Eclipse Tube Firing Burners
ThermThief Series (version 1.0)
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About this manual

AUDIENCE

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

- design/selection
- installation
- use
- maintenance.

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

SCOPE

Contents

This manual contains essential information that you need to deal with all the above mentioned aspects of the burner system.

Purpose

The purpose of this manual is to make sure that you carry out design, installation, use and maintenance in a safe, effective and trouble-free way.

IMPORTANT NOTICES

- Read this manual carefully. Make sure that you understand the structure and contents of this manual.
- Obey all the safety instructions.
- Do not deviate from any instructions or application limits in this manual without written advice from Eclipse Combustion, Inc.
- If you do not understand any part of the information in this manual, then do not continue. Contact your Eclipse representative or Eclipse Combustion, Inc.
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 practices 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 the text thoroughly.

**Related Documents**
- EFE 825 (Combustion Engineering Guide)
- Eclipse bulletins and Info Guides: 610, 710, 720, 730, 742, 744, 760, 930, I-354.

**How to Get Help**
If you need help, you can contact your local Eclipse representative. You can also contact Eclipse Combustion at these addresses:

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Fax: +1 815 877 3120
E-mail: eclipse@eclipsenet.com
http://www.eclipsenet.com

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Phone: +31 182 515988
Fax: +31 182 533269
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PRODUCT DESCRIPTION

The ThermThief Design Guide is a nozzle-mix tube-firing burner that is designed to fire into radiant tubes or immersion tubes.

Figure 1.1  The ThermThief Design Guide burners

Flame guidance
An alloy air tube maintains the proper air velocity past the nozzle, regardless of the heater tube diameter. The flame heats the heater tube uniformly without hot spots that might reduce the life of the tube or overheat the process fluid.

Heat exchanger
The ThermThief Design Guide can be used with or without an exhaust leg recuperator. An exhaust leg recuperator is a heat exchanger that transfers heat from the exhaust air to the combustion air. Preheating the combustion air can increase the fuel efficiency by as much as 20%. The ThermThief Design Guide can handle combustion air temperatures up to 800°F. The recommended recuperator for the ThermThief Design Guide is the Eclipse Bayonet Ultra (refer to Bulletin 318).
INTRODUCTION

In this section you will find important notices about safe operation of a burner system.

**Danger:**
The burners covered in this manual are designed to mix fuel with air and burn the resulting mixture. All fuel burning devices are capable of producing fires and explosions when improperly applied, installed, adjusted, controlled, or maintained.

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

Never try to light the burner if the burner shows signs of damage or malfunctioning. You can cause fires and explosions.

**Warning:**
The burner is likely to have HOT surfaces. Always wear protective clothing when approaching the burner.

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

**Note:**
Read this entire manual before you attempt to start the system. If you do not understand any part of the information in this manual, then contact your local Eclipse representative or Eclipse Combustion before you continue.

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 competent operator. Thoroughly instruct new operators so they demonstrate an adequate understanding of the equipment and its operation. Regular retraining must be scheduled to 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, and/or CGA approval where applicable.
This section gives a detailed overview of the specifications and options of the ThermThief burner family.

Figure 3.1  The ThermThief burners
Table 3.1  Options

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>OPTIONS</th>
<th>For any other mixed gas, contact Eclipse for orifice sizing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>• natural gas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• propane</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• butane</td>
<td></td>
</tr>
<tr>
<td>Flame detector</td>
<td>• U.V. scanner only</td>
<td></td>
</tr>
<tr>
<td>Ignition</td>
<td>• direct spark ignition (6 kVAC)</td>
<td></td>
</tr>
</tbody>
</table>

* When using the U.V. scanner, it is necessary to use mounting adaptor part #109750 to ensure that the U.V. scanner will not detect the ignition spark.

Operational zones
Eclipse Combustion, Inc. has determined through laboratory testing, that anywhere within the designated zone, the user can ignite the burner and will develop a stable flame signal.

