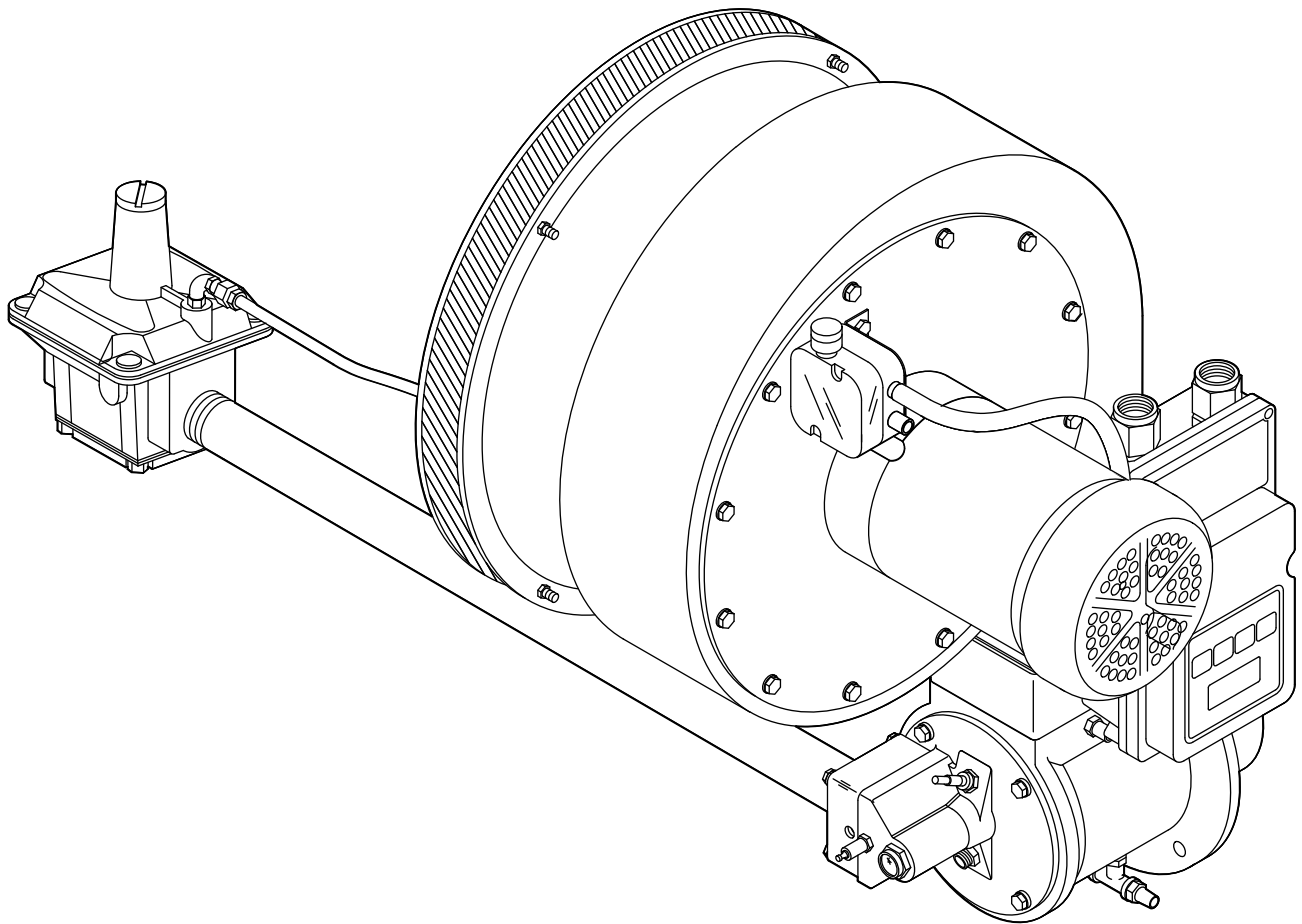


# Eclipse ImmersoPak

## Burners

IP Series  
Version 2



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There are several special symbols in this document. You must know their meaning and importance.

The explanation of these symbols follows below. Please read it thoroughly.

## **How To Get Help**

If you need help, contact your local Eclipse representative. You can also contact Eclipse at:

1665 Elmwood Rd.  
Rockford, Illinois 61103 U.S.A.  
Phone: 815-877-3031  
Fax: 815-877-3336  
<http://www.eclipsenet.com>

Please have the information on the product label available when contacting the factory so we may better serve you.

 <b>ECLIPSE</b> <small>Innovative Thermal Solutions</small>	<a href="http://www.eclipsenet.com">www.eclipsenet.com</a>
Product Name	
Item #	
S/N	
DD MMM YYYY	



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.



Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

**NOTICE**

Is used to address practices not related to personal injury.

**NOTE**

Indicates an important part of text. Read thoroughly.



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# Introduction

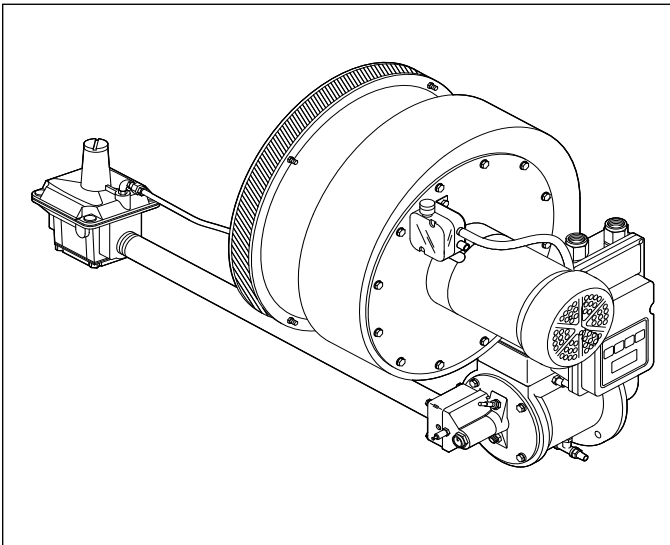
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## Product Description

The ImmersoPak burner (IP Series) is a nozzle-mix burner with a packaged combustion air blower that is designed to fire on-ratio (proportional air/gas control) or fixed air on smaller models over a turndown of 10:1. Integral gas and air orifices are provided to ease burner setup. The burner is designed for:

- efficient ratio controlled combustion
- reliable burner operation
- simple burner adjustment
- direct spark ignition
- multiple fuel capability

A wide variety of options and configurations are available due to the modular design of the burner.



