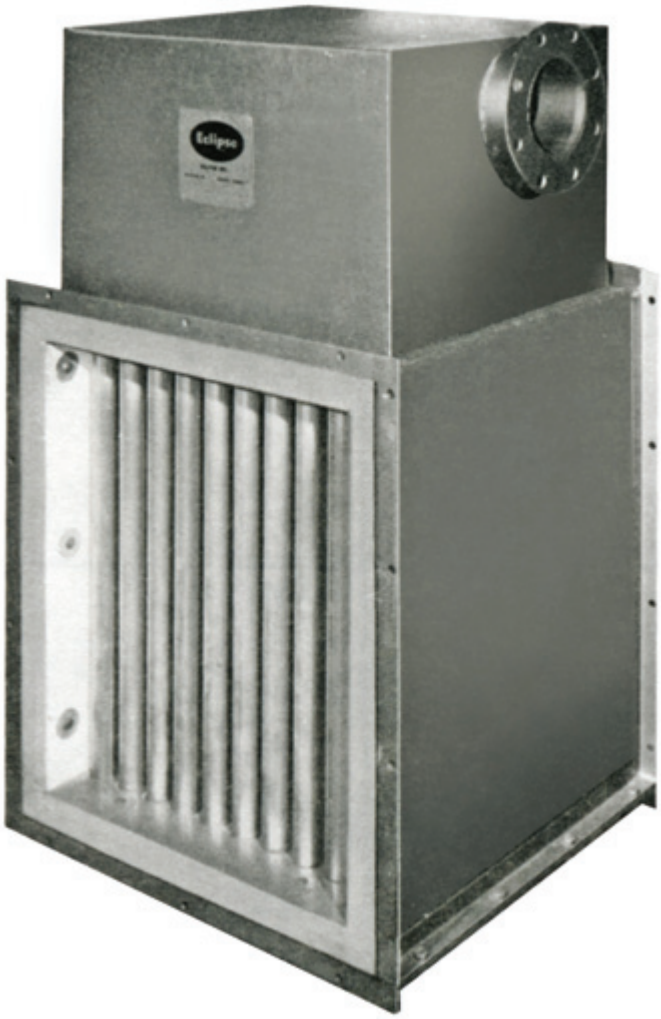
530 Design Guide
5/2/2011

Eclipse Cross-Flow Recuperators

Models CFR021 - CFR121

Version 1



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Any operation expressly prohibited in this manual, any adjustment, or assembly procedures not recommended or authorized in these instructions shall void the warranty.

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.

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.

ECLIPSE® Innovative Thermal Solutions www.eclipsenet.com
Product Name
Item #
S/N
DD MMM YYYY

⚠	This is the safety alert symbol. It is used to alert you to potential personal injurt hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.
⚠ **DANGER**	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ **WARNING**	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ **CAUTION**	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.

Table of Contents

Introduction 1

Product Description

Eclipse Cross-Flow recuperators are compact tubular air-to-air heat exchangers designed to recover the waste heat in industrial exhaust gases. The recovered heat is used to preheat the combustion air for the system's burners, thereby increasing the thermal efficiency. To ensure that all the wasted heat is drawn across the recuperator tubes the recuperator is typically mated with an Eclipse eductor.

The single-ended design of the Cross-Flow recuperator allows for free expansion of the recuperator tubes; no expansion joints are required.

The Cross-Flow recuperator is internally insulated; there is no need for additional external insulation.

Figure 1.1. Cross-Flow Recuperator

Audience

This manual has been written for personnel already familiar with all aspects of industrial heating equipment design.

These aspects are:

- Design/Selection
- Use
- Maintenance

The audience is expected to be qualified and have experience with this type of equipment and its working environment.

Purpose

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

Cross-Flow Recuperator Documents

Design Guide No. 530

- This document

Datasheet Series No. 530-1 through 530-4

- Available for individual Cross-Flow models
- Required to complete design calculations in this guide

Related Documents

- EFE 825 (Combustion Engineering Guide)
- Eclipse Bulletins and Information Guides: 610, 710, 720, 730, 742, 744, 760, 930

Safety

2

Introduction

Important notices will be found in this section. To avoid personal injury, damage to property or the facility, the following warnings must be observed. Read this entire manual. If any part of the information in this manual is not understood, contact Eclipse before continuing.