Figure 3.2  Operational zone 30TFB
Figure 3.3 Operational zone 75 TFB

Figure 3.4 Operational zone 200 TFB
**SPECIFICATIONS**

Main specifications

---

**Note:**

Pressures shown are for system sizing only. The supply pressure at the burner inlets must be at least 3" w.c. higher than the differential pressure shown in the tables.

The low firing rate represents the capability of the burner. Achievement of this rate will be affected by the control method and ratio-regulator used in system design.

**Table 3.2** 30 TFB performance data

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>BURNER INPUT (1000's BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Low firing rate (1000's Btu/hr)</td>
<td>Without U.V. scanner</td>
</tr>
<tr>
<td></td>
<td>With U.V. scanner</td>
</tr>
<tr>
<td>Differential air pressure (&quot;w.c.)</td>
<td>Between tap A and B (See Figure 3.1)</td>
</tr>
<tr>
<td>Recommended air orifice plate (in)</td>
<td>0.70</td>
</tr>
<tr>
<td>Air flow (SCFH)</td>
<td>At 15% excess air</td>
</tr>
<tr>
<td>Differential gas pressure (&quot;w.c.)</td>
<td>Between tap C and D (See Figure 3.1)</td>
</tr>
<tr>
<td></td>
<td>Propane</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
</tr>
<tr>
<td>Recommended gas orifice plate (in)</td>
<td>nat. gas</td>
</tr>
<tr>
<td></td>
<td>Propane</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
</tr>
</tbody>
</table>

---

**Table 3.3** 75 TFB performance data

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>BURNER INPUT (1000's BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Low firing rate (1000's Btu/hr)</td>
<td>Without U.V. scanner</td>
</tr>
<tr>
<td></td>
<td>With U.V. scanner</td>
</tr>
<tr>
<td>Differential air pressure (&quot;w.c.)</td>
<td>Between tap A and B (See Figure 3.1)</td>
</tr>
<tr>
<td>Recommended air orifice plate (in)</td>
<td>1.33</td>
</tr>
<tr>
<td>Air flow (SCFH)</td>
<td>At 15% excess air</td>
</tr>
<tr>
<td>Differential gas pressure (&quot;w.c.)</td>
<td>Between tap C and D (See Figure 3.1)</td>
</tr>
<tr>
<td></td>
<td>Propane</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
</tr>
<tr>
<td>Recommended gas orifice plate (in)</td>
<td>nat. gas</td>
</tr>
<tr>
<td></td>
<td>Propane</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
</tr>
</tbody>
</table>
Specifications

Note:
Pressures shown are for system sizing only. The supply pressure at the burner inlets must be at least 3"w.c. higher than the differential pressure shown in the tables.

The low firing rate represents the capability of the burner. Achievement of this rate will be effected by the control method and ratio-regulator used in system design.

Table 3.4  200TFB performance data

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>BURNER INPUT (1000's BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800</td>
</tr>
<tr>
<td>Low firing rate (1000's Btu/hr)</td>
<td></td>
</tr>
<tr>
<td>At 100% excess air</td>
<td></td>
</tr>
<tr>
<td>With U.V. scanner</td>
<td>50</td>
</tr>
<tr>
<td>Differential air pressure (&quot;w.c.) between tap A and B (See Figure 3.1)</td>
<td>4.7</td>
</tr>
<tr>
<td>Recommended air orifice plate (in)</td>
<td>2.13</td>
</tr>
<tr>
<td>Air flow (SCFH) At 15% excess air</td>
<td>9200</td>
</tr>
<tr>
<td>Differential gas pressure (&quot;w.c.) between tap C and D (See Figure 3.1)</td>
<td></td>
</tr>
<tr>
<td>nat. gas</td>
<td>3.8</td>
</tr>
<tr>
<td>propane</td>
<td>3.6</td>
</tr>
<tr>
<td>butane</td>
<td>2.8</td>
</tr>
<tr>
<td>Recommended gas orifice plate (in)</td>
<td></td>
</tr>
<tr>
<td>nat. gas</td>
<td>0.63</td>
</tr>
<tr>
<td>propane</td>
<td>0.51</td>
</tr>
<tr>
<td>butane</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Emission graphs

The graphs that follow give you an approximate picture of the emission performance. Should you want more exact information, contact Eclipse Combustion, Inc.