**Figure 1.1. ImmersoPak Burner**

## Audience

This manual has been written for people who are already familiar with all aspects of a nozzle-mix burner and its add-on components, also referred to as “the burner system”.

These aspects are:

- Installation
- Use
- Maintenance

The audience is expected to have previous experience with this type of equipment.

## ImmersoPak Documents

### **Installation Guide No. 360**

- This document

### **Datasheet, Series No. 360**

- Available for individual IP models
- Required to complete installation

### **Design Guide No. 206**

- Used with Datasheet to complete installation

### **Related Documents**

- EFE 825 (Combustion Engineering Guide)
- Eclipse Bulletins and Info Guides: 710, 732, 760, 818, 832, 852, 854, 856, 610, 620, 630, 826, 820, 930, I-354

## Purpose

The purpose of this manual is to ensure that you carry out the installation of a safe, effective, and trouble free combustion system.

# Safety

Important notices which help provide safe burner operation will be found in this section. To avoid personal injury and damage to the property or facility, the following warnings must be observed. All involved personnel should read this entire manual carefully before attempting to start or operate this system. If any part of the information in this manual is not understood, contact Eclipse before continuing.

## Safety Warnings

### **DANGER**

- **The burners, described herein, are designed to mix fuel with air and burn the resulting mixture. All fuel burning devices are capable of producing fires and explosions if improperly applied, installed, adjusted, controlled or maintained.**
- **Do not bypass any safety feature; fire or explosion could result.**
- **Never try to light a burner if it shows signs of damage or malfunction.**

### **WARNING**

- **The burner and duct sections are likely to have HOT surfaces. Always wear the appropriate protective equipment when approaching the burner.**
- **Eclipse products are designed to minimize the use of materials that contain crystalline silica. Examples of these chemicals are: respirable crystalline silica from bricks, cement or other masonry products and respirable refractory ceramic fibers from insulating blankets, boards, or gaskets. Despite these efforts, dust created by sanding, sawing, grinding, cutting and other construction activities could release crystalline silica. Crystalline silica is known to cause cancer, and health risks from the exposure to these chemicals vary depending on the frequency and length of exposure to these chemicals. To reduce the risk, limit exposure to these chemicals, work in a well-ventilated area and wear approved personal protective safety equipment for these chemicals.**

### **NOTICE**

- **This manual provides information regarding the use of these burners for their specific design purpose. Do not deviate from any instructions or application limits described herein without written approval from Eclipse.**

## Capabilities

Only qualified personnel, with sufficient mechanical aptitude and experience with combustion equipment, should adjust, maintain or troubleshoot any mechanical or electrical part of this system.

## Operator Training

The best safety precaution is an alert and trained operator. Train new operators thoroughly and have them demonstrate an adequate understanding of the equipment and its operation. A regular retraining schedule should be administered to ensure operators maintain a high degree of proficiency.

## Replacement Parts

Order replacement parts from Eclipse only. All Eclipse approved valves or switches should carry UL, FM, CSA, CGA and/or CE approval where applicable.

# Installation

In this section you will find the information and instructions that you need to install the burner.

## **Handling**

- Make sure that the area is clean.
- Use the appropriate support and handling equipment when lifting the burner.
- Protect the components from the weather, damage, dirt and moisture.
- Protect the components from excessive temperatures and humidity.
- Take care not to drop or damage components.

## **Storage**

- Make sure that the components are clean and free of damage.
- Store the components in a cool, clean, dry room.
- After you have made sure that everything is present and in good condition, keep the components in the original package as long as possible.

## **Approval of Components**

### **Limit Controls & Safety Equipment**

All limit controls and safety equipment must comply with all applicable local codes and/or standards and must be listed for combustion safety by an independent testing agency. Typical application examples include:

- American: NFPA 86 with listing marks from UL, FM, CSA
- European: EN 746-2 with CE mark from TuV, Gastec, Advantica

### **Electrical Wiring**

All the electrical wiring must comply with all applicable local codes and/or standards such as:

- NFPA Standard 70
- ANSI-C11981
- EN 746-2

### **Gas Piping**

All the gas piping must comply with all applicable local codes and/or standards such as:

- NFPA Standard 54
- ANSI Z223
- EN 746-2

### **Where to Get the Standards:**

#### **The NFPA Standards are available from:**

National Fire Protection Agency  
Batterymarch Park  
Quincy, MA 02269  
[www.nfpa.org](http://www.nfpa.org)

#### **The ANSI Standards are available from:**

American National Standard Institute  
1430 Broadway  
New York, NY 10018  
[www.ansi.org](http://www.ansi.org)

#### **The UL Standards are available from:**

333 Pfingsten Road  
Northbrook, IL 60062  
[www.ul.com](http://www.ul.com)

#### **The FM Standards are available from:**

1151 Boston-Providence Turnpike  
PO Box 9102  
Norwood, MA 02062  
[www.fmglobal.com/approvals](http://www.fmglobal.com/approvals)

#### **Information on the EN standards and where to get them is available from:**

Comité Européen de Normalisation  
Stassartstraat 36  
B-1050 Brussels  
Phone: +32-25196811  
Fax: +32-25196819  
[www.cen.eu](http://www.cen.eu)

Comité Européen de Normalisation Electronique  
Stassartstraat 36  
B-1050 Brussels  
Phone: +32-25196871  
Fax: +32-25196919  
[www.cenelec.org](http://www.cenelec.org)

## Checklist Before Installation

### Intake

To admit fresh combustion air from outdoors, provide an opening in the room of at least one square inch per 4,000 BTU/hr (6 cm<sup>2</sup> per 1 kW). If there are corrosive fumes or materials in the air, then supply the burner with clean air from an uncontaminated area, or provide a sufficient air filtering system.