Safety Warnings

DANGER

- **The surface of the recuperator and preheated air pipe work are likely to have HOT surfaces. Always wear protective clothing when approaching the recuperator.**

NOTICE

- **This manual provides information in the use of these recuperators for their specific design purpose. Do not deviate from any instructions or application limits in this manual without written advice from Eclipse Inc.**
- **Read this entire manual before attempting to start the system. If any part of the information in this manual is not understood, then contact your local Eclipse representative or Eclipse Inc. before continuing.**

Capabilities

Only qualified personnel, with good 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. Any customer supplied valves or switches should carry UL, FM, CSA, CGA and/or CE approvals where applicable.

System Design 3

Furnace Temperature Limits

Up to 1800°F (982°C) - no special safeguards are required to protect the recuperator. See "Flue Gas Restrictions" for aluminum melting or holding applications.

1800°F (982°C) - 2100°F (1148°C) - to ensure that the safe operating temperature of the recuperator tubes is not exceeded, air flow must not fall below the following limits:

21 Tube Model	500 scfh (14 Nm^3/hr)
48 Tube Model	1500 scfh (42 Nm^3/hr)
80 Tube Model	2500 scfh (70 Nm^3/hr)
121 Tube Model	3550 scfh (100 Nm^3/hr)

The recuperator must be positioned so that it will not be exposed to direct radiation from the furnace. This is to protect the recuperator during shutdown or power failure.

CAUTION

- **When shutting a process down, air must be supplied to the exchanger until the exhaust inlet temperature falls below 1800°F (982°C).**

2100°F (1148°C) - 2400°F (1315°C) - Dilution air must be introduced to the air stream to maintain exhaust temperature below 2100°F (1148°C). The amount of dilution air can be determined from the Dilution Air section, on page 7. When using dilution air do not operate with excess fuel, either gas or oil. The resulting fire would destroy the recuperator.

A high temperature protection limit switch must be fitted to ensure flue temperatures do not exceed 2100°F (1148°C).

The recuperator must be positioned so that it will not be exposed to direct radiation from the furnace. This is to protect the recuperator during shutdown or power failure.

The low flow air requirements listed above must be observed.

CAUTION

- **When shutting a process down, air must be supplied to the exchanger until the exhaust inlet temperature falls below 1800°F (982°C).**

Flue Gas Restrictions

The recuperator must not be used with any chloride, sulfide, potassium, sodium, or lithium salts in the flue gas.

Special precautions for aluminum melting or holding: If the recuperator is to be used on aluminum melting furnaces where flux is used, special precautions must be taken to protect the recuperator during the fluxing cycle. When flux is being used, the exit of the eductor should be closed off and a by-pass duct opened until the fluxing is complete and no fluxing agents are present in the exhaust. Closing the damper on the eductor will force the eductor air back through the recuperator ensuring that no contaminated exhaust gases enter the recuperator. See figure 3.1.

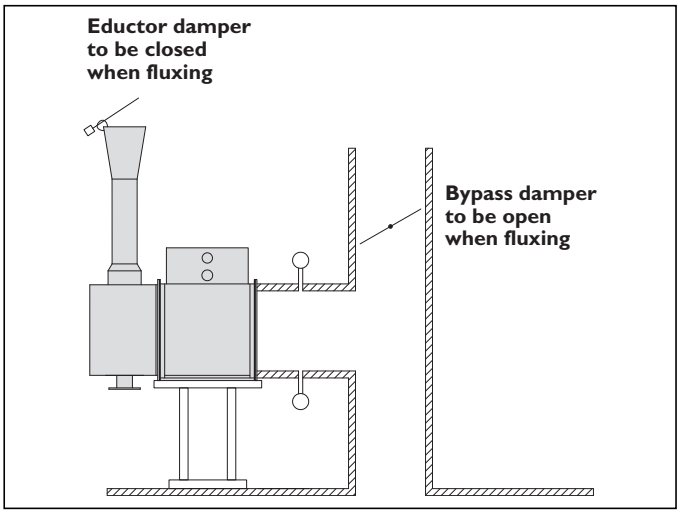


Figure 3.1

In addition, when using the recuperators on aluminum melting or holding furnaces, the exhaust temperature must be diluted to less than 1300°F (704°C). This will ensure that any aluminum in the exhaust will condense out before entering the recuperator. Aluminum condensing on the recuperator tubes will cause damage. When in doubt consult Eclipse.

