rates, Premixed FGR	PRECAUTION

GENERAL SAFETY MEASURES

The safety measures listed below are tabulated for ease of reference – not in their order of importance:

1. No modifications to equipment described in this manual may be made without prior consultation with John Zink engineering personnel.

2. Only John Zink or John Zink trained and approved personnel should adjust the fuel/air ratio and FGR rate.

3. Do not operate the burner without either enough FGR or excess air to maintain NOx emissions below 30 ppm @ 3% O_2

4. Never operate the burner at greater turndowns than listed in Table 6-2.

5. Gas and oil cannot be co-fired at any load.

6. When the controls are released to automatic, fuel, air, and FGR control valves cannot be operated in manual.

7. Center fire gas valve supplied for RMB burners are used to balance the adjust center fire gas flow. These valves are set in place during startup. Re-adjusting can only be performed by John Zink or John Zink approved personnel.

8. In order to ensure plant and operation safety, only suitably trained personnel may perform the installation, operation, and maintenance of this equipment.

9. Before working on or operating the equipment, all relevant sections of this manual should be read and the requirements of associated equipment considered.

10. During maintenance procedures, the equipment should be isolated from the main electrical, fuel oil, steam, gas and high pressure air supplies (as applicable) for the system being maintained.

11. Always ensure that all pressure has been dissipated, and that fluid temperatures are down to safe working limits before dismantling system pipelines and components.

12. Prior to carrying out hydraulic tests on systems, the normal system pressure gauges and pressure switches must be removed or isolated to prevent damage. Suitable hydraulic gauges should be fitted to monitor test pressures employed.

13. Recommended procedures must be carried out when called for by the manufacturers of the equipment or as part of the operator's standing safety regulations (either during the normal operating procedure or when required prior to maintenance).

14. All systems are provided with a number of interlocks; these must not be by-passed. Refer also to PRECAUTIONS page – "Safety Interlocks – Routine Checks."

15. When combined fuel firing is employed (e.g. gas/oil) specific instructions should be given to operators on the correct changeover procedure.

16. Attention is drawn to the hazard associated with oil being sprayed onto hot refractory. If this is allowed to happen, the oil will vaporize and form an explosive concentration. An oil gun should never be purged into a hot furnace unless the fan is running to first purge the furnace. The burner ignitor is then initiated and the flame established to burn the oil off, followed by the oil gun purge initiation. Refer also to WARNING page "EXPLOSIONS."

17. Attention is drawn to the hazard of allowing oil to accumulate around the boiler, particularly if the oil is of low viscosity. For example, some types of crude oil are extremely dangerous. Refer also to WARNING page "EXPLOSIONS."

18. All moving machinery supplied with guards must have the prime mover effectively isolated before removal of the guards is undertaken for maintenance purposes. The guards must be correctly refitted before the machinery is brought back into operation.

19. During maintenance, the following procedures should be followed:

    a. Steam Lines

    Steam lines should be isolated, and whenever possible there should be two valves providing shut-off. Valves should be either locked or lashed and an appropriate notice attached to the valve.

    b. Oil Lines

    Oil lines should be isolated as stated above. Because hot oil can cause severe burns, it is recommended that drainage by breaking joints not be undertaken. Should this not be possible, the oil must first be allowed to cool to below (100 ^{o}F).

    c. Gas Lines

    Gas lines should be isolated as stated above. The gas lines should be vented outside the boiler house atmosphere, and purged with nitrogen. The gas should not be allowed to escape via block valves into the boiler or the boiler house.

    d. Electrical

    Normal safety precautions must be taken to avoid the possibility of electrical shock.

In Addition to the general safety measures stated above, the operators' current safety regulations must be complied with at all times.

WARNING – EXPLOSIONS

1. Before an explosion can occur, there must be a means of ignition, and an explosive mixture; if one of these can be eliminated an explosion cannot occur. As it is not possible to eliminate all causes of ignition, (for example, hot refractory), measure must be directed toward the prevention of explosive concentrations.

2. Most explosions can be traced to the unintentional entry of fuel oil or gas into combustion chambers. In this connection, gases and vapors, which readily mix with air, constitute a hazard. It should therefore be remembered that heavy grades of fuel oil in contact with hot surfaces produce sufficient vapor to provide an explosive concentration.

3. If a furnace is being purged with air it is unlikely that an explosive concentration will develop. If, however, a large quantity of fuel is leaking into the furnace, it is possible to generate an explosive concentration. Under these circumstances, the volume of the explosive mixture could be substantial.

