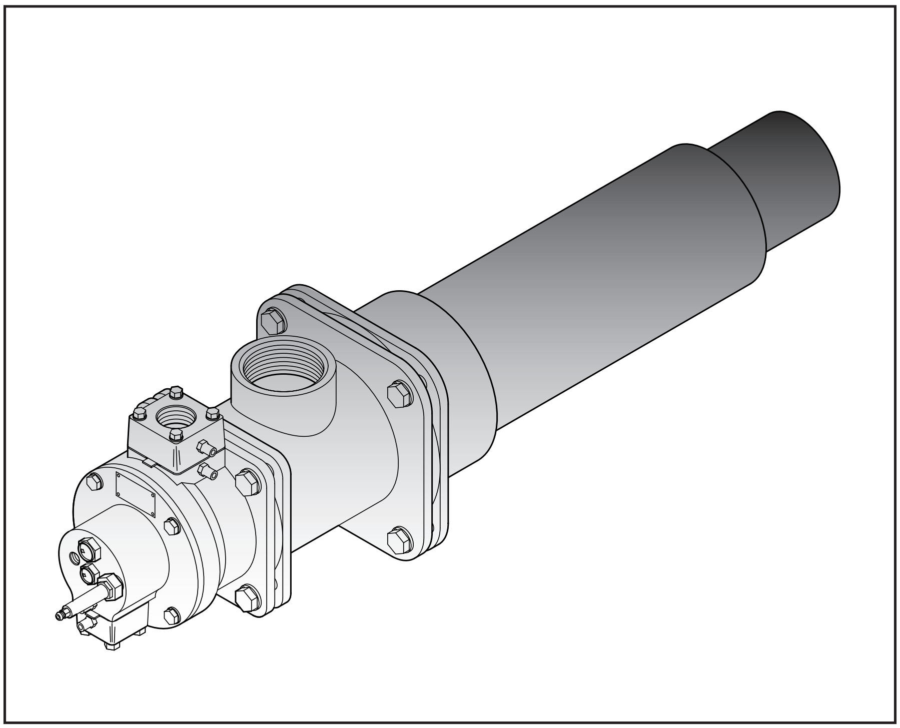
Design Guide
325, 1/25/05

Eclipse Combustion

Single Ended Recuperative Burners

Models SER450, SER600 & SER750

Version 3



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About this manual

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:
- design/selection
- use
- maintenance.

The audience is expected to have had experience with this kind of equipment.

PURPOSE

The purpose of this manual is to ensure that the design of a safe, effective, and trouble-free combustion system is carried out.

SER DOCUMENTS

Design Guide No. 325
- This document

SER Data Sheets, Series 325
- Available for individual SER models
- Required to complete design, selection & installation

Installation Guide No. 325
- Used with Data Sheet to complete installation

SER Price List No. 325 & 325-1
- Used to order burners

RELATED DOCUMENTS

- EFE 825 (Combustion Engineering Guide)
- Eclipse Bulletins and Info Guides: 684, 710, 732, 742, 756, 760, 930,

Document Conventions

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.

Danger:

Indicates hazards or unsafe practices which WILL result in severe personal injury or even death.
Only qualified and well trained personnel are allowed to carry out these instructions or procedures.
Act with great care and follow the instructions.

Warning:

Indicates hazards or unsafe pratices which could result in severe personal injury or damage.

Act with great care and follow the instructions.

Caution:
Indicates hazards or unsafe practices which could result in damage to the machine or minor personal injury, Act carefully.

Note:
Indicates an important part of the text. Read thoroughly.

How to Get Help

If you need help, contact your local Eclipse Combustion representative.

Table of Contents

Introduction

1

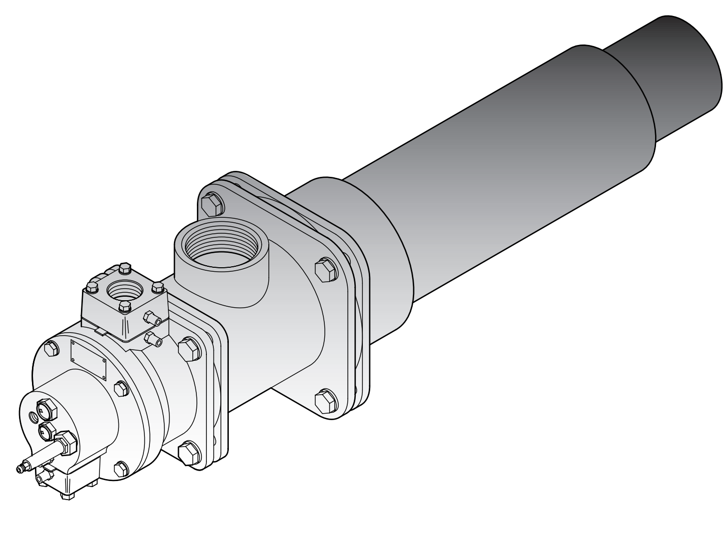
Product Description

Eclipse Model SER Version 3 Single Ended Recuperative burners incorporate the components of a tube firing burner system in a compact package. The SER burner is a nozzle mixing burner and recuperator coaxially mounted inside a single-ended radiant tube. Combustion air entering the SER burner is preheated in the recuperative section by exhaust gases providing higher efficiencies than stand alone burners. SER V3 burners are available in three diameters (4-1/2", 6", 7-1/2"). Radiant tube length is tailored to the application. SER burners have the added features of internal flue gas recirculation resulting in lower NOx emissions and ceramic inner tube sections allowing higher flux rates and promoting longer tube life.