CAUTION

- **Failure to observe these conditions can destroy the recuperator and will void the warranty.**

Recuperator Sizing

It is assumed that the net heat requirement is known. The table below is a rough guide for the efficiency with a cross flow recuperator at various furnace temperatures with 10% excess combustion air. This is sufficiently accurate to determine the size of recuperator to use; it should not be used to determine actual gas usage.

Furnace Temperature °F (°C)	Efficiency with Cross Flow Recuperator
1500 (815)	70%
1600 (871)	68.5%
1700 (926)	67%
1800 (982)	65.7%
1900 (1037)	64.4%
2000 (1093)	63%
2100 (1148)	60.6%
2200 (1204)	59.3%
2300 (1260)	58%

Calculate the gross BTU requirement using this efficiency then check the cross flow recuperator capacities in the datasheet to determine the size of recuperator.

Example: Net required 2mm BTU/hr with furnace temperature of 1700°F. From the table on page 10, the efficiency = 67%. Therefore, the gross input = 2mm/0.67 = 2.9mm BTU/hr. From the datasheets, a 48 tube cross flow with a capacity of 2mm to 5mm BTU/hr must be used.

Dilution Air

If the furnace temperature is above 2100°F (1148°C) dilution air must be introduced to cool the exhaust gases to 2100°F (1148°C) before they enter the recuperator.

As a guide, the following chart can be used to determine the amount of dilation air required.

US Units

		Burner Capacity MM BTU/hr					
		1	2	3	4	5	10
Volume scfh Cooling Air	2200°F Temp.	730	1460	2190	2920	3650	7300
	2300°F Temp.	1460	2920	4380	5840	7300	14600
	2400°F Temp.	2190	4380	6570	8760	10950	21900

Metric Units

		Burner Capacity kW					
		293	586	879	1172	1465	2930
Volume Nm^3/hr Cooling Air	1204°C Temp.	19.2	38.4	57.6	76.8	95.9	191.9
	1260°C Temp.	38.4	76.8	115.1	153.5	191.9	383.8
	1315°C Temp.	57.6	115.1	172.7	230.3	287.9	575.7

Number of Recuperators

It is recommended that one recuperator be used for each zone of control. This has the advantage that the combustion air flow is controlled on the cold side of the recuperator. All the subsequent instructions and descriptions are written with this assumption. If it is required that a single cross flow recuperator will pre-heat the combustion air for multiple zones, consult Eclipse.

Mounting the Recuperator

The cross flow recuperators are designed for horizontal mounting with the recuperator tubes hanging vertically down. If an alternative mounting arrangement is required contact Eclipse.

The recuperator must be supported by a structure that will allow it to freely expand and contract with temperature changes. Eclipse recommends the use of flexibles at the air inlet/outlet connections to accommodate expansion and contraction. See figure 3.2. Do not add additional insulation to the outside of the recuperator.

