Design Guide

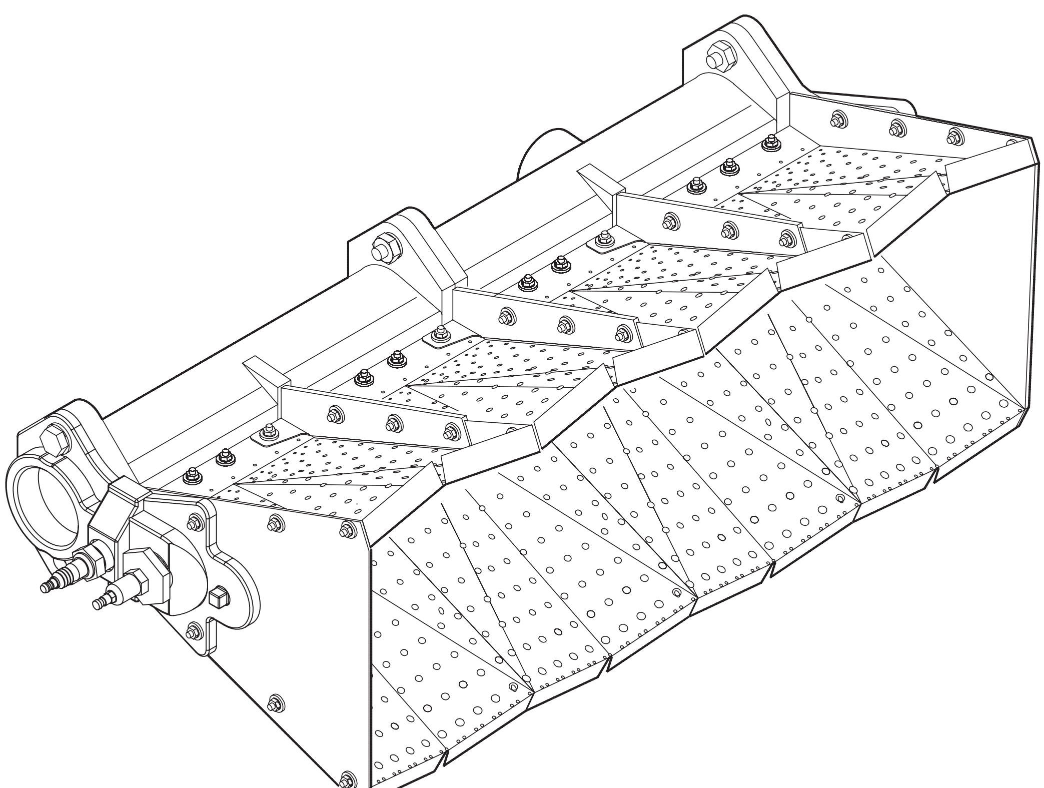
No. 160, 8/1/05

Eclipse Combustion

AirHeat Burners

AH-MA Series

Version 2



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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 an air heat 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.

AH-MA PUBLICATIONS

Design Guide No. 160
- This publication.

Data Sheet No. 160
- Required to complete design calculations in this guide.

Installation Guide No. 160
- Used with Data Sheet to complete installation.

Price Sheet No. 160
- Used to order burners.

RELATED PUBLICATIONS

- EFE-825 (Combustion Engineering Guide)
- Eclipse Bulletins & Instruction Manuals: 818, 820, 826, 832, 852, 854, 856

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 consent from Eclipse Combustion.
- If you do not understand any part of the information in this manual, do not continue. Contact your Eclipse sales office or Eclipse Combustion.

Document conventions

There are several special symbols in this document. You must know their meaning and importance.

The explanation of these symbols follows. 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.

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Introduction

1

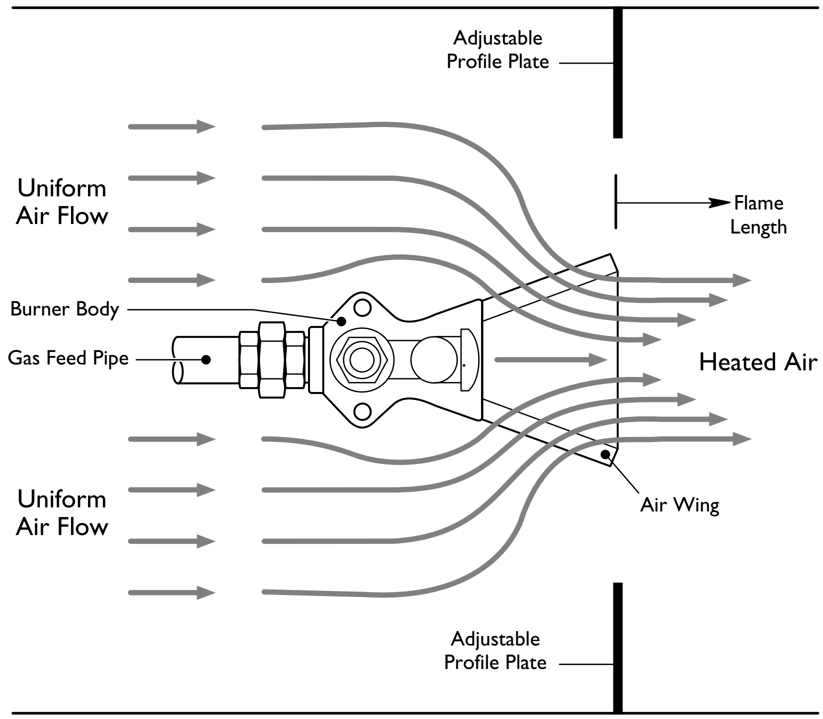
Product description

Eclipse AH-MA v2.10 Air Heat burners produce a uniform, odorless, and smokeless flame ideal for heating fresh air in make-up and process air heating applications. The AH-MA design provides stable operation over a wide range of velocities, inputs, and fuels.

AH-MA v2.10 burners are line type burners constructed of cast iron or aluminum burner bodies and diverging stainless steel air wings. The burner bodies supply fuel to the center of the air wings to control the air and fuel mixture inside the burner and to optimize emissions and efficiency. Completely corrosion resistant design options are available using aluminum burner bodies or electroless nickel plated cast iron burner bodies.

The AH-MA v2.10 Air Heat burner is assembled from straight sections, tees, and crosses to produce nearly any configuration required. Large burners can be built as a combination of staged, individually controlled sections to increase turndown.

Figure 1.1 **AH-MA v2.10 Air Heat Burner**



Safety

2

Introduction

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

Safety

Danger:

The burners covered in this manual are designed to mix fuel with air and burn the resulting mixture. All fuel burn-ing 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.