Features:

- Direct spark ignition
- Reliable burner operation
- Uniform tube temperature
- Tube life comparable to conventional radiant tubes
- Simple burner adjustment
- Multi-fuel capability

The Single Ended Recuperative Burner



Safety

2

Introduction

This section is provided as a guide for the safe operation of the SER burner system. All involved personnel should read this section carefully before operating this system.

Safety

Danger:

The SER 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 might have HOT surfaces. Always wear protective clothing when approaching the burner.

Note:
This manual provides information in the use of these burners for their specific design purpose. Do not deviate from any instructions or application limits described herein without written advice from Eclipse Combustion.

Read this entire manual and all related documents before attempting to start this system. If you do not understand any part of the information contained in this manual, contact your local Eclipse representative or Eclipse Combustion before continuing.

Capabilities

Only qualified personnel, with good mechanical aptitude and experience on 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 Combustion only. All Eclipse Combustion approved, customer supplied valves or switches should carry UL, FM, CSA, CGA, and/or CE approval, where applicable.

System Design

3

Design

Design structure

The design process is divided into the following steps:

1. **Burner option selection:**
2. **Control methodology:**
3. **Ignition system:**
4. **Flame monitoring control system:**
5. **Combustion Air system**
6. **Main gas shut-off valve train:**

Step 1: Burner option selection

Step 1 describes how to select burner options to suit an application. Use the SER Price List & Data Sheets No. 325-1, 325-2 and 325-3 when following this selection process.

Caution:

Consult EFE-825, Eclipse Combustion Engineering Guide, or contact Eclipse Combustion if you have special conditions or questions.

Burner Model / Size Selection

Consider the following when selecting the burner size:

- **Heat Input.** Calculate the required heat input to achieve the required heat balance.
- **Power Supply Frequency.** Burner capacity will vary with power supply frequency (50Hz or 60Hz power).
- **Altitude.** The maximum burner capacity is reduced by approximately 3% each 1000 feet (300 meters) above sea level.
- **Combustion Air Supply.** Combustion air should be fresh (20.9% O_2) and clean (without particles or corrosives).
- **Fuel Type.** Variation in calorific value and density will affect burner performance. Nominal burner performance is based on fuel properties in Table 1 on page 10.

Step 1: Burner option selection (continued)

Fuel Type

Table 1 Fuel Type

Fuel	Symbol	Gross Heating Value	Specific Gravity
Natural gas	CH_4 90%+	1004 BTU/ft^3 (40.1 MJ/m^3)	0.60
Propane	C_3H_8	2564 BTU/ft^3 (101.2 MJ/m^3)	1.55
Butane	C_4H_{10}	3333 BTU/ft^3 (133.7 MJ/m^3)	2.09

If using and alternative fuel supply, contact Eclipse Combustion with an accurate breakdown of the fuel components.

Burner Model & Input Level

Burner input level is determined by the heat required. See sizing example on page 11. The maximum firing rate is determined and orifices are selected based on model, fuel type and input level.

Burner Length

Two options are available, 350mm (13.7") or 500mm (19.7") for the version 3.00. Typically chosen with mounting flange to align the burner nozzle with the chamber wall. The longer burner has more recuperative length than the shorter and provides higher preheated air temperatures.

Inner Tube

The 6" and 7.5" burners have metallic inner tube options. Version 3.00 burners can also be supplied with ceramic inner tubes for higher flux applications. (Refer to Figure 1 on page 11.)

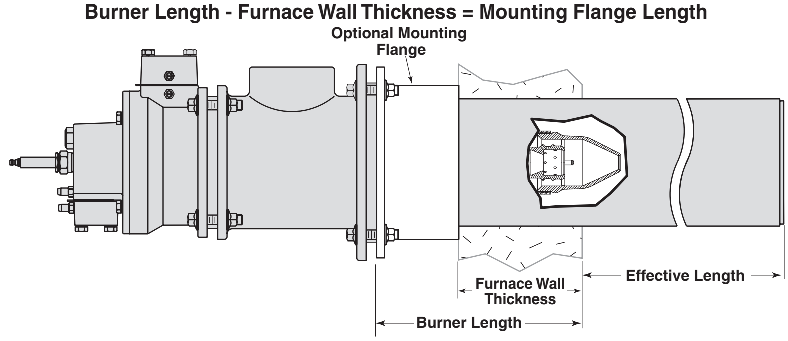
Outer Tube

4.5" and 6" burners have ceramic outer tube options available, contact factory. All sizes have a metallic outer tube option available. The chamber dimensions constrain the possible burner outer tube length. See individual 325 Data Sheet for available tube lengths.