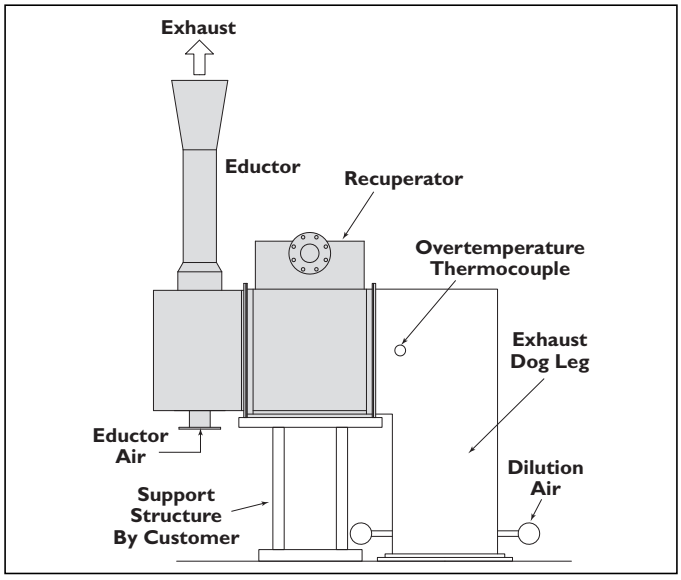


Figure 3.2

Mounting the Eductor

The eductor can be mounted directly to the recuperator. The outlet flange on the recuperator is of sufficient strength to support the weight of the eductor; no additional support is required for the eductor. The standard eductor is designed for vertical mounting, if horizontal mounting is required consult Eclipse.

No additional exhaust ducting should be connected directly to the eductor. There should be no restrictions at the eductor outlet; this would affect the eductor performance. The outside of the eductor should not be insulated.

Typical Air Pipe Work

The schematic on page 8 (Figure 3.4) shows a typical air control scheme. This uses one control valve to control the combustion air, eductor, and dilution air. As the burners turn down, the eductor air turns down to reduce the suction and keep the furnace at the desired pressure. If dilution air is fitted, this will also turn down, so as not to excessively cool the exhaust gas. A more sophisticated control is shown on page 9 (Figure 3.5). This assumes that more critical furnace pressure control is required. The eductor air has a separate control valve driven by the furnace pressure control.

The schematic on page 9 (Figure 3.6) shows a typical air scheme for controlling the maximum preheated combustion air (PCA). An air bypass line is included around the Cross-Flow Recuperator and ran directly to the PCA line. The mixture of PCA and ambient air is controlled by a control valve and temperature controller.

More details of the combustion circuits and methods of controlling the air and gas can be found in Design Guide 206 covering ThermJet Burners for Preheated Combustion Air.

CAUTION

- **When hard piping to eductor, be careful not to displace the eductor flange (keep square).**

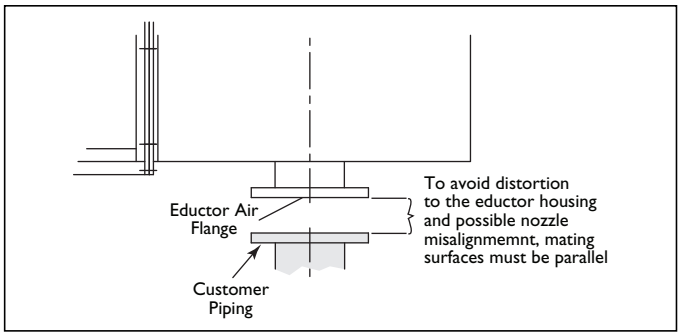


Figure 3.3

Eductor Air Flow

Eductors are designed to overcome the exhaust gas pressure drop through the recuperator. The eductor airflows given in the datasheets are the flows required to overcome the exhaust pressure drop at the maximum rating of the recuperator and an inlet exhaust temperature of 1900°F (1037°C). The entrainment air flow required will be different at other capacities or exhaust temperatures.

Cleaning the Recuperator

Dirt or other substances in the exhaust can accumulate on the outside of the recuperator tubes. Units can be cleaned with steam, compressed air, or any other method that accomplishes the task without damaging the insulation.