4. Fuel lines to main burners and ignitors are provided with shut-off valves, and under no circumstances should the function of these valves be interfered with. The valves should be included in a preventative maintenance program in order to guarantee their reliability. Attention is again drawn to the need for regular maintenance of all safety interlocks (and this includes devices such as flame monitoring equipment) which are provided to prevent the unintentional entry of fuel into a furnace.

5. If a plant is manually operated, it is important to follow all of the instructions, but particular attention should be given to the lightoff procedure, furnace purging, and the purging of oil atomizers.

6. From above it may seem that one of the major considerations, when designing the system and when developing the operating and maintenance procedures, is to prevent a combination of an explosive concentration and a source of ignition occurring together. All operators should be aware of this basic concept in order to appreciate the dangers involved in the use of incorrect operating procedures and lax maintenance routines.

WARNING – BOILER PURGE

1. A PURGE CYCLE SHALL ALWAYS BE CARRIED OUT BEFORE LIGHTING UP THE FIRST BURNER. This will ensure that any explosive gases which may have formed as a result of the previous operation are dispersed.

2. If difficulty is experienced when attempting to ignite the burner, unburned oil or gas may be introduced into the furnace, with the danger of forming an explosive mixture. CONSEQUENTLY, EACH FURTHER ATTEMPTED LIGHT-OFF SHALL BE PRECEDED BY ANOTHER COMPLETE PURGE CYCLE.

3. When purging a furnace, it is necessary to continue the purge for a sufficient time in order to give at least seven complete furnace volume changes of air.

4. With larger furnaces equipped with multiple burners, it is necessary to purge through more than one burner/register in order to enable the purge to be completed within a reasonable short period of time. This multiple burner purge procedure also ensures that the purge air sweeps the entire furnace and does not leave pockets of gas. For example, in the case of a horizontally fired furnace with the gas exit at the top, the bottom burner register should always be opened during the purge to ensure that the furnace does not retain gases in the lower portion of the furnace (in some cases this gas may be heavier than air). During purge, the FGR should remain closed. A high fire or open damper interlock is provided to prove the required amount of purge air is flowing through the boiler.

5. In some installations it may be necessary to make special arrangements to purge pockets of gas in the furnace which are out of the main purge stream and cannot be adequately purged with the burner register alone.

WARNING – HAZARDS OF SUB-STOICHIOMETRIC FIRING OF GAS

1. Attention is drawn to the hazard which exists when a sub-stoichiometric state (less air supplied than is needed for complete combustion) occurs in the boiler when firing on gas.

2. IN THE EVENT THAT A SUB-STOICHIOMETRIC STATE EXISTS, THE RAPID INTRODUCTION OF AIR IS DANGEROUS. THE CORRECT PROCEDURE IS TO REDUCE THE GAS QUANTITY TO BRING THE FURNACE BACK TO NORMAL CONDITIONS.

3. One of the most likely causes of sub-stoichiometric firing is when the boiler is under manual control with independent control of air and fuel.

4. Visual examination of a gas flame does not give a good indication of the air/fuel ratio.

5. O_2 meters cannot measure sub-stoichiometric conditions. As the air is continuously reduced, the meter will show the change in O_2 value only until it reaches the zero point of the meter. The O_2 meter cannot, therefore, indicate that a sub-stoichiometric state is existing.

6. Because of the above factors, suitable instrumentation must be used to indicate and record conditions in the furnace at any give time.

To indicate:

a. Stoichiometric and above – use O_2 and CO meters.

b. Sub-stoichiometric conditions – use CO meters.

WARNING – THE DANGER OF VISUAL SIGHTING FOR CORRECT AIR/FUEL RATIO WHEN FIRING ON GAS OR GAS/OIL COMBINATIONS

1. When gas-only burners, or dual oil/gas burners, are employed, visual examination of the flame does not give an accurate indication of the air/fuel ratio.

2. Because of the above factor, suitable instrumentation must be used to indicate conditions in the furnace when firing on gas or oil. To indicate:

    a. Stoichiometric and above – use O_2 and CO meters.

    b. Sub-stoichiometric conditions – use CO meters.

Attention is also drawn to the WARNING – "HAZARDS OF SUB-STOICHOIMETRIC FIRING ON GAS"

WARNING – HIGH ENERGY IGNITOR UNIT; THE ELECTRICAL DISCHARGE FROM THIS UNIT CAN BE LETHAL

Before any maintenance to the high energy ignitor unit, surface discharge plug and their associated H. T. supply cable may be carried out following an operating period, it is essential that A WAITING PERIOD OF AT LEAST 2 MINUTES SHALL BE OBSERVED.

