Design Guide 540
3/9/2009

Eclipse Extern-A-Therm Recuperators

Models 300 MA - 2500 MA

ECLIPSE®
Innovative Thermal Solutions

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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

2011 Williamsburg Road
Richmond, Virginia 23231 U.S.A.

Phone: 804-236-3800
Fax: 804-236-3882

http://www.peconet.com

	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.
 **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

The Extern-A-Therm 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 Extern-A-Therm recuperator allows for free expansion of the recuperator tubes; no expansion joints are required.

The design of the Extern-A-Therm, housing and eductor ensure ease of installation and efficient use of existing pipe work. The housings are internally insulated; there is no need for additional external insulation.

Figure 1.1. Extern-A-Therm Recuperator

Audience

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

These aspects are:

- Design/Selection
- Use
- Maintenance

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

Extern-A-Therm Documents

Design Guide No. 540

- This document

Datasheet, Series No. 540-1 through 540-4

- Available for individual Extern-A-Therm models
- Required to complete design calculations in this guide

Related Documents

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

Purpose

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

Safety

2

Important notices about safe burner operation will be found in this section. Read this entire manual before attempting to start the system. If any part of the information in this manual is not understood, contact Eclipse before continuing.

Safety Warnings

WARNING

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

NOTICE

- **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.**

Capabilities

Adjustment, maintenance and troubleshooting of the mechanical and the electrical parts of this system should be done by qualified personnel with good mechanical aptitude and experience with combustion equipment.

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, customer supplied valves or switches should carry UL, FM, CSA, CGA, and/or CE approval, where applicable.

System Design 3

Design

Furnace Temperature Limits

Up to 1800°F - No special safeguards are required to protect the recuperator. See “Special Precautions for Aluminum Melting or Holding” on this page, for aluminum applications.

1800°F - 2100°F - To ensure that the safe operating temperature of the recuperator tubes is not exceeded, air flow must not fall below the following limits:

- Model 300 MA - 90 scfh
- Model 600 MA - 180 scfh
- Model 1500 MA - 450 scfh
- Model 2500 MA - 750 scfh

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 shut down 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.**

2100°F - 2400°F - Dilution air must be introduced to the air stream to maintain exhaust temperature below 2100°F. (See Figure 3.4.) The amount of dilution air can be determined from the “Dilution Air” section, 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.

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.**

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.

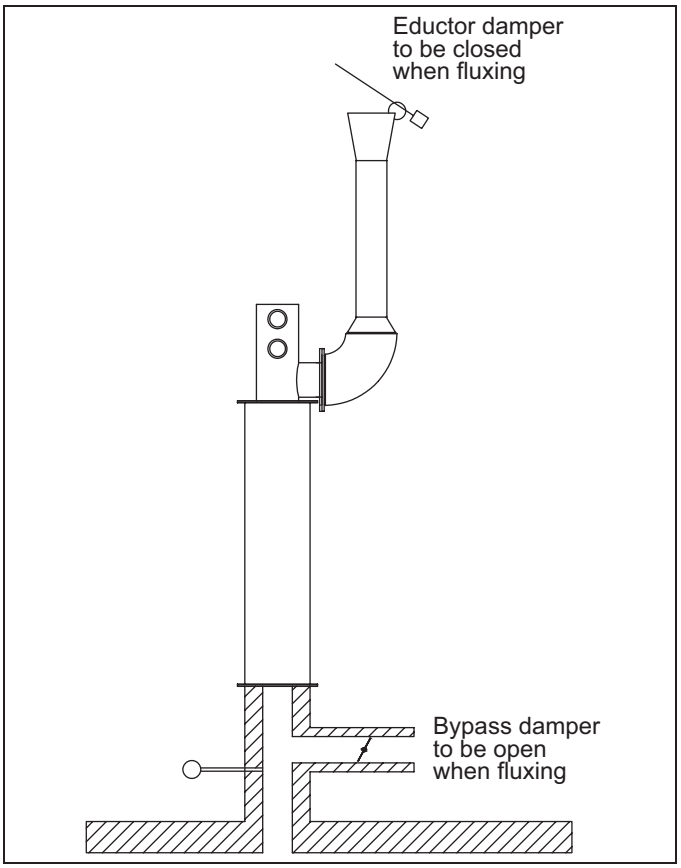

Figure 3.1.

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.**

Determine the Size of Recuperator Required

It is assumed that the net BTU requirement is known. The table below is an approximate guide for the efficiency with an Extern-A-Therm 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 Extern-A-Therm Recuperator
1500 (815)	70%
1600 (817)	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 Extern-A-Therm recuperator capacities in the datasheet to determine the size of recuperator.