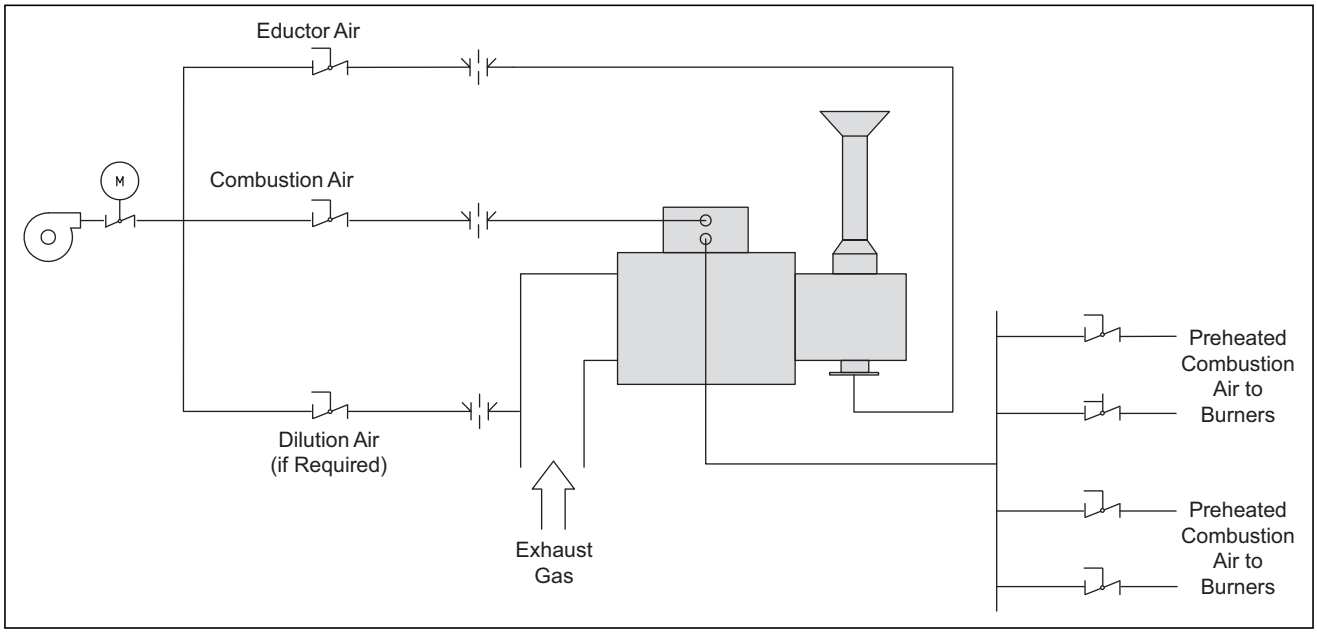


Figure 3.4

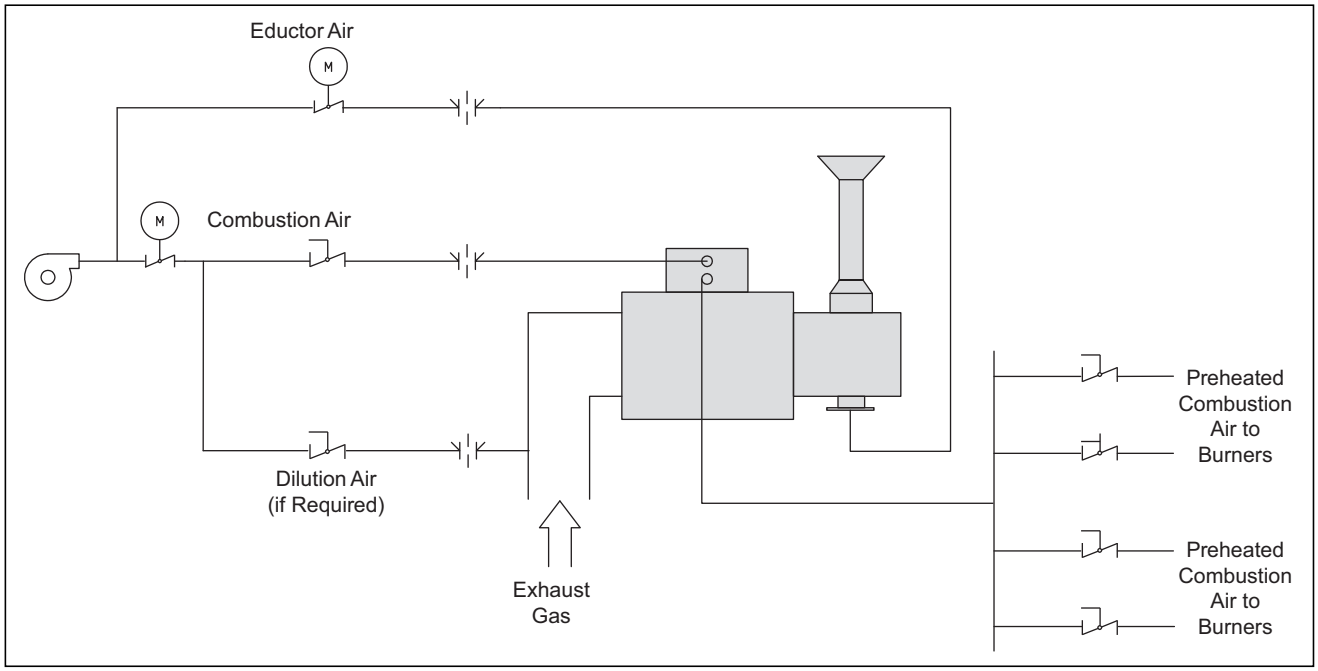


Figure 3.5

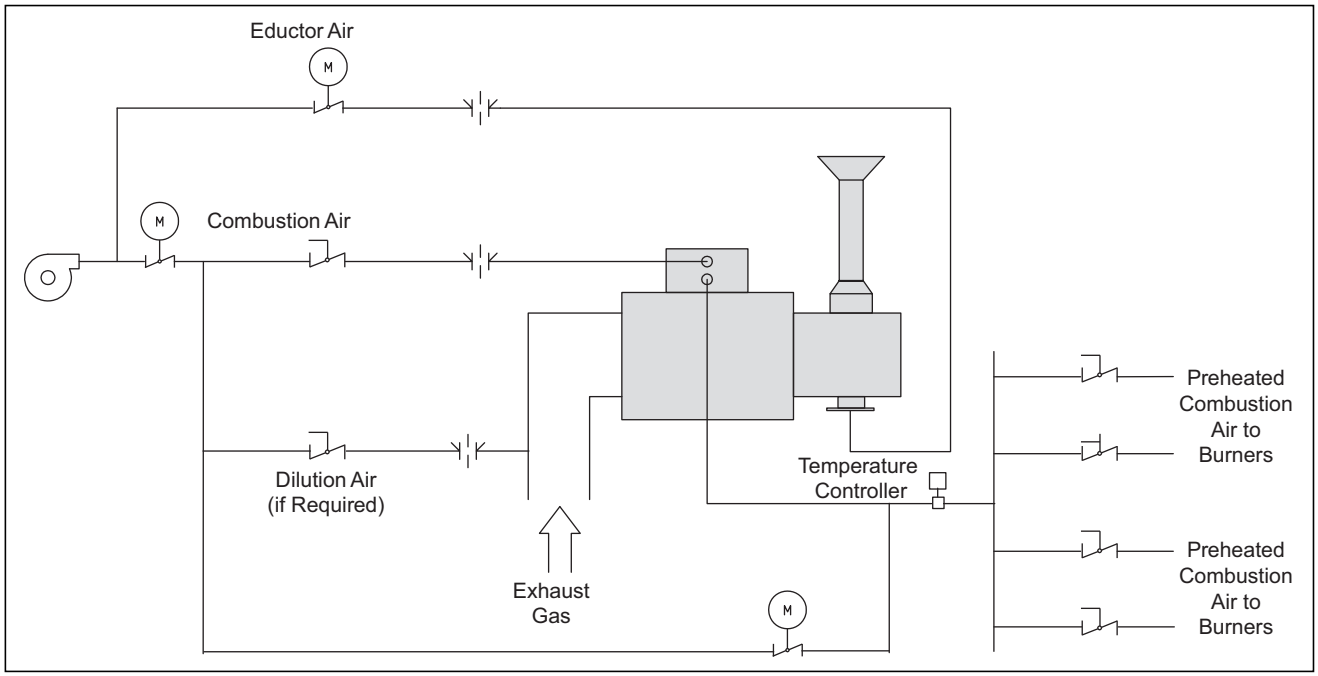


Figure 3.6

Appendix

Conversion Factors

Metric to English

From	To	Multiply By
actual cubic meter/h (am³/h)	actual cubic foot/h (acfh)	35.31
normal cubic meter/h (Nm³/h)	standard cubic foot /h (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)	14.5×10^{-3}
millimeter (mm)	inch (in)	3.94×10^{-2}
MJ/Nm³	Btu/ft³ (standard)	26.86

