Venting & Combustion Air Design Guide

CFR® Boilers

Models CFR 1500 and CFR 3000

Other documents for this product include:

- OMM-0163 Installation Manual
- OMM-0164 Operation-Service Manual
- TAG-0106 CFR Boiler Gas Guide
- TAG-0107 CFR Boiler Application Guide
- TAG-0108 CFR Boiler Electrical Guide

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1. GENERAL

The CFR gas-fired boiler is a fan-assisted, hydronic-heating unit with the following venting capabilities:

1. Room Combustion Air, Vertical Discharge
2. Ducted Combustion Air, Vertical Discharge

It is critical that the flue gas vent be designed to prevent condensation in the flue gas vent for safe operation. Condensation can occur in the CFR boiler, thus each is fitted with a condensate removal trap, as indicated in Figure #, which illustrates the air inlet, vent connections and condensate removal connection. However, with its advance technology, the CFR boiler always delivers dry flue gas for safe exhaust into Category I venting.

The following guidelines provide broad latitude while meeting the objectives of safety, longevity and optimum performance.

2. APPROVED VENT MATERIALS

The CFR Boiler is a fan-assisted Category I appliance, defined in the National Fuel Gas Code ANSI Z223.1/NFPA54 as "an appliance that operates with a non-positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent", which require careful attention to exhaust venting and combustion air details for safe operation.

The following vent materials are allowed and must be installed in accordance with the manufacturer's installation instructions:

- Factory-built chimneys listed in accordance with ANSI/UL 103, ANSI/UL 2561, or ANSI/UL 959
- Type B gas vents listed in accordance with ANSI/UL 441.

It is the responsibility of the design engineer and installing contractor to ensure all vent system designs and installations follow industry best practices, including proper pitch, support, and drainage to prevent failure.

Proper clearances to combustibles must be maintained per UL and the vent manufacturer requirements. The UL, National Fuel Gas Code (ANSI Z223.1/ NFPA54) guidelines are often the basis for state and local codes. AERCO's recommendations follow the guidelines of these agencies, unless more stringent codes govern the installation site. The venting and combustion air systems must meet all applicable code requirements.

2.1 Masonry Chimneys

Exterior Masonry Chimneys, defined as masonry chimneys exposed to the outdoors on one or more sides below the roof line, cannot be used due to high flue heat loss which can affect the draft produced in the system. When venting into interior masonry chimneys, refer and adhere to the latest publication of NFPA54 for chimney lining material, sizing, and termination requirements. When using an existing chimney, it must be approved for Cat I appliance, and inspected/cleaned to ensure it is structurally sound and free of blockage for proper operation. If the condition of existing chimney is deemed unsuitable to use, it must be relined, repaired, or replaced to comply with the latest publication of NFPA54.

3. CODE REQUIRED VENT TERMINATIONS

The guidelines provided in this bulletin should be followed to comply with the latest publication of UL, NFPA 54 (National Fuel Gas Code, ANSI Z223.1).

Vent terminations must be at least **4 feet (1.22 m)** below, **1 foot (0.30 m)** above or **4 feet (1.22 m)** removed horizontally from any window, door or gravity air inlet of a building. Such terminations must extend beyond the outside face of the wall by at least **6 inches (15.2 cm)**.

The bottom of the vent termination must be at least **12 inches (30.5 cm)** above both finished grade and any maximum snow accumulation level to avoid blocking the vent or air intake. The vent termination must be least **3 feet (0.91 m)** above any forced-air building inlet within **10 feet (3.05 m)**. Design must prevent flue gases from recirculating through the boiler air intake.

Vents must not terminate over public walkways or areas where condensate or vapor could create a nuisance or be detrimental to the operation of regulators, meters or related equipment.

Discharges must not be in high wind areas or corners or be located directly behind vegetation. Discharges in these locations may cause the flue pressures to fluctuate and result in flame instability. Generally, designs should minimize wind effects.

Roof penetrations must follow all applicable codes and the vent manufacturer's instructions. Vents must never be installed at less than required clearances to combustible materials, as enumerated in UL, NFPA, or local codes. "Double-wall" or “Thimble" assemblies are required when vents penetrate combustible walls or roofs.

Vertical discharges must extend at least **3 feet (0.9 M)** above the roof through properly flashed penetrations, and at least **2 feet (0.61 m)** above any object within a **10 foot (3.05 m)** horizontal distance.

Large-mesh screens can be applied to the vent termination to protect against the entry of foreign objects, but the “free area” should be at least 50% larger than the required flue cross-sectional area preceding the vent termination. It is recommended that a T termination be used if a screen is desired. Do not use mesh screens on velocity cones.

If the vent system is to be connected to an existing stack, the stack must be in accordance with NFPA54. Masonry stacks must be lined, and the vent penetration must terminate flush with, and be sealed to, this liner. Vents may enter the stack through the bottom or side. All side connections must enter at a 45-degree connection in the direction of flow and must enter at different elevations, with the smallest vent connection at the highest elevation. CFR boiler vents must not be connected to other AERCO models or another manufacturers' equipment.

The exhaust vent must be pitched upward toward the termination by a minimum of **1/4 inch per foot (21 mm per m)**. Condensate must flow back to the unit freely, without accumulating in the vent.

4. CONDENSATE REMOVAL

Because condensation can occur in the CFR boiler, each unit is fitted with a condensate removal trap. The CFR boiler always delivers dry flue gas for safe exhaust into Category I venting.

The exhaust vent system must be pitched back toward the unit by a minimum of **1/4 inch per foot (21 mm per m)** of duct length to enable condensate to drain back to the unit for disposal. Low spots in the vent must be avoided to prevent the condensate from collecting.

The condensate trap assembly is located directly below the exhaust manifold. Plastic hose must be connected to the trap assembly and run to drain. Care must be taken to avoid hose kinks and to avoid raising the hose above the trap assembly. Condensate must flow freely to drain. The condensate-to-drain run must not be hard-piped so the trap can be removed periodically for maintenance purposes.

If the condensate must be lifted above the trap assembly to a drain, it must be drained into a sump. From there, a pump can lift the condensate away.

Each unit will produce the following approximate condensate quantities:

- **CFR1500** = 9 gallons per hour
- **CFR2000** = 10 gallons per hour
- **CFR3000** = 13 gallons per hour

Condensate drain systems must be sized for above flow rates.

In multiple boiler applications, it is common to manifold these drains together in a plastic pipe manifold to a floor drain. Condensate manifolds must be large enough to handle the anticipated flow and must be properly secured and protected. Manifolds are generally located behind the boilers so that short runs of plastic tubing into the manifold can be used for the condensate drain. A base drain must be installed at the bottom of vertical common flue piping.

The pH level of the condensate produced by CFR boilers ranges between 3.0 and 3.2. The installation must be designed in accordance with local codes that specify acceptable pH limits. If required, any type of commercially available neutralizer may be used. Be sure to follow condensate neutralizer manufacturer's instructions.

5. COMBUSTION AIR SUPPLY

CFR Boilers require the following combustion air volumes when operating at full capacity.

UNIT	VOLUME at 60°F (15.6°C)
CFR1500	325 SCFM (9.20 m^3/min)
CFR2000	500 SCFM (14.16 m^3/min)
CFR3000	700 SCFM (19.82 m^3/min)

These flows MUST be accommodated. Air supply is a direct requirement of NFPA54 and local codes that should be consulted for correct design implementation.

5.1 Combustion Air Quality

In equipment rooms containing other air-consuming equipment — including air compressors and other combustion equipment — the combustion air supply system must be designed to accommodate all such equipment when all are operating simultaneously at maximum capacity.

WARNING!
Combustion air must be free of contaminants.

Combustion air intakes must be located in areas that will not induce excessive (>**0.10" W.C. (25 Pa)**) intake air pressure fluctuations. Designs should consider equipment blowers and exhausts when using room air for combustion.

Air intakes must be located to prevent infiltration of chlorine, chlorides, halogens or any other chemicals detrimental to combustion equipment. Common sources of these chemicals are swimming pools, degreasing compounds, water softener salts, plastic processing and refrigerants. This will ensure the longevity of the equipment and maintain warranty validation.

WARNING!
If the equipment room is in the vicinity of any of these chemicals, it must be supplied with clean combustion air and have a slightly positive room air pressure, provided by a powered combustion air supply louver or duct, to prevent infiltration of chemicals into the room.

Air intakes must not be in the proximity of garages, industrial and medical hood venting, loading docks or refrigerant vent lines. Boilers must not be installed in the proximity of activities that generate dust if that dust can enter the boiler intake. Boilers must be located to prevent moisture and precipitation from entering combustion air inlets.

When a boiler is used, temporarily, to provide heat during ongoing building construction or renovation, accumulated drywall dust, sawdust and similar particles can:

- Accumulate in the unit's combustion air intake and block combustion air flow
- Accumulate over the burner surface and restrict flow of air/fuel mixture

In these situations, AERCO requires that a disposable air intake filter be installed, temporarily, above the boiler combustion air inlet. Air filters may be required year-round in instances in which dust or debris can enter the combustion air tube. Consult the boiler Operations and Maintenance Manual for details.

Combustion air temperatures as low as **-30 °F (-34.4 °C)** can be used without affecting the integrity of the equipment; however, the combustion settings may require adjustment to compensate for site conditions.