Example:

Net required 1.0 mm BTU/hr with furnace temperature of 1700°F. Using the table above, the efficiency = 67%.

Therefore, the gross input = 1.0mm BTU/hr ÷ 0.67 = 1.49mm BTU/hr. From the datasheets, a 1500 MA Extern-A-Therm with a capacity of 0.4mm BTU/hr to 1.6mm BTU/hr must be used. If a higher preheated air temperature is required the 2500 MA should be used.

Dilution Air

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

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

Furnace Temp °F (°C)	Burner Capacity BTU/hr (kW)				
	100,000 (29.3)	200,000 (58.6)	500,000 (146.5)	1,000,000 (293.1)	2,000,000 (586.1)
2200 (1204)	75 (2.1)	150 (4.3)	375 (10.6)	730 (20.7)	1,460 (41.3)
2300 (1260)	150 (4.2)	300 (8.5)	750 (21.2)	1,500 (42.4)	3,000 (84.9)
2400 (1315)	220 (6.2)	440 (12.4)	1,100 (31.1)	2,200 (62.3)	4,400 (124.6)

Table Values for
Volume scfh (m^3/hr) Cooling Air

Number of Extern-A-Therm 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 Extern-A-Therm recuperator will pre-heat the combustion air for multiple zones, consult Eclipse.

Mounting the Recuperator

The Extern-A-Therm recuperators are designed for vertical mounting with the recuperator tubes hanging vertically down. If an alternative mounting arrangement is required, contact Eclipse.

The recuperator and exhaust housings have sufficient strength to be self supporting from the mounting flange, and can support the eductor if fitted. Eclipse recommends the use of flexible piping at the air inlet/outlet and entrainment air connections to accommodate expansion and contraction. See Figure 3.2 for a typical arrangement.

Do not add additional insulation to the outside of the recuperator, as this will damage the unit.

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. See Figure 3.3. The outside of the eductor should not be insulated.

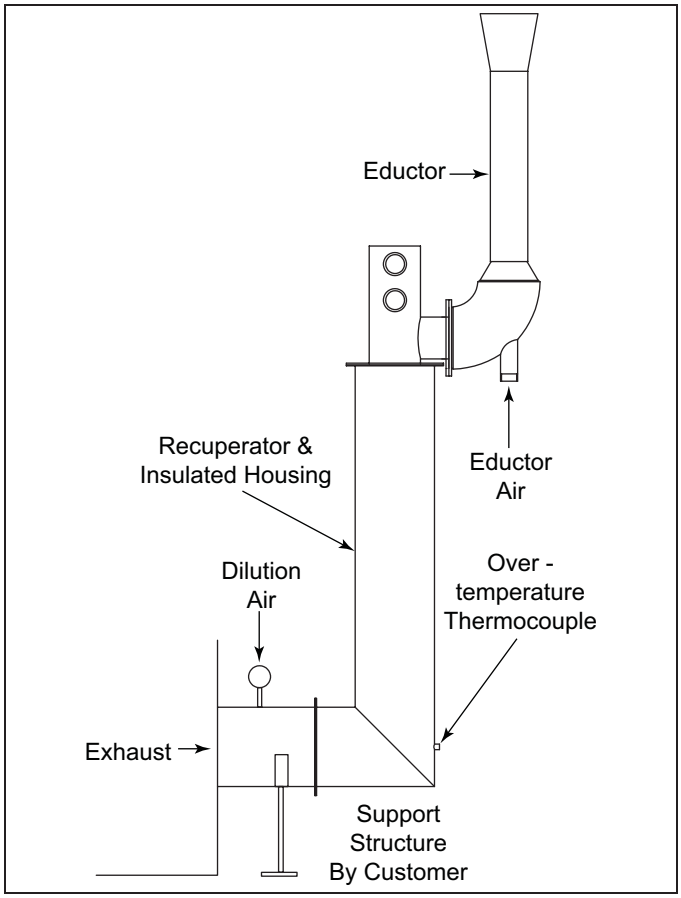

Figure 3.2.