Mounting Flange

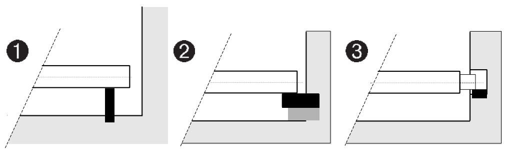
Available in 50-250mm (2" to 10") lengths in 1" (25mm) increments. Choose flange length with burner length to position nozzle at furnace wall.

Burner Length - Furnace Wall Thickness = Mounting Flange Length



Pipe Connections

Available in BSP and NPT thread standards.



Outer Tube Mounting Support

Outer tubes having a length greater than 36” (915mm) require external support. There are basically three means for providing support:

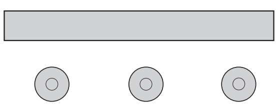
❶ Provide a simple support for the tube from the furnace hearth.

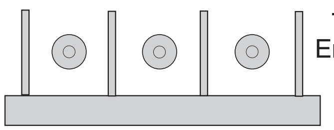
❷ Cantilever a simple support from the opposite furnace wall.

❸ Provide an opening in the opposite furnace wall to support an outer tube equipped with a mounting support.

Caution:
Call your Eclipse sales representative to review support method.

Note:
For vertical applications, contact Eclipse Sales Representative.



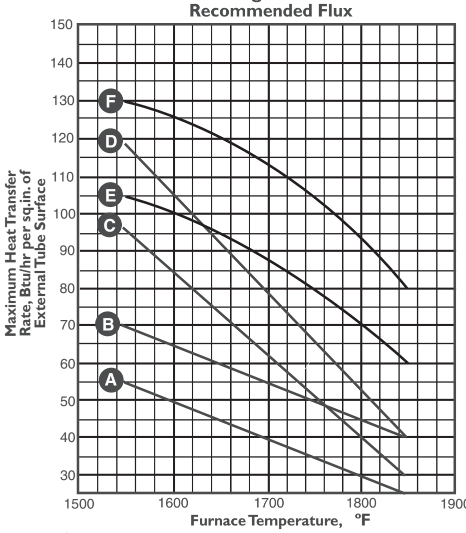


SER Burner Sizing Example

A furnace 70 inches (178 cm) wide at an operating temperature of 1650° F (900° C) will be equipped with 32 SER Burners and requires a total heat release of 2,400,000 Btu/hr. (700kW). 16 upper tubes will be free to radiate and the 16 lower tubes will be enclosed. The total heat release is determined by doing a heat balance on the process.

The effective length of the SER is determined by the physical dimensions of the furnace and in this example is 70 inches (178 cm). Using the desired furnace temperature and the configuration of the tubes, the maximum heat transfer can be determined. Next, the tube diameter is chosen and the maximum input determined. The maximum input is then compared to the capacity of the burner. Finally, the maximum heat release is compared to heat required. In this example we will choose a 6” (15.24cm) OD tube.

Figure 1
Recommended Flux



A Tube enclosed on three sides *Metalic inner & outer tube*
B Tube free to radiate *Metalic inner & outer tube*
C Tube enclosed on three sides *Ceramic inner metalic outer tube*
D Tube free to radiate *Ceramic inner metalic outer tube*
E Tube Enclosed *Ceramic inner & outer tube*
F Tube free to radiate *Ceramic inner & outer tube*

$$\textbf{Maximum Input} = \frac{\textbf{Maximum Heat Transfer x Surface Area}}{\textbf{Efficiency}}$$

The ***maximum heat transfer*** can be determined by using Figure 1 and in this example is 60 Btu/hr/in^2 *(2.7 watts/cm^2)* for the upper tubes and 45 Btu/hr/in^2 *(2 watts/cm^2)* for the lower tubes with metallic inner tubes. With ceramic inner tubes, it is 92.5 Btu/hr/in^2 *(4.1 watts/cm^2)* for the upper tubes and 72.5 Btu/hr/in^2 *(3.2 watts/cm^2)* for the lower tubes. With ceramic inner and outer tubes, it is 120 Btu/hr/in^2 *(5.3 watts/cm^2)* for the upper tubes and 95 Btu/hr/in^2 *(4.2 watts/cm^2)* for the lower tubes. The maximum heat transfer is the flux at which the burner can be operated without exceeding the the recommended tube temperature. The ***surface area*** = ***OD*** x π x ***effective length*** and in this example, is equal to 6 x 3.14 x 70 ~ 1320in^2 *(15.24 x 3.14 x 178 ~ 8518cm^2)* ***Efficiency*** can be estimated as .70 and is dependent on furnace temperature, tube length, burner length, excess air etc. If calculation shows the maximum input is within 10% of the capacity rating of the burner, a more precise determination of efficiency may be required. (Example continues on page 12.)