6. VENTING AND DUCTED COMBUSTION AIR OPTIONS

The figures below illustrate acceptable venting and ducted combustion layouts. For room air or fresh air combustion through louvers, see Section 8 of this guide.

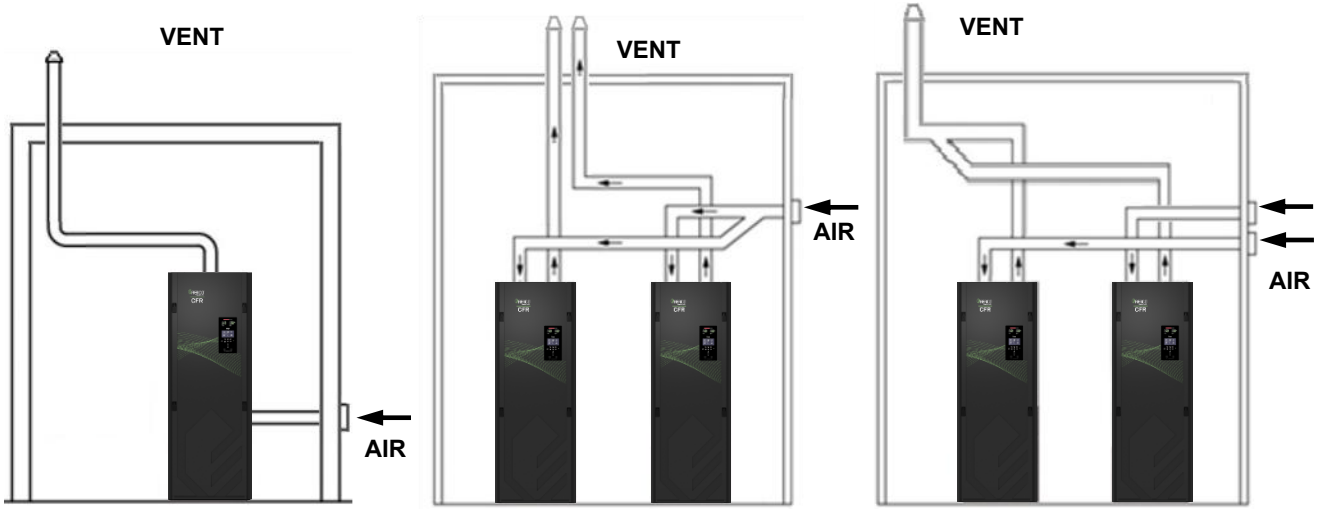


Figure 6-1: Venting and Ducted Combustion Air Options

NOTE: For high wind sites, a tee must be installed at the fresh air inlet. The leg of the tee connects to the combustion air intake.
On the flue vent side, a tee or exit cone (velocity cone) may be utilized in place of a rain cap for high wind sites.
The branches of the tee can be in the horizontal or vertical direction, as determined by the system designer and site conditions.

IMPORTANT!
Other configurations, not depicted in this guide, are possible. Please contact your local AERCO representative or the factory for project specific venting and combustion air configurations.

6.1 Installation Requirements for Vertical Venting

The vent termination must be located as follows (refer to Figure 6-2):

a. Combustion air inlet must be 3 ft. (0.9 m) below any vent outlet that is within 10 ft. (3.1 m).

b. Vertical terminations shall extend at least 3 ft. (0.9 m) above the highest point where it passes through a roof of a building and at least 2 ft. (0.6 m) higher than any portion of the building within a horizontal distance of 10 ft. (3.1 m). Terminations that extend more than 2 ft. above the roof must be laterally supported.

c. Combustion air inlet must also face away from the vent outlet.

d. Use vent pipe manufacturer's vent cap or exit cone (velocity cone), fire stop, support collar, roof flushing and storm collar.

e. AERCO recommends the use of an exit cone in lieu of a termination rain cap for normal installations and T- termination for high-wind areas.

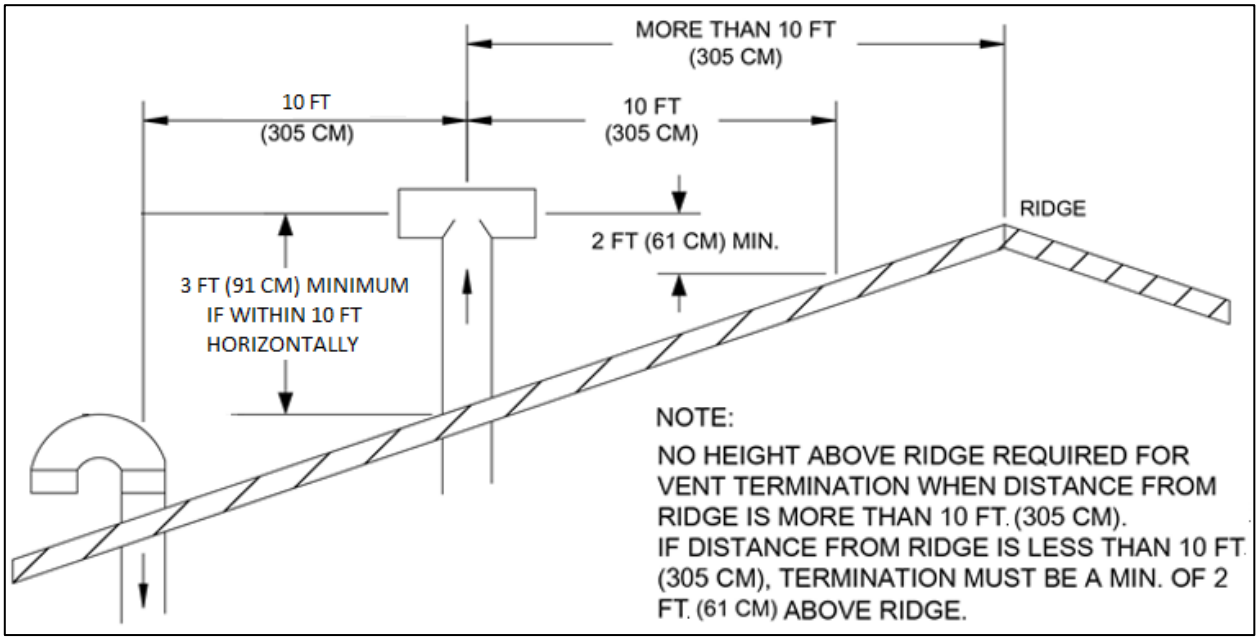


Figure 6-2: Acceptable Combustion Air Inlet & Vent Outlet Configuration

WARNING

Do not insulate or otherwise wrap vent pipe or fittings. Follow the vent pipe manufacturers installation instructions and local codes for vertical venting.

7. VENT & COMBUSTION AIR SYSTEM DESIGN

The minimum exhaust vent sizes are as follows:

Model	Combustion Air Duct Min. Diameter	Exhaust Vent Diameter
CFR1500	8 inch (20.3 cm)	Do not use appliance vent connection size as minimum vent size. Refer to latest edition of NFPA 54/ANSI Z223.1 for sizing Category I venting systems.
CFR2000	8 inch (20.3 cm)	
CFR3000	8 inch (20.3 cm)	

A **1/4-inch (6.35 mm)** NPT combustion test hole is provided on each unit's exhaust manifold connection.

The vent system should always be pitched up 1/4 inch per foot (21 mm per m) of run towards the vent termination to enable condensate to drain back to the unit for disposal. Low spots in the vent must be avoided. Periodic inspection must be performed to assure correct drainage.

CFR boiler vents must not be interconnected to those of other models or other manufacturers' equipment.

Horizontal vent and ductwork must be supported to prevent sagging, in accordance with local code and the vent manufacturer's requirements. Vertical vent and ductwork must be supported to prevent excessive stress on the horizontal runs. The exhaust manifold and inlet air adapter must never be used as weight-supporting elements. The supports must be arranged, and the overall layout designed to assure that stresses on the vent and combustion air connections are minimized.

7.1 Vent Starter Section

Each CFR Boiler is supplied with a vent starter piece that must be field installed.

IMPORTANT: Use only this vent starter section to allow the installation of the stack guard sensor. This sensor is critical for the CFR boiler to operate with dry flue gas in the stack. Do NOT use other commercial vent adapters.