Figure 3.5 Emissions

The emissions are influenced by:
- the fuel type
- the combustion air temperature
- the firing rate
- the percent of excess air.

For estimates of the emissions from your application, contact Eclipse.
**Specifications**

**Figure 3.6** Burner dimensions - 30 TFB/75 TFB

**Table 3.5** Burner - Dimensions & weight

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>30 TFB AND 75 TFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (in)</td>
<td>See &quot;Find dimension A&quot; on page 5-4</td>
</tr>
<tr>
<td>B (in)</td>
<td>See Table 3.7 on page 3-9</td>
</tr>
<tr>
<td>C (in)</td>
<td>3½</td>
</tr>
<tr>
<td>D (in)</td>
<td>3%</td>
</tr>
<tr>
<td>E</td>
<td>1½&quot; NPT or BSP</td>
</tr>
<tr>
<td>Air Inlet thread</td>
<td>2&quot; NPT or BSP</td>
</tr>
<tr>
<td>F</td>
<td>¾&quot; NPT or BSP</td>
</tr>
<tr>
<td>Gas Inlet thread</td>
<td>½&quot; NPT or BSP</td>
</tr>
<tr>
<td>G (in)</td>
<td>3¾</td>
</tr>
<tr>
<td>H (in)</td>
<td>3¾</td>
</tr>
<tr>
<td>J (in)</td>
<td>Ø 0.55</td>
</tr>
<tr>
<td>K (in)</td>
<td>4%</td>
</tr>
<tr>
<td>L (in)</td>
<td>6</td>
</tr>
<tr>
<td>M (in)</td>
<td>5½</td>
</tr>
<tr>
<td>N (in)</td>
<td>3½</td>
</tr>
<tr>
<td>Total weight (lb)</td>
<td>19.5-24</td>
</tr>
</tbody>
</table>
Figure 3.7  Burner dimensions - 200 TFB

Table 3.6  Burner - Dimensions & weight

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>200 TFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (in)</td>
<td>See Table 5.1 on page 5-4</td>
</tr>
<tr>
<td>B (in)</td>
<td>See Table 3.7 on page 3-9</td>
</tr>
<tr>
<td>C (in)</td>
<td>3%</td>
</tr>
<tr>
<td>D (in)</td>
<td>4%</td>
</tr>
<tr>
<td>E</td>
<td>Air Inlet thread 3&quot; NPT or BSP</td>
</tr>
<tr>
<td>F</td>
<td>Gas Inlet thread 1 1/2&quot; NPT or BSP</td>
</tr>
<tr>
<td>G (in)</td>
<td>3&quot;</td>
</tr>
<tr>
<td>H (in)</td>
<td>5&quot;</td>
</tr>
<tr>
<td>J (in)</td>
<td>Ø 0.47</td>
</tr>
<tr>
<td>K (in)</td>
<td>7 1/2</td>
</tr>
<tr>
<td>L (in)</td>
<td>8%</td>
</tr>
<tr>
<td>M (in)</td>
<td>-</td>
</tr>
<tr>
<td>N (in)</td>
<td>5%</td>
</tr>
<tr>
<td>Total weight (lb)</td>
<td>42-47</td>
</tr>
</tbody>
</table>
Air tube length

Each ThermThief burner is available in a number of variants, which have different air tube lengths (dimension B from Figure 3.6). Based on your furnace design and/or immersion tube design, choose the dimension closest to your requirements.

Table 3.7 AIR TUBE LENGTH

<table>
<thead>
<tr>
<th>Dimension B (IN)</th>
<th>30 TFB / 75 TFB</th>
<th>200 TFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>23%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>22%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>21%</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>19%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>18%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>17%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>16%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>14%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>13%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>12%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>11%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>9%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>7%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
This page is intentionally left blank!
Designing a burner system is a straightforward exercise of combining steps that add up to a reliable and safe system. These steps are:

2. Tube design.
3. Control methodology.
4. Ignition System.
5. Flame monitoring system.
7. Main gas shut-off valve train.