Warning:

The burner and duct sections are 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 limited design purpose. Do not deviate from any instructions 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 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, CGA and/or CE approval where applicable.

System Design

3

Design

Design structure

Designing a burner system is a straight-forward exercise of combining modules that add up to a reliable and safe system.

The design process is divided into the following steps:

1. Burner design
   a. calculating the maximum input requirements
   b. choosing design heat input at high fire
   c. determining the length of burner needed
   d. calculating the minimum input requirements
   e. layout of the burner sections
   f. sizing and layout of the gas manifold
   g. sizing the profile plates
   h. burner staging
2. Control methodology
3. Ignition system
4. Flame monitoring system
5. Gas valve train selection

Note:
Information in Data Sheet No. 160 is necessary to complete some of the procedures.

Step 1: Burner design

Calculating the maximum input requirements

To calculate the total burner maximum input required, solve:

Max. Input (Btu/hr) = 1.3 x SCFM x ΔT (max)

Caution:
This is an approximation based on the gross heating value of the fuel. For more accurate heat balance calculations, refer to the Eclipse Combustion Engineering Guide (EFE-825).

Choosing design heat input at high fire

See Data Sheet No. 160 for the following:

1) Use the "Operating Range" chart to determine the maximum and minimum heat inputs per foot of burner based on the known air pressure drop.
2) Use the "Flame Length" chart to check flame length versus available distance downstream of the burner for uniform temperature distribution.

Determining the length of burner needed

$$\textit{Burner length, feet} = \frac{\textit{max. heat input, total burner (Btu/hr)}}{\textit{heat input per foot (Btu/hr/ft)}}$$

Note:
Round fractional lengths (in ft.) up to the next half-foot.

Calculating minimum input required

1) ***Minimum Input (Btu/hr) = 1.3 x SCFM x ΔT (min)***
2) $$\textit{Min. Heat Input per foot, Btu/hr/ft} = \frac{\textit{min. heat input, total burner, Btu/hr.}}{\textit{burner length, feet}}$$
3) With the minimum heat input per foot, go to the "Operating Range" chart in Data Sheet No. 160 and confirm that the burner can operate at the input for the air pressure drop the burner will see. If the minimum input required is too low, there are two options to obtain this operating condition:
   a. Use a staged burner control (see burner staging and control methods in this section).
   b. Modulate the air flow to a lower pressure drop, thus lowering the minimum input capability of the burner.

Example: A make-up air heat burner will be used to heat 60,000 SCFM air from 0°F to 80°F maximum; and, from 75°F to 80°F minimum. Air ΔP across the burner is designed to be 0.7"w.c. at high fire. The fuel is natural gas.

1) Max. Input Required: Btu/hr = 1.3 X 60,000 X 80 = 6,240,000 Btu/hr.

2) From the "Operating Range" chart in Data Sheet No. 160, the maximum heat input at 0.7"w.c. air pressure drop is 800,000 Btu/hr/ft. The flame length from the "Flame Length" chart in Data Sheet No. 160 is 30".

$$\text{Burner length, feet} = \frac{6{,}240{,}000 \text{ Btu/hr}}{800{,}000 \text{ Btu/hr/ft}} = 7.8 \text{ feet; round up to 8 feet.}$$

3) Minimum: Btu/hr = 1.3 X 60,000 X 5 = 390,000 Btu/hr.

4) $$\text{Minimum per foot} = \frac{390{,}000 \text{ Btu/hr}}{8 \text{ ft.}} = 48{,}750 \text{ Btu/hr/ft.}$$

5) From the "Operating Range" chart in Data Sheet No. 160, the minimum input at 0.7" w.c. is 20,000 Btu/hr/ft. Therefore, the burner can operate over the desired input range.

Layout of the burner sections

Once the lineal feet of burner has been determined, use Figure 3.2 and the criteria below to define the burner geometry.

For optimum burner performance and a uniform temperature profile, even gas and air flow throughout the burner is essential. The following guidelines should be used to lay out a burner:

1) Every leg of a Tee or Cross section must be separated from another Tee or Cross section by at least 150mm (6") of burner.

2) Include the proper number of gas feed inlet sections. Use Table 3.1 as a guide to the number and size of gas feed inlets required based on the length of the burner.

Table 3.1 **Gas Feed Inlet Capacities**

Gas Inlet Pipe Size	Directon	Section Type	Gas Pressure	Max. Burner Length Per Inlet*
1"	Side	300mm straight section	standard	1
1-1/2"	Rear	300mm straight section, Cast Iron	standard	4
1-1/2"	Side	300mm straight section	standard	3
2"	Rear	300mm straight section, Aluminum	standard	4
2"	Rear	300mm x 300mm cross section	standard	6
2"	Side	300mm straight section	standard	4
1"	Side	300mm straight section	Low	.5
1-1/2"	Rear	300mm straight section, Cast Iron	Low	2
1-1/2"	Side	300mm straight section	Low	1.5
2"	Rear	300mm straight section, Aluminum	Low	2
2"	Rear	300mm x 300mm cross section	Low	6
2"	Side	300mm straight section	Low	2

* Number of feet or 300mm sections

Example: A six-foot burner for standard gas pressure will use 2" N.P.T. rear inlets to supply gas. How many gas inlets are required?

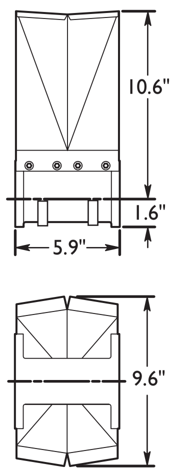
Solution: Each 2" back inlet can supply 4 feet of burner.

Therefore, 6/4 = 1.5, or 2 inlets are required

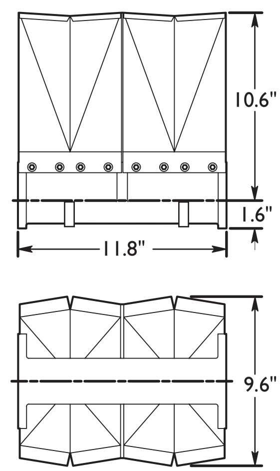
3) Space gas inlets equally to assure uniform gas distribution.