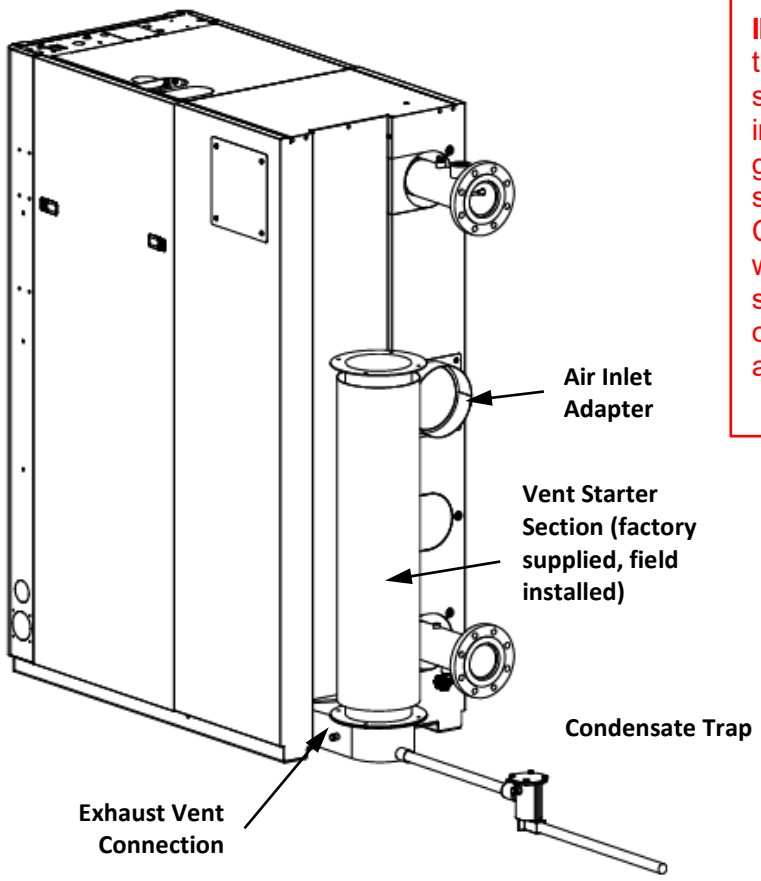


Figure 7-1: Vent Starter Section and Required Vent Terminations

7.2 Elbow Quantity And Separation

The quantity and angle of elbows and the distances between them can influence the system's exhaust and combustion air pressures, as well as its acoustic behavior. Designers should consider minimizing the number of elbows and maximizing the distance between them in the layout design. Use of angles less than 90° is recommended whenever possible. Five or fewer elbows are recommended for individual venting runs; five or fewer are similarly recommended for common sections. In flue and combustion air ducting runs, elbows should remain separated as much as possible. Where close elbows cannot be avoided, factory review is recommended to determine if changes need to be made.

8. SOURCE OF COMBUSTION AIR SUPPLY

8.1 Combustion Air From Within The Building

Where combustion air will originate from within the building, air must be provided to the equipment room from two permanent openings to an interior room (or rooms). Openings connecting indoor spaces must be sized and located in accordance with the following:

- Each opening must have a minimum free area of **1 inch^2 per 1,000 BTU/hr. (2,200 mm^2/kW)** of total input rating of all appliances in the space, but not less than **100 inch^2 (0.06 m^2)**.
- One opening must commence within **12 inches (300 mm)** of the top of the enclosure, and one opening must commence within **12 inches (300 mm)** of the bottom. (See Figure Figure 8-1: All Combustion Air from Adjacent Indoor Spaces).

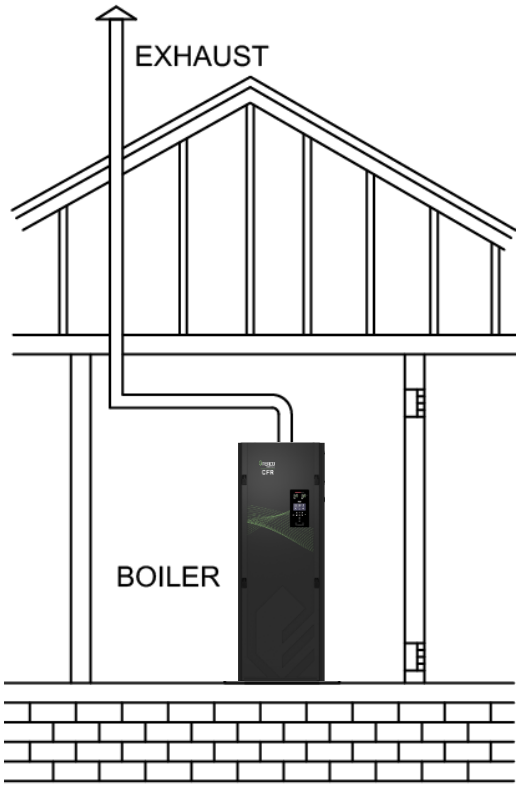


Figure 8-1: All Combustion Air from Adjacent Indoor Spaces

8.2 Combustion Air From Outside the Building

Outdoor combustion air must be provided through opening(s) to the outdoors in accordance with the methods described below. The minimum dimension of air openings must not be less than **3 inches (76 mm)**. The required size of the openings for combustion air must be based upon the net free area of each opening. When the free area through a louver, grille, or screen is known, it must be used to calculate the opening size required to provide the free area specified. For additional details, consult the latest publication of NFPA 54.

Two-Permanent-Openings Method (USA Only)

Two permanent openings must be provided; one commencing within **12 inches (304 mm)** of the top of the enclosure and one commencing within **12 inches (304 mm)** of the bottom. The openings must communicate directly — or by ducts — with the outdoors, or spaces that freely communicate with the outdoors, as show on the following pages:

1. When communicating directly with the outdoors or to the outdoors through vertical ducts, each opening must have a minimum free area of **1 inch^2 per 4,000 BTU/hr. (550 mm^2/kW)** of total input rating of all appliances in the space (see Figure 8-2 and Figure ***8-3***).

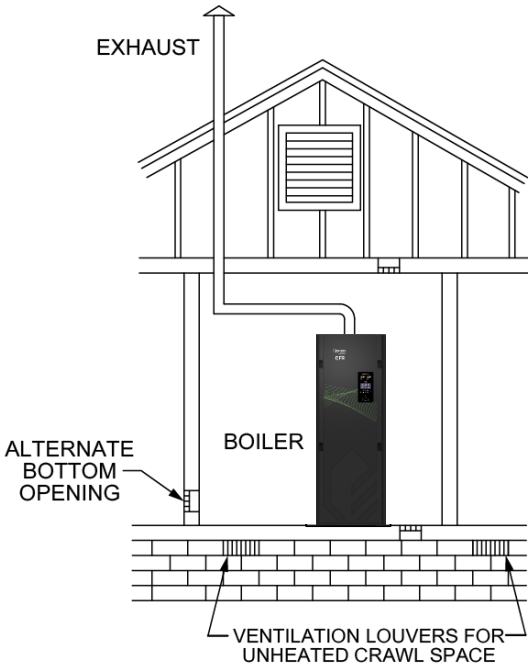


Figure 8-2: All Combustion Air from Outdoors - Inlet Air from Ventilated Crawl Space and Outlet Air to Ventilated Attic

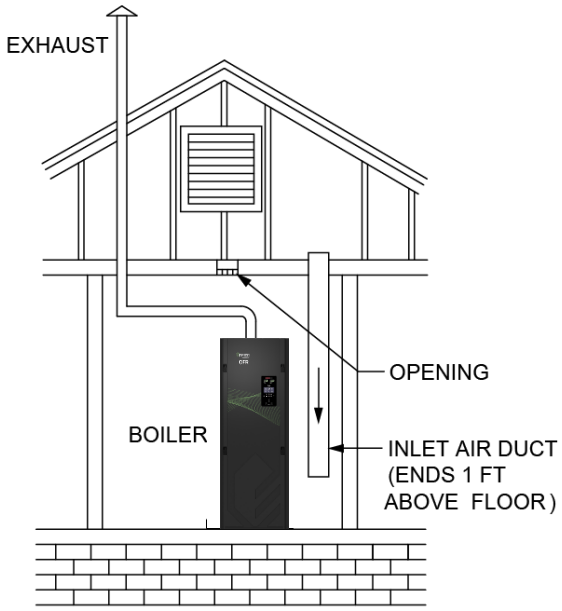


Figure 8-3: All Combustion Air from Outdoors - Through Ventilated Attic

2. When communicating with the outdoors through horizontal ducts, each opening must have a minimum free area of **1 inch^2 per 2,000 BTU/hr. (1100 mm^2/kW)** of total input rating of all appliances in the space.

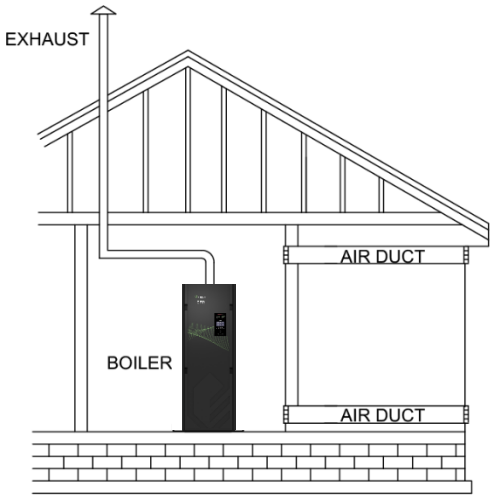


Figure 8-4: All Combustion Air from Outdoors Through Horizontal Ducts

One Permanent Opening Method

- One permanent opening must be provided, within **12 inches (300 mm)** of the top of the enclosure.
- The appliance must have clearances of at least **1 inch (25 mm)** from the sides and back of the appliance, and a clearance of 6 inches (150 mm) from the front.
- The opening must communicate with the outdoors directly or through a vertical or horizontal duct to the outdoors or spaces that freely communicate with the outdoors and have a minimum free area of **1 inch^2 per 3,000 BTU/hr. (700 mm^2/kW)** of the total input rating of all appliances located in the space.