Step 1: Burner option selection (continued)

Therefore, with metallic inner tubes, the ***Maximum Input*** in this example is:

Upper tubes = $\frac{60 \times 1320}{.7}$ = 113,142 Btu/hr. $\left(\frac{2.7 \times 8518}{.7} = 32{,}855 \text{ watts/cm}^2\right)$

Lower tubes = $\frac{45 \times 1320}{.7}$ = 84,857 Btu/hr. $\left(\frac{2.0 \times 8518}{.7} = 24{,}337 \text{ watts/cm}^2\right)$

With ceramic inner tubes, the ***Maximum Input*** is:

Upper tubes = $\frac{92.5 \times 1320}{.7}$ = 174,428 Btu/hr. $\left(\frac{4.1 \times 8518}{.7} = 49{,}873 \text{ watts/cm}^2\right)$

Lower tubes = $\frac{72.5 \times 1320}{.7}$ = 84,857 Btu/hr. $\left(\frac{2.0 \times 8518}{.7} = 24{,}337 \text{ watts/cm}^2\right)$

With ceramic inner and outer tubes, the ***Maximum Input*** is:

Upper tubes = $\frac{120 \times 1320}{.7}$ = 226,285 Btu/hr. $\left(\frac{5.3 \times 8518}{.7} = 64{,}493 \text{ watts/cm}^2\right)$

Lower tubes = $\frac{95.0 \times 1320}{.7}$ = 179,142 Btu/hr. $\left(\frac{4.2 \times 8518}{.7} = 51{,}108 \text{ watts/cm}^2\right)$

The maximum inputs are within the range of the burner. See Data 325-3 or 325-3S.

Maximum heat release = Maximum Input x Efficiency

This is the heat available for the process.

Metallic Inner Tubes
- Upper tubes = 113,142 x .7 = 79,200 *(32,885 x .7 = 23,020)*
- Lower tubes = 84,857 x .7 = 59,400 *(24,337 x .7 = 17,036)*

Ceramic Inner Tubes
- Upper tubes = 174,428 x .7 = 122,100 *(49,873 x .7 = 34,911)*
- Lower tubes = 136,714 x .7 = 95,700 *(38,939 x .7 = 27,257)*

Ceramic Inner & Outer Tubes
- Upper tubes = 226,285 x .7 = 158,399 *(64,493 x .7 = 45,145)*
- Lower tubes = 179,142 x .7 = 125,399 *(51,108 x .7 = 35,775)*

In this example, with 16 upper tubes and 16 lower tubes, using metallic inner tubes, the maximum heat release is 2,217,600 Btu/hr (641 kW) which is less than the 2,400,000 Btu/hr (700 kW) required. Using ceramic inner tubes, the maximum heat release is 3,484,800 Btu/hr (1020 kW) which meets the above requirements. Ceramic inner and outer tubes are also an option with maximum heat release of 4,540,768 Btu/hr (1330 kW).

If ceramic inner tubes are not an acceptable option and additional tubes cannot be added, a larger diameter tube is required.

Repeating the calculations using a 7-1/2 inch (19.05 cm) tube with metallic inner tubes:

Surface area = 1650in^2 *(10,646cm^2)*

Maximum input for tubes;

Upper tubes = 141,428 Btu/hr. *(41,063 watts)*

Lower tubes = 106,071 Btu/hr. *(30,417 watts)*

The maximum inputs are within the range of the burner. See Data 325-2

Maximum heat release*;*

Upper tubes = 99,000 Btu/hr x 16 = 1,584,000 Btu/hr

(28,744 x 16 = 459,904 [460kW])

Lower tubes = 74,250 Btu/hr x 16 = 1,188,000 Btu/hr

(21,292 x16 = 340,672 [341kW])

With 16 upper and 16 lower 7-1/2" (*19.05cm*) OD tubes the maximum heat release is 2,772,000 *(801kW)*which meets the specified 2,400,000 Btu/hr. *(700kW)*.

Step 2: Control methodology

The control methodology is the basis for the rest of the design process. Once the system is designed, the components can be selected. The control methodology chosen depends on the type of process to be controlled.

Note:

The stated operational characteristics only apply if the described control circuits are followed. Use of different control methods will result in unknown operational performance characteristics. Use the control circuits contained within this section or contact Eclipse Combustion for written, approved alternatives.

Control methods

There are three main methods to control the input of an SER burner system. These methods may be applied to single burner as well as multiple burner systems.

