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VENTING

Advanced

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VENTING
Advanced

This publication is designed to serve as a training guide and to be used in conjunction with a course taught by a qualified instructor.

The reader should use local codes and equipment manufacturer's specifications and instructions in setting up and maintaining equipment.

The editors have attempted to present accurate information, however, NORA does not make any representations or guarantees and does not assume or accept any responsibility or liability with respect thereto.

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Chapter 1
Venting

A properly functioning venting system of an oil-burning appliance removes all of the combustion gases from the appliance and safely directs them to a point outside the building.

The proper venting of combustion gases is an extremely important function, one which relies on the performance of the entire venting system. The consequences of a malfunctioning venting system (improperly pitched and assembled flue pipes, and/or a deteriorating chimney) could lead to property damage, illness or even death from carbon monoxide poisoning.

This booklet will explain the various types of venting systems available for today's oilheat appliances, including:

- Chimney vent
- Power vent
- Direct vent

Before examining the various venting options available, it is important to understand the need for adequate air to support combustion, dilution and ventilation. Air typically enters a building by infiltration (leaks around the foundation, building penetrations, windows and doors).

Combustion air *is the air that enters the burner through the air bands and mixes with oil during the combustion process. Figure 1.*

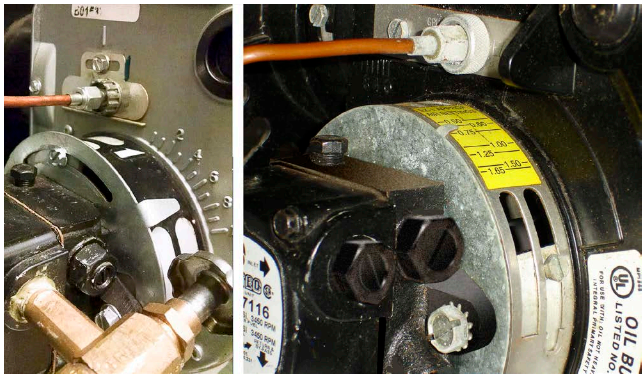


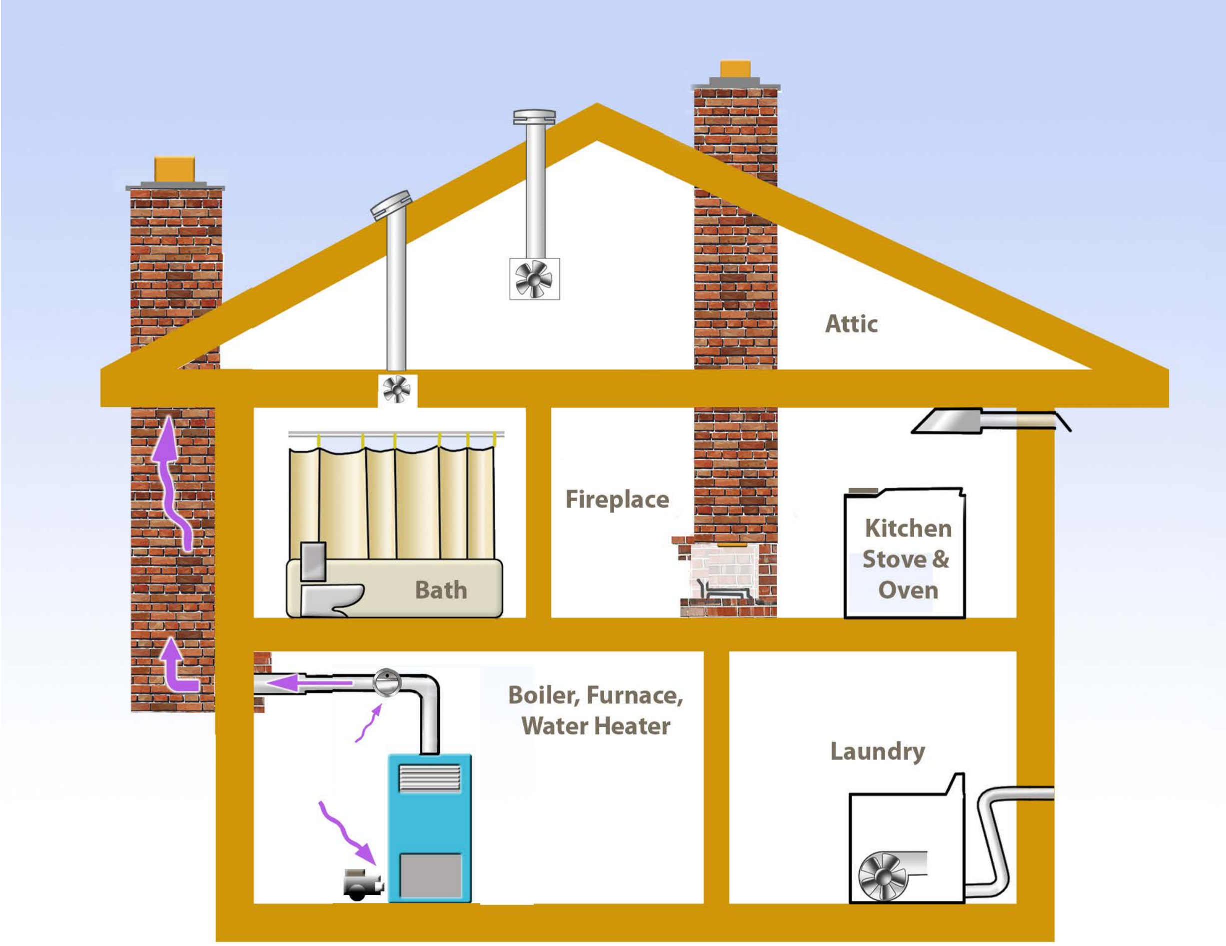
Figure 1: Oilburner air bands provide combustion air.

Dilution air *is the air drawn into the vent system through the draft control or other openings. Figure 2 below.*

Ventilation air *is air around an appliance that prevents the area from overheating during appliance operation.*

Figure 2: The draft regulator provides dilution air.

Figure 3



Ventilation Problems: The Heating System Competes With the

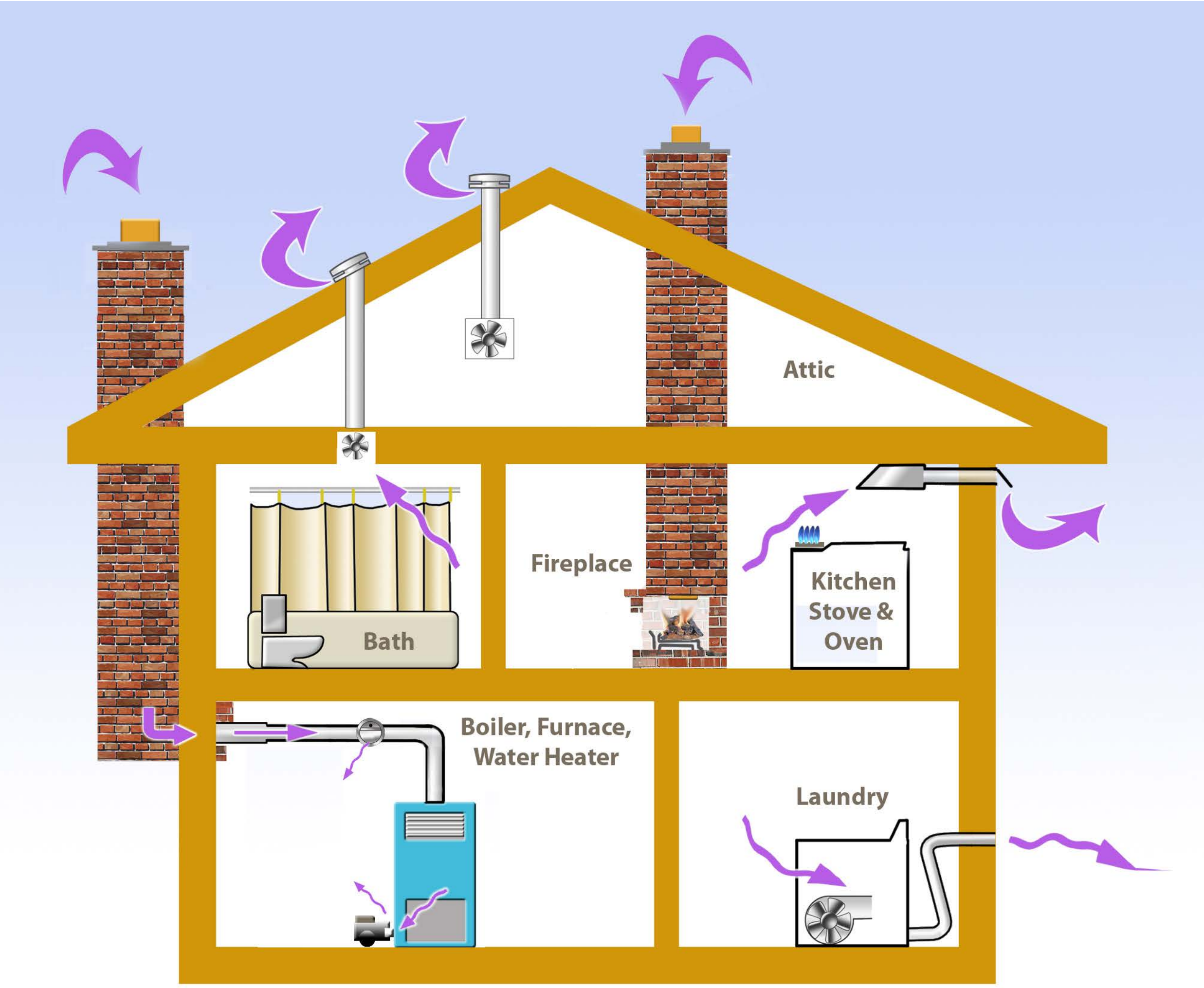
Oil burner combustion requires a great deal of air to operate properly—about 1,500 cubic feet per gallon. Insulation, tight windows and doors, and tight construction can prevent outside air from entering the building by infiltration. As a result, the building cannot "breathe" and receive fresh air for the inhabitants and for the appliances.

The heating system competes with the fireplace, exhaust fans, the clothes dryer and other appliances for air. All of these appliances using the air in a tight house make it difficult for the oil burner to have sufficient combustion, dilution and ventilation air. In a "tight" building, the indoor air pressure can drop below the outdoor air pressure and the appliance can backdraft, allowing products of combustion to be drawn into the building from the appliance and/or venting system. Figure 3.

Opening an outside door in a tight house can equalize the pressure between the inside and outside, which can temporarily fix the problem.

"…a service call caused by insufficient combustion air is the only situation in which a technician 'fixes' the problem just by showing up."

In fact, a service call caused by insufficient combustion air is the only situation in which a technician "fixes" the problem just by



Fireplace, Exhaust Fans, the Clothes Dryer and Other Appliances for Air.

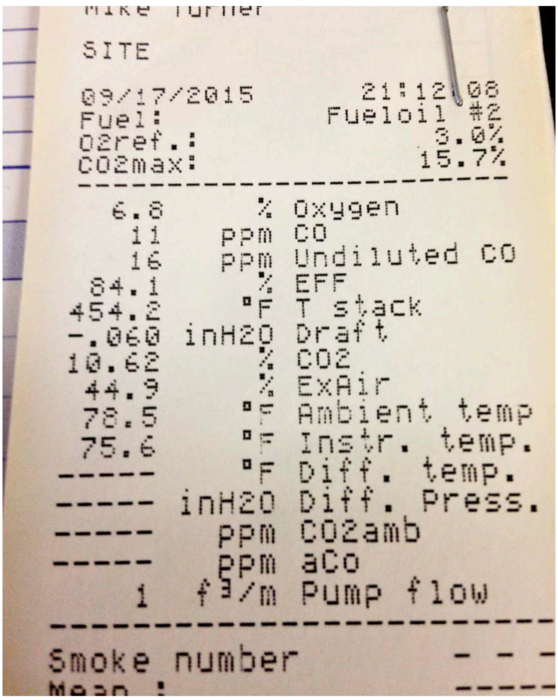
showing up. As the technician enters the home, the outside door is opened, allowing fresh air to enter. Then as the basement door and boiler room doors are opened, the pressure equalizes and the insufficient air problem is "solved" (but this only lasts until the doors are closed again).