Step 1: Radiant tube burner application

The design of a combustion system for radiant tubes and immersion tubes is significantly different. For this reason, we have divided the process for burner selection into two separate sections;

- "Step 1a: Radiant tube burner application" on page 4-1
- "Step 1b: Immersion tube burner application" on page 4-6.

Calculate the required heat release

Given the net heat requirement of the furnace, divide by the number of radiant tubes to determine the required heat release per tube.

Calculate the tube surface area

The burner radiates its heat to the process through the wall of the tube. To calculate the required burner input you must know the total area of the tube inside the furnace.
To calculate the tube surface area, use this formula:

\[ \text{Tube surface area} = \text{OD} \times \pi \times n \times L \]

- \( \text{OD} \) = the outside diameter of the tube [in]
- \( \pi = 3.142 \)
- \( n = \) number of tube legs
  - 2 for a U-tube
  - 3 for a trident tube
  - 4 for a W-tube.
- \( L = \) the total length of each leg [in].

**Determine the maximum heat transfer rate**

The maximum heat transfer rate is the maximum amount of heat that the tube can radiate to the process per time unit.

The maximum heat transfer rate of a tube depends on the temperature of the chamber and how the tube is mounted inside the furnace. A tube can be enclosed in the structure of the furnace or not enclosed.

An enclosed tube has a lower maximum heat transfer rate than a tube which is free to radiate in all directions.

<table>
<thead>
<tr>
<th>Table 4.1 Maximum heat transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEMPERATURE (°F)</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>1300</td>
</tr>
<tr>
<td>1550</td>
</tr>
<tr>
<td>1650</td>
</tr>
<tr>
<td>1750</td>
</tr>
<tr>
<td>1850</td>
</tr>
</tbody>
</table>

**Calculate the maximum heat release**

Multiply the previously calculated tube surface area by the maximum heat transfer rate:

\[ \text{Maximum heat release} = \text{tube surface area} \times \text{max heat transfer rate} \]

**Compare the heat releases**

Compare the required heat release with the maximum heat release. If the required heat release is greater than the maximum heat release, then the number or the size of the radiant tubes must be increased.
Caution:  
Exceeding the maximum heat release will significantly shorten the tube life.

Determine efficiency

Decide whether or not you want to use a recuperator. A recuperator is a heat exchanger which uses heat from the exhaust to pre-heat the combustion air. The effect of a recuperator on the efficiency of the system can be significant, as shows from the figure and table below.

Table 4.2 Efficiency

<table>
<thead>
<tr>
<th>Furnace Chamber Temperature (°F)</th>
<th>% Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Recuperator (Ambient Air)</td>
</tr>
<tr>
<td>1000</td>
<td>57</td>
</tr>
<tr>
<td>1300</td>
<td>51</td>
</tr>
<tr>
<td>1550</td>
<td>47</td>
</tr>
<tr>
<td>1650</td>
<td>44</td>
</tr>
<tr>
<td>1750</td>
<td>41</td>
</tr>
<tr>
<td>1850</td>
<td>39</td>
</tr>
</tbody>
</table>

Calculate the gross burner input

Calculate the gross burner input (Btu/hr) with this formula:

\[
\text{Gross burner input} = \frac{\text{Max heat transfer rate} \times \text{Tube surface area}}{\text{Efficiency}}
\]
Compare the gross burner input

Compare the gross burner input with the maximum tube input. If the gross burner input from the table below is greater than the maximum tube input, then the size of the radiant tube must be increased.

Table 4.3 Maximum tube input

<table>
<thead>
<tr>
<th>TUBE I.D. (IN INCHES)</th>
<th>MAXIMUM INPUT (1000'S BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>600</td>
</tr>
<tr>
<td>6</td>
<td>900</td>
</tr>
<tr>
<td>8</td>
<td>1500</td>
</tr>
<tr>
<td>10</td>
<td>2500</td>
</tr>
<tr>
<td>12</td>
<td>3500</td>
</tr>
</tbody>
</table>

Exceeding these inputs may result in burner pulsation or other operational problems.