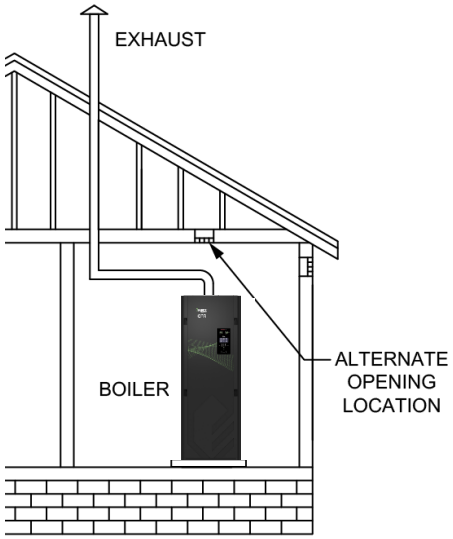


Figure 8-5: All Combustion Air from Outdoors Through Single Combustion Air Opening

Opening a Louver Through the CFR Boiler

A louver can be opened using the auxiliary relay contacts of the CFR boiler. These contacts are provided by a single pole double throw (SPDT) relay that is energized when there is a demand for heat and is de-energized after that demand is satisfied. The relay contacts are rated for 120 VAC at 5 amps, resistive.

NOTE: Do NOT power the louver directly using the Auxiliary Relay. An external relay (not supplied) must be used for this purpose. The boiler power cannot support external accessories.

If the louver features a proof-of-open switch, it must be connected to the boiler's delayed interlock. The delayed interlock must be closed for the unit to fire. If the louver requires time to open, a time-delay must be programmed to hold the start sequence of the boiler long enough for the proof-of-open switch to make (Parameter: **Auxiliary Delay** — programmable from 0 to 240 seconds). If the proof-of-open switch does not prove within the programmed time frame, the boiler will shut down.

For wiring connections and further details regarding the auxiliary relay, delayed interlock and the **Auxiliary Delay** parameter, refer to the Edge Operation Manual, OMM-0139.

If an AERCO Control System (ACS) is being used to manage a multiple boiler installation, the louver must be opened using the System Start Relay of the ACS. Refer to the ACS Operations and Maintenance Manual, OMM-0081, for wiring connections and further details.

8.3 Ducted Combustion Air

The CFR boiler is approved for ducted combustion air installations; i.e., it can draw all combustion air from the outdoors through a metal or PVC duct connected between the CFR unit(s) and the outdoors. This configuration is useful when room air is insufficient or otherwise unsuitable for combustion. The minimum ducted combustion-air duct sizes for CFR boilers are as follows:

CFR1500: 6-inch diameter (15.2 cm) **CFR3000:** 8-inch diameter (20.3 cm)

Combustion air typically enters the CFR boilers through the air inlet on the rear of the unit. CFR 3000 units have the option of installing a side air inlet adapter kit. Two kits are available, for CFR 3000 units only:

1. **58080-1** - 8" Side Air Inlet Adapter Kit
2. **58080-2** - 10" Side Air Inlet Adapter Kit; requires enlarging opening in side panel to fit

For CFR 1500 side air inlet, use the bolt pattern shown in Figure 8-6 for combustion air ductwork installation.

A mesh screen at least 1” x 1” (2.54 mm x 2.54 mm) must be installed at the inlet of the air duct.

See Section 6 for ducted combustion air configuration options.

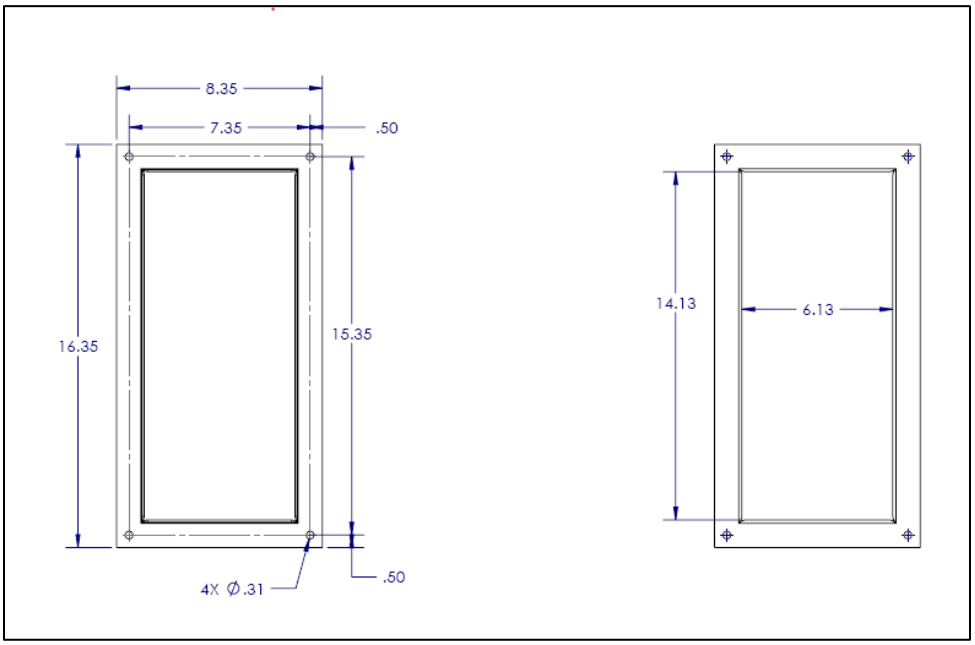


Figure 8-6: Recommended Bolt Pattern for CFR 1500 Side Air Inlet Combustion Ductwork

9. VENT SIZING REQUIREMENTS

An exhaust starter kit consisting of the vent starter section and a vent increaser is provided by AERCO to be field installed. It must be specified when ordering the CFR boiler. The choices are:

1. 8" Flg x 10" crimped (**P/N 99325-10**). Use this when Category I vent sizing from NFPA54 tables require the following individual vent or connection size: 9", 10", 12" and 14".
2. 8" Flg x 18" crimped (**P/N 99325-18**). Use this when Category I vent sizing from NFPA54 tables require the following individual vent or connection size: 16", 18", 20" and 22".
3. 10" Exhaust starter kit (**P/N 24790-10**: an 8" vent starter section and an 8" x 10" vent increaser). Use this when Category I vent sizing from NFPA54 tables require the following individual vent or connection size: 9", 10", 12" and 14".

IMPORTANT: For retrofit applications, replacing a system with the same total BTU capacity does not necessarily mean the existing vent size will work. Size the vent in accordance with NFPA54 as a fan-assisted Category I appliance to determine the correct size.

9.1 Acceptable Pressure Ranges

For individually vented units, the exhaust system must be designed so that the pressure measured is within the range of -0.01 to -0.08" w.c.

For common vented units, the exhaust system must be designed so that the pressure measured is within the range of -0.01 to -0.08" w.c.

Barometric Damper

To ensure that the above pressure range is maintained, the CFR boiler requires a barometric damper to be installed immediately after the factory supplied starter piece (see Figure 9-1). Do not use the appliance vent connection size to determine the size of barometric damper. Refer to latest edition of NFPA 54/ANSI Z223.1 for sizing Category I venting systems to size the vent. Then use that same diameter to size a barometric damper that will be installed immediately after the factory provided starter piece. Refer to the manufacturer's instruction on barometric damper installation, operation, and maintenance.

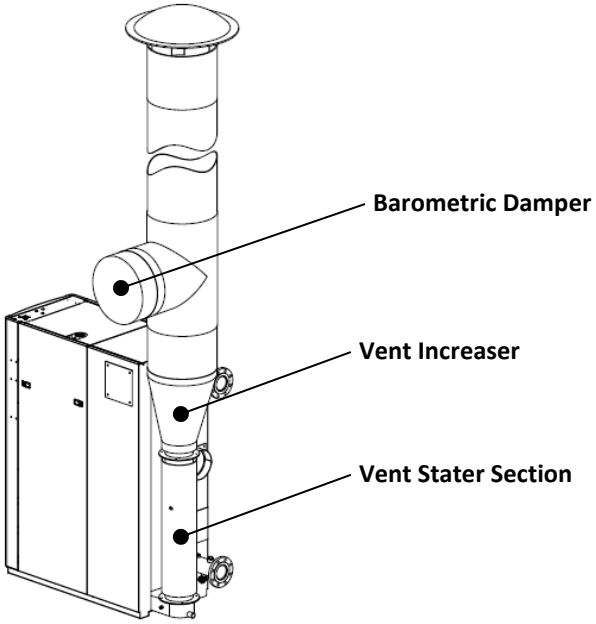


Figure 9-1: Barometric Damper

Exhaust Fans

The CFR boiler is a Category I appliance. The exhaust system must be designed to run at negative pressure. It is suggested that this be accomplished by sizing the system in accordance with the latest publication of National Fuel Gas Code (ANSI Z223.1/ NFPA54) as a fan-assisted Category I appliance.

If the CFR boiler's exhaust system incorporates an exhaust fan, the system designer must size the vent pipe diameters, select the fan, and determine the location of the fan sensor to maintain a -0.01 to -0.08" w.c. pressure range at the outlet of each boiler. Also, the designer must ensure that the exhaust fan material is acceptable for use with Category I appliances.