Effects of Insufficient Combustion Air

For years, it was assumed that a heating appliance installed in an unconfined space would have sufficient air for combustion, dilution and ventilation. However, new building construction standards reduce a building's leakage rate from infiltration, and many of the energy efficiency improvements that homeowners do also reduce infiltration. The amount of infiltration air that enters a home is referred to as *air changes per hour* or ACH. The installation of vapor retardants, more insulation, improved windows, doors and the use of new construction techniques all reduce the amount of air available for combustion, even in unconfined spaces.

Insufficient air problems are most noticeable on the coldest days, when the heat loss is the greatest and the windows or doors are closed for extended periods of time. These conditions can lead to incomplete combustion and the creation of carbon monoxide (CO) inside the combustion chamber and vent system.

Figure 4: Technician performs a smoke test with combustion analysis results below.



SITE

09/17/2015 21:12:08
Fuel: Fueloil #2
O2ref.: 3.0%
CO2max: 15.7%

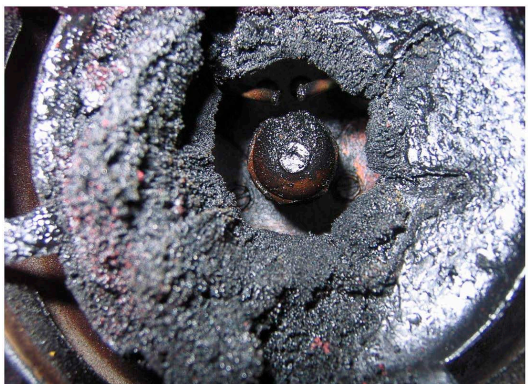
6.8	%	Oxygen
11	ppm	CO
16	ppm	Undiluted CO
84.1	%	EFF
454.2	°F	T stack
-.060	inH2O	Draft
10.62	%	CO2
44.9	%	ExAir
78.5	°F	Ambient temp
75.6	°F	Instr. temp.
-----	°F	Diff. temp.
-----	inH2O	Diff. Press.
-----	ppm	CO2amb
-----	ppm	aCO
1	f³/m	Pump flow

Smoke number - - -

CO is odorless, colorless and tasteless; therefore, in order to detect its presence, technicians should perform combustion tests (Figure 4) and look for symptoms such as:

- Loose, corroded or disconnected venting system connections
- Excessive moisture on the inside of windows or walls
- Visible smoke in the living space
- Customer complaints about odors or smoke in the building
- Carbon Monoxide alarm going off
- Soot on the unit
- Burner rumbling
- Soot streaks around the inspection port
- A sooted-up cad cell and/or drawer assembly
- Coking at the nozzle or burner head (after drip). Figure 5

Figure 5: Coking of oilburner nozzle.



Confined vs. Unconfined Space

When installing new equipment, or troubleshooting existing equipment, a determination needs to be made whether the equipment is installed in a confined or unconfined space, as defined in NFPA 31.

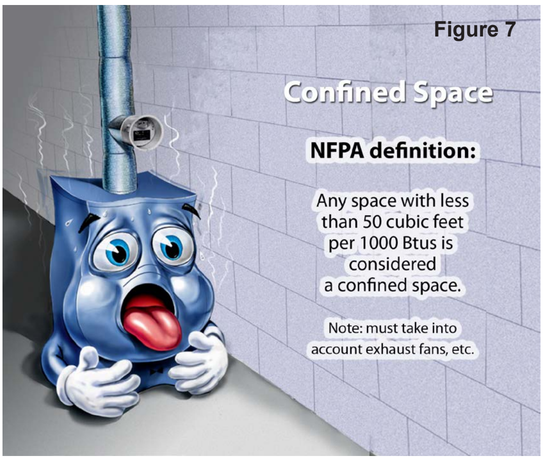
Figure 6
NFPA 31 cover.

The 2011 edition of NFPA 31 (Figure 6) provides the following definitions:

3.3.14 Confined Space. *For the purposes of this standard, a space whose volume is less than 50 ft^3 per 1000 Btu/hr (4.8 m^3 per kW) of the aggregate input rating of all appliances installed in that space.*

3.3.60* Unconfined Space. *Any space whose volume is equal to or greater than 50 ft^3 per 1000 Btu/hr (4.8 m^3 per kW) of the aggregate input rating of all fuel-burning appliances installed therein.*

So, any space that provides less than 50 cubic feet per 1,000 BTUs of total appliance input is considered a confined space. Figure 7.



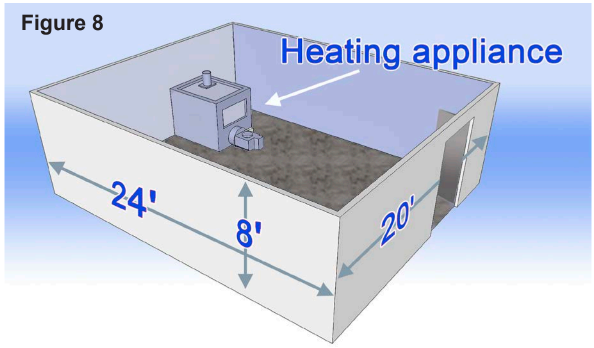
To determine the maximum total firing rate allowable in a room, the total cubic feet must be known.

To determine the total cubic feet of the room, multiply the length times the width times the height:

L x W x H = Total cubic feet

So, if you have a utility room that is 20' long, 24' wide with an 8' ceiling (Figure 8):

20 x 24 x 8 = 3,840 cubic feet.



To determine the maximum BTU firing rate allowable in this room, multiply 3,840 x 1,000 BTU/50 (3,840 x 20)

3,840 x 20 = 76,800 maximum BTU input.

A gallon of #2 oil contains approximately 138,690 BTUs; to determine the maximum allowable firing rate, divide 76,800 by 138,690:

76,800/138,690 = .55 GPH

The maximum firing rate for this room is .55 GPH. Any unit—or units—with a higher firing rate requires that additional air be made available.

If the appliance, or appliances, installed in this room have a firing rate greater than 55 GPH per hour, this would be considered a “confined space.”

Chapter 5 of NFPA 31 details the requirements of the standard to ensure that adequate air is available for the safe operation of oil fired appliances:

5.3 Appliances Located in Unconfined Spaces.

5.3.1* *In unconfined spaces in buildings of conventional frame, brick, or stone construc-*

tion, air for combustion and ventilation shall be permitted to be supplied by normal infiltration.

5.3.2 *If normal infiltration is not sufficient because of tight construction, air for combustion and ventilation shall be obtained directly from outdoors or from spaces that freely communicate with outdoors by means of a permanent opening or openings having a total free area of not less than 1 square inch per 5,000 Btu/hr (28 square inches per gal/hr) based on the total input rating of* ***all*** *appliances in the space.*

5.4 Appliances Located in Confined Spaces. *For appliances installed in confined spaces, air for combustion and ventilation shall be provided using one of the methods set forth in this section.*

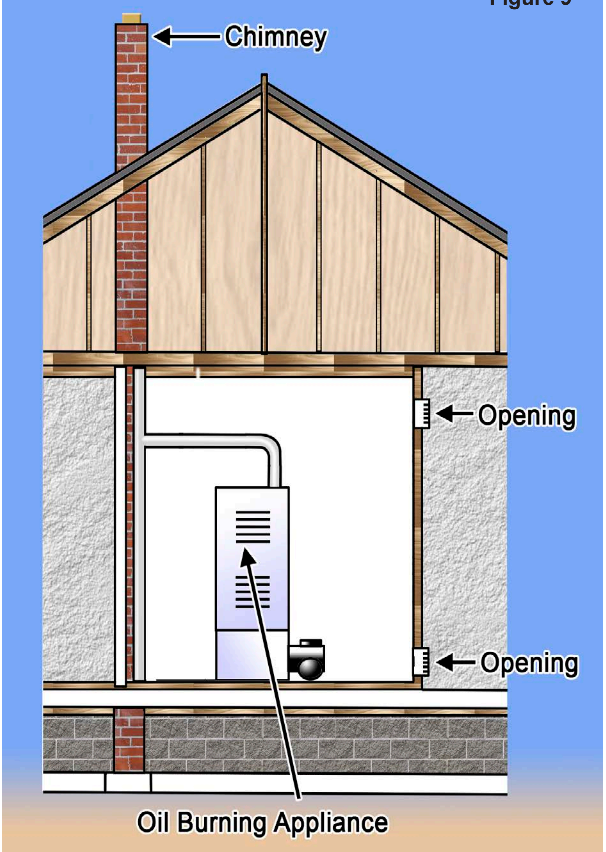


Figure 9

5.4.1 All Air Taken from Inside the Building.

5.4.1.1 *The confined space shall be provided with two permanent openings, one near the top of the space and one near the bottom.* (Figure 9). For more information reference the current version of NFPA 31.

Testing to Determine if there is Sufficient Air Available for the Appliance

The confined space calculation does not take into account other factors in the home which also affect the amount of combustion, dilution and ventilation air available. These include:

Attic Fan
Central Vacuum
Range Hood
Microwave
Bathroom Exhaust Fan
Clothes Dryer
Fireplaces

NFPA has developed a "worst case draft test" that enables technicians to determine if a combustion air problem might arise in the future.

Residential Clothes Dryer

How much air does a clothes dryer exhaust? It depends on what model of dryer.

An Energy Star Clothes Dryer *will use up to 12,000 cubic feet of air. With this type of dryer, one 60-minute cycle will exhaust all the air from a 1,500 square foot home.*

A Standard Clothes Dryer will use up to 6,000 cubic feet of air. This type of dryer will exhaust all the air from a 1,500 sq. ft. home in two 60-minute cycles.

Basically, the test simulates what happens if all of the air stealing appliances, except for a whole house exhaust fan, are on at the same time. To conduct a worst case draft test, the technician should perform the following tasks:

(1) Close fireplace dampers and fireplace doors, close all exterior doors and windows in the building, and close all interior doors in the building.

(2) Turn on the building's air exhaust systems, including clothes dryers, range hoods, bathroom exhausts, and mechanical ventilation and forced-air heating or cooling system blowers and operate them at their highest speed setting. Do ***not*** operate a whole-house exhaust fan.

(3) Operate the burner in the oilheating appliance with the lowest firing rate first, and then other appliances in order of increasing capacity. Measure and record the breech draft and over-fire draft of each appliance, and check for flue gas spillage.

(4) Check that the breech and over-fire draft are at a level that is required by the oilheating equipment manufacturer as specified in the installation and operating manuals for the appliance. Over-fire draft values in oil appliances are usually negative 0.01 to negative 0.02 in. of water column (-0.01" wc to -0.02" wc).

(5) If the draft is maintained at the manufacturer's recommended level, the technician should return doors, windows, exhaust fans, fireplace dampers, and appliances to their previous conditions of use.

(6) If the draft is NOT maintained at the manufacturer's recommended level, take action as needed to correct excessive depressurization of the appliance combustion air zone and return the flue draft and over-fire draft to the requirements of the oilheat equipment manufacturer. If additional steps are necessary, shut the appliance down until the situation can be corrected.

Notify the homeowner, building owner, or occupant if combustion air zone depressurization impacts the operation of the oilheating equipment and of all actions and modifications that are required to allow the flue draft and over-fire draft to be maintained at the level required by the oilheating equipment manufacturer.

Dealing with Confined Spaces and Other Combustion Air Challenges

In addition to the NFPA recommendations that address getting additional air either from the outside or from areas inside the building, there are two other possible solutions to correct a combustion air problem.

Additional air can be brought from the outside into the combustion air zone through the use of *direct* or *indirect connections* to the outside.

Direct Connection

A direct connection brings in outside air directly to the oil burner. This can be done by adding an "air boot" (Figure 10) that connects directly to the oil burner, such as the one pictured here.