### Exhaust

Do not allow exhaust to accumulate in the work area. Provide some positive means for exhausting them from the furnace and the building.

### Access

Make sure that you install the burner in such a way that you can get easy access for inspection and maintenance.

### Environment

Make sure the local environment matches the original operating specifications. Check the following items:

- Voltage, frequency and stability of the electrical power
- Type and supply pressure of the fuel
- Availability of enough fresh, clean combustion air
- Humidity, altitude and temperature of air
- Presence of damaging corrosive gases in the air
- Prevent direct exposure to water

## Install the Burner

### Dimensions

Bolt the burner to the immersion tank wall or immersion tube flange. For bolt hole patterns, see the datasheet for your ImmersoPak model.



- If adapters are used, burner flange should not be spaced further than 4" from tank wall.

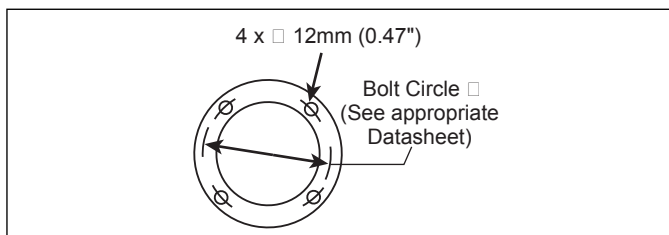


Figure 3.1. Bolt Hole Pattern

### Tank wall

Make sure that the wall of the tank is strong enough to carry the weight of the burner. If necessary, reinforce the tank wall area where you plan to install the burner.

### Burner Piping

The burner is factory assembled and shipped as ordered.

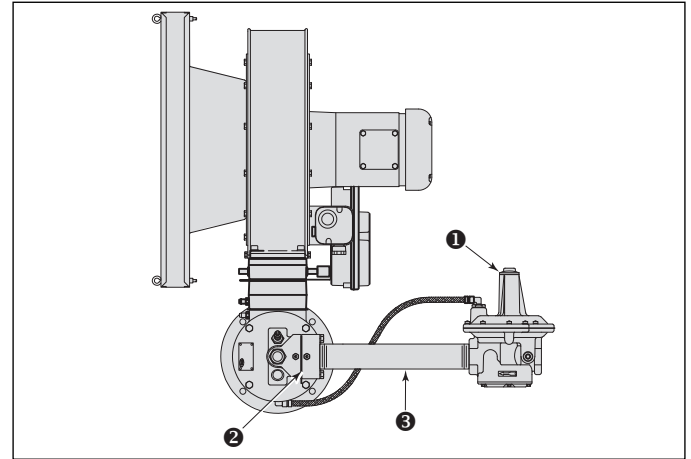


Figure 3.2.

**NOTE:** It is not recommended to redirect piping. If necessary, be sure the:

- Ratio regulator spring column ❶ is pointing up.
- Arrow on the ratio regulator points in the direction of gas flow.
- Integral fuel orifice and o-rings ❷ are re-installed.
- Same straight runs of pipe ❸ remains between the ratio regulator and the burner.
- IP004 and IP005 burners may contain BSP or NPT transition piping.

### Supply Piping

Install the piping using the following steps:

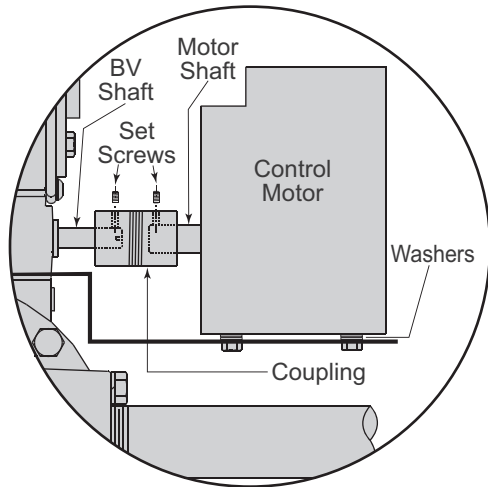
- Locate the valve train close to the burner. The gas must reach the burner during the fixed trial for ignition.
- Sufficiently size shut off valves in the valve train.
- Make sure piping is large enough.
- Minimize piping elbows.

### Pipe Connections

- Installation of a pipe union in the gas line is recommended to simplify burner removal.
- Use of flexible pipe is optional.

### Control Motor

Install a control motor to modulate the air butterfly valve if not previously installed on the burner.



**Figure 3.3.**

**NOTE:** Be sure the control motor shaft and air butterfly valve shaft are aligned properly. If using an Eclipse Actuator Mounting Parts Kit, the supplied washers may be used as shims (stacked 0, 1, or 2 high) to ensure proper alignment. Additionally, a flexible coupling can be used to handle minor misalignment.

### **Install the Flame Sensor**

1. Install the flame sensor into the 1/2" NPT opening in the rear cover.
2. Make sure that you connect the flame sensor of a burner to the electrical circuit of that burner.