The methods and variants are:

1. High/low control (Preferred):
   - High/low air & gas biased control with excess air at low fire (pulse firing) on page 14.
2. On/off control:
   - High/off air & gas control (pulse firing) on page 14.
3. Modulating control (Consult your Eclipse Representative):
   - Modulating gas & air, biased ratio control with excess air at low fire on page 15.

In the pages that follow you will find schematics of these control methods. The symbols in the schematics are explained in the "Key to System Schematics" (see Appendix).

Note:

The following control methods do not illustrate flame safety. Flame safety is discussed in Step 4 on page 17 of this guide. Any decisions regarding the use and/or type of flame safety should be made in accordance with local safety and/or insurance requirements.

Step 2: Control methodology (Continued)

High/Low air & gas control (pulse firing) (Figure 2)

A burner system with high/low control gives a high or low fire input to the process. No input between high and low fire is possible.

1. Air

a. Low fire:

A control input closes the solenoid valve ❶. As a result, the CRS valve ❷ quickly moves to low fire.

b. High fire:

A control input opens the solenoid valve ❶. As a result, the CRS valve ❷ quickly moves to high fire.

2. Gas

a. Low fire:

Low fire is controlled by the proportionator valve ❸.

b. High fire:

High fire gas is limited by the manual butterfly valve ❹.

High/Low air & gas control (pulse firing)

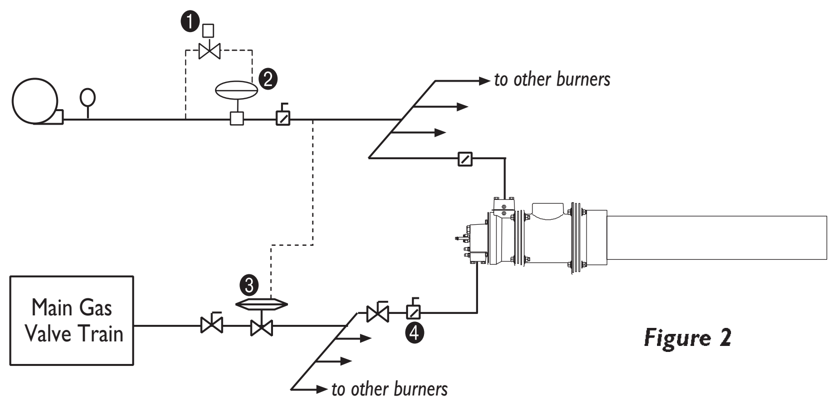


Figure 2

If fast high/low control is not necessary, the CRS valve ❷ and the solenoid valve ❶ can be replaced with a two-position automatic butterfly valve.

On/Off air & gas control (pulse firing) (Figure 3)

A burner system with on/off control gives a high fire input to the process. No input other than high fire is possible.

1. Air

A control input opens and closes the solenoid valve ❶ to supply or "close off" the air supply. A small amount of air can be allowed through to cool the burner nozzle.

2. Gas

A control input opens and closes the solenoid valve ❷ to supply or "close off" the gas supply. High fire gas is set by the manual butterfly valve ❸.

On/Off Control

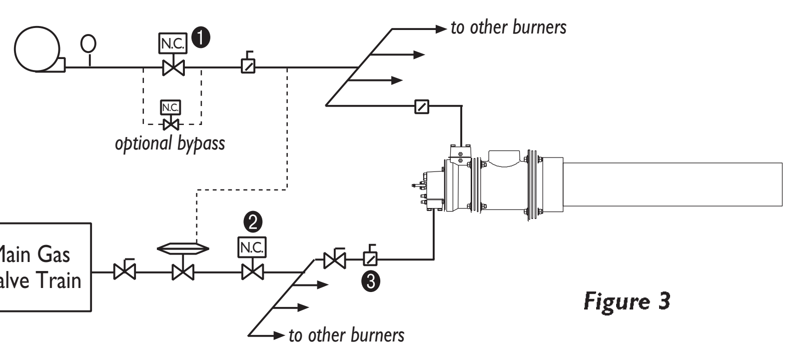


Figure 3

Step 2: Control methodology (Continued)

Modulating gas & air (Figure 4)
Biased ratio control with excess air @ low fire

A burner system with modulating control gives an input that is in proportion with the demands of the process. ANY input between high and low fire is possible.

1. Air

The control valve ❶ is in the air line. It can modulate air flow to any position between low and high fire air.

2. Gas

The ratio regulator ❷ allows the on-ratio amount of gas to go to the burner. Low fire gas is limited by the ratio regulator ❷. High fire gas is set by the manual butterfly valve ❸.

Note:

The ratio regulator should be biased to give excess air at low fire

Note:

Adjustable limiting orif ices (ALO) require more pressure drop than butterfly valves. This should be considered when using an ALO as the high fire gas limiting valve ❸ in a proportional system .