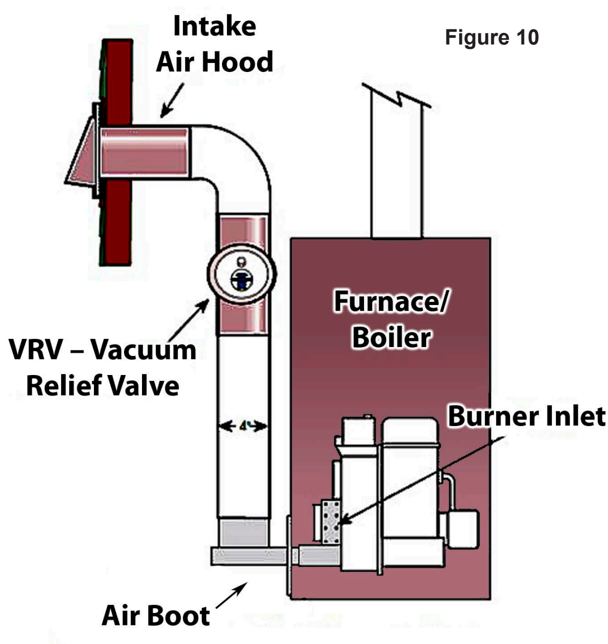


Figure 10

There are different air boots for different burners and it is critically important to use the correct one for the burner it is installed on.

The main factors that must be taken into consideration when utilizing air boots are:

- Each model has a maximum equivalent length of the air intake run.
- Each elbow must be included in the calculation of equivalent length; typical elbows have an equivalent length of 7' to 14'.
- The air intake must be supported and secured to prevent physical damage and joint separation.

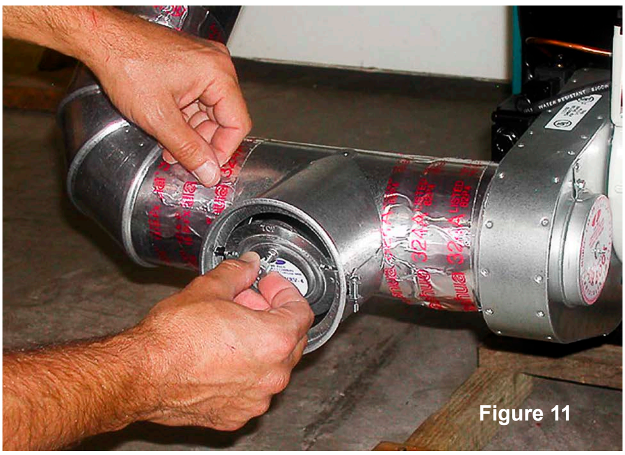


Figure 11

- All joints and seams should be secured with screws and foil-taped to prevent air leakage into the duct.
- A minimum of 12' of intake duct is recommended to temper the outside air being brought to the burner.
- A Vacuum Relief Valve (VRV) must be installed to guard against combustion problems associated with directly connecting burners to the outside, such as blockage of the intake termination, icing up of the ductwork and the effects of wind (Figure 11). The VRV will allow indoor air to be used if the outside air intake becomes blocked.
- If the heating appliance is sidewall vented, the intake hood must be on the same side of the building as the vent outlet.

Because air inlet temperatures vary during the year, it's necessary to set the O_2 and/or CO_2 at different values for different inlet air temperatures. The burner manufacturer's guidelines for minimum and maximum O_2 and CO_2 must be followed. See Table 1 below.

Table 1 **EZ-1 oil burner combustion air settings**

Inlet air temperature during setup	CO_2 Max and O_2 Min at setup #2 Fuel oil			
	CO_2 min	CO_2 max	O_2 max	O_2 min
-20 °F to 0 °F	8.8 %	10.6 %	8.9 %	6.4 %
5 °F to 30 °F	9.9 %	11.9 %	7.4 %	4.7 %
35 °F to 60 °F	10.5 %	12.5 %	6.6 %	3.9 %
65 °F or higher	11.0 %	13.2 %	5.9 %	2.9 %

Indirect Connection

An indirect connection supplies air to the combustion air zone by using a mechanical fan located near the appliance. The fan must be electrically interlocked to the appliance with a proving circuit to provide air any time the burner runs. A device such as the “fan in a can” (Figure 12) operates as follows:

- When the thermostat, pressuretrol or aquastat calls for heat, it energizes a relay which activates the fan.
- Once the fan is up to speed, an internal air pressure switch closes, completing a circuit and allowing the burner to fire.
- Once the call for heat has been satisfied, the fan and burner shut off (Some models have a post-purge cycle).

The main factors that must be taken into consideration when utilizing a “fan in a can” are:

- The fan unit should be located on a flat surface in the combustion air zone.
- Each model has a maximum equivalent length of the air intake run.
- The air intake must be supported and secured to prevent physical damage and joint separation.
- All joints and seams should be secured with screws and foil-taped to prevent air leakage into the duct.
- A minimum of 12' of intake duct is recommended to temper the outside air being brought in.
- The Vacuum Relief Valve (VRV) should be placed directly on the air inlet of the fan unit.
- If the heating appliance is power vented, the intake hood should be at least 10' from the exhaust outlet and on the same wall of the building.
- The unit should be cleaned periodically in accordance with the manufacturer’s instructions.

Figure 12

Fan in a can

Important

Remember to always follow the manufacturer's instructions when installing or servicing a specific product.

Chapter 2

Chimney Venting

Chimney venting was required for early Oilheat equipment to remove the flue gases from the building and to draw in combustion air. It is still the most common type of venting for Oilheat systems in use today.

Chimneys can be “lined” or “unlined.” (Figure 1). A lined chimney is typically made of brick and mortar on the outside with an inside liner made of clay or stainless steel. The liner protects the chimney walls from heat and corrosion.

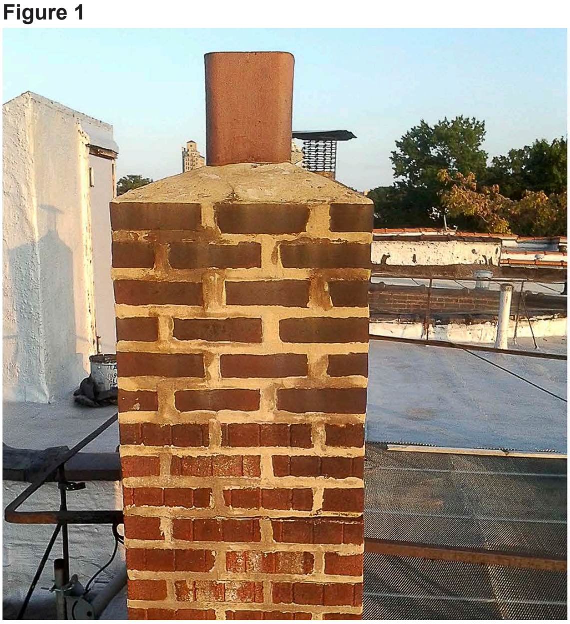
Unlined chimneys provide no means of protection for the chimney walls, are not permitted under current NFPA regulations and are not recommended for Oilheat systems.

Here’s how chimney venting works: Since hot combustion gases weigh less than room air or outdoor air, they tend to rise. During the combustion process, heated gases expand and rise through the heating appliance to the flue pipe. They then travel up the chimney, creating negative pressure or suction, also known as “negative draft”, before being released to the outside atmosphere.

All venting systems rely on draft. Draft is a pressure difference that causes gases or air to flow through a chimney, vent, flue, or appliance.

In practical terms, draft is a force that “pulls” or “sucks” the exhaust gases out of the heat-

Figure 1



Lined Chimney

Unlined Chimney

ing appliance, up the chimney and out of the building.

There are two types of draft that affect the operation of a standard chimney venting system: thermal draft (sometimes called "natural draft") and currential draft.

Thermal draft (Figure 2) is produced by the difference in the weight of a column of flue gases within a chimney or vent system and a corresponding column of air of equal dimension outside the chimney or venting system. (Hot gases rise because they are less dense and weigh less.)

Currential draft occurs when wind passing across the top of a chimney creates suction and draws gases and/or air up. Currential draft can also cause "down drafts" and push air down the chimney.

Three main factors control the amount of chimney draft that is generated:

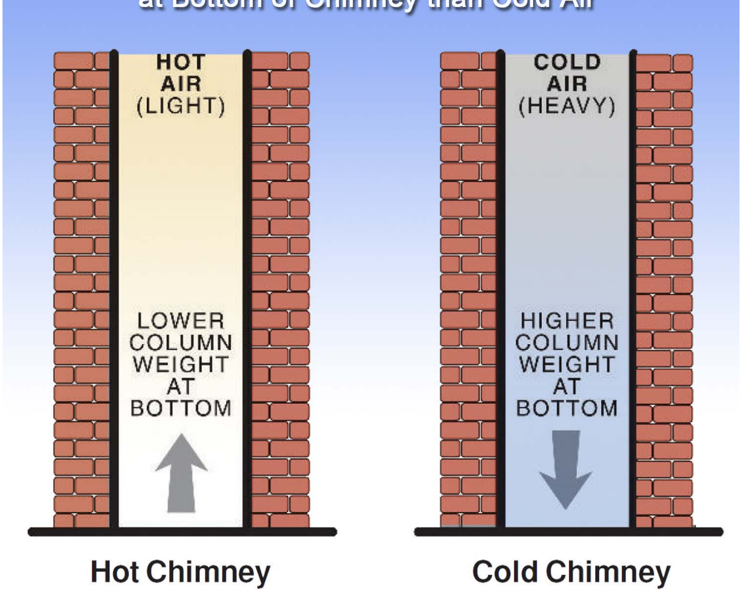
1. Chimney height—the higher the chimney, the greater the draft;

2. The temperature of the combustion gases—the hotter they are, the greater the draft;

3. The temperature of the air outside the home—the colder it is outside, the greater the draft.

Figure 2

Hot Air Causes Lower Weight (Pressure) at Bottom of Chimney than Cold Air



How Much Draft Does an Appliance Need?

Oilheat equipment manufacturers specify the amount of draft required "over the fire" and also what the "draft drop" should be through the appliance.

Over the fire draft is the draft measured at the flame observation door, just above the combustion chamber. It is normally about -.02 inches water column (-.02" wc). "Normally" is emphasized because the manufacturer's guidelines must be followed and there are some oil-fired appliances that require positive over-the-fire draft. Figure 3 on following page.

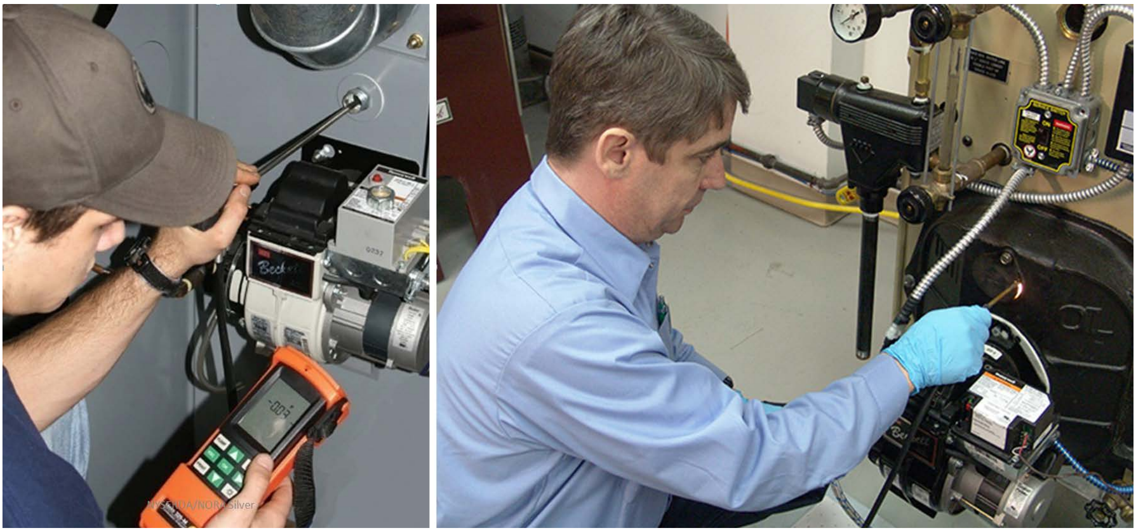
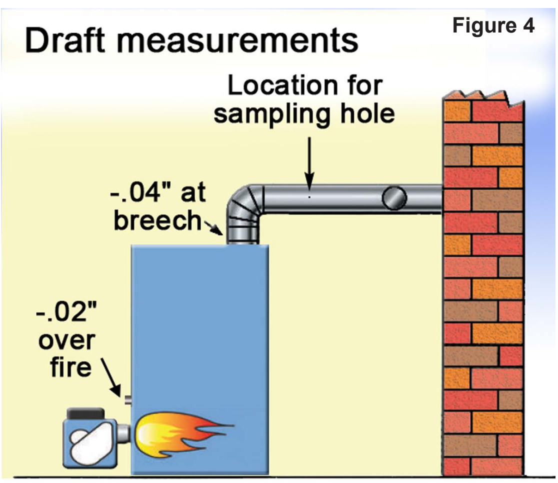


Figure 3: Measuring over-fire draft.