Application parameters

- 4 U-tubes - 4.5" OD x 75" effective length per stretch of tube
- 500,000 Btu/hr net required - recuperated
- 1650 °F chamber temperature
- open radiant angles (not enclosed tubes).

1. The required heat release:

\[
\text{Required heat release} = \frac{\text{net required input}}{\text{number of tubes}}
\]

- \(\frac{500,000}{4} = 125,000\) Btu/hr

2. Tube surface area for each tube:

\[
\text{Tube surface area} = OD \times \pi \times n \times L
\]

- \(4.5 \times 3.142 \times 2 \times 75 = 2120.85\) in\(^2\).

\(n=2\) Because it is a U-tube which has two legs.

3. From Table 4.1 "Maximum heat transfer rate" on page 4-2 follows the maximum heat transfer rate:

- \(60\) Btu/in\(^2\)/hr.
4. The maximum permissible heat release (per tube) is:

\[ \text{Maximum heat release} = \text{tube surface area} \times \text{max heat transfer rate} \]

\[ = 2120.85 \times 60 = 127,251 \text{ Btu/hr.} \]

5. This is sufficient, because only 125,000 Btu/hr is required.

6. From Table 4.2 "Efficiency" on page 4-3 follows the efficiency with a recuperator at 1650 °F:

- 64%.

7. The gross burner input (per tube) is:

\[ \text{Gross burner input} = \frac{\text{Net required input} \times 100}{\text{Efficiency}} \]

\[ = \frac{(125,000 / 64) \times 100}{1} = 195,312 \text{ Btu/hr.} \]

Size the system for 200,000 Btu/hr per burner.

8. Compare the result you got in step 7 to the required maximum inputs in Table 4.3 on page 4-4.

**Fuel type**

The usable fuel types are:

- natural gas
- propane
- butane.

For other fuels, contact Eclipse Combustion with an accurate breakdown of the fuel contents.

**Air type**

In radiant tube applications, the ThermThief burners can be used in conjunction with an exhaust leg recuperator such as the Eclipse Bayonet-Ultra, Bulletin 318. By transferring heat from the exhaust to the combustion air supply, recuperators can increase fuel efficiency by as much as 20%. The ThermThief burners can be used with combustion air temperatures up to 800 °F.

- ambient
- preheat.
**Air tube length**

The air tube length varies based on the location of the hot face of the furnace relative to the mounting flange of the burner.

*Figure 4.1 Air tube length*

The end of the air tube 1 must be within 1/4" of the face of the furnace wall 2.

You must choose the length closest to your requirements. You can find the air tube lengths (dimension B) that are available in Table 3.7 "Air tube length" on page 3-10.

**Step 1b: Immersion tube burner application**

**Determine the net output required to the tank**

The net output to the tank follows from heat balance calculations. These calculations are based on the heatup- and steady state-requirements of the process, and take into account surface losses, tank wall losses and tank heat storage. Detailed guidelines for heat balance calculations are in the Eclipse Combustion Engineering Guide (EFE 825).

**Determine the efficiency**

The efficiency of the tube is directly linked to the effective tube length. The diameter of the tube has no influence on the efficiency. The efficiency of the tube is the factor between the burner input to the tube and net output to the tank. At a given burner input, the net output to the tank is higher for a longer tube than for a relatively short tube.
Note:
A commonly used efficiency is 70%. Efficiencies greater than 85% will produce condensation in the tube which may shorten tube life or disrupt the system.

Figure 4.2 below shows the relationship between the tube length and the efficiency.

**Figure 4.2 Effective tube length**

The effective tube length required is a function of the efficiency chosen.

The effective length of a tube is the total length of straight tube covered by liquid. Add 13 in for each 90° bend.

**Calculate the gross burner input**

Calculate the gross burner input, in (Btu/hr) with this formula:

\[
\text{Burner input} = \frac{\text{Net output to the tank}}{\text{Tube efficiency}}
\]
Compare the gross burner input

Compare the gross burner input with the maximum tube input. If the gross burner input from the table below is greater than the maximum tube input, then the size of the radiant tube must be increased.