Figure 3.1

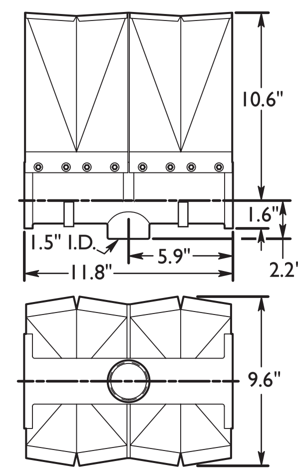
Cast Iron Burner Sections



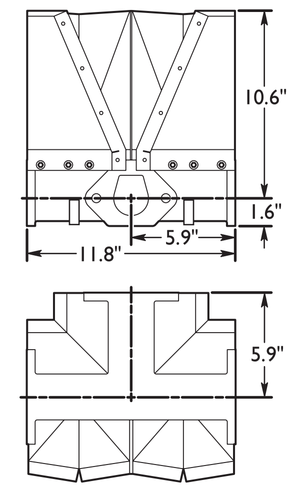
150mm Straight Section



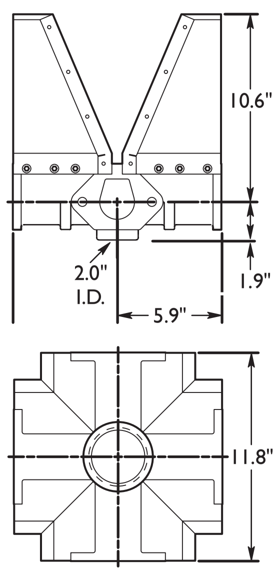
300mm Straight Section



300mm Straight Section with Back Inlet



150mm x 300mm Tee Section



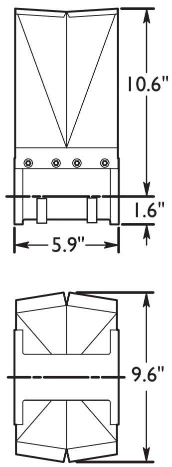
300mm x 300mm Cross

Burner Sections Assembly Numbers, Dimensions & Weights

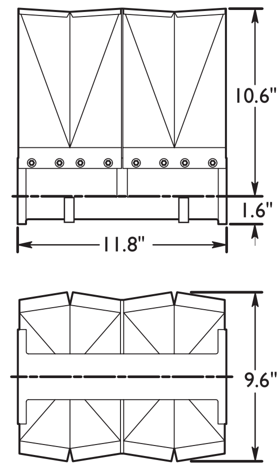
DESCRIPTION	ASSEMBLY NUMBERS			WEIGHT (LBS.)
	CAST IRON BURNER BODIES	CORROSION RESISTANT BURNER BODIES	LOW PRESSURE CAST IRON BURNER BODIES	
150mm Straight Section	102250	102250-1	102250-2	7
300mm Straight Section	102238	102238-1	102238-2	14
300mm Straight Section w/Back Inlet, BSP	102240	102240-1	102240-2	16
300mm Straight Section w/Back Inlet, NPT	102239	102239-1	102239-2	16
300mm x 150mm Tee Section	102251	102251-1	102251-2	19
300mm x 300mm Cross Section, BSP	102255	102255-1	102255-2	30
300mm x 300mm Cross Section, NPT	102254	102254-1	102254-2	30

Figure 3.1 (Continued)

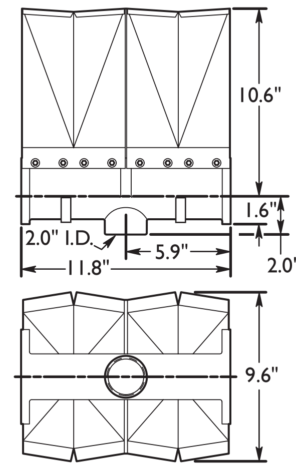
Aluminum Burner Sections



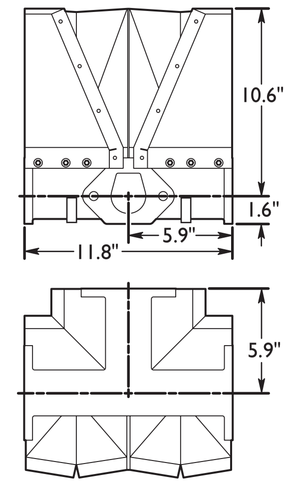
150mm Straight Section



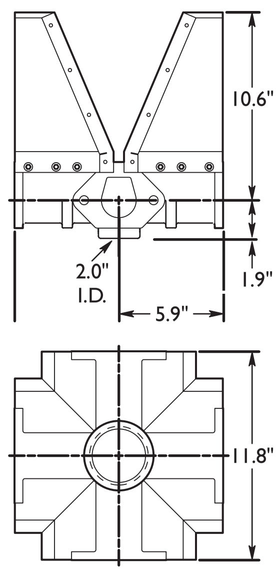
300mm Straight Section



300mm Straight Section
with Back Inlet



150mm x 300mm Tee Section



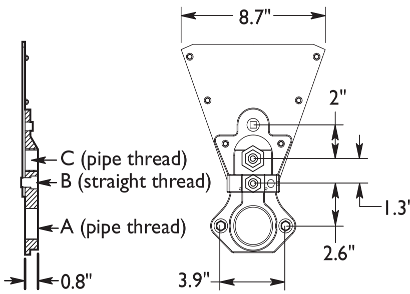
300mm x 300mm Cross

Burner Sections Assembly Numbers, Dimensions & Weights

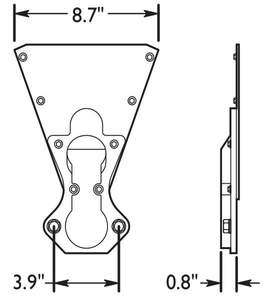
DESCRIPTION	ASSEMBLY NUMBERS		WEIGHT (LBS.)
	ALUMINUM BURNER BODIES	LOW PRESSURE ALUMINUM BURNER BODIES	
150mm Straight Section	102250-3	102250-4	3.5
300mm Straight Section	102238-3	102238-4	7.0
300mm Straight Section w/Back Inlet, BSP	102240-3	102240-4	8.0
300mm Straight Section w/Back Inlet, NPT	102239-3	102239-4	8.0
300mm x 150mm Tee Section	102251-3	102251-4	9.0
300mm x 300mm Cross Section, BSP	102255-3	102255-4	14.0
300mm x 300mm Cross Section, NPT	102254-3	102254-4	14.0

Figure 3.1 (Continued)

End Plate Assemblies



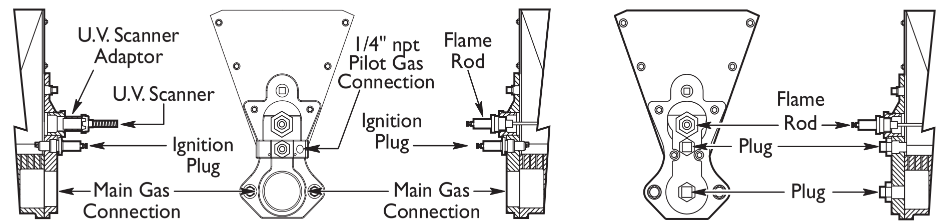
Pilot, Flame Monitoring and Burner Feed End Plate Assemblies