9.2 Gross Natural Draft

Flue gases have a lower density (and are lighter) than air and will rise, creating "gross natural draft." Gross natural draft is created when flue gases exit the vent at an elevation above the CFR boiler. The amount of draft depends upon the height of the stack and the difference between the flue gas temperature and the surrounding air temperatures (densities).

When sizing the exhaust system per National Fuel Gas Code (ANSI Z223.1/ NFPA54), the selection obtained considers the draft produced.

Contact your AERCO sales representative or AERCO International for design assistance and approval when designing manifolded exhaust vent systems.

9.3 Corrections For Altitude

When sizing the exhaust vent system per the National Fuel Gas Code (ANSI Z223.1/ NFPA54), its charts and instruction provide guidance on how to take into account for high altitude installations.

For combustion air system, the tables in Section 13.2 list correction factors for installation altitudes above sea level. These factors must be applied to the pressure drops of combustion air ducts. The pressure drop through combustion air ducts will increase at higher elevations.

10. INDIVIDUALLY VENTED SYSTEMS

The CFR boiler supports room combustion/vertical discharge and ducted combustion/vertical discharge configurations.

The exhaust system must be sized in accordance with the latest publication of National Fuel Gas Code (ANSI Z223.1/ NFPA54) as a fan-assisted Category I appliance. For individually vented units, the exhaust system must be designed so the pressure measured is within the range of -0.01 to -0.08" w.c.

Consult your local AERCO sales representative for ducted combustion air sizing guidelines.

It should be noted that flow and vent or duct diameter have the most significant effects on overall system pressure drop.

If a rectangular duct is to be used, consult the table in Section 13.3 for a round diameter duct size that has the identical pressure drop per length of rectangular duct.

11. MANIFOLDED SYSTEMS

IMPORTANT:

Contact your AERCO sales representative or AERCO International for design assistance and review when designing manifolded exhaust and manifolded combustion air systems.

In many instances it may be practical to connect multiple units using a manifolded air intake or exhaust configuration. However, when multiple units are connected by a manifolded air intake or exhaust vent, the operation of a given unit can be affected by the others, if the venting or combustion air system is not designed properly. Properly designed common vent and air supply systems can be installed that will prevent "operational interaction" between units.

AERCO CFR fan-assisted boilers are designed suitable for application in common vent systems. The common vent system shall be sized in accordance with the latest publication of National Fuel Gas Code (ANSI Z223.1/ NFPA54) as a fan-assisted Category I appliance. For common vented units, the exhaust system must be designed so that the pressure measured at every point is negative, within the range of -0.01 to -0.08" w.c.

Consult your local AERCO sales representative for ducted combustion air sizing guidelines.

11.1 Two or More Appliances Connected to a Single Vent

Where two or more openings are provided into one chimney flue or vent, either of the following shall apply:

(1) The openings shall be at different levels.

(2) The connectors shall be attached to the vertical portion of the chimney or vent at an angle of 45 degrees or less relative to the vertical. Where two or more vent connectors enter a common vent, chimney flue, or single-wall metal pipe, the smaller connector shall enter at the highest level consistent with the available headroom or clearance to combustible material.It is best practice to use a 45° elbow/wye fitting, when available, to connect to common vent breeching or duct work in the direction of flow in the main breeching. The required minimum common venting vertical vent run should be 10 feet (3.1 m) up to vertical termination after the last boiler is connected to common header.

The vent system should always be pitched up 1/4-inch per foot (21 mm per m) of run towards the vent termination (see Figure 11-1).

It is highly recommended to use one duct size for the common run (See Figure 11-).

CFR boiler vents must not be interconnected to those of other AERCO models or other manufacturers' equipment.

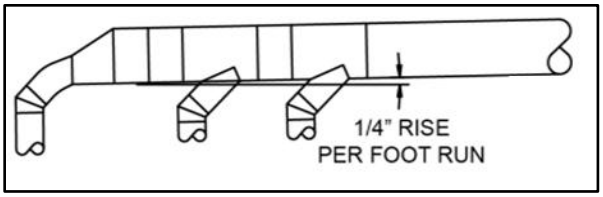


Figure 11-1: Connection of Unit at End of Vent Main

11.2 Removal of Existing Boiler from Common Venting

When an existing boiler is removed from a common venting system, the common venting system is likely to be too large for proper venting of the appliances remaining connected to it. At the time of removal of an existing boiler, the following steps shall be followed with each appliance remaining connected to the common venting system placed in operation, while the other appliances remaining connected to the common venting system are not in operation.

1. Seal any unused openings in the common venting system.
2. Visually inspect the venting system for proper size and horizontal pitch and determine there is no blockage or restriction, leakage, corrosion or other unsafe deficiencies.
3. Insofar as is practical, close all building doors and windows and all doors between the space in which the appliances remaining connected to the common venting system are located and other spaces of the building. Turn on clothes dryers and any appliance not connected to the common venting system. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers.
4. Place in operation the appliance being inspected. Follow the lighting instructions. Adjust thermostat so appliance will operate continuously.
5. Test for spillage at the draft hood relief opening after 5 minutes of main burner operation. Use the flame of a match or candle, or smoke from a cigarette, cigar, or pipe.
6. After determining that each appliance remaining connected to the common venting system properly vents when tested as outlined above, return doors, windows, exhaust fans, fireplace dampers, and any other gas-burning appliance to their previous condition of use.

Any improper operation of the common venting system should be corrected so the installation conforms with the National Fuel Gas Code, ANSI Z223.1/NFPA 54. When resizing any portion of the common venting system, the common venting system should be resized to approach the minimum size as determined using the appropriate tables in Chapter 13 of the National Fuel Gas Code, ANSI Z223.1/NFPA 54.

12. EXHAUST MUFFLER GUIDELINES

An exhaust muffler is recommended when installed in a noise-sensitive application and when the exhaust vent ducting is relatively short in length. Do not use the appliance vent connection size to determine the diameter exhaust muffler. Refer to latest edition of NFPA 54/ANSI Z223.1 for sizing Category I venting systems to size the vent, and then use that same diameter to size a muffler that will be installed immediately after the factory provided starter piece.

The following criteria must be used to determine when to include a field-installed muffler:

- The exhaust is **sidewall vented** and the vent is terminated in close proximity to residences, offices, hotel/hospital rooms, classrooms etc.

-OR-

- The **total vertical and horizontal section** of exhaust vent is **less than 25 linear feet (7.6 m)** from the last unit, and the vent terminates in close proximity to residences, offices, classrooms etc.

For ***manifolded exhaust*** systems, the total vertical section length includes both horizontal and common vertical; individual boiler vertical connectors are included in the determination as well.

EXAMPLE: For an installation that has a **20 foot (6 m)** common vertical, **5 foot (1.5 m)** common horizontal after the last boiler, and each boiler has a **10 foot (3.1 m)** vertical connector, the total section length considered is **35 feet (10.7 m)**. Because this is greater than **25 feet (7.6 m)**, a muffler is ***not*** required.

Contact your local AERCO sales representative for more information on the AERCO exhaust muffler.