Table 4.4 Maximum tube input

<table>
<thead>
<tr>
<th>TUBE I.D. (IN)</th>
<th>MAXIMUM INPUT (1000's BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>600</td>
</tr>
<tr>
<td>6</td>
<td>900</td>
</tr>
<tr>
<td>8</td>
<td>1500</td>
</tr>
<tr>
<td>10</td>
<td>2500</td>
</tr>
<tr>
<td>12</td>
<td>3500</td>
</tr>
</tbody>
</table>

Exceeding these inputs may result in burner pulsation or other operational problems.

Note:
It is recommended that you do not exceed 50 Btu/hr per in² for cooking oil.

Fuel type

The usable fuel types are:

- natural gas
- propane
- butane.

For other fuels, contact Eclipse Combustion with an accurate breakdown of the fuel contents.
Air tube length

The air tube length should be as short as possible to maximize the exposure of the immersion tube to the flame.

*Caution:*

Any section of immersion tube that extends beyond the nozzle, must be submerged in the liquid.

Figure 4.3 Air tube length

You must choose the length closest to your requirements. You can find the air tube lengths (dimension B) that are available in Table 3.7 "Air tube length" on page 3-10.

1. Elbows
   a. We recommend the use of standard and sweep elbows only.
   b. The first elbow should be at least eight tube diameters from the face of the burner.

2. Stack
   a. Make sure that the stack is large enough to handle the exhaust flow plus the dilution air.
   b. The stack must be at least one pipe size larger than the tube exhaust.

*Note:*

If you use a common stack for more than one burner, then make sure that the stack is large enough to handle the exhaust flow plus any dilution air from all the burners. Detailed guidelines for flue sizing calculations are in the Eclipse Combustion Engineering Guide (EFE 825).
3. Draft breaking hood

A draft breaking hood is an open connection between the heater tube exhaust and the exhaust stack. It allows fresh dilution air to pass into the exhaust and mix with the exhaust gases.

The advantages of a draft hood are:

- the burner operation is less sensitive to atmospheric conditions
- the temperature of the exhaust gases is lower when they pass through the roof.

Note:

Make sure that it is possible to get access between the draft hood and the tube exhaust. Then you can install a damper plate if acoustic feedback occurs in the tube.

Step 3: Control methodology

The control methodology is the basis for the rest of the design process. Once you know what your system will look like, you can select the components that are in it. Which control methodology you choose depends on the type of process that you want to control.

Control methods

There are two main methods to control the input of a ThermThief system.

1. Modulating control

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. The burner operates at 15% excess air at high fire, and 100% excess air (min.) at low fire.

2. High/low control

A system with high/low control gives a high or low fire input to the process. No input between high and low fire is possible. The burner operates at 15% excess air at high fire, and 100% excess air (min.) at low fire.

On page 4-11 you will find schematics of these control methods. The symbols in the schematics are explained in the Appendix, on page -2.
Automatic gas shut-off by burner (optional)
As an option, an automatic gas shut-off valve can be installed.
If the flame monitoring system detects a failure, then the gas shut-off valve closes the gas supply to the burner that causes the failure.

System schematics
1. Air
   The control valve ① is in the air line. It sets the air flow to the required value.

2. Gas
   The ratio regulator ① allows the required amount of gas to go to the burner. Low fire gas is limited by ratio regulator ①. High fire gas is limited by the manual butterfly valve ①.

Figure 4.4 System schematics

Combustion air at ambient temperature
(Radiant & Immersion applications)

Pre-heated combustion air
(Radiant applications)
Step 4: Ignition System

For the ignition system you should use:

- 6000 VAC transformers
- full wave spark transformers
- one transformer per burner.

Do NOT use:

- 10,000 VAC transformers
- twin outlet transformers
- distributor type transformers
- half wave spark transformers.

ThermThief burners are capable of direct spark ignition anywhere within the listed operating range. However, it is recommended that low fire start be used. Local safety and insurance requirements demand that you limit the maximum time that a burner takes to ignite. These time limits vary from country to country. For the USA the time limit is 15 seconds, for Europe it is 3 seconds.