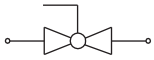
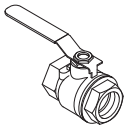
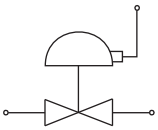
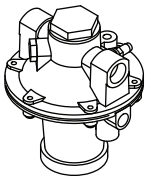
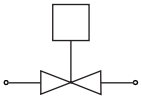
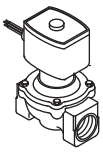
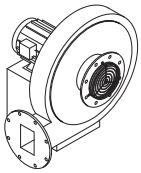
Metric to Metric

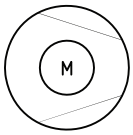
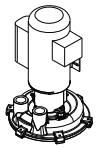
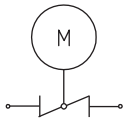
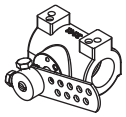
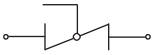
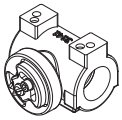
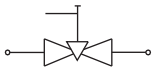
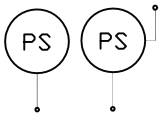
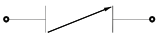
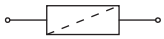
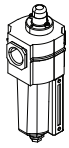
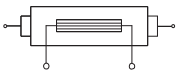
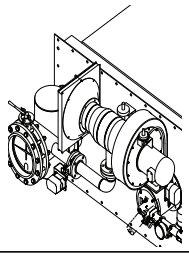
From	To	Multiply By
kiloPascals (kPa)	millibar (mbar)	10
meter (m)	millimeter (mm)	1000
millibar (mbar)	kiloPascals (kPa)	0.1
millimeter (mm)	meter (m)	0.001

English to Metric

From	To	Multiply By
actual cubic foot/h (acfh)	actual cubic meter/h (am³/h)	2.832×10^{-2}
standard cubic foot /h (scfh)	normal cubic meter/h (Nm³/h)	2.629×10^{-2}
degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32) x 5/9
pound (lb)	kilogram (kg)	0.454
Btu/h	kilowatt (kW)	0.293×10^{-3}
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/ft³ (standard)	MJ/Nm³	37.2×10^{-3}

System Schematics

Symbol	Appearance	Name	Remarks	Bulletin/ Info Guide
		Gas Cock	Gas cocks are used to manually shut off the gas supply.	710
		Ratio Regulator	A ratio regulator is used to control the air/gas ratio. The ratio regulator is a sealed unit that adjusts the gas pressure in ratio with the air pressure. 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 burner body.	
Main Gas Shut-Off Valve Train		Main Gas Shut-Off Valve Train	Eclipse strongly endorses NFPA as a minimum.	790/791
Pilot Gas Shut-Off Valve Train		Pilot Gas Valve Train	Eclipse strongly endorses NFPA as a minimum.	790/791
		Automatic Shut-Off Valve	Shut-off valves are used to automatically shut off the gas supply on a gas system or a burner.	760
		Orifice Meter	Orifice meters are used to measure flow.	930
		Combustion Air Blower	The combustion air blower provides the combustion air to the burner(s).	610

Symbol	Appearance	Name	Remarks	Bulletin/ Info Guide
		Hermetic Booster	Booster is used to increase gas pressure.	620
		Automatic Butterfly Valve	Automatic butterfly valves are typically used to set the output of the system.	720
		Manual Butterfly Valve	Manual butterfly valves are used to balance the air or gas flow at each burner.	720
		Adjustable Limiting Orifice	Adjustable limiting orifices are used for fine adjustment of gas flow.	728/730
		Pressure Switch	A switch activated by rise or fall in pressure. A manual reset version requires pushing a button to transfer the contacts when the pressure set point is satisfied.	840
		Pressure Gauge	A device to indicate pressure.	940
		Check Valve	A check valve permits flow only in one direction and is used to prevent back flow of gas.	780
		Strainer	A strainer traps sediment to prevent blockage of sensitive components downstream.	
		Flexible Connector	Flexible connectors isolate components from vibration, mechanical, and thermal stresses.	
		Heat Exchanger	Heat exchangers transfer heat from one medium to another.	500
		Pressure Taps	Pressure taps measure static pressure.	