13. PRESSURE DROP AND DRAFT DATA TABLES

13.1 Ducted Combustion Air Duct Pressure Drop

Table 13-a: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR1500 Boiler

		Outside Air Temperature in °F (°C)								
Inlet Duct & No. Boilers	**Duct Section Type**	**-30 °F (-34.4)**	**-15 °F (-26.1)**	**0 °F (-17.8)**	**20 °F (-6.7)**	**40 °F (4.4)**	**60 °F (15.6)**	**80 °F (26.7)**	**100 °F (37.8)**	**120 °F (48.9)**
6" Duct Single Boiler	Straight Run	0.98 (0.98)	1.00 (1.00)	1.02 (1.02)	1.06 (1.06)	1.09 (1.09)	1.13 (1.13)	1.16 (1.16)	1.20 (1.20)	1.24 (1.24)
	90° Elbow	4.97 (1.515)	5.21 (1.588)	5.47 (1.667)	5.84 (1.78)	6.23 (1.899)	6.64 (2.024)	7.09 (2.161)	7.56 (2.304)	8.07 (2.46)
	45° Elbow	3.78 (1.152)	3.97 (1.21)	4.17 (1.271)	4.44 (1.353)	4.74 (1.445)	5.06 (1.542)	5.4 (1.646)	5.76 (1.756)	6.14 (1.871)
	Ent. Loss	7.33 (2.234)	7.69 (2.344)	8.07 (2.46)	8.60 (2.621)	9.18 (2.798)	9.79 (2.984)	10.45 (3.185)	11.15 (3.399)	11.89 (3.624)
8" Duct Single Boiler	Straight Run	0.23 (0.23)	0.24 (0.24)	0.24 (0.24)	0.25 (0.25)	0.26 (0.26)	0.27 (0.27)	0.28 (0.28)	0.29 (0.29)	0.30 (0.30)
	90° Elbow	1.19 (0.363)	1.25 (0.381)	1.31 (0.399)	1.39 (0.424)	1.49 (0.454)	1.59 (0.485)	1.69 (0.515)	1.81 (0.552)	1.93 (0.588)
	45° Elbow	0.89 (0.271)	0.94 (0.287)	0.98 (0.299)	1.05 (0.32)	1.12 (0.341)	1.19 (0.363)	1.27 (0.387)	1.36 (0.415)	1.45 (0.442)
	Ent. Loss	2.32 (0.707)	2.43 (0.741)	2.55 (0.777)	2.72 (0.829)	2.90 (0.884)	3.10 (0.945)	3.31 (1.009)	3.53 (1.076)	3.76 (1.146)
10" Duct Two Boilers	Straight Run	0.24 (0.24)	0.25 (0.25)	0.26 (0.26)	0.28 (0.28)	0.30 (0.30)	0.32 (0.32)	0.34 (0.34)	0.36 (0.36)	0.38 (0.38)
	90° Elbow	1.60 (0.488)	1.68 (0.512)	1.77 (0.539)	1.88 (0.573)	2.01 (0.613)	2.14 (0.652)	2.29 (0.698)	2.44 (0.744)	2.60 (0.792)
	45° Elbow	1.21 (0.369)	1.27 (0.387)	1.33 (0.405)	1.42 (0.433)	1.51 (0.46)	1.61 (0.491)	1.72 (0.524)	1.84 (0.561)	1.96 (0.597)
	Ent. Loss	3.80 (1.158)	3.98 (1.213)	4.18 (1.274)	4.46 (1.359)	4.76 (1.451)	5.08 (1.548)	5.42 (1.652)	5.78 (1.762)	6.16 (1.878)
12" Duct Two Boilers	Straight Run	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)	0.14 (0.14)	0.15 (0.15)	0.16 (0.16)
	90° Elbow	0.70 (0.213)	0.73 (0.223)	0.77 (0.235)	0.82 (0.25)	0.88 (0.268)	0.93 (0.283)	1.00 (0.305)	1.06 (0.323)	1.13 (0.344)
	45° Elbow	0.53 (0.162)	0.56 (0.171)	0.59 (0.18)	0.62 (0.189)	0.67 (0.204)	0.71 (0.216)	0.76 (0.232)	0.81 (0.247)	0.86 (0.262)
	Ent. Loss	1.83 (0.558)	1.92 (0.585)	2.02 (0.616)	2.15 (0.655)	2.29 (0.698)	2.45 (0.747)	2.61 (0.796)	2.79 (0.85)	2.97 (0.905)
12" Duct Three Boilers	Straight Run	0.20 (0.20)	0.21 (0.21)	0.22 (0.22)	0.24 (0.24)	0.26 (0.26)	0.27 (0.27)	0.29 (0.29)	0.31 (0.31)	0.33 (0.33)
	90° Elbow	1.57 (0.479)	1.65 (0.503)	1.73 (0.527)	1.85 (0.564)	1.97 (0.6)	2.10 (0.64)	2.24 (0.683)	2.39 (0.728)	2.55 (0.777)
	45° Elbow	1.20 (0.366)	1.26 (0.384)	1.32 (0.402)	1.41 (0.43)	1.50 (0.457)	1.60 (0.488)	1.71 (0.521)	1.82 (0.555)	1.94 (0.591)
	Ent. Loss	4.12 (1.256)	4.32 (1.317)	4.54 (1.384)	4.84 (1.475)	5.16 (1.573)	5.51 (1.679)	5.88 (1.792)	6.27 (1.911)	6.69 (2.039)

Table 13-a: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR1500 Boiler – Continued

		Outside Air Temperature in °F (°C)								
Inlet Duct & No. Boilers	**Duct Section Type**	**-30 °F (-34.4)**	**-15 °F (-26.1)**	**0 °F (-17.8)**	**20 °F (-6.7)**	**40 °F (4.4)**	**60 °F (15.6)**	**80 °F (26.7)**	**100 °F (37.8)**	**120 °F (48.9)**
14" Duct Three Boilers	Straight Run	0.09 (0.09)	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)	0.14 (0.14)	0.14 (0.14)	0.15 (0.15)
	90° Elbow	0.82 (0.25)	0.86 (0.262)	0.9 (0.274)	0.96 (0.293)	1.02 (0.311)	1.09 (0.332)	1.17 (0.357)	1.24 (0.378)	1.33 (0.405)
	45° Elbow	0.63 (0.192)	0.66 (0.201)	0.70 (0.213)	0.74 (0.226)	0.79 (0.241)	0.85 (0.259)	0.90 (0.274)	0.96 (0.293)	1.03 (0.314)
	Ent. Loss	2.22 (0.677)	2.33 (0.71)	2.45 (0.747)	2.61 (0.796)	2.79 (0.85)	2.97 (0.905)	3.17 (0.966)	3.38 (1.03)	3.61 (1.100)
14" Duct Four Boilers	Straight Run	0.16 (0.16)	0.17 (0.17)	0.18 (0.18)	0.19 (0.19)	0.2 (0.20)	0.22 (0.22)	0.23 (0.23)	0.25 (0.25)	0.26 (0.26)
	90° Elbow	1.45 (0.442)	1.53 (0.466)	1.60 (0.488)	1.71 (0.521)	1.82 (0.555)	1.94 (0.591)	2.07 (0.631)	2.21 (0.674)	2.36 (0.719)
	45° Elbow	1.12 (0.341)	1.18 (0.36)	1.24 (0.378)	1.32 (0.402)	1.41 (0.43)	1.50 (0.457)	1.60 (0.488)	1.71 (0.521)	1.83 (0.558)
	Ent. Loss	3.95 (1.204)	4.15 (1.265)	4.35 (1.326)	4.64 (1.414)	4.95 (1.509)	5.29 (1.612)	5.64 (1.719)	6.02 (1.835)	6.42 (1.957)
16" Duct Four Boilers	Straight Run	0.08 (0.08)	0.09 (0.09)	0.09 (0.09)	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)	0.13 (0.13)
	90° Elbow	0.84 (0.256)	0.88 (0.268)	0.93 (0.283)	0.99 (0.302)	1.06 (0.323)	1.13 (0.344)	1.20 (0.366)	1.28 (0.39)	1.37 (0.418)
	45° Elbow	0.66 (0.201)	0.69 (0.21)	0.73 (0.223)	0.78 (0.238)	0.83 (0.253)	0.88 (0.268)	0.94 (0.287)	1 (0.305)	1.07 (0.326)
	Ent. Loss	2.32 (0.707)	2.43 (0.741)	2.55 (0.777)	2.72 (0.829)	2.9 (0.884)	3.10 (0.945)	3.31 (1.009)	3.53 (1.076)	3.76 (1.146)

NOTES: 1) Calculation assumes 300 SCFM (8.49 m^3/min) per boiler at full fire rate

2) Units for "Straight Run" pressure drop values are equivalent feet per foot (eq. m / m)

3) Units for "Elbows" and "Ent. Loss" are equivalent feet per item (eq. m / item)