Draft drop is the difference between the measured draft over the fire and the draft at "the breech"—a straight piece of the flue pipe on the appliance side of and at least 6" from the draft regulator.

If there are -.04" wc of draft at the breech and -.02" wc over the fire, the draft drop is -.02" wc. Figure 4.



As with all settings for Oilheat appliances, the manufacturer's instructions must be followed.

Notice that the draft drop through the appliance is not the same for all boiler sizes. Be sure to adjust each appliance to the manufacturer's specifications. Figure 5

Figure 5

Sections	Draft loss through boiler (in. wc)
2	.020
3	.020
4	.010
5	.015
6	.015
7	.015
8	.025
9	.030

Draft Regulators (aka Barometric Draft Controls)

Oilheat systems require steady draft. Once the unit reaches steady state efficiency, the draft over the fire must remain constant to allow for proper combustion and efficiency.

Since natural draft varies depending on several factors (including atmospheric pressure, temperature and wind), barometric draft controls are needed to stabilize draft for most oilfired appliances. Barometric draft controls lower draft by allowing room air to mix with the combustion gases as they rise through the flue pipe. They also help to dry moisture from chimneys during the burner's off cycle.

The 2011 edition of NFPA 31 addresses the draft regulator issue in section 6.4.1:

> *"A draft regulator shall be provided for each oil-burning appliance that is connected to a chimney or power venting system unless the appliance design, conditions of installation, or combinations thereof preclude excessive chimney draft, or the appliance is listed for use without one."*

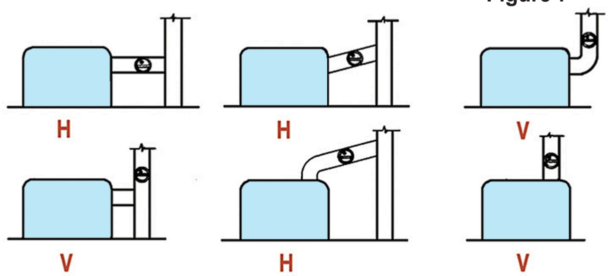
The reason NFPA mentions "unless…the appliance is listed for use without one," is that some oil heating appliances are designed to operate without a draft regulator. Their burners create enough force (static pressure) to move the combustion products up the chimney and their heat exchangers are designed to resist the effects of strong and variable draft. Figure 6.

Figure 6: Draft Regulator

Draft controls must:

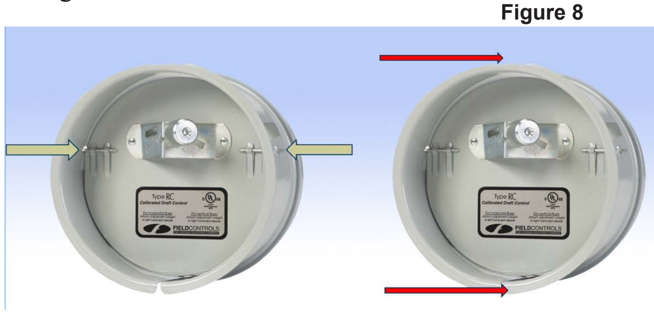
1. Be installed in one of the locations shown in Figure 7:

Figure 7



2. Be horizontally level and vertically plumb; Figure 8.

Figure 8



3. Have the weights installed in the proper location depending on whether the device is located on a vertical or horizontal flue tee. Figure 9.

Figure 9

When several appliances are vented into a common chimney connector (Figure 10), each should have its own draft control located in the uptake between the appliance and the main breech (location A).

If the uptake is too short to allow the installation, locate the control in the main breech (location B).

If neither location is possible, install a single large control between the chimney and the nearest appliance (location C).

How Draft Controls Work

Figure 11, bottom of page, shows how draft controls work in overcoming excessive drafts and improve the combustion of fuel.

Figure 10

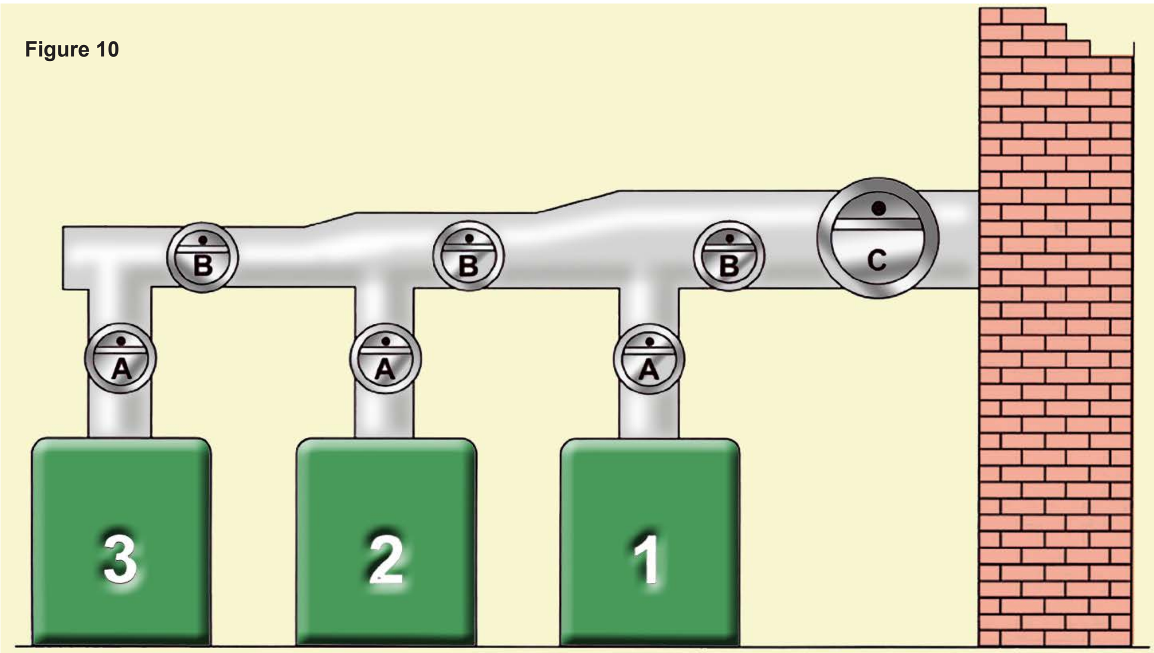
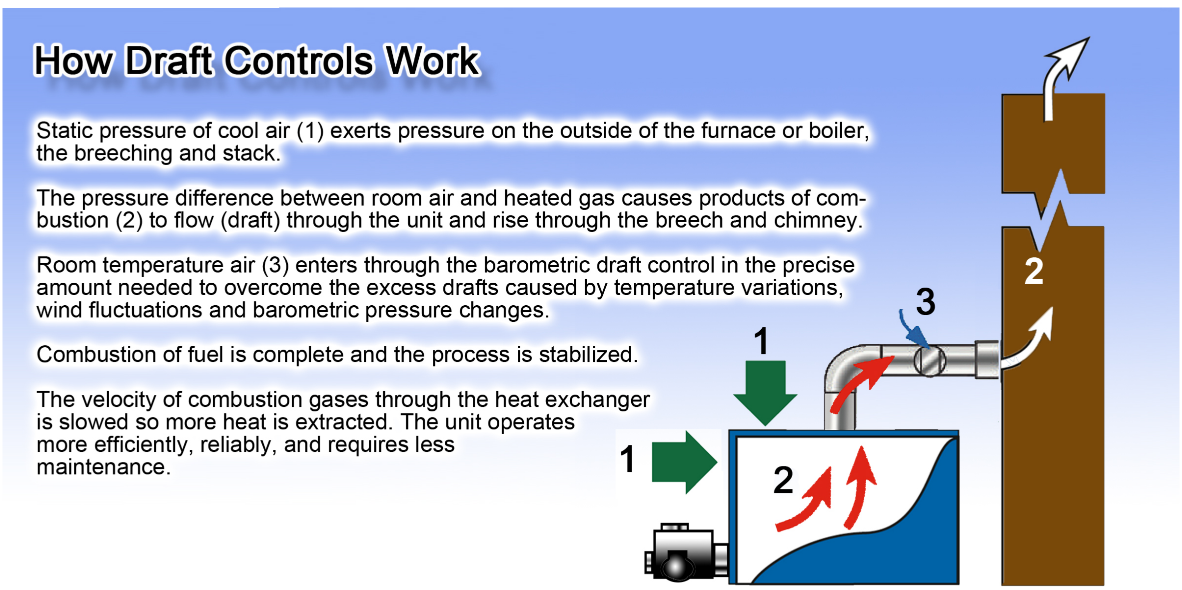


Figure 11



Sizing Draft Controls

For most applications, appliance manufacturers recommend that the draft control should be the same size as the flue pipe. Tall chimneys often require larger controls, as shown in the draft control sizing chart below.

Draft Inducers

Sometimes the venting system cannot develop sufficient draft to safely vent the combustion gases from the building. Short chimneys, undersized venting systems, long horizontal vent runs, negative building pressures and/or

Diameter of Flue or Breeching	If Chimney Height is	Use This Size Control	If Chimney Height is	Use This Size Control	If Chimney Height is	Use This Size Control
4	15' or less	4"	16' or more	5"		
5	15' or less	5"	16' or more	6"		
6	15' or less	6"	16' or more	7"		
7	15' or less	7"	16' or more	8"		
8	15' or less	8"	16' or more	9"		
9	15' or less	9"	16'-30'	10"	31' or more	12"
10	20' or less	10"	21'-40'	12"	41' or more	14"
11	20' or less	12"	21'-40'	12"	41' or more	14"
12	20' or less	12"	21'-40'	14"	41' or more	16"
13	22' or less	14"	23'-45'	16"	46' or more	18"
14	22' or less	14"	23'-45'	16"	46' or more	18"
15	22' or less	16"	23'-45'	16"	46' or more	18"
16	30' or less	16"	31'-50'	18"	51' or more	20"
17	30' or less	18"	31'-50'	20"	51' or more	20"
18	30' or less	18"	31'-50'	20"	51' or more	20"
19	30' or less	20"	31'-50'	20"	51' or more	24"
20	30' or less	20"	31'-50'	20"	51' or more	24"
21	30' or less	20"	31'-50'	24"	51' or more	24"
22	30' or less	24"	31'-50'	24"	51' or more	24"
23	35' or less	24"	36'-60'	24"	61' or more	28"
24	35' or less	24"	36'-60'	24"	61' or more	28"
25	35' or less	28"	36'-60'	28"	61' or more	28"