Plain End Plate Assembly

End Plate Examples

(shown with optional UV scanner, flame rod & spark plug installed)



Pilot End with U.V. Scanner

Pilot End with Flame Rod

Flame Monitoring End with Flame Rod

End Plate Assembly Numbers, Dimensions & Weights

DESCRIPTION	ASSEMBLY NUMBERS: CAST IRON END PLATES*	ASSEMBLY NUMBERS: CORROSION RESISTANT END PLATES	DIMENSIONS: A	DIMENSIONS: B	DIMENSIONS: C	WEIGHT (LBS.)
Plain End Plate	102257	102257-1	—	—	—	4
Pilot End Plate, No Gas Feed	10010970	10010970-1	—	14mm	1" NPT	4
Pilot End Plate, 1" Gas Feed NPT	10010972	10010972-1	1" NPT	14mm	1" NPT	4
Pilot End Plate, 1" Gas Feed BSP	10010974	10010974-1	1" BSP	14mm	1" BSP	4
Pilot End Plate, 1.5" Gas Feed NPT	10010975	10010975-1	1.5"NPT	14mm	1" NPT	4
Pilot End Plate, 1.5" Gas Feed BSP	10010976	10010976-1	1.5" BSP	14mm	1" BSP	4
Pilot End Plate, 2" Gas Feed NPT	10010977	10010977-1	2" NPT	14mm	1" NPT	4
Pilot End Plate, 2" Gas Feed BSP	10010978	10010978-1	2" BSP	14mm	1" BSP	4
Pilot End Plate, Angled Flame Monitor NPT	10010979	10010979-1	—	14mm	1" NPT	4
Pilot End Plate, Angled Flame Monitor BSP	10010980	10010980-1	—	14mm	1" BSP	4
Flame Monitoring End Plate, BSP	101237	101237-1	—	—	1" BSP	4
Flame Monitoring End Plate, NPT	101238	101238-1	—	—	1" NPT	4
Burner Feed/Flame Monitoring End Plate, BSP	101233	101233-1	1-1/2" BSP	**	1" BSP	4
Burner Feed/Flame Monitoring End Plate, NPT	101234	101234-1	1-1/2" NPT	**	1" NPT	4
Burner Feed End Plate, BSP	101235	101235-1	1-1/2" BSP	—	—	4
Burner Feed End Plate, NPT	101236	101236-1	1-1/2" NPT	—	—	4

* Standard Cast Iron End Plates with powder coated surface finish are supplied on burners with aluminum gas manifolds.

** 14mm plug may be replaced by ignition plug for direct spark ignition of burners 450mm (18") or less.

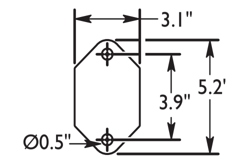
Accessories

DESCRIPTION	PART NUMBER
Mtg. Brkt. for Hanger Rods	21509
Ignition Plug	13047-1
Flame Rod ❶	13093
Divider Plate for Staging	76506
UV Scanner Adapter – 1/2" NPT ❷	202010
UV Scanner Adapter – 3/4" NPT	202011
UV Scanner Adapter – 1" NPT ❸	18767
Pilot Gas Cock	12659

❶ Flame rod ordered with burner includes adapter to pilot or flame monitoring endplate.

❷ Adapter fits Eclipse straight, Eclipse 90 and Honeywell C7027A U.V. scanners.

❸ Adapter fits Eclipse self-check and Honeywell C7035A U.V. scanners.



Divider Plate for Staging

Sizing and layout of the gas manifold

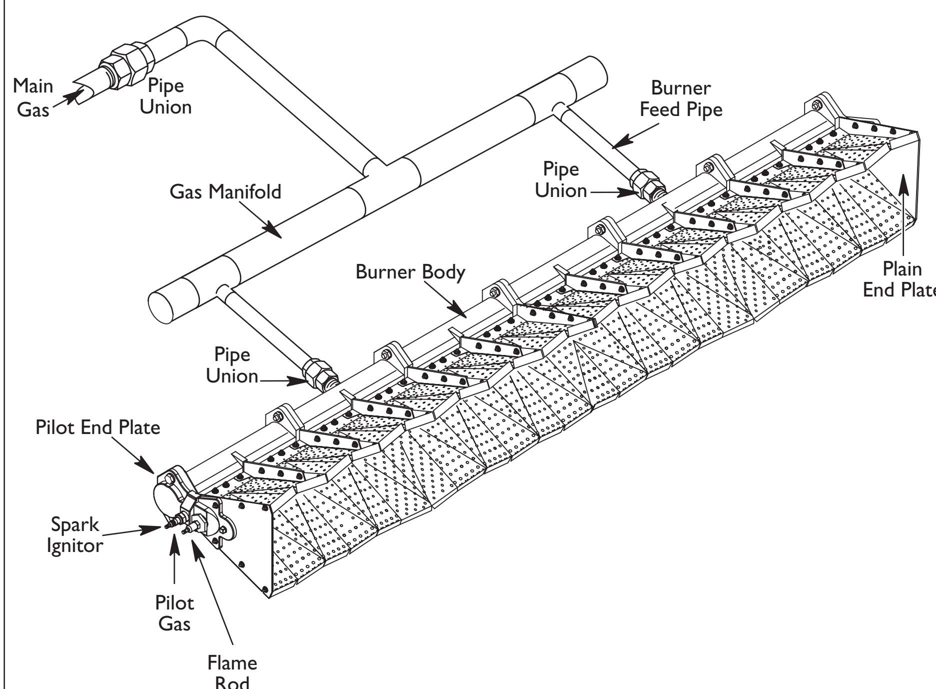
Choose the gas manifold size to evenly supply gas to each of the sections, using Table 3.3 and Figure 3.2.

Table 3.3 Gas Pipe Sizing & Layout

MAXIMUM GAS INPUT (MMBTU/HR.)	MANIFOLD PIPE SIZE (INCHES)	MAXIMUM GAS INPUT (MMBTU/HR.)	MAIN GAS PIPE SIZE (INCHES)
1.4	1-1/2	0.3	1/2
2.5	2	0.6	3/4
5.2	2-1/2	1.1	1
8.0	3	3.2	1-1/2
14.0	4	6.6	2
45.0	6	13.0	2-1/2
80.0	8	20.0	3

Note:
Maximum inputs shown for natural gas only. For propane, multiply inputs by 1.5; for butane, multiply inputs by 1.7.

Figure 3.2 **Gas Manifold Sizing & Layout**



Example: A gas manifold is supplying gas to two 1-1/2" N.P.T. rear inlets on a burner. Each of the rear inlets supplies a maximum of 2,000,000 Btu/hr.