Modulating Control

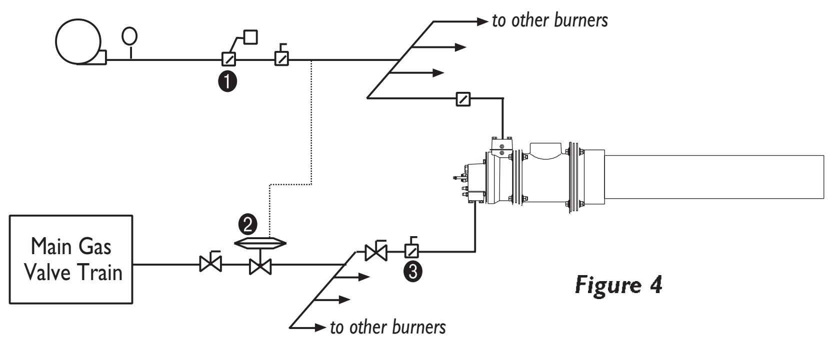


Figure 4

Note:

Modulating control is not preferred. Inputs may be too low. Contact an Eclipse representative to review your application.

Step 3: Ignition system

For the ignition system use:

- 6,000 VAC transformer
- full-wave spark transformer
- one transformer per burner

<u>DO NOT USE:</u>

- 10,000 VAC transformer
- twin outlet transformer
- distributor type transformer
- half-wave transformer

It is recommended that high fire start be used for cold starts (furnace temperatures below 400° F (204° C). SER burners are capable of direct spark ignition anywhere within the ignition envelope shown on page 2 of the appropriate Data Sheet. See Installation Guide for detailed start information.

<u>Note:</u>

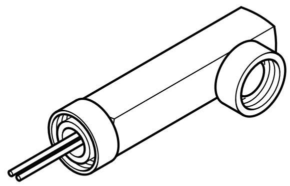
You must follow the control circuits described in the previous section, "Control Methodology," to obtain reliable ignition.

Local safety and insurance require limits on the maximum trial for ignition time. These time limits vary from country to country.

The time it takes for a burner to ignite depends on:

- the distance between the gas shut-off valve and the burner
- the air/gas ratio
- the gas flow at start conditions

Step 4: Flame monitoring control system



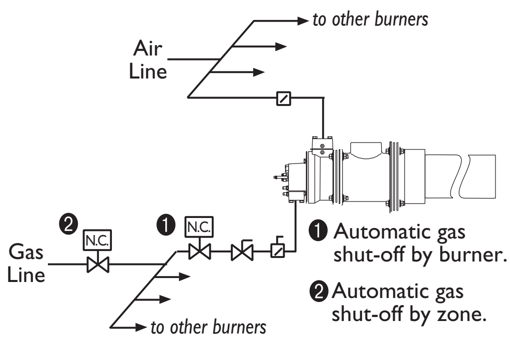


Figure 5

A flame monitoring system consists of two main parts:
- a flame sensor
- flame monitoring control

Flame sensor

Flame sensing is by flame rod (all fuels) or U.V. scanner (natural gas).
Eclipse recommends the following U.V. scanners for use with the Eclipse flame monitoring controls listed below:
- straight UV scanner; Bulletin / Info Guide 854
- 90° UV scanner; Bulletin / Info Guide 852
- self-check UV scanner; Bulletin / Info Guide 856
- solid state UV/IR scanner; Bulletin / Info Guide 855.

Flame monitoring control (Figure 5)

The flame monitoring control is the equipment that processes the signal from the U.V. scanner or flame rod.
For flame monitoring control selection there are several options including:

1. Automatic gas shut-off by burner
   If the flame monitoring system detects a failure, the gas shut-off valves close the gas supply to the burner that caused the failure.

2. Automatic gas shut-off by zone
   If the flame monitoring system detects a failure, the gas shut-off valves close the gas supply to all the burners in the zone that caused the failure.

There are three flame monitoring controls that are recommended:
- Veri-flame (Installation Manual 818)
- Bi-flame series (Installation Manual 826)
- Multi-flame series 6000 (Installation Manual 820)

Eclipse recommends the use of flame monitoring control systems which maintain spark for the entire trial for ignition period with U.V. scanners.

Step 5: Combustion Air System: Blower and air pressure switch

Effects of atmospheric conditions

The blower data is based on the International Standard Atmosphere (ISA) at Mean Sea Level (MSL), which means that it is valid for:

- sea level
- 29.92" Hg (1,013 mbar)
- 70°F (21°C)

The make-up of the air is different. above sea level or in a hot area. The density of the air decreases, and as a result, the outlet pressure and the flow of the blower decrease. An accurate description of these effects is in the Eclipse Combustion Engineering Guide (EFE 825). The Guide contains tables to calculate the effect of pressure, altitude and temperature on air.

Blower

The rating of the blower must match the system requirements. You can find all the blower data in:

- Bulletin / Info Guide 610

Follow these steps:

1. Calculate the outlet pressure

When calculating the outlet pressure of the blower, the total of these pressures must be calculated.

