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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. You can also contact Eclipse at:

2011 Williamsburg Road
Richmond, Virginia 23231
Phone: 804-236-3800
Fax: 804-236-3882
http://www.peconet.com

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

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.

Is used to address practices not related to personal injury.

Indicates an important part of text. Read thoroughly.
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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.

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

Figure 1.1. Cross-Flow Recuperator
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

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 Nm³/hr)
- 48 Tube Model: 1500 scfh (42 Nm³/hr)
- 80 Tube Model: 2500 scfh (70 Nm³/hr)
- 121 Tube Model: 3550 scfh (100 Nm³/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.

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.

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

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

CAUTION

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

CAUTION

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

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

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 (1048°C) dilution air must be introduced to cool the exhaust gases to 2100°F (1048°C) before they enter the recuperator.

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

<table>
<thead>
<tr>
<th>US Units</th>
<th>Burner Capacity MM BTU/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Volume scfh Cooling Air</td>
<td>2200°F Temp.</td>
</tr>
<tr>
<td></td>
<td>2300°F Temp.</td>
</tr>
<tr>
<td></td>
<td>2400°F Temp.</td>
</tr>
</tbody>
</table>

**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.

**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 9 (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.

![Figure 3.3](image)

**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.

- **CAUTION**

  - When hard piping to eductor, be careful not to displace the eductor flange (keep square).
Figure 3.6
## Conversion Factors

### Metric to English

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual cubic meter/hr (am³/h)</td>
<td>actual cubic foot/hr (acfh)</td>
<td>35.31</td>
</tr>
<tr>
<td>normal cubic meter/hr (Nm³/h)</td>
<td>standard cubic foot/hr (scfh)</td>
<td>38.04</td>
</tr>
<tr>
<td>degrees Celsius (°C)</td>
<td>degrees Fahrenheit (°F)</td>
<td>(°C x 9/5) + 32</td>
</tr>
<tr>
<td>kilogram (kg)</td>
<td>pound (lb)</td>
<td>2.205</td>
</tr>
<tr>
<td>kilowatt (kW)</td>
<td>BTU/hr</td>
<td>3415</td>
</tr>
<tr>
<td>meter (m)</td>
<td>foot (ft)</td>
<td>3.281</td>
</tr>
<tr>
<td>millibar (mbar)</td>
<td>inches water column (&quot;w.c.&quot;)</td>
<td>0.402</td>
</tr>
<tr>
<td>millibar (mbar)</td>
<td>pounds/sq in (psi)</td>
<td>14.5 x 10⁻³</td>
</tr>
<tr>
<td>millimeter (mm)</td>
<td>inch (in)</td>
<td>3.94 x 10⁻²</td>
</tr>
<tr>
<td>MJ/Nm³</td>
<td>BTU/ft³ (standard)</td>
<td>26.86</td>
</tr>
</tbody>
</table>

### Metric to Metric

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>kiloPascals (kPa)</td>
<td>millibar (mbar)</td>
<td>10</td>
</tr>
<tr>
<td>meter (m)</td>
<td>millimeter (mm)</td>
<td>1000</td>
</tr>
<tr>
<td>millibar (mbar)</td>
<td>kiloPascals (kPa)</td>
<td>0.1</td>
</tr>
<tr>
<td>millimeter (mm)</td>
<td>meter (m)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

### English to Metric

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual cubic foot/hr (acfh)</td>
<td>actual cubic meter/hr (am³/h)</td>
<td>2.832 x 10⁻²</td>
</tr>
<tr>
<td>standard cubic foot /hr (scfh)</td>
<td>normal cubic meter/hr (Nm³/h)</td>
<td>2.629 x 10⁻²</td>
</tr>
<tr>
<td>degrees Fahrenheit (°F)</td>
<td>degrees Celsius (°C)</td>
<td>(°F - 32) x 5/9</td>
</tr>
<tr>
<td>pound (lb)</td>
<td>kilogram (kg)</td>
<td>0.454</td>
</tr>
<tr>
<td>BTU/hr</td>
<td>kilowatt (kW)</td>
<td>0.293 x 10⁻³</td>
</tr>
<tr>
<td>foot (ft)</td>
<td>meter (m)</td>
<td>0.3048</td>
</tr>
<tr>
<td>inches water column (&quot;w.c.&quot;)</td>
<td>millibar (mbar)</td>
<td>2.489</td>
</tr>
<tr>
<td>pounds/sq in (psi)</td>
<td>millibar (mbar)</td>
<td>68.95</td>
</tr>
<tr>
<td>inch (in)</td>
<td>millimeter (mm)</td>
<td>25.4</td>
</tr>
<tr>
<td>BTU/ft³ (standard)</td>
<td>MJ/Nm³</td>
<td>37.2 x 10⁻³</td>
</tr>
</tbody>
</table>