Solution: The total fuel supplied is 2 x 2,000,000 = 4,000,000 Btu/hr.

Referring to Table 3.3, the choice for manifold size is 2-1/2"; the choice for main gas pipe size is 2".

Profile plate sizing

Profile plates are required to ensure sufficient air pressure drop across the burner. An example of profile plate layout is shown in Figure 3.4 on the next page.

Caution:
It is essential that even air flow is delivered to the burner to obtain optimum performance.

To calculate the profile gap sizes, you will need to know the following:

1) SCFM = Total air flow around and through the burner in cubic feet per minute.
2) Design pressure drop across the burner.
3) G_P = Profile gap area required per flow from Figure 3.3; see Table 3.4 for corrections at higher or lower burner air inlet temperatures.

$$\text{Profile area}, A_g = \frac{\text{SCFM} \times G_P}{1000}$$

Where:
A_g = Area in square inches of the gap between the profile plates and the burner.

The areas on the sides of the burners should first be calculated based on a fixed gap of 2". Then calculate the gap size required on the top and bottom to obtain the required profile gap area.

Example: Size a profile plate for a seven-foot long AH-MA v2.00 burner. Air flow around and through the burner will be 60,000 SCFM. The design pressure drop is 0.7"w.c.

Note:
Use a burner wing width of 8.9" for profile gap sizing on top and bottom.

From Figure 3.3: $G_P = 48$

$$A_g = \frac{60{,}000 \times 48}{1{,}000} = 2{,}880 \text{ sq. in.}$$

Calculate gap sizes:

Side Area = 2 x 2" x 8.9" = 36 sq. in.

Area Top & Bottom = 2,880 – 36 = 2,844 sq. in.

$$\text{Therefore, Top \& Bottom Gap} = \frac{2{,}844 \text{ sq. in.}}{(7 \times 12) \times 2 \text{ gaps}} = 16.9 \text{ inches}$$

where 7 x 12 = burner length in inches

Figure 3.3 Profile Gap Area vs. Air Pressure Gap

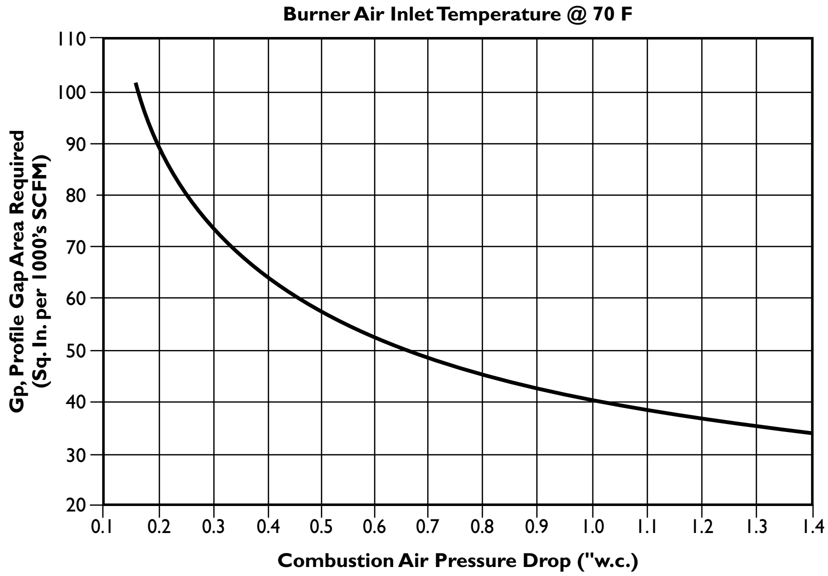


Table 3.4 Profile Gap Area Inlet Air Temperature Correction

Gp @ Air Temp. = Gp from Fig. 3.4 x Correction Factor										
Air Temp. (°F)	0	30	70	150	200	250	300	350	400	450
Correction Factor	0.87	0.92	1.00	1.15	1.25	1.34	1.43	1.53	1.62	1.72

Figure 3.4 Single Burner Profile Plates

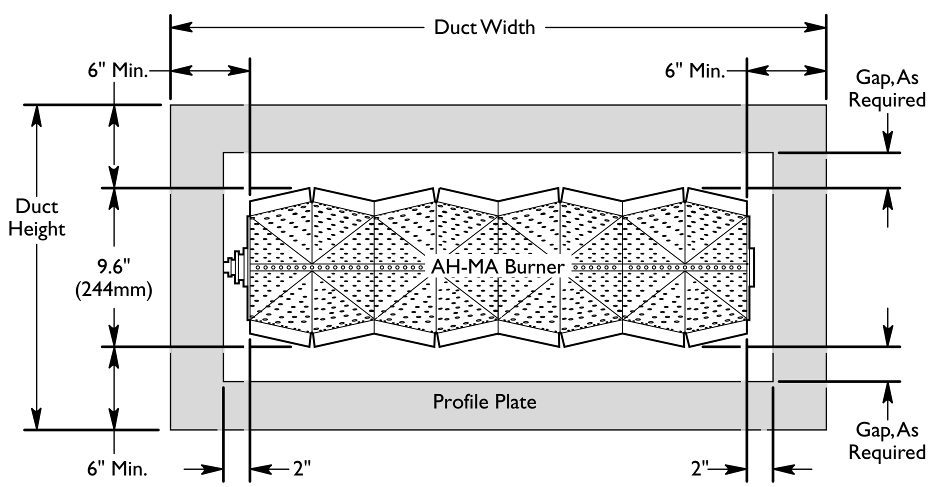
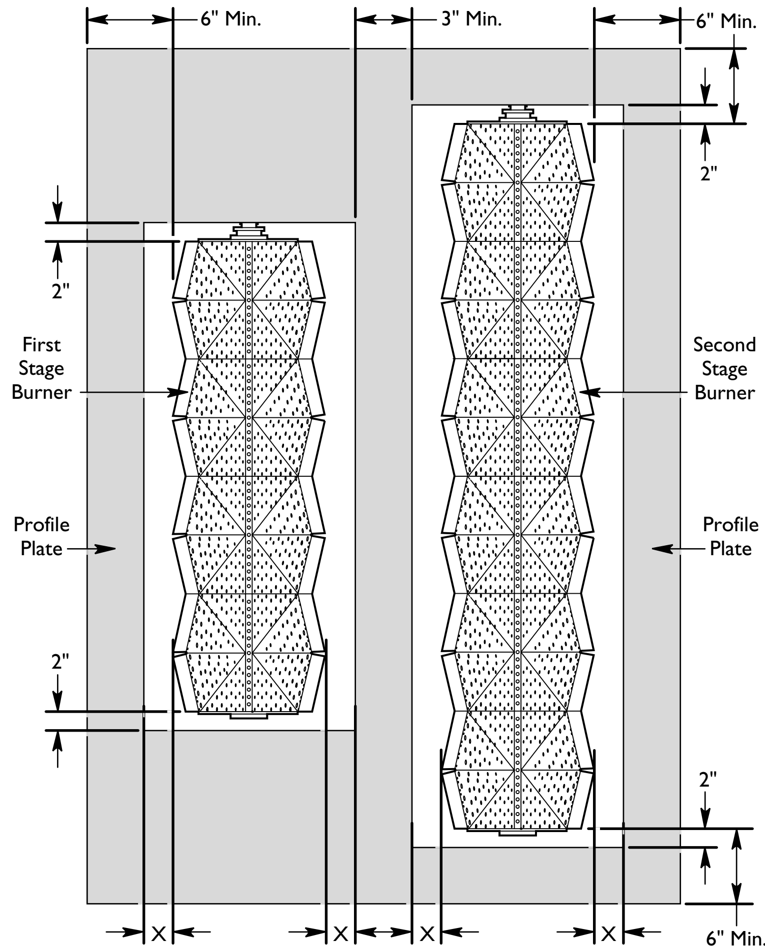
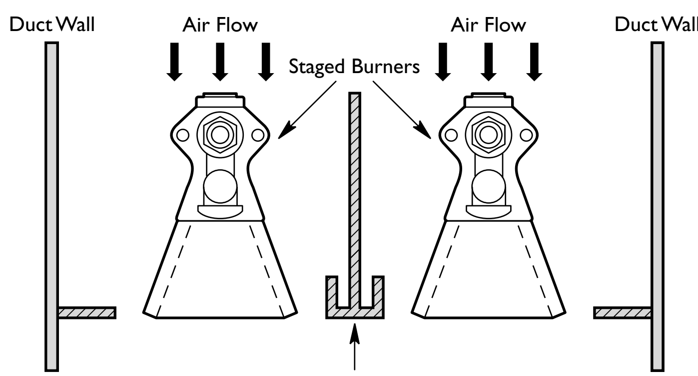