It is essential that the high energy ignitor unit SHALL BE DISCONNECTED FROM THE MAIN ELECTRICAL SUPPLY BEFORE COMMENCING MAINTENANCE OPERATIONS.

WARNING – GAS IGNITOR

It is essential that the ELECTRICAL AND GAS SUPPLIES shall be disconnected and isolated from this unit before any maintenance is carried out.

WARNING – ULTRA-VIOLET FLAME MONITORING HEAD

Ultra-Violet flame monitoring heads contain high voltage, as high as 2000 VDC. Properly trained personnel with the correct tools should service this equipment.

WARNING – INFRA RED SCANNER HOT REFRACTORY HOLD IN

Infra Red scanners are prone to mistaking hot refractory for a stable flame. Proper sighting of the scanner is critical. Please refer to the scanner manufacturer's operations manual.

PRECAUTION – SAFETY INTERLOCKS – ROUTINE CHECKS

1. Installations are provided with a number of safety interlocks, some of which are listed below:

    a. Boiler water level

    b. Fluid Temperature & Pressures

    c. Position Switches

For others, refer to Maintenance Details on page 43.

2. It is important that these shall not be by-passed

3. Routine checks should be made to ensure the satisfactory operation of all interlocks. The frequency of the checks depends on the type of interlock and the environment. The following frequency is given for guidance, although, when appropriate, the manufacturer's instructions should be followed.

    a. Fluid level alarms . . . . Weekly

    b. Flame Monitoring System . . . . . Weekly

    c. Pressure Switches . . . . Monthly

    d. Temperature Switches . . . . Monthly

    e. Position Switches . . . . Monthly

PRECAUTION – HIGH FGR RATES, PREMIX FGR

The use of FGR fans of any percentage of combustion air flow will provide the possibility of high FGR rates during burner turndown. In the 25-50% load range, flame stability can be affected, even by FGR systems designed for recirculation as low as 15%. At about 30% load, low oxygen levels, in combination with maximum FGR capability can cause very low windbox oxygen concentrations. Safe burner operation can be achieved at these low windbox oxygen levels, but operational O_2 and FGR curves must be carefully optimized to maintain a sufficient safety margin on O_2. Additionally, flame scanners must be tuned precisely to detect flame detachment that can occur at these low windbox oxygen levels.

PART IX

MAINTENANCE DETAILS AND SCHEDULE

The following maintenance section of this manual is provided to assist the Purchaser of this burner in maintaining various components of the burner assembly. However, it is strongly emphasized that the Purchaser's maintenance personnel familiarize themselves with the design and operation of this burner system by reading all other sections of this manual before any maintenance be carried out on the equipment. In particular, the potential hazards associated with maintenance of various components of the system should be noted, with special emphasis placed on review of the "WARNINGS" in the SAFETY SECTION of this manual. All personnel assigned to maintenance of the equipment should have completed a walkdown of the system, secured proper clearances, and familiarized themselves with all safety checks and codes.

The details of the maintenance procedures refer to specific components in the major subassemblies. For details on these components, please refer to the appropriate section of the "Burner Components" portion of this manual.

GENERAL

Although the RMB system is designed to be a low maintenance system, several system components require periodic maintenance and calibration.

Indicators of serious system problems are listed below. If any of these signs are encountered it is recommended that a complete equipment inspection, by qualified personnel, be performed to determine the source of the problem.

Flame failures, even a single flame failure during operation in automatic is an indication of a control or equipment problem. Repeated flame failures, particularly at higher loads, is an indication of a serious problem and boiler should be taken out of service until the problem is resolved.

Boiler vibration, onset of boiler vibration is also an indicator of a control or equipment problem. Typically boiler vibration occurs if the excess air becomes too low (2 to 4% depending on the installation), or if the NOx becomes so low that the flame becomes unstable (typically 5 ppm or less).

Based on a calibrated CEM, or other accurate emissions monitoring device, either high or low NOx emissions, relative to the original set-up data, are an indicator of a controls problems. Significant deviation in the stack O_2 from the original boiler tuning is also a good indicator of a system problem.