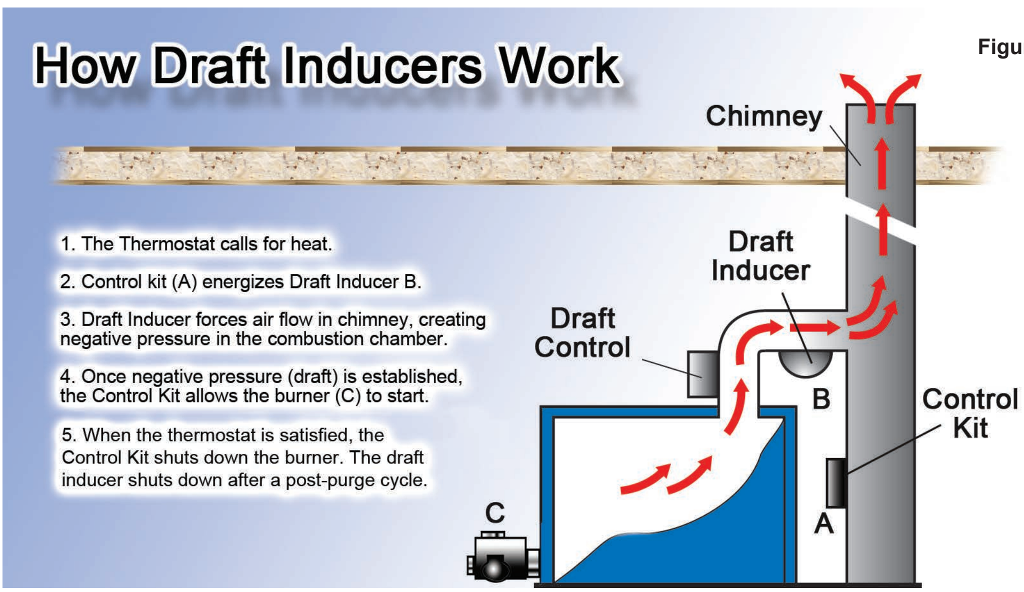
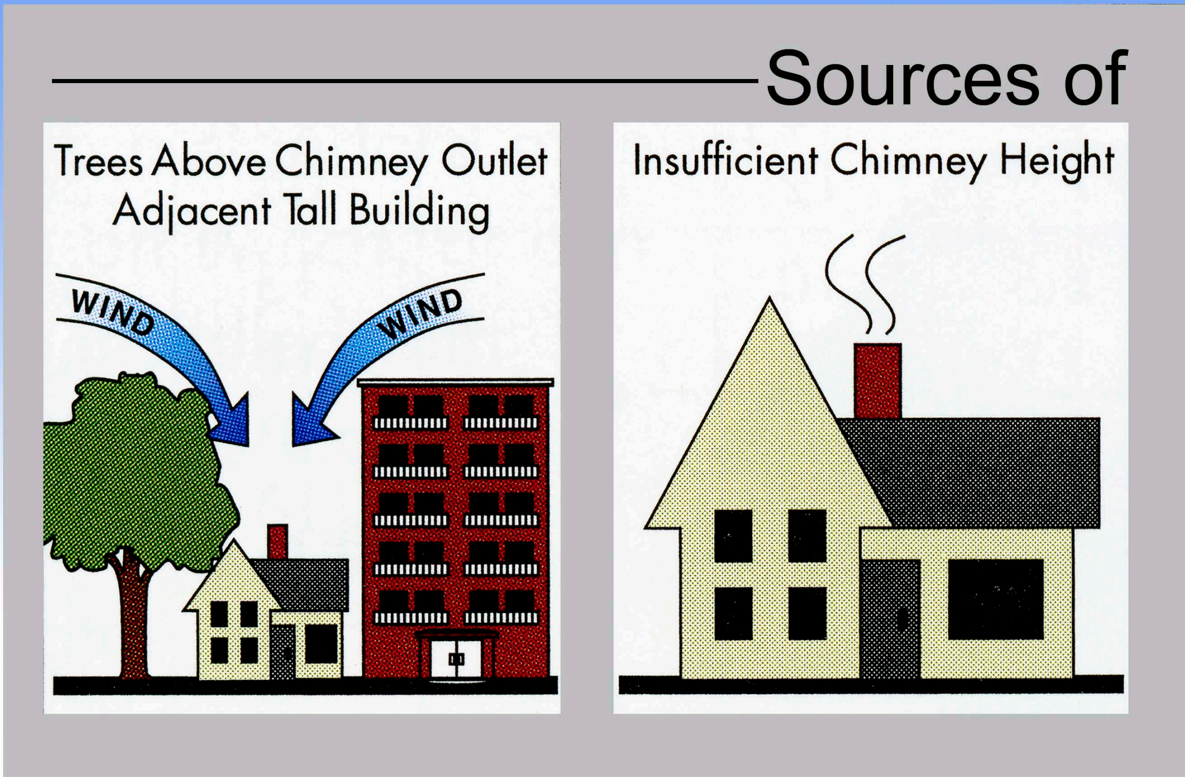


Figure 13

Figure 12



outside exposed chimneys can cause drafting problems. Figure 12 above.

When that happens, a draft inducer (aka a "draft fan"), in conjunction with a control kit, can be installed to provide the necessary draft. A draft fan should be installed as close to the chimney as practical and must be electrically interlocked with the appliance, utilizing a proving circuit before combustion takes place.

How Draft Inducers Work

Figure 13, on preceding page, illustrates how draft inducers, installed with a control kit, provide necessary draft when needed.

Figure 14

MINIMUM RECOMMENDED BREECHING AND CHIMNEY SIZE

BOILER MODEL	MINIMUM BREECHING DIA. (INCHES)	MINIMUM CHIMNEY REQUIREMENTS		
		ROUND I.D. (IN.)	SQUARE. TILE SIZE (NOMINAL)	HEIGHT (FT.)
FWZ060	5	6	8 X 8	15
FWZ080	5	6	8 X 8	15
FWZ100	6	6	8 X 8	15
FWZ130	6	7	8 X 8	15
FWZ160	7	7	8 X 8	15

Flue Pipe (Chimney Connector)

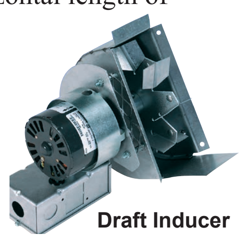
Flue pipe sizing is determined by the appliance manufacturer. Figure 14.

There are a number of regulations in NFPA 31 regarding the connection between the appliance and the chimney. Technicians should refer to the current edition of the standard and the local authority having jurisdiction for the most up-to-date requirements. The 2011 version of NFPA 31 requires the following for natural draft appliances (Figure 15):

1. The flue pipe must be at least 18" from a combustible wall or ceiling.

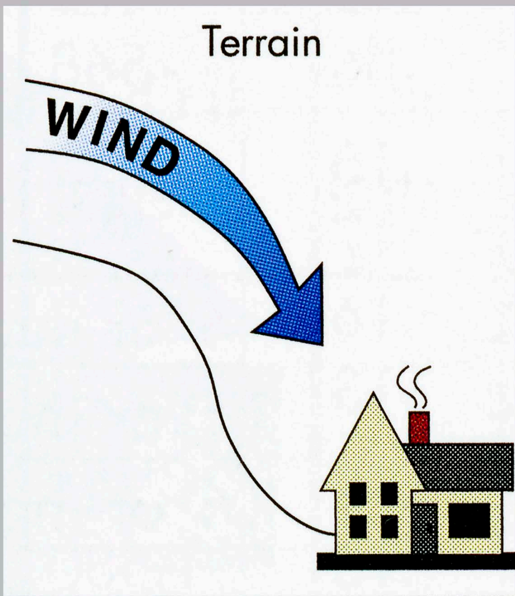
2. The flue pipe must maintain a pitch or rise of at least ¼ in./ft. of horizontal length of pipe from the appliance to the chimney.

3. The horizontal length of a flue pipe must not exceed 10' unless a draft fan is used.



Draft Inducer

Draft Problems



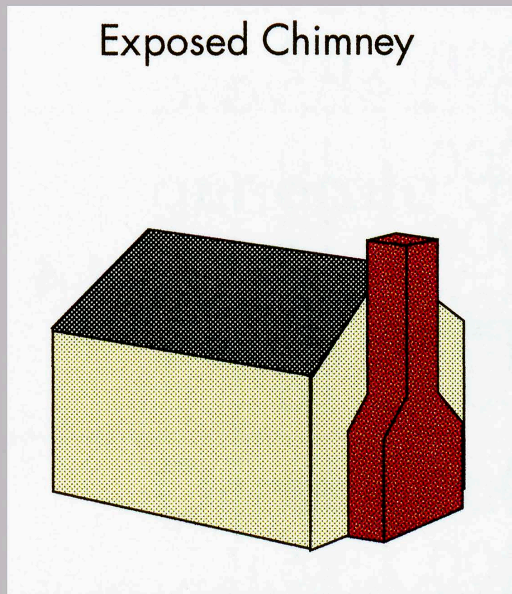
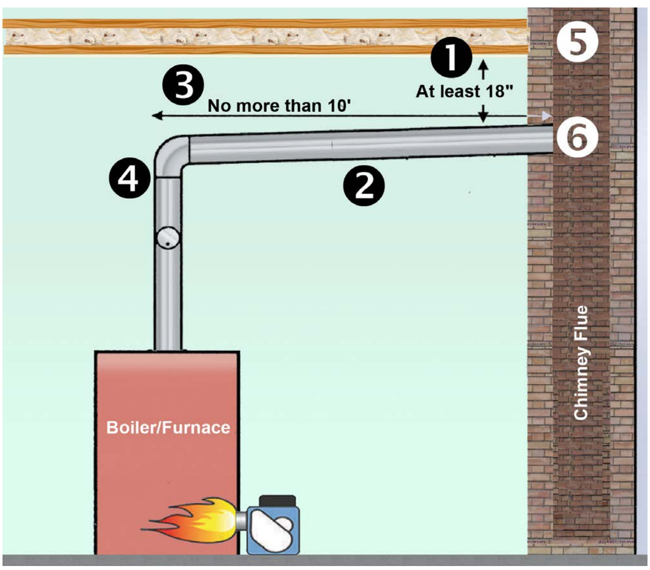


Figure 15



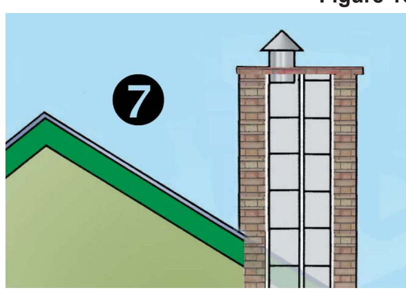
4. Each joint of the flue pipe shall be fastened with at least three screws.

5. The flue pipe must not be longer than 75 percent of the portion of the chimney above the chimney inlet. (For example, if the chimney extends 20' above where the flue pipe connects, the flue pipe can be no longer than 15'.)

6. In masonry chimneys, the flue pipe must extend through the chimney wall to the inner face or liner, but not beyond, and shall be firmly cemented in place.

7. The flue gas exit of a chimney must be at least three feet above the highest point where it passes through the roof and at least 2' higher than any portion of a building within 10' of the chimney. Figure 16.

Figure 16



Blocked Vent Safety Control for Oil-fired Appliances

Venting systems can malfunction or become blocked. Animals sometimes enter the system, soot can accumulate, chimney liners can deteriorate, etc. When the vent malfunctions, flue gases, including carbon monoxide, can enter the building.

Thermal safety switches detect flue gas spillage caused by blocked flues, continuous downdrafts and/or inadequate draft conditions. Figure 17.

These manual reset devices “lock out” when they sense a temperature over 200°F. They are mounted as close to the breech of the appliance as possible and wired in series with the primary control to prevent the burner from operating if there is a blockage in the venting system. Figures 18 & 19.

Figure 17

Chimney Venting Today

As a result of the energy crisis in the 1970s, there have been many improvements relating to the efficiency of homes and the heating equipment installed in them.