Figure 3.5 Two-Stage Burner Profile Plates



Note:
Make all profile gaps equal (shown as "X" above); profile plate width between the burners should be at least 3".



Steel channel of the correct width can be used as the center profile plate. Install with the legs pointing toward the incoming air flow.

Note:
To compensate for changes in actual air flow versus calculated, provide adjustable profile plates so that final settings can be made in the field. Figure 3.6 shows an example of an adjustable profile plate design.

Figure 3.6 Adjustable Profile Plates

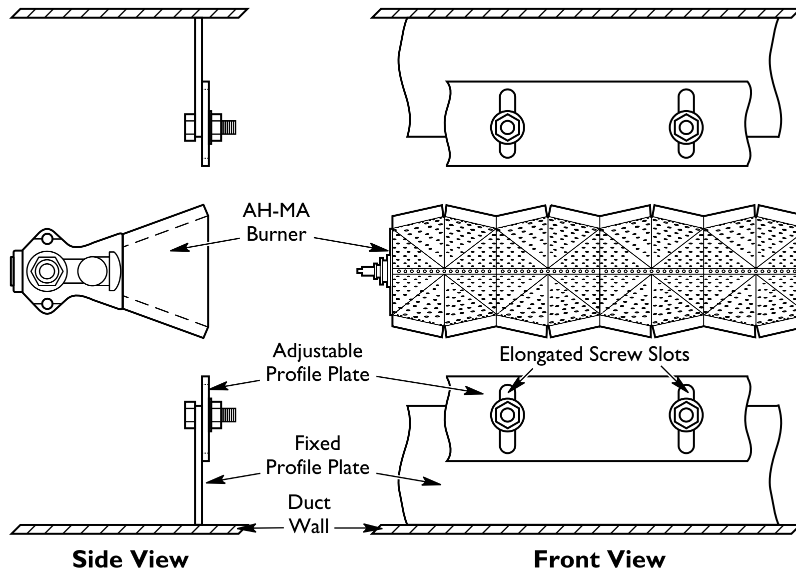
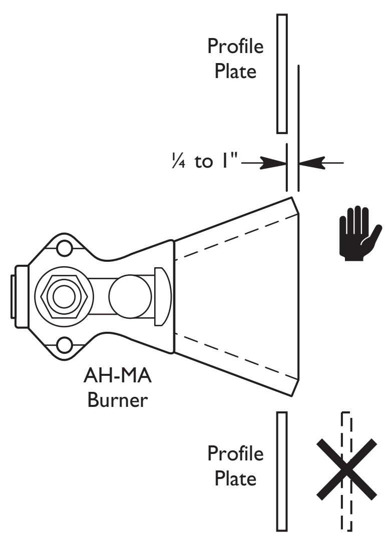


Figure 3.7 Profile Plate Positioning



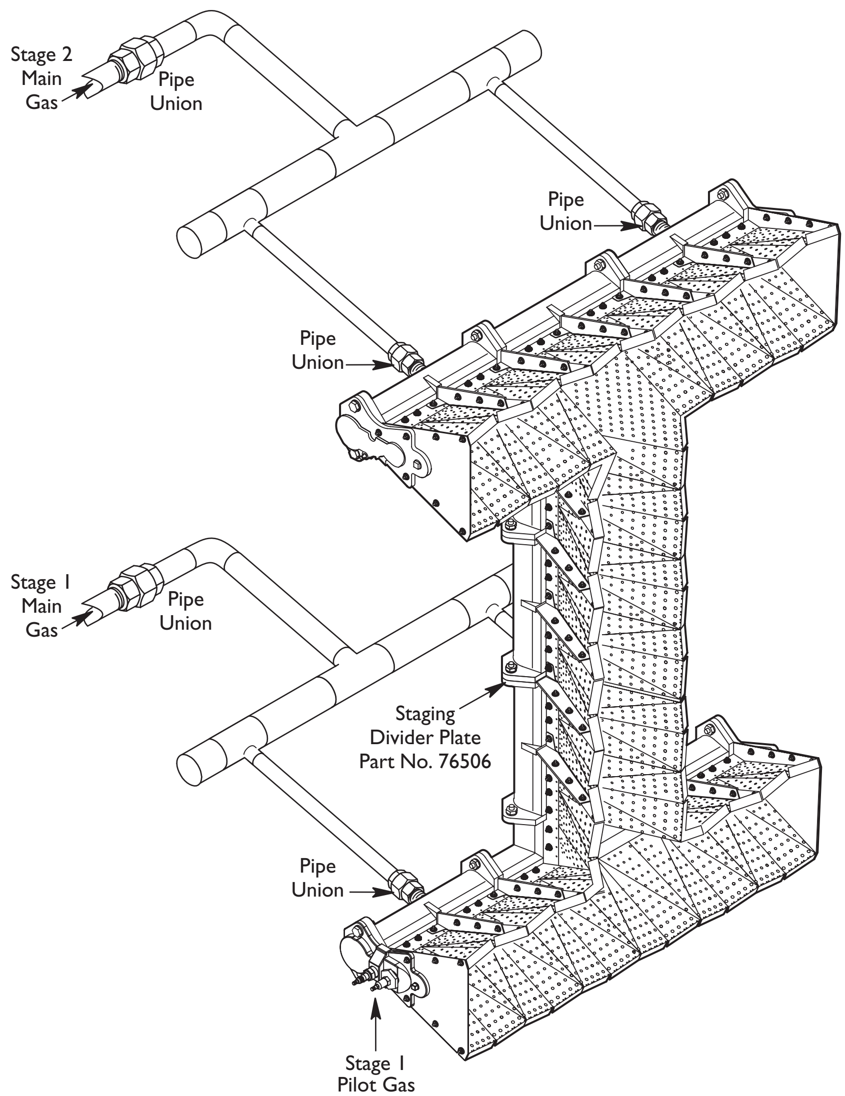
Caution:
Profiles plate should be positioned upstream of the firing end of the burner. If necessary, the plates can be located up to 1" back from the firing end, but under no circumstances should they be in front of the burner.