CONTROL SYSTEM

The main components of the system that require attention is the gas control valve. Typically, the valve requires retuning at 6 month intervals, to maintain the proper fuel/air ratio across the load range. If the system is located in a dirty environment and/or the unit is subject to frequent load swings, a retuning interval more often than 6 months may be required. Tuning of the gas control valve should only be performed by trained personnel with proper equipment.

Additionally, at regular intervals, but no longer than 6 months, the entire linkage should be inspected for loose connections or signs of wear in ball joints or other moving parts. Dampers should also be inspected for loose or broken components. Any worn components should be replaced and the gas valve returned following the replacement to reproduce the original setup data.

The calibration of the fuel and air positioner and FGR positioner should be calibrated yearly to reproduce the original response for an input signal. The FGR actuator should be checked to ensure that the original performance specifications are satisfied (0.5% accuracy and repeatability and 1% hysterysis).

All bearings and other components having grease fittings should be greased at a yearly interval (or more often in a dirty environment).

All gas train components, including safety shut off valves, gas pressure switches, control valves etc., should be inspected and tested on a yearly basis.

BURNER REFRACTORY AND INTERNALS

The burner should be inspected on a yearly basis for signs of overheating and/or refractory damage. Overheating of metal portions of the burner may be indications of control problems. Badly cracked or broken refractory pieces should be replaced.

The internals of the burner windbox should be inspected yearly, to ensure all baffling is intact and all windbox components are in proper working order.

GAS TRAIN

All gas train components, including safety shut off valves, gas pressure switches, control valves etc., should be inspected and calibrated on a yearly basis. Test safety shut off valves, in both the pilot and main gas lines, for leaks per NFPA guidelines. Empty strainers in the main and gas lines.

ATOMIZER NOZZLE CLEANING

a. Wash the atomizer nozzle in safety solvent, removing any deposits with a bristle brush. If any of the passages are blocked, appropriately sized soft copper wire may be used to clean them (hardened metal cleaning tools should not be used).

b. Clean the oil ports first, cleaning them from the rear. Clean the atomizing media ports second, cleaning them from the front.

c. Blow through the ports with high pressure air to remove any foreign matter.

d. Place the atomizer nozzle in front of a strong light source to ensure final cleanliness of the atomizer.

e. Check the atomizer orifice wear limits using standard number and/or fraction drills. The nominal limit of wear is 10%.

f. Wash out the oil and atomizing media passages in the block and tubes with a safety solvent.

g. Blow out the passages with high pressure air to dry and remove any foreign matter.

h. Ensure that the atomizer nozzle and adapter body mounting faces are clean and undamaged.

i. Liberally lubricate the threads with a high temperature anti-seize compound. Failure to use the high temperature compound may result in thread damage during the next required disassembly.

j. Hand-tighten the atomizer nozzle onto the adapter body. Do not force the nozzle. If the nozzle does not spin on freely, remove and examine the threads.

BURNER HEAD MAINTENANCE

With the primary register removed, the blades are accessible for inspection and cleaning as follows:

Remove any carbon deposits from the blades, and thoroughly clean with a wire brush. Inspect the blades for damage, distortion, and security of the blades. The blades should be inspected for cracks and repaired or replaced as required. The gas exit holes should also be clean.

PRIMARY REGISTER REASSEMBLY

Install a new ceramic rope gasket between the primary register and the frontplate.

Insert the primary register through the frontplate, taking special care that no damage occurs through contact with any other components of the burner assembly.

Reinstall the primary register securing nuts and washers.

Reconnect the gas line to the primary register.

BURNER QUARL

With the aid of a strong light, and following proper safety precautions, visually check the burner quarl for damage. If the damage is excessive, the quarl should be repaired as follows:

1. Only a good grade of refractory material should be used. Alumina content of the refractory should be at least 70%.

2. If the damage is not extensive, the repair may be made with local patching following the refractory manufacturer's recommendations. Chip away all loose material and undercut the firm refractory to give a key for the patch. Tamp the new refractory into the hole, and level off smoothly after filling.

3. Pack plastic refractory as tightly as possible to give a firm smooth shape. Do not attempt to add excess water in order to make the material more easily workable. Normally, the correct constituency is when the material will just stick together if clasped in the hand.

4. Combustion efficiency is affected if the quarl is not formed to the correct shape and angle. The furnace edge should be even and well defined, since irregularities in the quarl lip and its length can produce unevenness of air distribution, turbulence, and flame shape.

5. If the damage to the refractory is too extensive to be repaired with local patching, a new frontplate should be purchased.