- **If you connect the flame sensor of a burner to the electrical circuit of the wrong burner, then you can cause fires and explosions.**

There are two different types of flame sensors: UV scanner and flamerod.



- **Adjustments may vary from Eclipse published values if the flame controls other than those recommended in the Design Guide are used. Consult with the engineer who specified the alternate control for limitations.**

### **UV Scanner**

For detailed information on how to install and connect a UV scanner, refer to scanner information guide.

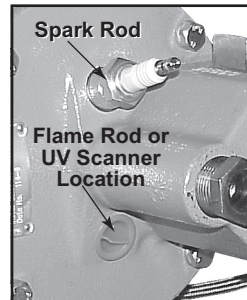
### **Flame Rod**

If the flame rod option was selected when the burner was ordered, the burner will be delivered with the flame rod already installed on the burner.

**NOTE:** Only specific burner sizes are capable of using a flame rod. These models are IP004, 005, and 006.

For detailed information on how to install and connect a flame rod, refer to:

- Bulletin / Info Guide 832



**Figure 3.4.**

### **Checklist After Installation**

To verify proper system installation, do the following:

1. Make sure that there are no leaks in the gas and air lines.
2. Make sure all the components of the flame monitoring control system are properly installed. This includes verifying that all switches are installed in correct locations and all wiring, pressure and impulse lines are properly connected.
3. Make sure components of spark ignition system are installed and functioning properly.
4. Make sure that the blower rotates in the correct direction. If incorrect, have a qualified electrician rewire the blower to reverse its rotation.
5. Make sure all valves are installed in the proper location and correctly oriented relative to the gas or air flow direction.



# Adjustment, Start & Stop

# 4

In this chapter you will find instructions on how to adjust a system, and how to start and stop a system.

## DANGER

- Do not bypass any safety feature. You can cause fires and explosions.

### Step 1: Reset the System

1. Set the air flow switch so that it drops out at 20% below the maximum pressure of the combustion air blower.
2. Set the low gas pressure switch at 20% below the gas pressure measured at the inlet to the main gas valve train.
3. Set the high gas pressure switch at 20% above the gas pressure measured at the inlet to the main gas valve train.
4. Close all the burner (and by-pass pilot, if applicable) gas valves, manual and automatic.
5. Start the combustion air blower.
6. Try to ignite the burner; be sure the flame monitoring system indicates a flame failure.

## CAUTION

- Make sure blower rotates in the correct direction. If incorrect, have a qualified electrician rewire the blower to reverse it.

7. Activate the pressure switches and other limit interlocks. Be sure the switches fail as intended in the event of a power failure.

## DANGER

- If simulated limits or simulated flame failures do not shut down the fuel system within the required failure response time, immediately correct the problem before proceeding.

8. Adjust main gas inlet pressure to the ratio regulator within the range specified in the appropriate datasheet.

## WARNING

- Gas inlet pressures must stay within the specified range. Pressure above the specified range can damage the ratio regulator.
  - Pressure below the specified range can impair the ability of the ratio regulator to control the gas flow.
  - Operating the system outside the specified range can cause excess fuel consumption and the possible accumulation of unburned fuel in the tube.
  - In extreme cases, this accumulation of unburned fuel may cause fires or explosions.
9. With modulating air burners, verify that the actuator opens the air BV towards the back of the burner as shown. If it doesn't, refer to the actuator's literature for instructions on how to reverse the direction.

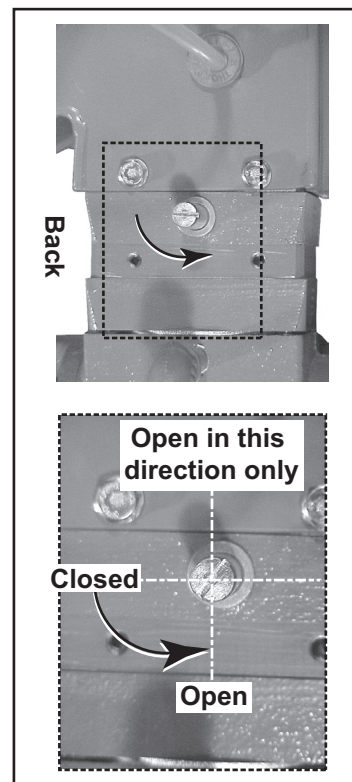
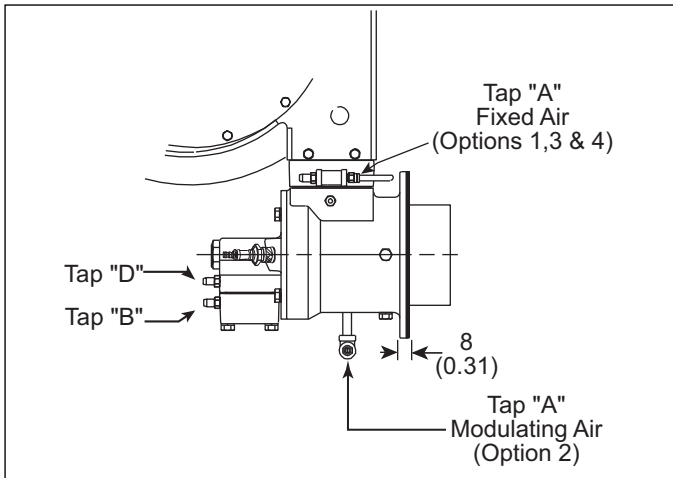


Figure 4.1. Air BV

## Step 2: Verify Air Flow



**Figure 4.2. Pressure Tap Locations**

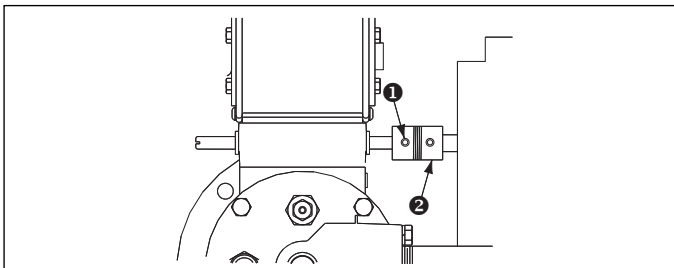
1. Set the system to high fire, but **DO NOT** ignite the burner(s).
2. Start the combustion air blower.
3. Use the data from the appropriate ImmersoPak datasheet to find the static air pressure at high fire. This is now the target value for high fire.