The time that a burner takes 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.

In the USA, with a time of 15 seconds to ignition, there should be sufficient time to ignite the burners. It is possible, however, to have the low fire too low to ignite within the time limit. Under these circumstances you must consider the following options:

- start at higher input levels
- resize and/or relocate the gas controls

Step 5: Flame monitoring system

A flame monitoring system consists of two main parts:

- a flame sensor
- flame safeguard.

Note:

A flame monitoring system may not be required. Check your local standards to verify.

Flame sensor

You can find information in:

- Info Guide 852; 90° U.V. scanner
- Info Guide 854; straight U.V. scanner

Note:

When using the U.V. scanner it is necessary to use mounting adaptor part #109750 to ensure that the U.V. scanner will not detect the ignition spark.
Flame safeguard
The flame safeguard is the equipment that processes the signal from the U.V. scanner.

For flame safeguard selection you have several options:
- flame safeguard for each burner: if one burner goes down, only that burner will be shut-off.
- multiple burner flame safeguard: if one burner goes down, all burners will be shut-off.

There are three flame safeguards that are recommended:
- Bi-flame series; see Bulletin/Info guide 826
- Multi-flame series 6000; see Bulletin/Info guide 820
- Veri-flame; see Bulletin/Info guide 610, 620, 630.

All industrial models are acceptable.

Step 6: Combustion Air System: Blower and air pressure switch

The effects of atmospheric conditions
The blower data are based on the International Standard Atmosphere (ISA) at Mean Sea Level (MSL), which means that it is valid for:
- sea level
- 29.92" Hg
- 70°F.

If you are above sea level or in a hot area, the properties of the air are different. The density of the air decreases, and as a result of that, 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 for 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:

Follow these steps:

1. Calculate the outlet pressure.
   
   When you calculate the outlet pressure of the blower, you must calculate the total of these pressures:
   - the static air pressure required at the burner
   - the total pressure drops in the piping
   - the total of the pressure drops across the valves
   - the pressure in the radiant or immersion tube (suction or pressurized)
   - recommend safety margin of 10%.
2. Calculate the flow.

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

\[
\text{Air flow} = \text{Gas flow} \times \text{Air/gas ratio} \times \text{Air factor} \times \text{Number of burners}
\]

Example:
- 4 burners
- gross input 750,000 Btu/hr, each burner
- natural gas → heating value = 1000 Btu/ft^3
  \[
  \text{air/gas ratio (stoichiometric)} = 9.41 : 1
  \]
- 15% excess air → excess air ratio = 1.15

\[
\begin{align*}
\text{Gas flow} &= \frac{\text{Input}}{\text{Heating value}} \\
&= \frac{750,000}{1000} = 750 \text{ scfh} \\
\text{Air flow} &= 750 \times 9.41 \times 1.15 \times 4 = 32465 \text{ scfh}
\end{align*}
\]

Note:
scfh = standard cubic feet per hour = ft^3/hr at standard conditions.

3. Find the blower catalog number and motor Horse Power (HP).

With the output pressure and the specific flow, you can find the blower catalog number and the motor HP in the blower Bulletin / Info Guide.

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 Clock Wise (CW) or Counter Clock Wise (CCW).

Note:
The standard direction of rotation is CCW. If you order a CW version, the unit is more expensive and has a longer delivery time.

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

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 data that you should have now:
- blower catalog number
- motor HP
- TEFC
- voltage, number of phases, frequency
- rotation direction (CW or CCW).

This is everything that you need to order a blower with motor.

**Air pressure switch**

The air pressure switch gives a signal to the safety system when there is not enough air pressure from the blower. The suggested pressure switch for the ThermThief combustion system is:
- Eclipse-Dungs Model A2.

You can find more information on this switch in:
- Blower Bulletin 610
- Bulletin I-354.

**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 representative or Eclipse Combustion.

Note:
Eclipse Combustion supports NFPA regulations (two shut-off valves) on a minimum standard for main gas "safety shut-off valves".

**Consult Eclipse**

The process temperature control system is used to control and monitor the temperature of the system.

There is a wide variety of control equipment and measuring equipment available.