- the static air pressure required at the burner
- the total pressure drop in the piping
- the total of the pressure drops across the valves
- recommend a minimum safety margin of 10%

2. Calculate the required flow

The blower output is the air flow delivered under standard atmospheric conditions. It must be enough to feed all the burners in the system at high fire.

Combustion air blowers are normally rated in terms of standard cubic feet per hour (scfh) of air.

An example calculation follows the information tables below:

Table 2 Required calculation information

Description	Unit of measure	Formula symbol
Total system heat input	Btu/hr	Q
Number of burners	-	-
Type of fuel	-	-
Gross heating value of fuel	Btu/ft^3	q
Desired excess air percentage (Typical excess air percentage @ high fire is 15%)	percent	%
Air/Gas ratio (Fuel specific, see table below)	-	α
Air flow	scfh	V_{air}
Gas flow	scfh	V_{gas}

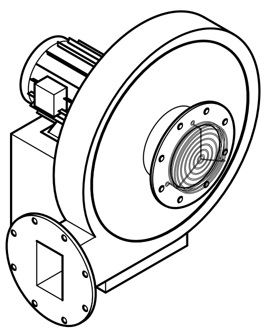
Step 5: Combustion Air System: Blower and air pressure switch (continued)

Table 3 Fuel gas heating values

Fuel gas	Stoichiometric* air/gas ratio α (ft^3_{air}/ft^3_{gas})	Gross heating value q (Btu/ft^3)
Natural gas (Birmingham, AL)	9.41	1,004
Propane	23.82	2,564
Butane	30.47	3,333

* Stoichiometric: No excess air. The precise amount of air and gas are present for complete combustion.

Example Blower Calculation



Application example:

A furnace has been designed and requires a heat input of 2,400,000 btu/hr. The burners will operate on natural gas using 15% excess air at high fire.

Calculation example:

a. Calculate required gas flow:

$$V_{gas} = \frac{Q}{q} = \frac{2{,}4000{,}000 \text{ btu/hr}}{1{,}002 \text{ Btu/ft}^3} = 2{,}395 \text{ ft}^3\text{/hr}$$

- Gas flow of 2,395 ft^3/hr is required

b. Calculate required stoichiometric air flow:

$$V_{air\text{-}Stoichiometric} = \alpha \text{ (air/gas ratio)} \times V_{gas} = 9.41 \times 2{,}395 \text{ ft}^3\text{/hr}$$
$$= 22{,}537 \text{ ft}^3\text{/hr}$$

- Stoichiometric air flow of 22,537 scfh required

c. Calculate final blower air flow requirement based on the desired amount of excess air:

$$V_{air} = (1 + \text{excess air \%}) \times V_{air\text{-}Stoichiometric}$$
$$= (1 + 0.15) \times 22{,}537 \text{ ft}^3\text{/hr} = 25{,}918 \text{ ft}^3\text{/hr}$$

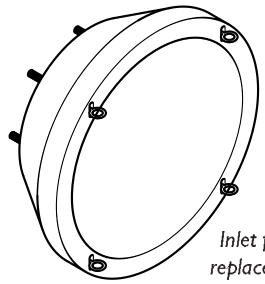
- For this example, total combustion air flow requirement is 25,918 scfh at 15% excess air. Depending on the number of zones (i.e. 4 zones of 8 burners each) 4 blowers would be required each capable of providing 1/4 of the total air requirement (25,918 / 4 = 6,480 scfh).

Note:

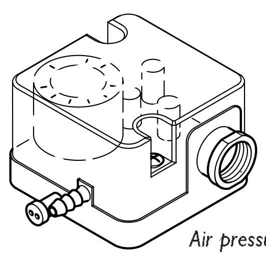
It is common practice to add an additional 10% to the final blower air flow requirement as a safety margin.

3. Find the blower model number and motor horsepower (hp). With the outlet pressure and the specific flow, the blower catalog number and motor hp can be found in Bulletin 610.

Step 5: Combustion Air System: Blower and air pressure switch (continued)



Inlet filter with replaceable filter element



Air pressure switch

Step 6: Main gas shut-off valve train

Main gas shut-off valve train

4. Eclipse Combustion recommends that you select a Totally Enclosed Fan Cooled (TEFC) motor.

5. Select the other parameters:

- inlet filter or inlet grille
- inlet size (frame size)
- voltage, number of phases, frequency
- blower outlet location, and rotation direction Clockwise (CW) or Counter Clockwise (CCW).

Note:

The use of an inlet air filter is strongly recommended. The system will perform longer and the settings will be more stable.

Note:

When selecting a 60 Hz Blower for use on 50 Hz, a pressure and capacity calculation is required. See Eclipse Combustion Engineering Guide (EFE 825)

The total selection information you should now have:

- blower model number
- motor hp
- motor enclosure (TEFC)
- voltage, number of phases, frequency
- rotation direction (CW or CCW).