**NOTE:** Tube back pressure may limit the burner from reaching the datasheet value.

**NOTE:** A pressure tap is open when the screw inside the tap is unscrewed approximately half a turn.

- a. Make sure that pressure tap A is open.
- b. Connect the manometer to tap A.
- c. Verify target value from step 3 above. Verify that the slot on the end of the butterfly valve shaft (if applicable) is parallel to flow (fully open). If necessary, adjust the control motor travel for high fire.

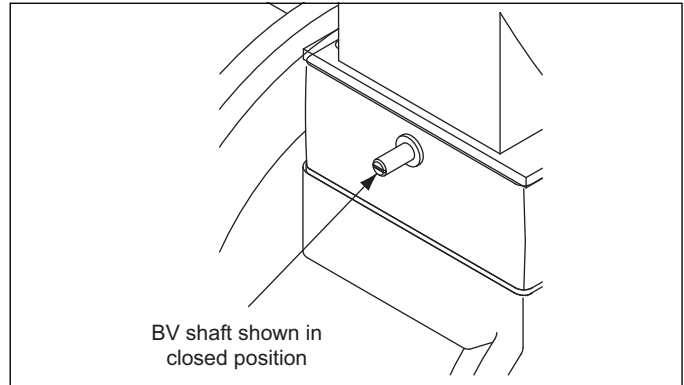
## Step 3: Set low fire air



**Figure 4.3. Air BV Adjustment**

1. Start combustion air blower.
2. Drive control motor to low fire position.
3. Set low fire air.
  - a. Loosen the set screw ① on burner side of coupling ②.

**NOTE:** There is a slot in the end of the BV shaft that is parallel to the air damper. This slot is used for visual indication of the BV position. The BV is closed when the shaft slot is perpendicular to the direction of air flow through the BV.



**Figure 4.4. Air BV Shaft**

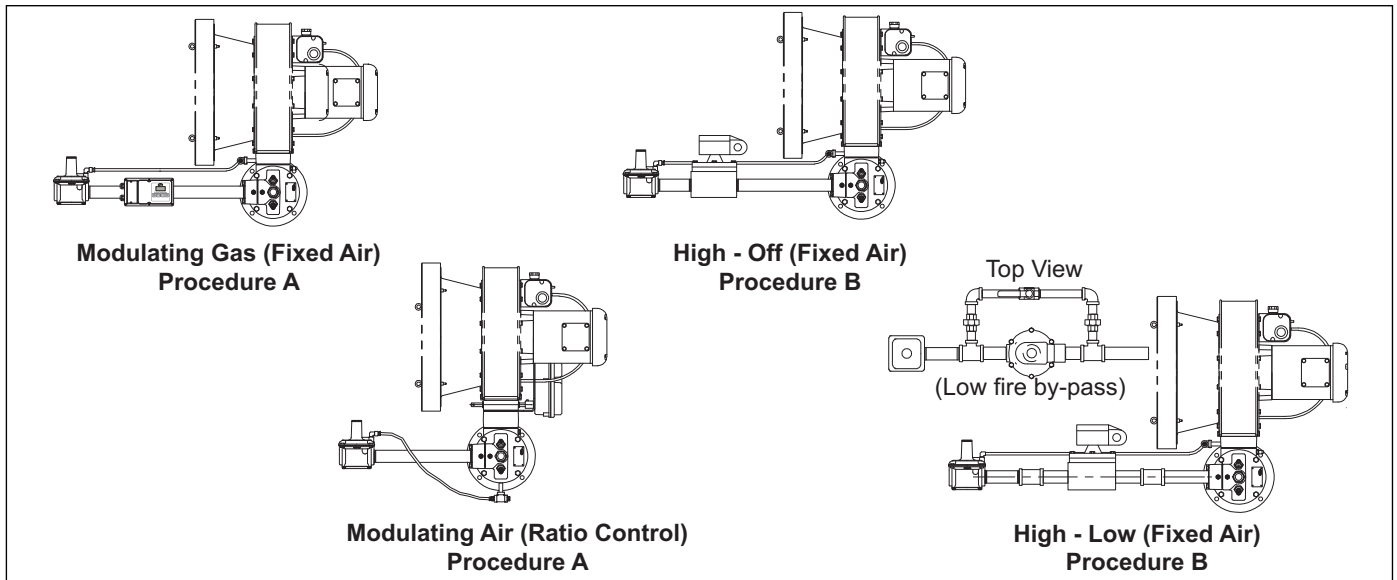
- a. Rotate air BV shaft to fully closed position. (Holes in BV damper will supply low fire air.)
  - c. Hold BV shaft firmly in place and tighten set screw ①.
4. Verify high fire air.
  5. Return the control motor to the low fire position.
  6. Close the pressure taps.