Step 2: Control Methodology

The simplest control method is fuel modulation at fixed air flow. If required turndown is greater than the burner's capabilities, there are two options:

1. **Air Modulation**
To lower the minimum input of the burner, the air flow can be decreased as long as the pressure drop across the burner does not go outside of the operating limits given in the "Operating Ranges" chart in Data Sheet No. 160. The air flow can be changed with a two-speed air handling system or a modulated system. As an example, the air flow could be turned down from a pressure drop of 1"w.c. to 0.25"w.c., giving a total air turndown of 2:1. This could extend the minimum input level from 20,000 to 13,000 Btu/hr/ft.

Figure 3.8 Staged Burners



2. Burner Fuel Staging

To further increase the burner turndown, AH-MA v2.10 burners can be fuel staged. This can be done by installing two or more separate burners in a duct, each with its own gas control valve, or by dividing a single burner assembly into separate zoned sections. For example, to double the effective turndown, two burner sections may be "staged" as shown in Figure 3.8 on the previous page. If more heat is required, stage 2 is lit by simply supplying gas to it. It will pilot from the adjacent stage.

Warning:
Lockouts must be provided to shut off gas flow to stage 2 unless flame is proven on stage 1.

A spacer (part #76506) must be installed between the burner bodies to separate the different gas feed sections.

Note:
Ignition performance is enhanced if the gas inlet to stage 2 is as close to the piloting section as possible.

Step 3: Ignition System

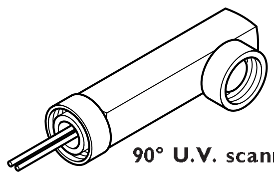
AH-MA v2.10 Air Heat burners have an integral spark-ignited gas pilot for lighting the burner. The pilot fuel is fed into the pilot end casting which is separate from the main fuel. A pilot adjusting valve is required to adjust the pilot gas flow (Eclipse part number 12659 is recommended). The needed pilot capacity is 20,000 Btu/hr, but the pilot will operate equally well at higher or lower inputs. The pilot is shut off after successfully igniting the main burner to protect the ignitor.

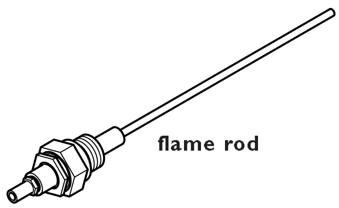
Local safety and insurance requirements demand that you limit the maximum time that a burner takes to ignite. These time limits vary from country to country. For the USA, the time limit is 15 seconds; for Europe, it is typically 3 seconds. Local requirements may require shorter time limits. Verify local regulation and insurance requirements with the authority having jurisdiction.

The time that a burner takes to ignite depends on:

- the distance between the gas shut-off valve and the burner
- the air pressure drop across the burner
- the gas flow at start conditions.

Step 4: Flame monitoring system





A flame monitoring system consists of two main parts:

- a flame sensor
- a flame safeguard.

Flame Sensor

There are two types that you can use for an AH-MA v2.10 Air Heat burner:

- U.V. scanner
- flame rod.

You can find information on U.V. scanners in:

- Instruction Manual No. 852; 90° U.V. scanner
- Instruction Manual No. 854; straight U.V. scanner
- Instruction Manual No. 855; solid state U.V./IR scanner
- Instruction Manual No. 856; self-check U.V. scanner.

You can find information on flame rods in:

- Bulletin/Info Guide No. 832.

Flame Monitoring Control

The Flame Monitoring Control processes the signal from the flame rod or U.V. scanner and controls both the start-up sequence and the main gas shut-off valve sequence..

For flame safeguard selection there are two options for staged burners depending on the application requirements:

- 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.

Eclipse Combustion recommends the use of flame monitoring control systems which maintain a spark for the entire trial for ignition time when using U.V. scanners. Some of these flame monitoring models are:

- Veri-Flame series; see Bulletin/Instruction Manual No. 818
- Bi-Flame series; see Bulletin/Instruction Manual No. 826
- Multi-Flame series; see Bulletin/Instruction Manual No. 820.

Burners over 5 lineal feet include flame supervision at the far end. If pilot ignition is being used, two flame supervision units are required; one for the pilot and one for the far end. Per NFPA 86, if using direct spark on the main flame, only flame supervision at the far end is required providing ignition can be accomplished within 15 seconds.

Step 5: Gas Valve Train Selection

Figures 3.9 and 3.10 illustrate gas valve trains for single and staged burner systems respectively.

The typical main gas valve train for a staged burner has the same valve layout as a single burner except each burner has an individual solenoid valve to independently shut down each section. A common gas shut-off valve train can be used.