Homes have been made “tighter” by adding insulation and caulking around windows and doors. These energy-saving improvements reduce

Figure 18

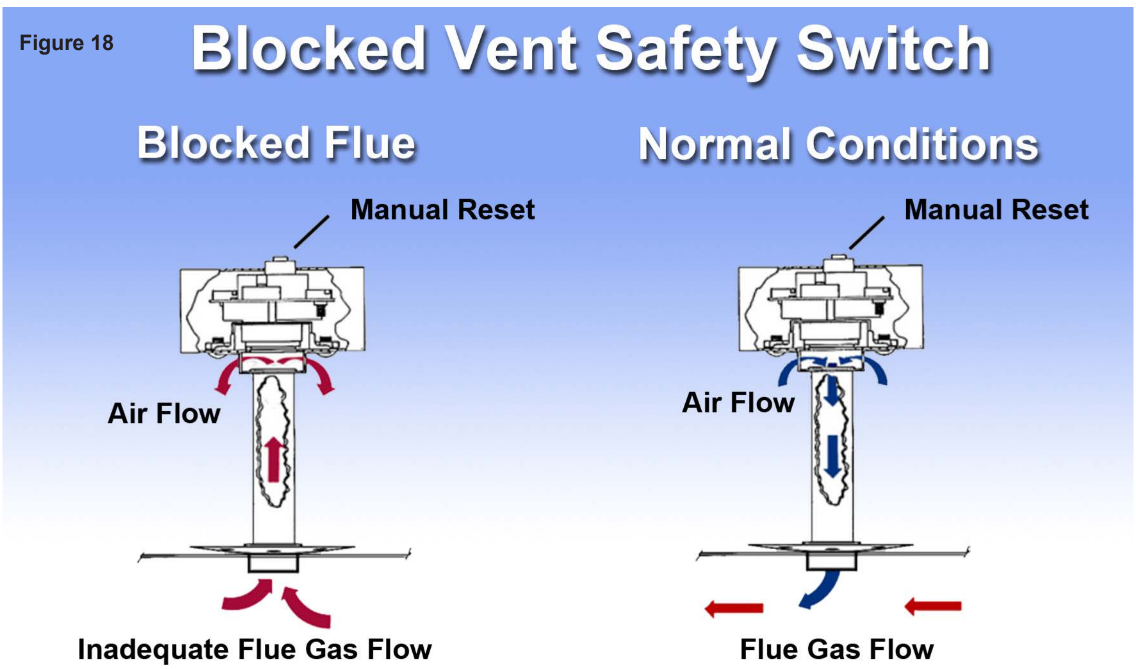
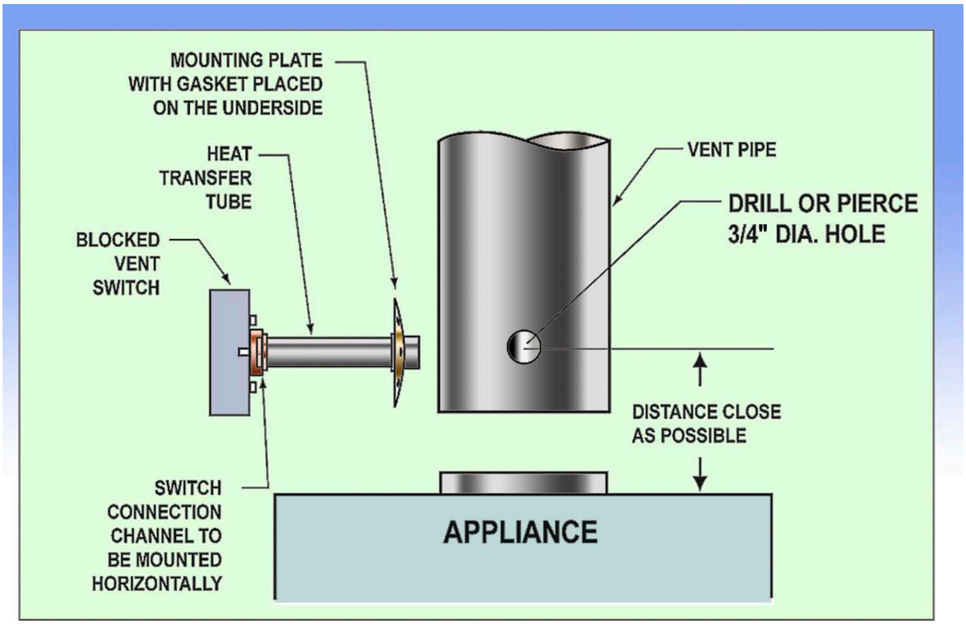


Figure 19: Blocked vent switch installation diagram.



the heat loss of the building and allow smaller Oilheat appliances to be installed.

Boilers and furnaces are much more efficient than those that were available 40 years ago. Common gross flue gas temperatures before the energy crisis were in the 650–700 degree range and typical firing rates ranged from 1.25–1.50 gallons per hour (gph).

Today's high efficiency Oilfired heating systems have gross stack temperatures that typically range from 300–500 degrees with average firing rates of .75–.85 gph.

All of these improvements have led to problems with chimneys that had functioned properly with older, less efficient Oilheat equipment. Exhaust temperatures decrease as efficiency increases and chimney draft decreases as the flue gas temperature drops. In addition, flue gas temperature at the top of the chimney decreases as the gross stack temperature drops. Installing higher efficiency heating equipment in larger and/or older chimneys increases the probability of flue-gas condensation and related chimney concerns. Figure 20.

This view, looking up a masonry chimney, shows cracks and flaking of the liner due to condensation.

Signs that a Chimney Needs Repair/Relining

NORA recommends that Service Technicians begin troubleshooting before they enter a customer's home or business. As the technician approaches the building, he or she should look at the chimney for any indications of a problem. Once inside the structure, the inspection should continue.

Among the more common indications that a chimney needs repair/relining are:

- Leaning chimneys—Such a chimney is clearly in need of a major repair. The appliance that is venting into this chimney should be shut down until a repair or replacement is completed. Figure 21.

- Chimney crown damage—Crown damage due to freeze/thaw cycling is the most common damage. The outdoor chimney crown is a good indicator of chimney condition. Figure 22.

- Loose bricks and/or mortar—This indicates condensate damage to the masonry chimney; in such cases, relining is necessary to prevent further damage to the vent system. Figure 23.

- White powder (efflorescence) on exterior brick surfaces—Figure 24 shows efflorescence —salt deposits being driven from the chimney's bricks due to flue gas condensate.

- Moisture on the exterior walls of the chimney—Figure 25 shows moisture and efflorescence at the roofline due to condensation.

- Moisture or stains on interior walls near the chimney—Figures 26 show plaster that fell off interior walls due to condensate.

- Visual evidence of damage—This severe damage includes missing, broken, cracked and separated tile—and warrants shutting the system down. Figure 27.

- Debris in the cleanout—Mortar, tile liner and flakes are a clear indicators that the chimney needs repair or relining. Figure 28.

- Misaligned terra-cotta tiles at the joints—In addition to the misalignment, Figure 29 shows a liner with missing, broken, cracked and flaking tiles.

- No liner installed —Oilheat systems should NOT be connected to a chimney without a liner. Figure 30.

Steps to Take Installing a New Oilheat System into a Chimney

Chimney inspection

NORA recommends that chimney cleanings and inspections be performed before a new high efficiency Oilheat appliance is installed to replace an older unit.

The inspection should include the following:

- If there is a clean-out door, make sure that it is shut tight and sealed.

- Observe the exterior of the chimney. If it is damaged, deteriorating or leaning to one side, further inspection by a chimney professional should be recommended.

- Remove the flue pipe from the chimney breech and inspect the inside of the chimney with a light and a flame mirror for signs of damage or deterioration.

Even if the chimney inspection shows that there are no problems, remember that the gross flue gas temperatures for high-efficiency systems range from about 300°F–500°F at the outlet of the unit. These temperatures are reduced before reaching the chimney because of heat loss from the flue pipe and dilution air from the draft regulator. The resulting flue gas temperatures are usually insufficient to sustain adequate draft in an older, oversized masonry chimney and they allow condensate to form in the chimney.

Fig. 21: Leaning chimney

Fig. 22: Chimney crown damage

Fig/ 23: Loose bricks and/or mortar

Fig. 24: White powder

Fig. 25: Moisture on exterior walls of chimney

Fig. 26: Moisture or stains on interior walls near chimney

Fig. 27: Visual evidence of damage

Fig. 28: Debris in the clean-out

Fig. 29: Misaligned terra-cotta tiles at the joints

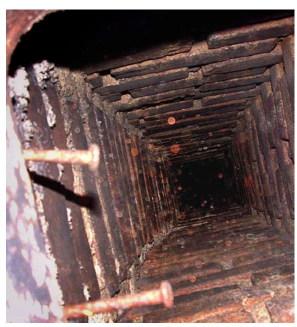


Fig. 30: No liner installed

In some situations, a metal chimney liner might be needed to increase draft and reduce condensation during burner operation, especially with large chimneys. Figure 31.

Annex E of NFPA 31 provides guidance for the relining of masonry chimneys. Venting tables are included that contain recommended sizes for metal liners based on the firing rates of the installed appliances.

These two tables below are provided for units with 88% and 84% steady-state efficiency. Additional tables for other steady-state efficiencies are published in NFPA 31.

Figure 31

This table is for an appliance with a steady-state efficiency of 88% with 12% CO_2 and 300 degrees gross stack temperature.

Height ft.	Lateral ft.	Liner 6 in.	Liner 5 in.	Liner 4 in.
10	4	0.5–1.0	0.4–0.65	0.25
	10	0.4–0.75	NR	NR
15	4	0.65–1.25	0.4–0.75	0.4
	10	0.5–1.0	0.4–0.75	0
20	4	0.65–1.5	0.5–0.85	0.4
	10	0.65–1.25	0.65–0.85	0.4–0.5
25	4	0.75–1.5	0.65–1.0	0.5
	10	0.85–1.25	0.65–0.85	0.5
35	4	1.0–1.75	0.75–1.0	0.5
	10	1.0–1.5	0.75–1.0	0.5
45	4	1.25–1.75	.85–1.0	0.65
	10	1.25–1.75	0.85–1.0	0.65

NR= Not recommended

The table above shows that for a 10' chimney with a 10' flue connector, the maximum firing rate is 0.75 gallons per hour with a 6" liner. It also indicates that 4" and 5" liners are not recommended with a 10' flue connector.

This table is for an appliance with a steady-state efficiency of 84% with 12% CO_2 and 440 degrees gross stack temperature.

Height ft.	Lateral ft.	Liner 6 in.	Liner 5 in.	Liner 4 in.
10	4	0.4–1.5	0.25–0.85	0.25–0.5
	10	0.4–1.25	0.25–0.85	0.25–0.4
15	4	0.5–1.7	0.4–1.0	0.25–0.65
	10	0.65–1.5	0.4–1.0	0.4–0.5
20	4	0.65–1.75	0.5–1.25	0.4–0.65
	10	0.65–1.75	0.5–1.	0.4–0.5
25	4	0.65–2.0	0.5–1.25	0.4–0.75
	10	0.65–2.0	0.5–1.25	0.4–0.65
35	4	0.85–2.25	0.65–1.5	0.5–0.75
	10	0.85–2.25	0.65–1.25	0.5–0.75
45	4	1.0–2.25	0.75–1.5	0.65–0.75
	10	1.0–2.25	0.75–1.5	0.65–0.75

The table above shows that for a 10' chimney with a 10' flue connector, the maximum firing rate is 1.25 gallons per hour with a 6" liner, .85 gph with a 5" liner and 0.4 gph with a 4" liner.

Chapter 3

Alternative Venting Systems

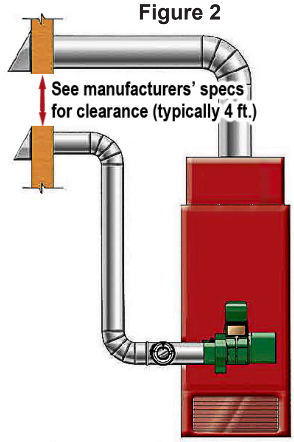
With chimney venting, the flue gases travel through the heating appliance and up the venting system because hot gases naturally rise.

Today's high-efficiency appliances absorb more heat and produce lower temperature flue gases that do not rise as quickly, or as reliably, as they do with older, less efficient systems. As discussed in Chapter 2, these lower flue gas temperatures often require chimney liners to be installed when high efficiency appliances are installed. One alternative to chimney lining is to install an alternative venting system that does not rely on high temperature flue gases.

This chapter will explain two types of alternative venting systems for non-condensing Oilheat appliances.

Power-venting: a fan, attached to the flue pipe where it exits the building, pulls the flue gases out of the heating unit. According to NFPA-31, power venting is "The application of a mechanical means of removing combustion products to the outside atmosphere." See Figure 1.