6. After the refractory has been installed, the burner system must be reinstalled and started up. The refractory must be cured in accordance with the refractory manufacturer's recommendations regarding rate of temperature increase, length of curing time, and various other parameters.

MAINTENANCE/LUBRICATION SCHEDULE

A. DAILY

1. Inspect every flame for unusual flame pattern. Also look for flame behind the vanes or red vanes (indicating overheating).

B. WEEKLY

1. Check burner internals (through view port) for indications of any burner malfunction.

2. Check the fittings and connection of the gas train with explosimeter or soap water for leaks. Repair any leaks immediately. Test safety shutoff valves for leaks per NFPA guidelines.

C. MONTHLY

1. Empty fuel strainers of the oil, gas, and ignitor lines.

D. EVERY OUTAGE (SCHEDULED MAINTENANCE SHUTDOWN)

1. Inspect windbox internals for loose or damaged items.

2. Inspect vanes for distortion, heat damage, cracks, and damaged welds.

3. Check burner mounting on front windbox face for tears and air leak paths.

4. Remove and clean scanner lens and view ports.

5. Empty gas strainers.

E. EVERY FURNACE INSPECTION (MINIMUM OF ONCE/YEAR)

1. Inspect swirl vanes for distortion, overheating, loose components, and concentricity.

2. Inspect refractory quarl for any damage.

3. Remove and inspect the oil atomization assembly. Remove the atomizer nozzle and inspect for cleanliness.

4. Calibrate/test safety interlocks.

5. Inspect gas orifice cleanliness.

PERIODIC TESTING RECOMMENDED CHECKLIST			
ITEM	FREQUENCY	ACCOMPLISHED	REMARKS
Gauges, monitors and indicators	Daily	Operator	Make visual inspection and record readings in log
Instrument and equipment settings	Daily	Operator	Make visual check against recommended specifications
Firing rate control	Weekly Semi-annually Annually	Operator Service Technician Service Technician	Verify factory settings Verify factory settings Check with combustion test
Flue, vent, stack or outlet dampers	Monthly	Operator	Make visual inspection of linkage, check for proper operation
Ignitor	Weekly	Operator	Make visual inspection, check flame signal strength if meterfitted (see “Combustion safety controls”)
Fuel Valves			
Pilot and main gas of main oil	Weekly	Operator	Open limit switch – make aural and visual check – check valve position indicators and check fuel meters if so fitted
Pilot and main gas or main oil	Annually	Service Technician	Perform leakage tests – refer to instructions
Combustion safety controls			
Flame failure main	Weekly	Operator	Close manual fuel supply for (1) pilot, (2) fuel cock, and/or valve(s); check safety shutdown timing; log
Flame signal strength	Weekly	Operator	I flame signal meter installed, read and log; for both pilot and main flames, notify service organization if readings are very high, very low, or fluctuating; refer to instructions
Pilot turndown tests	As required/ annually	Service Technician	Required after any adjustments to flame scanner mount or pilot burner verify annually – refer to instructions
Refractory hold in	As required/ annually	Service Technician	See “Pilot turndown tests”

PERIODIC TESTING RECOMMENDED CHECKLIST			
ITEM	FREQUENCY	ACCOMPLISHED	REMARKS
Low-water fuel cutoff and alarm	Daily/Weekly Semi-annually	Operator Operator	Refer to instructions Perform a slow drain test in accordance with ASME Boiler and Pressure Vessel Code Section VI
High limit safety control	Annually	Service Technician	Refer to instructions
Operating control	Annually	Service Technician	Refer to instructions
Low draft, fan, air pressure, and damper position interlocks, including high fire air and FGR damper	Monthly	Operator	Refer to instructions
Atomizing air/steam interlock	Annually	Service Technician	Refer to instructions
High and low gas pressure interlocks	Monthly	Operator	Refer to instructions
High and low oil pressure interlocks	Monthly	Operator	Refer to instructions
Fuel valve interlock switch	Annually	Service Technician	Refer to instructions
Purge switch	Annually	Service Technician	Refer to instructions
Low fire start interlock	Annually	Service Technician	Refer to instructions
Safety valves	As required	Operator	In accordance with procedure in Section VI, ASME Boiler and Pressure Vessel Code, Recommended Rules for Care and Operation of Heating Boilers
Inspect burner components	Semi-annually	Service Technician	Refer to instructions

PART X

SUPPLEMENTARY DATA

This manual should be kept with other literature on your boiler room equipment as a complete reference source for maintenance and service.