The air pressure switch gives a signal to the monitoring system when there is not enough air pressure from the blower.
You can find more information on pressure switches in:

- Blower Bulletin 610

Warning:

Eclipse Combustion supports NFPA regulations, which require the use of an air pressure switch in conjunction with other safety components, as a minimum standard for main gas safety shut-off systems.

Consult Eclipse

Eclipse can help you design and obtain a main gas shut-off valve train that complies with the current safety standards.

The shut-off valve train must comply with all the local safety standards set by the authorities that have jurisdiction.

For details, please contact your local Eclipse Combustion representative or Eclipse Combustion.

Note

Eclipse Combustion supports NFPA regulations (two shut-off valves) as a minimum standard for main gas safety shut-off systems.

Appendix

CONVERSION FACTORS

Metric to English.

From	To	Multiply By
cubic meter (m^3)	cubic foot (ft^3)	35.31
cubic meter/hour (m^3/h)	cubic foot/hour (cfh)	35.31
degrees Celsius (ºC)	degrees Fahrenheit (ºF)	(ºC x 1.8) + 32
kilogram (kg)	pound (lb)	2.205
kilowatt (kW)	BTU/hr	3414
meter (m)	foot (ft)	3.28
millibar (mbar)	inches water column (“w.c.)	0.401
millibar (mbar)	pounds/sq in (psi)	14.5×10^{-3}
millimeter (mm)	inch (in)	3.94×10^{-2}

Metric to Metric.

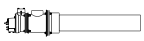
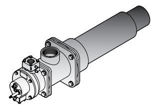
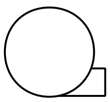
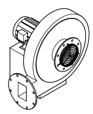
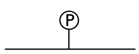
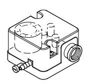
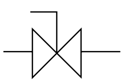
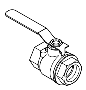
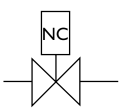
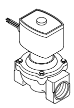
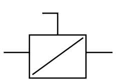
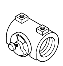
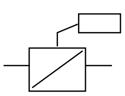
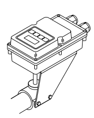
kiloPascals (kPa)	millibar (mbar)	10
meter (m)	millimeter (mm)	1000
millibar (mbar)	kiloPascals (kPa)	0.1
millimeter (mm)	meter (m)	0.001

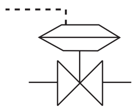
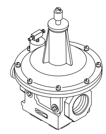
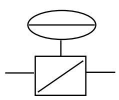
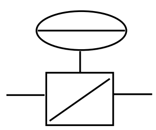
English to Metric.

From	To	Multiply By
BTU/hr	kilowatt (kW)	0.293×10^{-3}
cubic foot (ft^3)	cubic meter (m^3)	2.832×10^{-2}
degrees Fahrenheit (ºF)	degrees Celsius (ºC)	(ºF – 32) ÷ 1.8
foot (ft)	meter (m)	0.3048
inches (in)	millimeter (mm)	25.4
inches water column (“wc)	millibar (mbar)	2.49
pound (lb)	kilogram (kg)	0.454
pounds/sq in (psi)	millibar (mbar)	68.95

Key to system schematics

These are the symbols used in the schematics.

Symbol	Appearance	Name	Remarks	Bulletin/ Info guide
		SER Burner		
		Main gas shutoff valve train	Eclipse Combustion, Inc. strongly endorses NFPA as a minimum	756
		Combustion air blower	The combustion air blower provides the combustion air pressure to the burner (s).	610
		Air pressure switch	The air pressure switch gives a signal to the safety system when there is not enough air pressure from the blower.	610 I-354
		Gas cock	Gas cocks are used to manually shut off the gas supply on both sides of the main gas shut-off valve train.	710
		Solenoid valve (normally closed)	Solenoid valves are used to automatically shut off the gas supply on a bypass gas system or on small capacity burner systems.	760
		Manual butterfly valve	Manual butterfly valves are used to balance the air or gas flow at each burner, and/or to control the zone flow.	720
		Automatic butterfly valve	Automatic butterfly valves are typically used to set the output of the system.	720

Symbol	Appearance	Name	Remarks	Bulletin/ Info guide
		Ratio regulator	A ratio regulator is used to control the air/gas ratio. The ratio regulator is a sealed unit that adjusts the gas flow in ratio with the air flow. To do this, it measures the air pressure with a pressure sensing line, the impulse line. This impulse line is connected between the top of the ratio regulator and the air supply line. The cap must stay on the ratio regulator after adjustment.	742
		CRS valve	A CRS valve is used in a high/ low time-proportional control system to quickly open and close the air supply.	744
		Pressure taps	The schematics show the advised positions of the pressure taps.	
— — — —		Impulse line	The impulse line connects the ratios regulator to the air supply line.	

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