Table 13-b: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR2000 Boiler

		Outside Air Temperature in °F (°C)								
Inlet Duct & No. Boilers	**Duct Section Type**	**-30 °F (-34.4)**	**-15 °F (-26.1)**	**0 °F (-17.8)**	**20 °F (-6.7)**	**40 °F (4.4)**	**60 °F (15.6)**	**80 °F (26.7)**	**100 °F (37.8)**	**120 °F (48.9)**
8" Duct Single Boiler	Straight Run	0.40 (0.40)	0.41 (0.41)	0.42 (0.42)	0.43 (0.43)	0.44 (0.44)	0.46 (0.46)	0.47 (0.47)	0.49 (0.49)	0.50 (0.50)
	90° Elbow	2.13 (0.649)	2.24 (0.683)	2.35 (0.716)	2.51 (0.765)	2.67 (0.814)	2.85 (0.869)	3.04 (0.927)	3.25 (0.991)	3.47 (1.058)
	45° Elbow	1.61 (0.491)	1.69 (0.515)	1.77 (0.539)	1.89 (0.576)	2.02 (0.616)	2.15 (0.655)	2.29 (0.698)	2.45 (0.747)	2.61 (0.796)
	Ent. Loss	4.12 (1.256)	4.32 (1.317)	4.54 (1.384)	4.84 (1.475)	5.16 (1.573)	5.51 (1.679)	5.88 (1.792)	6.27 (1.911)	6.69 (2.039)
10" Duct Single Boiler	Straight Run	0.13 (0.13)	0.13 (0.13)	0.14 (0.14)	0.14 (0.14)	0.15 (0.15)	0.15 (0.15)	0.16 (0.16)	0.16 (0.16)	0.17 (0.17)
	90° Elbow	0.76 (0.232)	0.80 (0.244)	0.84 (0.256)	0.89 (0.271)	0.95 (0.29)	1.01 (0.308)	1.08 (0.329)	1.15 (0.351)	1.23 (0.375)
	45° Elbow	0.58 (0.177)	0.61 (0.186)	0.64 (0.195)	0.68 (0.207)	0.73 (0.223)	0.78 (0.238)	0.83 (0.253)	0.88 (0.268)	0.94 (0.287)
	Ent. Loss	1.69 (0.515)	1.77 (0.539)	1.86 (0.567)	1.98 (0.604)	2.11 (0.643)	2.26 (0.689)	2.41 (0.735)	2.57 (0.783)	2.74 (0.835)
12" Duct Two Boilers	Straight Run	0.16 (0.16)	0.17 (0.17)	0.18 (0.18)	0.19 (0.19)	0.21 (0.21)	0.22 (0.22)	0.23 (0.23)	0.25 (0.25)	0.26 (0.26)
	90° Elbow	1.32 (0.402)	1.39 (0.424)	1.46 (0.445)	1.56 (0.475)	1.66 (0.506)	1.77 (0.539)	1.89 (0.576)	2.02 (0.616)	2.15 (0.655)
	45° Elbow	1.02 (0.311)	1.08 (0.329)	1.13 (0.344)	1.20 (0.366)	1.28 (0.39)	1.37 (0.418)	1.46 (0.445)	1.56 (0.475)	1.66 (0.506)
	Ent. Loss	3.26 (0.994)	3.42 (1.042)	3.58 (1.091)	3.82 (1.164)	4.08 (1.244)	4.35 (1.326)	4.64 (1.414)	4.95 (1.509)	5.29 (1.612)
14" Duct Two Boilers	Straight Run	0.08 (0.08)	0.08 (0.08)	0.08 (0.08)	0.09 (0.09)	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.12 (0.12)	0.12 (0.12)
	90° Elbow	0.66 (0.201)	0.70 (0.213)	0.73 (0.223)	0.78 (0.238)	0.83 (0.253)	0.89 (0.271)	0.95 (0.29)	1.01 (0.308)	1.08 (0.329)
	45° Elbow	0.52 (0.158)	0.54 (0.165)	0.57 (0.174)	0.61 (0.186)	0.65 (0.198)	0.69 (0.21)	0.74 (0.226)	0.79 (0.241)	0.84 (0.256)
	Ent. Loss	1.76 (0.536)	1.84 (0.561)	1.93 (0.588)	2.06 (0.628)	2.2 (0.671)	2.35 (0.716)	2.51 (0.765)	2.67 (0.814)	2.85 (0.869)
16" Duct Three Boilers	Straight Run	0.08 (0.08)	0.09 (0.09)	0.09 (0.09)	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)	0.13 (0.13)
	90° Elbow	0.82 (0.25)	0.86 (0.262)	0.91 (0.277)	0.97 (0.296)	1.03 (0.314)	1.10 (0.335)	1.18 (0.36)	1.25 (0.381)	1.34 (0.408)
	45° Elbow	0.64 (0.195)	0.67 (0.204)	0.71 (0.216)	0.76 (0.232)	0.81 (0.247)	0.86 (0.262)	0.92 (0.28)	0.98 (0.299)	1.04 (0.317)
	Ent. Loss	2.32 (0.707)	2.43 (0.741)	2.55 (0.777)	2.72 (0.829)	2.90 (0.884)	3.10 (0.945)	3.31 (1.009)	3.53 (1.076)	3.76 (1.146)

Table 13-b: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR2000 Boiler – Continued

Inlet Duct & No. Boilers	Duct Section Type	Outside Air Temperature in °F (°C)								
		-30 °F (-34.4)	-15 °F (-26.1)	0 °F (-17.8)	20 °F (-6.7)	40 °F (4.4)	60 °F (15.6)	80 °F (26.7)	100 °F (37.8)	120 °F (48.9)
18" Duct Three Boilers	Straight Run	0.05 (0.05)	0.05 (0.05)	0.05 (0.05)	0.05 (0.05)	0.06 (0.06)	0.06 (0.06)	0.07 (0.07)	0.07 (0.07)	0.08 (0.08)
	90° Elbow	0.49 (0.149)	0.51 (0.155)	0.54 (0.165)	0.57 (0.174)	0.61 (0.186)	0.65 (0.198)	0.7 (0.213)	0.74 (0.226)	0.79 (0.241)
	45° Elbow	0.38 (0.116)	0.4 (0.122)	0.42 (0.128)	0.45 (0.137)	0.48 (0.146)	0.51 (0.155)	0.54 (0.165)	0.58 (0.177)	0.62 (0.189)
	Ent. Loss	1.45 (0.442)	1.52 (0.463)	1.59 (0.485)	1.70 (0.518)	1.81 (0.552)	1.93 (0.588)	2.06 (0.628)	2.20 (0.671)	2.35 (0.716)
18" Duct Four Boilers	Straight Run	0.08 (0.08)	0.08 (0.08)	0.09 (0.09)	0.09 (0.09)	0.10 (0.10)	0.11 (0.11)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)
	90° Elbow	0.87 (0.265)	0.91 (0.277)	0.96 (0.293)	1.02 (0.311)	1.09 (0.332)	1.16 (0.354)	1.24 (0.378)	1.32 (0.402)	1.41 (0.43)
	45° Elbow	0.68 (0.207)	0.71 (0.216)	0.75 (0.229)	0.80 (0.244)	0.85 (0.259)	0.91 (0.277)	0.97 (0.296)	1.03 (0.314)	1.10 (0.335)
	Ent. Loss	2.57 (0.783)	2.70 (0.823)	2.83 (0.863)	3.02 (0.92)	3.22 (0.981)	3.44 (1.049)	3.67 (1.119)	3.91 (1.192)	4.18 (1.274)
20" Duct Four Boilers	Straight Run	0.05 (0.05)	0.05 (0.05)	0.05 (0.05)	0.06 (0.06)	0.06 (0.06)	0.06 (0.06)	0.07 (0.07)	0.07 (0.07)	0.08 (0.08)
	90° Elbow	0.55 (0.168)	0.57 (0.174)	0.60 (0.183)	0.64 (0.195)	0.68 (0.207)	0.73 (0.223)	0.78 (0.238)	0.83 (0.253)	0.88 (0.268)
	45° Elbow	0.43 (0.131)	0.45 (0.137)	0.47 (0.143)	0.5 (0.152)	0.53 (0.162)	0.57 (0.174)	0.61 (0.186)	0.65 (0.198)	0.69 (0.21)
	Ent. Loss	1.69 (0.515)	1.77 (0.539)	1.86 (0.567)	1.98 (0.604)	2.11 (0.643)	2.26 (0.689)	2.41 (0.735)	2.57 (0.783)	2.74 (0.835)

NOTES: 1) Calculation assumes 500 SCFM (14.16 m^3/min) per boiler at full fire rate

2) Units for "Straight Run" pressure drop values are equivalent feet per foot (eq. m / m)

3) Units for "Elbows" and "Ent. Loss" are equivalent feet per item (eq. m / item)

Table 13-c: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR3000 Boiler

		Outside Air Temperature in °F (°C)								
Inlet Duct & No. Boilers	**Duct Section Type**	**-30 °F (-34.4)**	**-15 °F (-26.1)**	**0 °F (-17.8)**	**20 °F (-6.7)**	**40 °F (4.4)**	**60 °F (15.6)**	**80 °F (26.7)**	**100 °F (37.8)**	**120 °F (48.9)**
8" Duct Single Boiler	Straight Run	0.85 (0.85)	0.87 (0.87)	0.89 (0.89)	0.91 (0.91)	0.94 (0.94)	0.97 (0.97)	1.00 (1.00)	1.03 (1.03)	1.06 (1.06)
	90° Elbow	4.75 (1.448)	4.98 (1.518)	5.23 (1.594)	5.58 (1.701)	5.95 (1.814)	6.35 (1.935)	6.77 (2.063)	7.23 (2.204)	7.71 (2.35)
	45° Elbow	3.57 (1.088)	3.75 (1.143)	3.93 (1.198)	4.2 (1.28)	4.48 (1.366)	4.78 (1.457)	5.09 (1.551)	5.44 (1.658)	5.8 (1.768)
	Ent. Loss	9.27 (2.825)	9.73 (2.966)	10.21 (3.112)	10.89 (3.319)	11.62 (3.542)	12.39 (3.776)	13.22 (4.029)	14.11 (4.301)	15.05 (4.587)
10" Duct Single Boiler	Straight Run	0.28 (0.28)	0.28 (0.28)	0.29 (0.29)	0.3 (0.30)	0.31 (0.31)	0.32 (0.32)	0.32 (0.32)	0.33 (0.33)	0.34 (0.34)
	90° Elbow	1.6 (0.488)	1.68 (0.512)	1.77 (0.539)	1.88 (0.573)	2.01 (0.613)	2.14 (0.652)	2.29 (0.698)	2.44 (0.744)	2.6 (0.792)
	45° Elbow	1.21 (0.369)	1.27 (0.387)	1.33 (0.405)	1.42 (0.433)	1.51 (0.46)	1.61 (0.491)	1.72 (0.524)	1.84 (0.561)	1.96 (0.597)
	Ent. Loss	3.8 (1.158)	3.98 (1.213)	4.18 (1.274)	4.46 (1.359)	4.76 (1.451)	5.08 (1.548)	5.42 (1.652)	5.78 (1.762)	6.16 (1.878)
12" Duct Two Boilers	Straight Run	0.35 (0.35)	0.37 (0.37)	0.38 (0.38)	0.41 (0.41)	0.43 (0.43)	0.46 (0.46)	0.49 (0.49)	0.52 (0.52)	0.55 (0.55)
	90° Elbow	2.8 (0.853)	2.93 (0.893)	3.08 (0.939)	3.28 (1)	3.5 (1.067)	3.74 (1.14)	3.99 (1.216)	4.25 (1.295)	4.54 (1.384)
	45° Elbow	2.13 (0.649)	2.23 (0.68)	2.34 (0.713)	2.5 (0.762)	2.67 (0.814)	2.85 (0.869)	3.04 (0.927)	3.24 (0.988)	3.46 (1.055)
	Ent. Loss	7.33 (2.234)	7.69 (2.344)	8.07 (2.46)	8.6 (2.621)	9.18 (2.798)	9.79 (2.984)	10.45 (3.185)	11.15 (3.399)	11.89 (3.624)
14" Duct Two Boilers	Straight Run	0.16 (0.16)	0.17 (0.17)	0.18 (0.18)	0.19 (0.19)	0.2 (0.20)	0.21 (0.21)	0.23 (0.23)	0.24 (0.24)	0.25 (0.25)
	90° Elbow	1.45 (0.442)	1.53 (0.466)	1.6 (0.488)	1.71 (0.521)	1.82 (0.555)	1.94 (0.591)	2.07 (0.631)	2.21 (0.674)	2.36 (0.719)
	45° Elbow	1.12 (0.341)	1.18 (0.36)	1.24 (0.378)	1.32 (0.402)	1.41 (0.43)	1.5 (0.457)	1.6 (0.488)	1.71 (0.521)	1.83 (0.558)
	Ent. Loss	3.95 (1.204)	4.15 (1.265)	4.35 (1.326)	4.64 (1.414)	4.95 (1.509)	5.29 (1.612)	5.64 (1.719)	6.02 (1.835)	6.42 (1.957)
16" Duct Three Boilers	Straight Run	0.18 (0.18)	0.19 (0.19)	0.19 (0.19)	0.21 (0.21)	0.22 (0.22)	0.23 (0.23)	0.25 (0.25)	0.27 (0.27)	0.28 (0.28)
	90° Elbow	1.90 (0.579)	1.99 (0.607)	2.09 (0.637)	2.23 (0.68)	2.38 (0.725)	2.54 (0.774)	2.71 (0.826)	2.89 (0.881)	3.08 (0.939)
	45° Elbow	1.49 (0.454)	1.56 (0.475)	1.64 (0.5)	1.74 (0.53)	1.86 (0.567)	1.99 (0.607)	2.12 (0.646)	2.26 (0.689)	2.41 (0.735)
	Ent. Loss	5.21 (1.588)	5.47 (1.667)	5.74 (1.75)	6.12 (1.865)	6.53 (1.99)	6.97 (2.124)	7.44 (2.268)	7.94 (2.42)	8.47 (2.582)