Figure 2

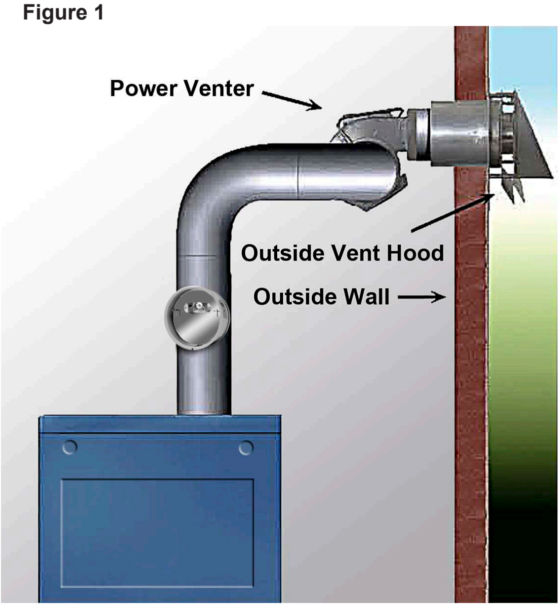


Direct-venting: the static pressure created by the burner pushes the combustion gases through the heat exchanger and out of the building. Figure 2.

Both of these types of venting are often referred to as sidewall venting.

Direct venting requires that the oil burner primary control has valve-on delay and burner-motor-off delay features. Power venting requires that the oil burner primary control has valve-on delay and burner-motor-off delay features and/or the vent must have pre-purge and post-purge cycles.

Figure 1



Advantages

The advantages of alternative venting systems include:

- Better draft control
- No cold chimney problems
- Lower initial cost than a chimney
- Less floor and wall space used
- Elimination of back drafts
- Reduction in standby losses

Power Vent

Power vents are mounted near or on the outside of the building and pull the combustion gases from the appliance using negative pressure. They require controls that interlock with the appliance control circuit to ensure that proper draft is established before the oil burner is activated. A power vent control system includes a draft-proving switch and either a thermal or timed post purge cycle.

> **Stainless steel power vents must be used with Oilheat appliances**; aluminized power vents are designed for gas systems and do not hold up when installed with Oilheat appliances.

Power vent systems are available as a combination unit that can also supply outdoor combustion air to the burner. These units combine the benefits of power vent with those of “air boots” direct connect combustion air explained in Chapter 1.

How a Power Vent System Works

See Figure 3 below.

1. A call for heat energizes the power vent (A).

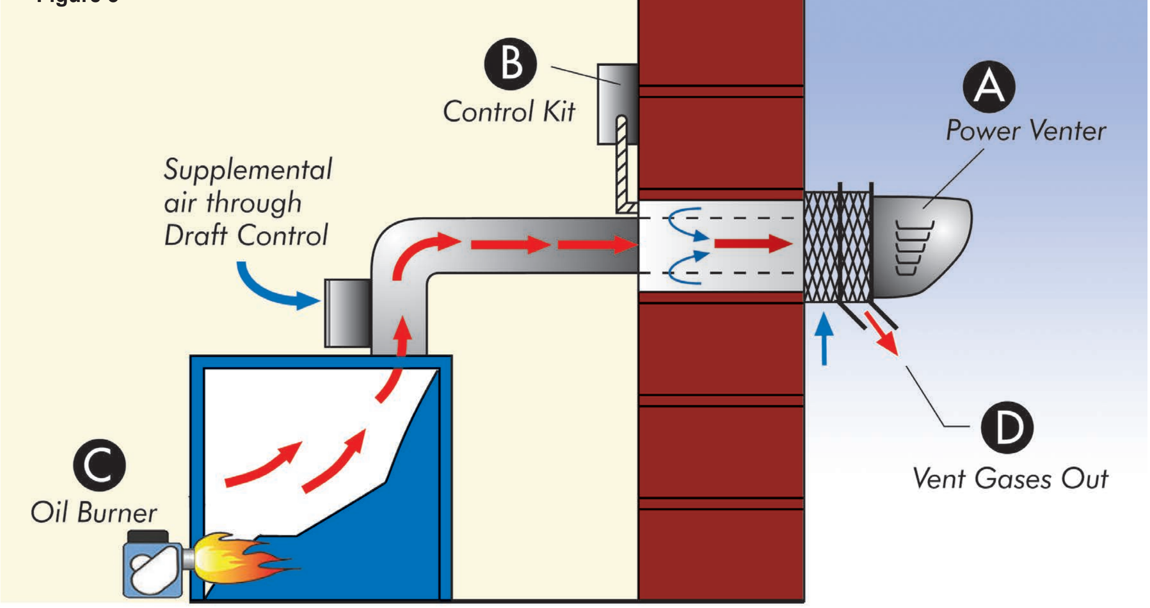
2. Negative pressure (draft) is established, closing a pressure switch (B).

3. The burner (C) is activated and combustion gases are exhausted (D).

4. After the call for heat is satisfied, the burner shuts off and the power vent continues to operate, exhausting residual flue gases.

5. When the post-purge timer or temperature control is satisfied, the power vent shuts off.

Figure 3



The Power Venter pulls combustion gases to the outside, creating negative pressure in the vent pipe.

Sizing the Power Venter

Power vents are sized based on the input firing rate of the appliance AND the equivalent feet of vent pipe for the installation. If the power vent is being used for multiple appliances, it must be sized based on the total firing rate and total equivalent feet of all connected appliances.

Table 1

Equivalent Feet for Vent Pipe Fitting										
Vent Pipe Fittings	Vent Pipe Diameter									
	3"	4"	5"	6"	7"	8"	9"	10"	12"	14"
Tee	19	25	31	38	44	50	56	63	75	89
Y-Connection	10	13	16	20	23	26	29	32	39	45
90° Elbow	5	7	9	11	12	14	16	18	21	25
45° Elbow	3	4	4	5	6	7	8	9	10	13

Calculating the Equivalent Feet of a Venting System

To determine the total equivalent feet:

1. Determine the total equivalent feet for each type of fitting used in the venting system from Tables 1 and 2.

2. Calculate the total length of the straight lengths of pipe.

3. Add the equivalent feet of the fittings to the total length of the straight pipe to determine the total equivalent feet of the vent system.

4. Find the total equivalent feet in Table 3 to determine the proper model for the installation.

Table 2

Equivalent Feet for a Reducer/Increaser										
Large Pipe Size	Small Pipe Size									
	3"	4"	5"	6"	7"	8"	9"	10"	12"	14"
3"	0									
4"	2	0								
5"	4	2	0							
6"	5	4	2	0						
7"	6	5	4	1	0					
8"	7	7	6	3	2	0				
9"	7	8	7	5	4	2	0			
10"	8	8	8	6	6	4	2	0		
12"	8	10	10	8	9	8	6	4	0	
14"	9	10	12	10	12	11	9	8	3	0
16"	9	11	12	11	14	13	13	11	8	3
18"	9	11	13	12	15	15	15	14	11	7
20"	9	12	14	13	16	17	17	17	15	11

To estimate the equivalent feet length of the Reducer/ Increaser, find the figure at the intersection of the small pipe size and the large pipe size.

***For example**, for a vent system made up of 6" pipe:*

***Step 1**: Two 6" 90° elbows equivalent to 11′ each = 22′*

***Step 2**: Five 4′ lengths of 6" pipe = 20′*

***Step 3**: One 6" x 4" reducer = 4′*

***Step 4**: 22′ + 20′ + 4′ = 46′ total equivalent feet.*

If the calculated equivalent feet is greater than what is specified for the power vent, increase the diameter of the vent pipe or use the next larger size power vent.

Table 3

MODEL	MAX* OIL GPH INPUT 100psi	MAX* OIL GPH INPUT 140psi	Maximum Equivalent Feet of Vent Pipe		VENT PIPE SIZE
			AT MAX BTU/hr. INPUT	AT 60% OF MAX BTU/hr. INPUT	
SWG-4HD, 4HDs CV-4	1.10	.90	35	100	4"
			65	100	5"
			100	100	6"
			100	100	7"
SWG-5, 5s CV-5	1.85	1.55	16	44	4"
			51	100	5"
			95	100	6"
			100	100	7"
SWG-6, 6s	2.65	2.25	28	78	5"
			68	100	6"
			100	100	7"
SWG-8	4.75	4.0	26	72	7"
			51	100	8"
			70	100	9"
SWG-10	9	7.5	10	100	8"
			30	100	10"
			75	100	12"
SWG-12	13.5	11.5	16	100	10"
			40	100	12"
			86	100	14"
SWG-14	21	17.75	8	85	12"
			18	100	14"
			35	100	16"

Note: The maximum equivalent footage allowable for the vent pipe is given for two points: 1) the maximum BTU/hr venting capacity and 2) at 60% of the maximum. This allows for estimating values between the two given points.

Terminal Location of a Power Vent System

The location of the terminal of a vent system must comply with manufacturer's instructions, NFPA 31 and the local authority having jurisdiction.

Manufacturer's instructions and local codes generally require that (See Figure 4):

A. It must be at least 7' above grade when located adjacent to a public walkway.

B. It must be at least 4' below, 4' horizontally from, or 1' above any door, window or air inlet into a building.

C. It must be at least 3' above any forced air inlet located within 10'.

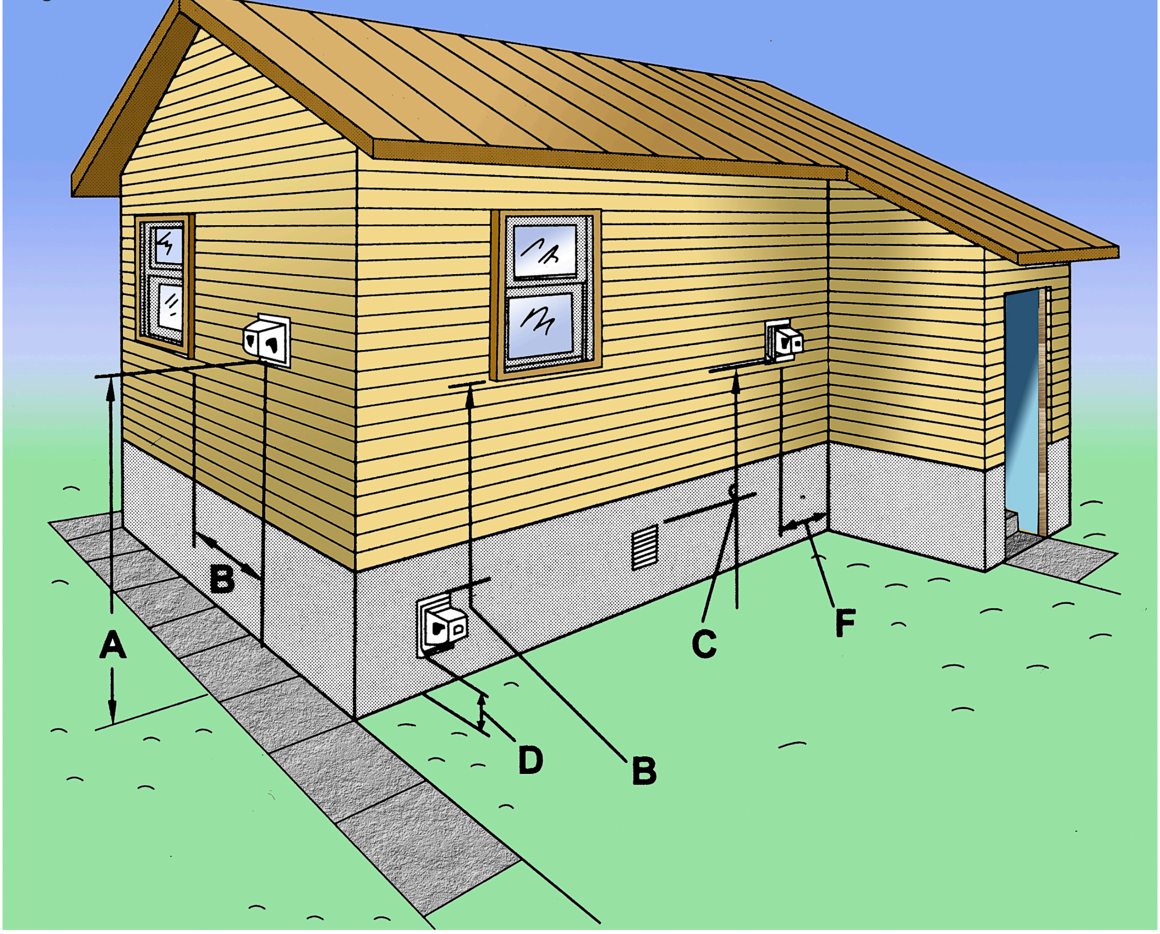
D. The bottom of the terminal must be at least 1' above finished grade or the anticipated snow load.