## Step 4: Ignite the burner



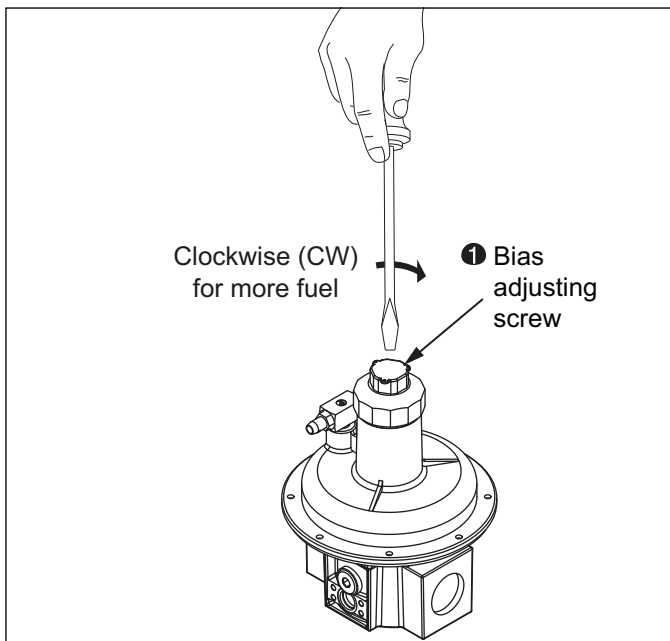
- This procedure is written with the assumption the burner has a flame monitoring control system installed and operating. A proper purge cycle must be part of the system and purge timing should not be bypassed.

Determine system layout and use the applicable ignition procedure. See Figure 4.5.



**Figure 4.5. System Layout**

**Procedure A: Low fire start  
(Modulating Air or Gas)**



**Figure 4.6. Ratio Regulator**

1. Drive air or gas control motor to low fire.
2. Be sure combustion air blower is running.
3. Verify bias adjusting screw ❶ on ratio-regulator spring column is six full clockwise turns ( $360^\circ \times 6$ ) down from the top (initial setting).
4. Open main gas manual shut off valves.

5. Set system control to stay at low fire during and after ignition sequence.
6. Attempt to ignite burner.
7. If burner does not ignite:
  - a. Attempt to ignite burner again to purge air from the gas piping.
  - b. **(Modulating Air)** If burner still does not ignite, turn bias adjusting screw ❶ a half turn clockwise to increase gas flow.
  - (Modulating Gas)** If burner still does not ignite, adjust the control motor to incrementally increase gas flow.
  - c. Attempt to ignite burner.
  - d. Repeat steps **b** and **c** until burner ignites. If necessary, refer to Chapter 5 for troubleshooting tips.
8. Flame signal strength: Adjust gas flow as described above in step **7b** to maintain a stable flame signal and reliable ignition.

**NOTE:** If viewing the flame, it should be blue with flashes of yellow. When firing propane or butane, a proper low fire flame may have sustained flashes of yellow.

9. Verify low fire flame:
  - a. Shut off gas. Allow process to cool.
  - b. Verify repeatability of ignition and low fire flame signal at cold conditions.

## Procedure B: Fixed Air (High/Low or High/Off)

1. Be sure combustion air blower is running.
2. Verify bias adjusting screw ① on ratio-regulator spring column is six full clockwise turns (360° x 6) down from the top (initial setting).
3. Be sure the main gas manual shut off valves are closed.
4. Open adjustable limiting orifice gas cock ② in the low fire bypass (if applicable).
5. Open the main gas manual shut off valves.
6. Attempt to ignite burner.

**NOTE:** Gas solenoid valve ③ must be open for high/off and closed for high/low.

7. If burner does not ignite:
  - a. Attempt to ignite burner again to purge air from the gas piping.
  - b. **(High/Low)** If burner still does not ignite, turn adjusting screw 4 a half turn counterclockwise to increase gas flow.

**(High/Off)** There is no adjustment.

  - c. Attempt to ignite burner.
  - d. Repeat steps **a**, **b** and **c** until burner ignites. If necessary, refer to Chapter 5 for troubleshooting tips.

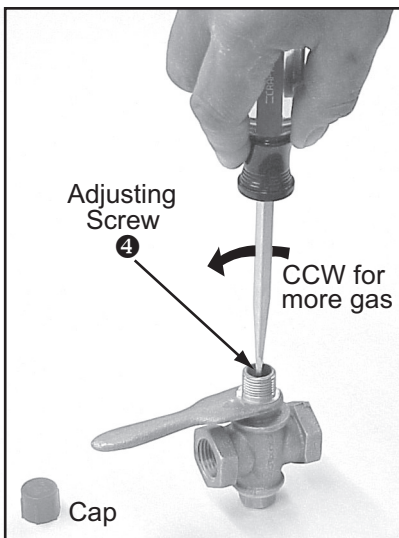


Figure 4.7. Adjustable Limiting Orifice, Gas Cock

8. Flame signal strength: Adjust bypass gas flow with adjusting screw ④ (if applicable) to maintain a stable flame signal and reliable ignition.

**NOTE:** If viewing the flame, it should be blue with flashes of yellow. When firing propane or butane, a proper low fire flame may have sustained flashes of yellow.

9. Verify low fire flame (if applicable):
  - a. Shut off gas. Allow process to cool.
  - b. Verify repeatability of ignition and low fire flame signal at cold conditions.
10. Shut down the system.