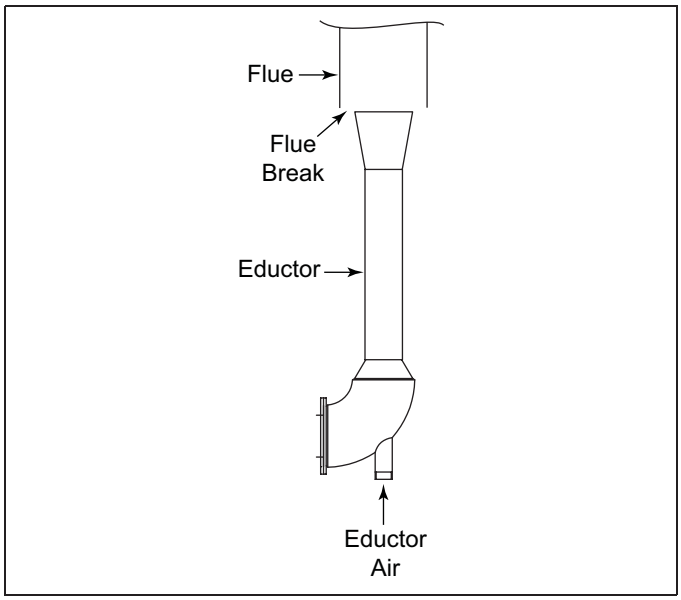

Figure 3.3.

Typical Air Pipe Work

The schematic, Figure 3.4, shows a typical air control scheme. This uses one control valve to control the combustion air, eductor air and dilution air. As the burners turn down, the eductor air lowers to reduce the suction and keep the furnace at the desired pressure. If dilution air is necessary, this will also be reduced, so as not to excessively cool the exhaust gas. A more sophisticated control, Figure 3.5. This assumes that greater furnace pressure control is required. The eductor air has a separate control valve driven by the furnace pressure control.

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.

Eductor Air Flow

Eductors are designed to overcome the exhaust gas pressure drop through the recuperator. The eductor airflows given in the datasheet 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.