Table 13-c: Ducted Combustion Air Duct Pressure Drop in Eq. Ft. (m) for CFR3000 Boiler – Continued

		Outside Air Temperature in °F (°C)								
Inlet Duct & No. Boilers	**Duct Section Type**	**-30 °F (-34.4)**	**-15 °F (-26.1)**	**0 °F (-17.8)**	**20 °F (-6.7)**	**40 °F (4.4)**	**60 °F (15.6)**	**80 °F (26.7)**	**100 °F (37.8)**	**120 °F (48.9)**
18" Duct Three Boilers	Straight Run	0.10 (0.10)	0.10 (0.10)	0.11 (0.11)	0.11 (0.11)	0.12 (0.12)	0.13 (0.13)	0.14 (0.14)	0.15 (0.15)	0.16 (0.16)
	90° Elbow	1.16 (0.354)	1.22 (0.372)	1.28 (0.39)	1.37 (0.418)	1.46 (0.445)	1.56 (0.475)	1.66 (0.506)	1.77 (0.539)	1.89 (0.576)
	45° Elbow	0.92 (0.28)	0.96 (0.293)	1.01 (0.308)	1.08 (0.329)	1.15 (0.351)	1.23 (0.375)	1.31 (0.399)	1.4 (0.427)	1.49 (0.454)
	Ent. Loss	3.26 (0.994)	3.42 (1.042)	3.58 (1.091)	3.82 (1.164)	4.08 (1.244)	4.35 (1.326)	4.64 (1.414)	4.95 (1.509)	5.29 (1.612)
18" Duct Four Boilers	Straight Run	0.17 (0.17)	0.18 (0.18)	0.19 (0.19)	0.2 (0.20)	0.21 (0.21)	0.22 (0.22)	0.24 (0.24)	0.25 (0.25)	0.27 (0.27)
	90° Elbow	2.07 (0.631)	2.17 (0.661)	2.28 (0.695)	2.43 (0.741)	2.59 (0.789)	2.77 (0.844)	2.95 (0.899)	3.15 (0.96)	3.36 (1.024)
	45° Elbow	1.63 (0.497)	1.71 (0.521)	1.80 (0.549)	1.92 (0.585)	2.04 (0.622)	2.18 (0.664)	2.33 (0.71)	2.48 (0.756)	2.65 (0.808)
	Ent. Loss	5.79 (1.765)	6.07 (1.85)	6.37 (1.942)	6.8 (2.073)	7.25 (2.21)	7.74 (2.359)	8.25 (2.515)	8.81 (2.685)	9.40 (2.865)
20" Duct Four Boilers	Straight Run	0.10 (0.10)	0.11 (0.11)	0.11 (0.11)	0.12 (0.12)	0.12 (0.12)	0.13 (0.13)	0.14 (0.14)	0.15 (0.15)	0.16 (0.16)
	90° Elbow	1.3 (0.396)	1.37 (0.418)	1.44 (0.439)	1.53 (0.466)	1.63 (0.497)	1.74 (0.53)	1.86 (0.567)	1.98 (0.604)	2.12 (0.646)
	45° Elbow	1.03 (0.314)	1.08 (0.329)	1.13 (0.344)	1.21 (0.369)	1.29 (0.393)	1.37 (0.418)	1.46 (0.445)	1.56 (0.475)	1.67 (0.509)
	Ent. Loss	3.8 (1.158)	3.98 (1.213)	4.18 (1.274)	4.46 (1.359)	4.76 (1.451)	5.08 (1.548)	5.42 (1.652)	5.78 (1.762)	6.16 (1.878)

NOTES: 1) Calculation assumes 700 SCFM (19.82 m^3/min) per boiler at full fire rate

2) Units for "Straight Run" pressure drop values are equivalent feet per foot (eq. m / m)

3) Units for "Elbows" and "Ent. Loss" are equivalent feet per item (eq. m / item)

13.2 Combustion Air Altitude Correction

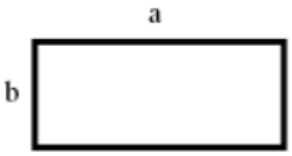
Altitude Correction Table

Site Elevation Above Sea Level		Altitude Correction Factor (CF)
Feet	**Meters**	
0	0	1
500	152.4	0.982
1000	304.8	0.964
1500	457.2	0.947
2000	609.6	0.930
2500	762.0	0.913
3000	914.4	0.896
3500	1066.8	0.880
4000	1219.2	0.864
4500	1371.6	0.848
5000	1524.0	0.832
5500	1676.4	0.817
6000	1828.8	0.801
6500	1981.2	0.787
7000	2133.6	0.772
7500	2286.0	0.758
8000	2438.4	0.743
8500	2590.8	0.729
9000	2743.2	0.715
9500	2895.6	0.701
10000	3048.0	0.688

13.3 Round vs Rectangular Duct

Round Duct of Identical Pressure Drop to Rectangular Duct

Formula: $d_e = 1.3\,(a \times b)^{0.625} / (a + b)^{0.25}$



In Inches

Adjacent Side of Duct in inches	Side of Rectangular Duct in Inches									
	6	8	10	12	14	16	18	20	22	24
6	6.6									
8	7.6	8.7								
10	8.4	9.8	10.9							
12	9.1	10.7	12	13.1						
14	9.8	11.5	12.9	14.2	15.3					
16	10.4	12.2	13.7	15.1	16.4	17.5				
18	11	12.9	14.5	16	17.3	18.5	19.7			
20	11.5	13.5	15.2	16.8	18.2	19.5	20.7	21.9		
22	12	14.1	15.9	17.6	19.1	20.4	21.7	22.9	24	
24	12.4	14.6	16.5	18.3	19.9	21.3	22.7	23.9	25.1	26.2

In Centimeters

Adjacent Side of Duct in cm	Side of Rectangular Duct in *Centimeters*									
	15.24	20.32	25.4	30.48	35.56	40.64	45.72	50.8	55.88	60.96
15.24	16.76									
20.32	19.30	22.10								
25.4	21.34	24.89	27.69							
30.48	23.11	27.18	30.48	33.27						
35.56	24.89	29.21	32.77	36.07	38.86					
40.64	26.42	30.99	34.80	38.35	41.66	44.45				
45.72	27.94	32.77	36.83	40.64	43.94	46.99	50.04			
50.8	29.21	34.29	38.61	42.67	46.23	49.53	52.58	55.63		
55.88	30.48	35.81	40.39	44.70	48.51	51.82	55.12	58.17	60.96	
60.96	31.50	37.08	41.91	46.48	50.55	54.10	57.66	60.71	63.75	66.55

Reference:

1. *National Fuel Gas Code, 2006 edition*, American National Standards Institute, Inc (ANSI Z223.1-2006) and National Fire Protection Association (NFPA54-2006)

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