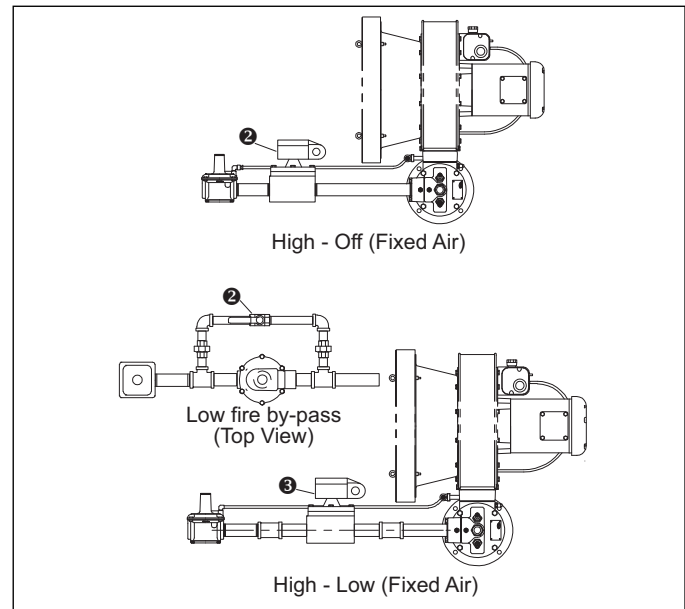


Figure 4.8.

### Step 5: Verify Settings

1. With burner lit, go to high fire.
2. Wait for the process to reach normal operating conditions.
3. Measure high fire fuel differential pressure between tap "D" and tap "B". Compare this to the "Fuel Orifice  $\Delta P$  vs. Input" graph in the datasheet for your burner.

**NOTE:** If modulating air or gas, adjustment of the control motor to set high fire gas to the desired input /efficiency calculated for your process is necessary.

4. Measure high fire air static pressure tap "A". Compare this pressure to the datasheet for your burner.
5. Go to low fire (if applicable) and verify low fire flame signal and flame appearance (if viewing).

**NOTE:** Gas pressure at low fire will be too low to measure and verify the fuel settings.

6. Cycle burner from high to low (if applicable) several times to check repeatability of settings.
7. Readjust burner if the settings do not repeat as expected. If necessary, refer to Chapter 5, Maintenance & Troubleshooting.
8. Record all setup data as an aid for future troubleshooting and setup operations.



- **Do not turn the combustion air blower off immediately.**
  - **Allow time for the process to cool. This will prevent hot gases from back flowing into the burner and blower causing damage to the burner.**
9. Stop the burner.

# Maintenance & Troubleshooting

## 5

This chapter is divided into two sections:

- Maintenance procedures
- Troubleshooting guide

### **Maintenance**

Preventive maintenance is the key to a reliable, safe and efficient system. The core of any preventive maintenance system is a list of periodic tasks. The following are suggestions for a monthly list and a yearly list.

**NOTE:** The monthly list and yearly lists are an average interval. If your environment is dirty, the intervals may be shorter.

### **Monthly Checklist**

1. Inspect flame-sensing devices for good condition and cleanliness.
2. Check for proper inlet air/gas ratios.
3. Test all the alarm systems for proper signals.
4. Check ignition spark plugs and check proper gap.
5. Check valve motors and control valves for free, smooth action and adjustment.
6. Check for proper operation of the ventilating equipment.
7. Test the interlock sequence of all safety equipment; manually make each interlock fail, noting that related equipment closes or stops as specified by the manufacturer.
8. Test flame monitoring control system by manually shutting off gas to burner.
9. Test main fuel hand-valves for operation.
10. Clean or replace the combustion air blower filter.

### **Yearly Checklist**

1. Test (leak test) safety shut-off valves for tightness of closure.
2. Test air pressure switch settings by checking switch movements against pressure settings and comparing with actual impulse pressure.
3. Visually check ignition cable and connectors.
4. Inspect impulse piping for leaks.
5. Clean and inspect all the burners.

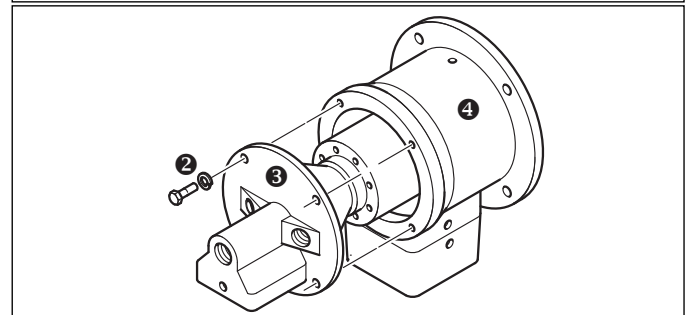
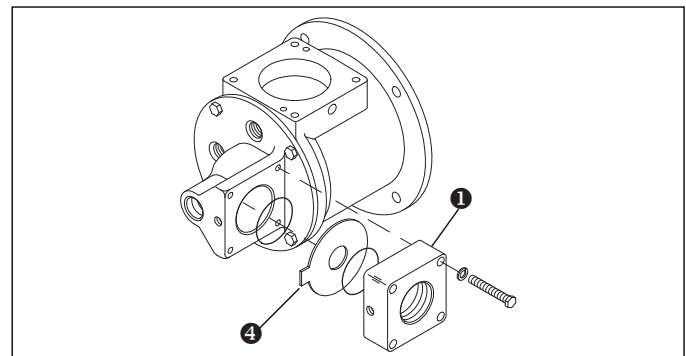
6. Remove and clean the orifice plates ❹.

7. Make sure that the following components are not damaged or distorted:

- burner nozzle
- spark plugs
- flame sensors
- flame tube or combustion block

The nozzle and combustion tube/block can be inspected without removing the burner from the chamber wall or entering the chamber. Perform the following:

- a. Shut the burner off and manually close the main gas shut off cocks.
- b. Allow the chamber temperature to cool down to 250°F (121°C).
- c. Disconnect the gas piping at a union or the gas inlet flange ❶ provided on the burner.
- d. Remove the four bolts ❷.
- e. Remove the rear cover ❸ from the burner housing ❹.
- f. To re-assemble, follow this sequence in the reverse order.