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

---

Eclipse ThermThief Design Guide 310-3/96
## Conversion Factors

### Metric to English

This table also contains a few Metric to Metric conversions.

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>lb</td>
<td>2.205</td>
</tr>
<tr>
<td>kPa</td>
<td>mbar</td>
<td>10</td>
</tr>
<tr>
<td>kW</td>
<td>Btu/hr</td>
<td>3414</td>
</tr>
<tr>
<td>m</td>
<td>ft</td>
<td>3.28</td>
</tr>
<tr>
<td>m³</td>
<td>ft³</td>
<td>35.31</td>
</tr>
<tr>
<td>m³/h</td>
<td>cfm</td>
<td>35.31</td>
</tr>
<tr>
<td>mbar</td>
<td>in wc</td>
<td>0.401</td>
</tr>
<tr>
<td>mbar</td>
<td>kPa</td>
<td>0.1</td>
</tr>
<tr>
<td>mbar</td>
<td>Psi</td>
<td>14.5 x 10^-3</td>
</tr>
<tr>
<td>mm</td>
<td>in</td>
<td>3.94 x 10^-2</td>
</tr>
</tbody>
</table>

°F = 9/5°C + 32

### English to Metric

This table also contains a few English to English conversions.

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Btu/hr</td>
<td>kW</td>
<td>0.293 x 10^-3</td>
</tr>
<tr>
<td>cfm</td>
<td>m³/h</td>
<td>2.832 x 10^-2</td>
</tr>
<tr>
<td>ft</td>
<td>m</td>
<td>0.3048</td>
</tr>
<tr>
<td>ft³</td>
<td>m³</td>
<td>2.832 x 10^-2</td>
</tr>
<tr>
<td>in</td>
<td>ft</td>
<td>8.333 x 10^-2</td>
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<tr>
<td>in</td>
<td>mm</td>
<td>25.4</td>
</tr>
<tr>
<td>in wc</td>
<td>mbar</td>
<td>2.49</td>
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<tr>
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<td>kg</td>
<td>0.454</td>
</tr>
<tr>
<td>Psi</td>
<td>mbar</td>
<td>68.95</td>
</tr>
</tbody>
</table>

°C = 5/9 (°F - 32)
**Key to the System Schematics**

These are the symbols that are used in the schematics.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Appearance</th>
<th>Name</th>
<th>Remarks</th>
<th>Bulletin/Info Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>ThermThief burner</td>
<td>Available sizes: • 30 TFB • 75 TFB • 200 TFB.</td>
<td></td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Recuperator</td>
<td>A recuperator is a heat exchanger. It transfers heat from the exhaust gases to the combustion air. Doing that can improve the thermal efficiency of the burner by as much as 20%.</td>
<td>318</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Safety valve train</td>
<td>Eclipse Combustion, Inc. strongly endorses NFPA as a minimum.</td>
<td>756</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Combustion air blower</td>
<td>The combustion air blower provides the combustion air to the burner(s).</td>
<td>610</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Air pressure switch</td>
<td>The air pressure switch gives a signal to the safety system when there is not enough air pressure from the blower.</td>
<td>610 1-354</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Gas cock</td>
<td>Gas cocks are used to manually shut off the gas supply on both sides of the main gas shut-off valve train.</td>
<td>710</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Solenoid valve</td>
<td>Solenoid valves are used to automatically shut off the gas supply on small capacity burner systems.</td>
<td>760</td>
</tr>
<tr>
<td>![Symbol]</td>
<td>![Appearance]</td>
<td>Manual butterfly valve</td>
<td>Manual butterfly valves are used to balance the air flow at each burner, and/or to control the zone flow.</td>
<td>720</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>APPEARANCE</td>
<td>NAME</td>
<td>REMARKS</td>
<td>BULLETIN/INFO GUIDE</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automatic butterfly valve</td>
<td>Automatic butterfly valves are typically used to set the output of the system.</td>
<td>720</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ratio regulator</td>
<td>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 ratio regulator and the air supply line.</td>
<td>742</td>
</tr>
</tbody>
</table>
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