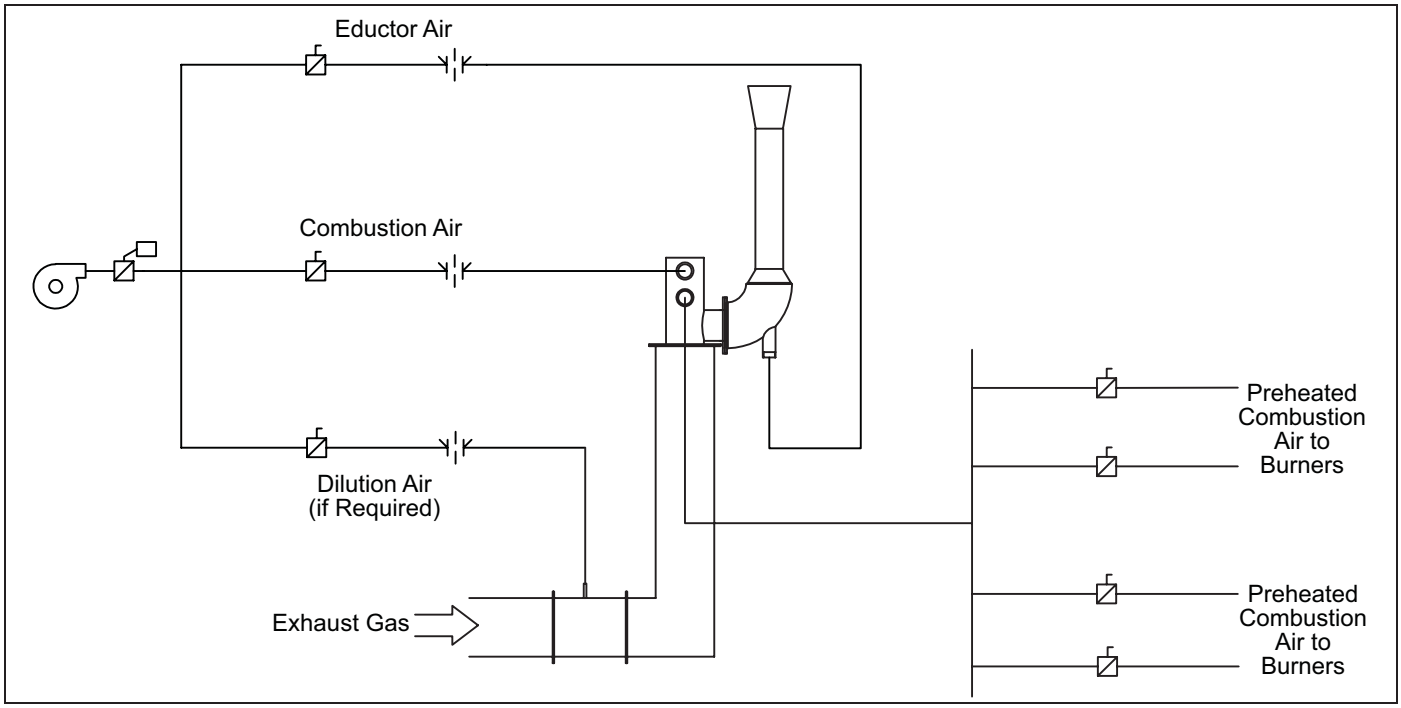

Figure 3.4. P & ID of Typical Piping

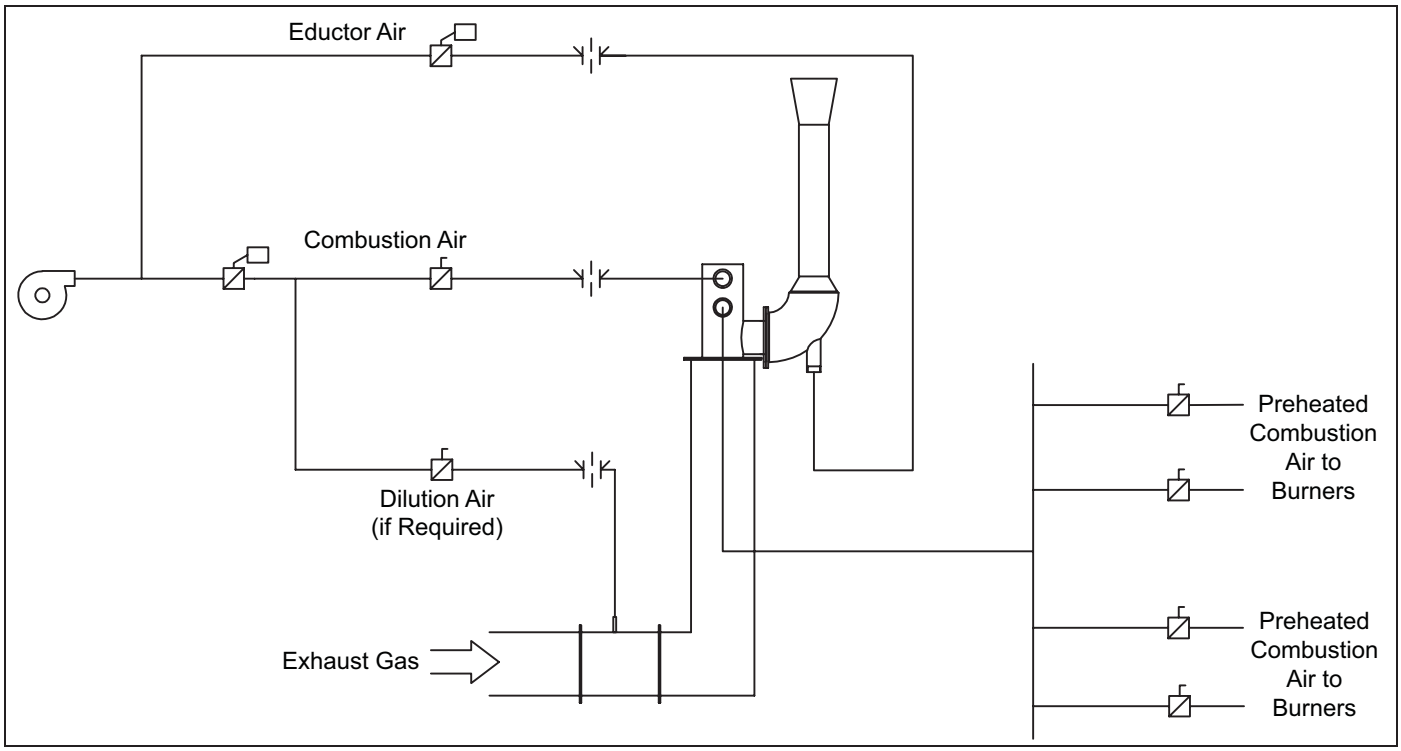

Figure 3.5. P & ID of Typical Piping for Greater Furnace Pressure Control

Appendix

Conversion Factors

Metric to English

From	To	Multiply By
cubic meter (m^3)	cubic foot (ft^3)	35.31
cubic meter/hr (m^3/h)	cubic foot/hr (cfh)	35.31
degrees Celsius (°C)	degrees Fahrenheit (°F)	(°C x 9/5) + 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}
MJ/Nm^3	BTU/ft^3 (standard)	2.491×10^{-2}

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
BTU/hr	kilowatt (kW)	0.293×10^{-3}
cubic foot (ft3)	cubic meter (m3)	2.832×10^{-2}
cubic foot/hour (cfh)	cubic meter/hour (m3/h)	2.832×10^{-2}
degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32) ÷ 5/9
foot (ft)	meter (m)	0.3048
inch (in)	millimeter (mm)	25.4
inches water column ("w.c.)	millibar (mbar)	2.49
pound (lb)	kilogram (kg)	0.454
pounds/sq in (psi)	millibar (mbar)	68.95
BTU/ft^3 (standard)	MJ/Nm^3	40.14

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