## Troubleshooting Procedures

<b>Problem</b>	<b>Possible Cause</b>	<b>Solution</b>
Start-up sequence runs but burner does not light.	No ignition; there is no power to the ignition transformer.	Restore the power to the ignition transformer.
	No ignition; open circuit between the ignition transformer and the igniter.	Repair or replace the wiring to the igniter.
	No ignition; the igniter needs cleaning.	Clean the igniter.
	No ignition; the igniter is not correctly grounded to the burner.	Clean the threads on the igniter and the burner. <b>NOTE:</b> Do not apply grease to the threads on the igniter.
	No ignition; igniter insulator is broken. Igniter is grounding out.	Inspect the igniter. Replace if broken.
	Not enough gas; the gas pressure going into the ratio regulator is too low.	Check the start-up settings. Measure the gas pressures and adjust where necessary.
	Not enough gas; the impulse line to the ratio regulator is leaking.	Repair any leaks.
	Not enough gas; the pilot adjusting valve or bypass valve is not open far enough.	Adjust bypass or low fire gas.
	Not enough gas; start gas solenoid valve does not open.	Check the solenoid valve coil for proper operation. Replace it if necessary.
	Not enough gas; gas valve does not open.	Check the wiring to the automatic gas shut-off valve. Check the output from the flame safeguard. Open manual gas cock.
	Not enough gas; ratio regulator is incorrectly set.	Adjust the ratio regulator to the proper setting.
	No flame signal; Broken flamerod or Dirty UV scanner lens.	Inspect and clean sensor. Replace if necessary.
	No flame signal; spark plug and flamerod reversed.	Exchange spark plug/flamerod or their wiring.
	Too much gas; wrong or missing burner fuel orifice.	Check ImmersoPak Datasheets, series 360 for fuel orifice and the given fuel.
The low fire flame is weak or unstable.	Not enough gas flowing to the burner.	Adjust the ratio regulator to increase the gas flow.
	Not enough air.	Check for proper blower rotation. Check air filter for blockage. Compensate for chamber by opening the low fire air butterfly valve position.
The burner goes out when it cycles to high fire.	Not enough gas pressure into the ratio regulator.	Check the start-up settings. Measure the gas pressures and adjust them where necessary. Check for valve train pressure loss.
	Loading line to the ratio regulator is leaking.	Repair the leak in the loading line.

<b>Problem</b>	<b>Possible Cause</b>	<b>Solution</b>
The burner is erratic and does not respond to adjustment.	Internal damage to the burner; some parts inside the burner are loose, dirty, or burned out.	Contact your Eclipse representative or Eclipse for further information.
The burner is unstable or produces soot, smoke, or excessive carbon monoxide.	The air/gas ratio is out of adjustment.	Measure all the gas pressures and air pressures. Compare these pressures to the documented initial start-up settings and adjust them where necessary.
The burner cannot achieve full capacity.	Air filter is blocked.	Clean or replace the air filter.
	Gas pressure going into the ratio regulator is too low.	Adjust the gas pressure.
	Tube back pressure is limiting performance.	Review system design.
Cannot initiate a start sequence.	Air pressure switch has not made contact.	Check air pressure switch adjustment. Check air filter. Check blower rotation. Check outlet pressure from blower.
	High gas pressure switch has activated.	Check incoming gas pressure. Adjust gas pressure if necessary. Check pressure switch setting and operation.
	Low gas pressure switch has activated.	Check incoming gas pressure. Adjust gas pressure if necessary. Check pressure switch setting and operation.
	Malfunction of the flame safeguard system (e.g., shorted-out flame sensor or electrical noise in the sensor line).	Have a qualified electrician troubleshoot and correct the problem.
	No power to the control unit.	Have a qualified electrician troubleshoot and correct the problem.
	Main power is off.	Be sure the main power to the system is switched to the "on" position.





# Appendix

## Conversion Factors

### Metric to English

From	To	Multiply By
actual cubic meter/hr (am <sup>3</sup> /h)	actual cubic foot/hr (acfh)	35.31
normal cubic meter/hr (Nm <sup>3</sup> /h)	standard cubic foot /hr (scfh)	38.04
degrees Celsius (°C)	degrees Fahrenheit (°F)	(°C x 9/5) + 32
kilogram (kg)	pound (lb)	2.205
kilowatt (kW)	Btu/h	3415
meter (m)	foot (ft)	3.281
millibar (mbar)	inches water column ("w.c.)	0.402
millibar (mbar)	pounds/sq in (psi)	14.5 x 10 <sup>-3</sup>
millimeter (mm)	inch (in)	3.94 x 10 <sup>-2</sup>
MJ/Nm <sup>3</sup>	Btu/ft <sup>3</sup> (standard)	26.86

### Metric to Metric

From	To	Multiply By
kiloPascals (kPa)	millibar (mbar)	10
meter (m)	millimeter (mm)	1000
millibar (mbar)	kiloPascals (kPa)	0.1
millimeter (mm)	meter (m)	0.001

### English to Metric

From	To	Multiply By
actual cubic foot/hr (acfh)	actual cubic meter/hr (am <sup>3</sup> /h)	2.832 x 10 <sup>-2</sup>
standard cubic foot /hr (scfh)	normal cubic meter/hr (Nm <sup>3</sup> /h)	2.629 x 10 <sup>-2</sup>
degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32) x 5/9
pound (lb)	kilogram (kg)	0.454
Btu/h	kilowatt (kW)	0.293 x 10 <sup>-3</sup>
foot (ft)	meter (m)	0.3048
inches water column ("w.c.)	millibar (mbar)	2.489
pounds/sq in (psi)	millibar (mbar)	68.95
inch (in)	millimeter (mm)	25.4
Btu/ft <sup>3</sup> (standard)	MJ/Nm <sup>3</sup>	37.2 x 10 <sup>-3</sup>