Figure 3.9 Single-Staged Burner Valve Layout

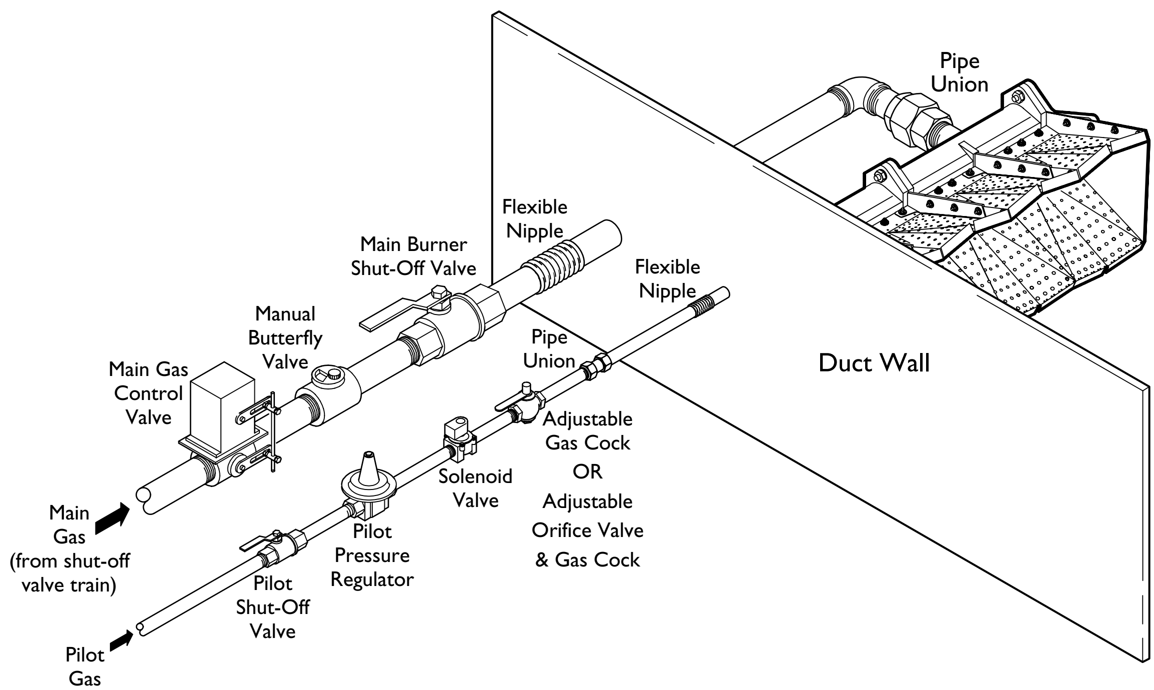
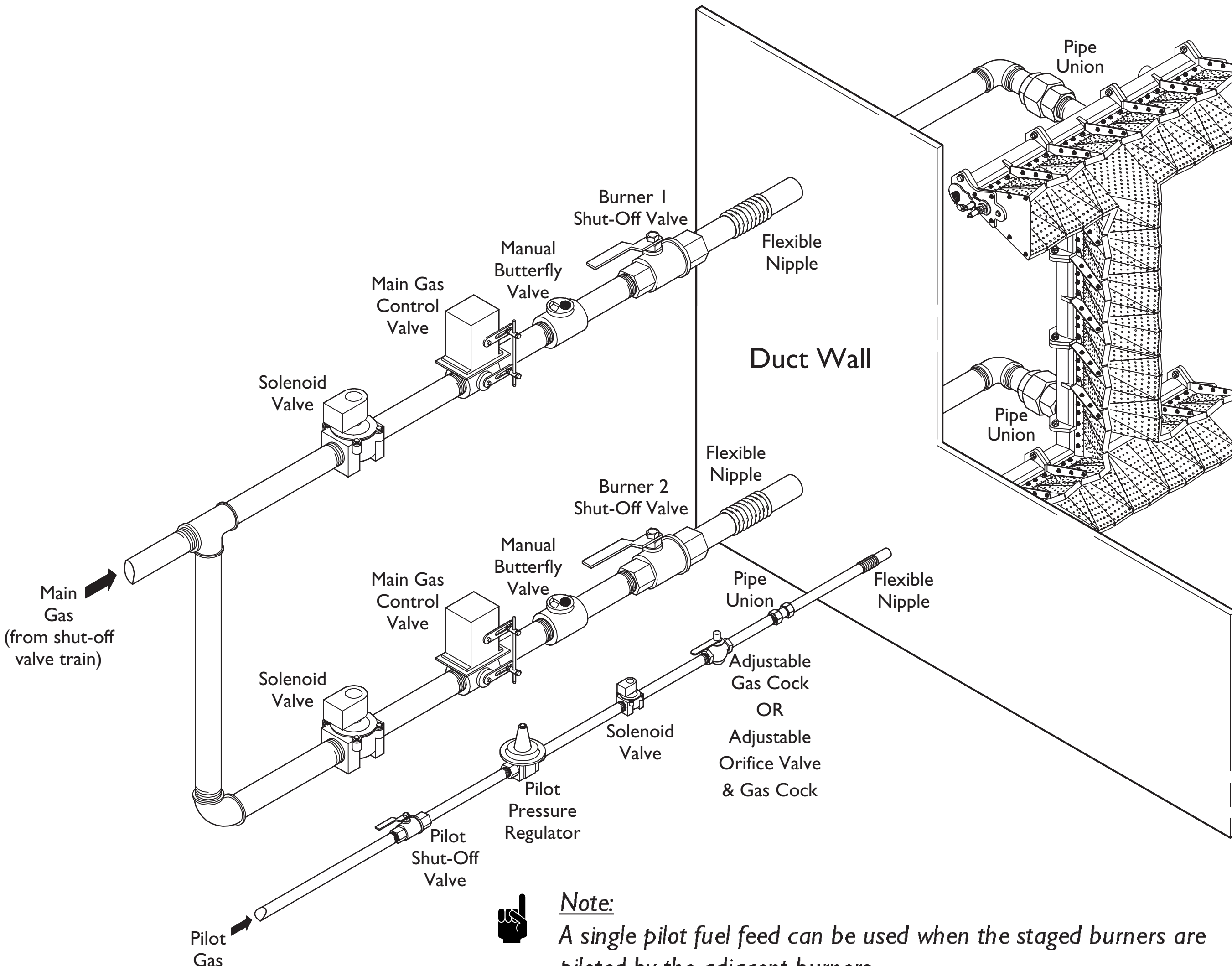


***Figure 3.10* Staged Burner Valve Layout**



Note:
A single pilot fuel feed can be used when the staged burners are piloted by the adjacent burners.

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 local safety standards set by authorities that have jurisdiction.

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

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

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 (°C)	degrees Fahrenheit (°F)	(°C 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 ("wc)	0.401
millibar (mbar)	pounds/sq in (psi)	14.5×10^{-3}
millimeter (mm)	inch (in)	3.94×10^{-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 (ft^3)	cubic meter (m^3)	2.832×10^{-2}
cubic foot/hour (cfh)	cubic meter/hour (m^3/h)	2.832×10^{-2}
degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F – 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

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