E. It must not be mounted directly above or within 3' horizontally from an oil tank vent or gas meter (not shown).

F. It must be at least 3' from an inside corner of an L shaped structure.

Vent risers are available for basement installations where a window well is used, or in situations where the vent terminal cannot be mounted to maintain the minimum clearance above grade or the anticipated snow load. Figure 5.

Figure 4



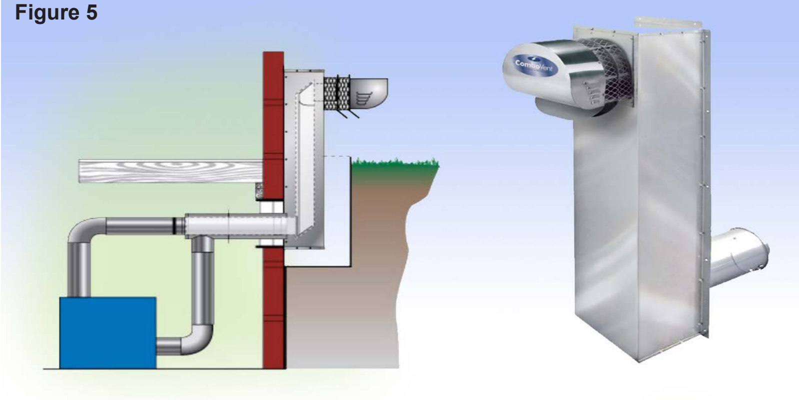


Figure 5

Setup and Adjustment

The proper procedures for adjusting a power venter are found in the manufacturer's instructions and are typically the following, Figure 6:

1. Set the choke plate on the power vent to its full open position. (Some power vent systems have the choke plate on the inside at the power vent unit and some are adjusted on the outside of the building at the power vent.)
2. Set the draft control adjustment to its midpoint position.
3. Fire the system and let it run for 5–10 minutes to stabilize stack temperature.
4. Check the appliance manufacturer's specifications for draft over the fire and at the breech.
5. Close the choke plate on the power vent until the draft above the draft control reads approximately -.04" greater than the recommended breech draft. Figure 7.

Figure 7

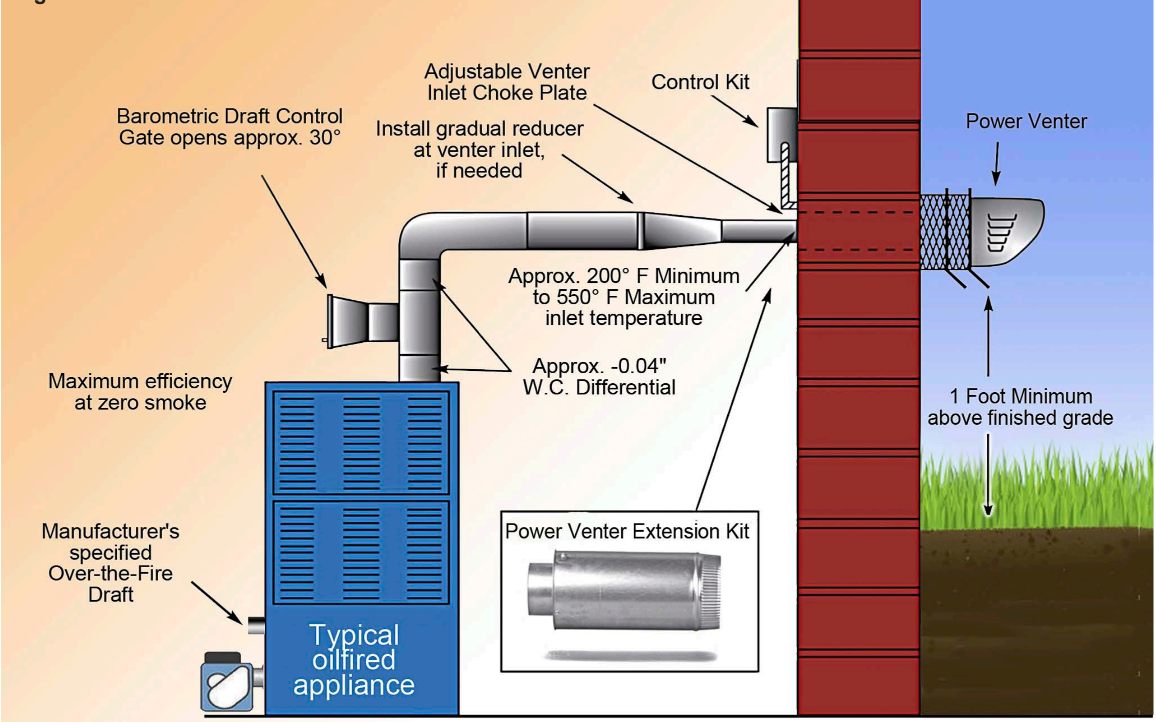



Figure 6

6. Adjust the barometric draft control to obtain the appliance manufacturer's recommended draft at the breech and over the fire. The draft control gate should be open approximately half its full swing during normal operation.

7. If the proper draft cannot be obtained at the breech or if the gate does not open as described, adjust the choke plate to reduce or increase the airflow. Readjust the draft control to obtain the required draft (adjusting the choke plate changes the system draft).

8. Once the proper draft is obtained, perform a smoke test and adjust the burner air intake (if necessary) to obtain zero smoke. As the air intake is adjusted, the draft may change. If it does, repeat steps 4 through 8 to readjust the draft control and choke plate before continuing.

9. Calculate the combustion efficiency and verify it is at the manufacturer's recommendation with zero smoke. Measure the exhaust gas temperature at the power vent inlet and confirm it is within the manufacturer's recommendation, typically between 200°F and 500°F.

10. If the manufacturer's recommended efficiency at zero smoke yields a temperature below 200° F at the inlet to the venter, the following suggestions must be considered:

A. Increase the firing rate if the appliance manufacturer's instructions allow it.

B. Insulate the flue pipe to minimize heat loss.

C. Seal the flue pipe joints to reduce uncontrolled dilution air.

D. Minimize the vent length from the appliance to power vent system.

11. Adjust the pressure switch (Figure 8) by doing the following:

A. Turn the adjustment screw clockwise until the burner shuts off.

B. Then slowly turn it counter-clockwise until the burner starts.

C. Turn an additional ¼ to ½ turn.

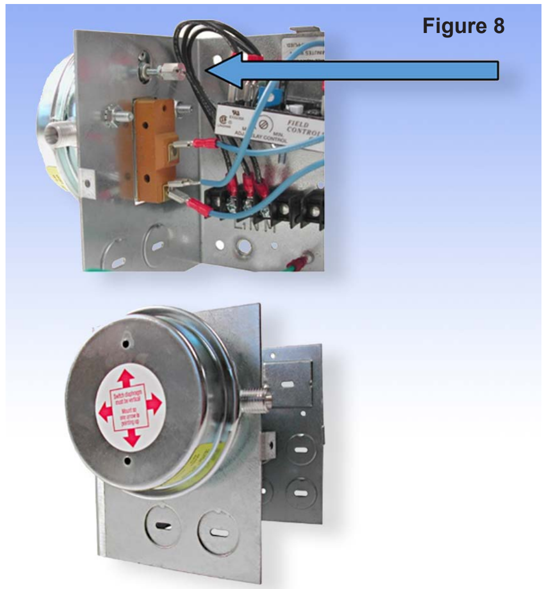


Figure 8

Annual Maintenance

A power-vent system should be inspected and maintained according to the manufacturer's guidelines. During the annual maintenance the service technician should:

1. Check to be sure the motor and fan rotate freely.

2. Lubricate the motor and fan shaft with the lubricant specified by the manufacturer. The use of non-approved lubricants often leads to premature failure.

3. Inspect the power-vent wheel and clear out any soot, debris or coating that inhibits either rotation or air flow.

4. Remove and clean the air sensing tube.

5. Inspect all vent connections for tightness, evidence of corrosion, and/or flue gas leakage.

6. Replace, seal, and/or tighten all of the pipe connections as necessary.

7. Check the choke plate to insure it is secured in place.

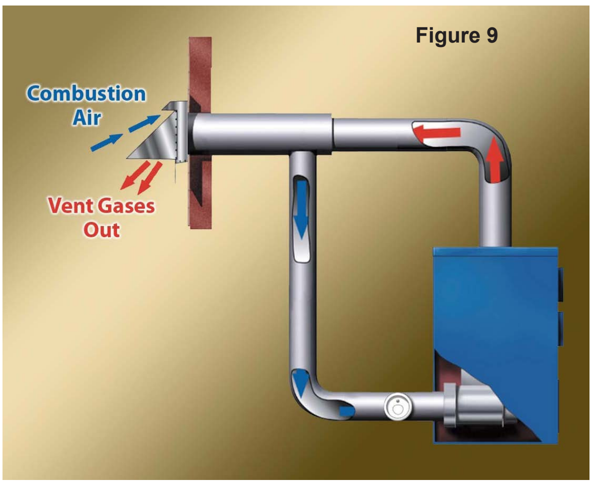
8. Check the barometric draft control to insure the gate swings freely.

9. Check the safety system devices—start the heating system, and then disconnect the pressure sensing tube from the pressure switch—this should stop the burner. Reconnecting the tube should restart the burner.

10. Correct all deficiencies found and adjust the appliance to the manufacturer's specifications.

Direct Venting

Direct-vent Oilheat systems use the power of the burner fan to push products of combustion through the appliance to the venting system and out of the building (Figure 9). They require high static pressure burners and outside air is used for combustion.



Unlike chimney venting and power venting, the appliance exhaust is under positive pressure. If there is a leak in the exhaust pipe, products of combustion will leak into the building. The intake is under negative pressure and must be sealed according to manufacturer's instructions to prevent chamber pressure imbalances that lead to nuisance lock-outs. Because of this, it is critically important that the system be completely sealed according to the manufacturer's instructions.

It is always important to follow manufacturer's instructions but special mention is made here because the instructions may be significantly different from those with which an installer is familiar.

> Direct-vent systems are sold as complete listed and approved packages. Mixing and matching components and/or do-it-yourself engineering is not approved and creates hazardous conditions.

For example, consider this statement:

"PB Heat, LLC requires that the vent slopes down 1/4" per foot towards the vent terminal. This takes precedence over the requirements shown in the Z-Flex manual."

If the installer followed the flue manufacturer's instructions, rather than the appliance manufacturer's, the appliance may not operate properly and/or may present a safety hazard.

> With both chimney venting and power venting, each joint of the flue pipe must be fastened with at least three screws. Since direct vent systems are under positive pressure, there should not be any screws into the flue pipe. Typical manufacturer's instructions say, "Do not install screws into or otherwise penetrate any part of the vent pipe under any circumstances."

Installation Considerations

The installation criteria for a direct vent system are similar to those for power vent systems, with a few differences:

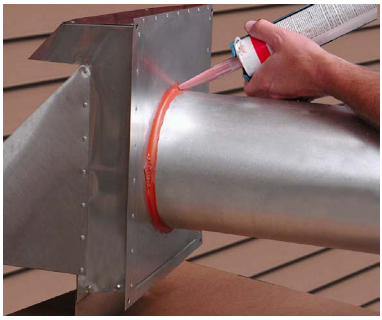
- All joints on the venting system must be sealed with a high temperature sealant.

• Adjust burner for highest CO_2 (no more than 13%) while maintaining a 0 smoke spot. Pressure or draft over-fire and in-flue cannot be adjusted. However, draft and/or pressure measurements must be taken in these two locations and recorded for reference.

• Combustion efficiency tests should be taken at the port provided on the unit by the manufacturer. Do not puncture the stainless steel vent tubing.

Installation Procedures

1. Select the terminal location and cut a hole through it. (See No. 4).



2. Seal the backside of the base plate.

3. Mount the vent terminal through the wall from the outside, fasten and seal the edges of the base plate with high temperature silicone sealant.

4. Mount the backing plate from the inside of the structure and fasten it with appropriate hardware.

5. Assemble the tee and attach it using screws. Not a positive pressure location, but requires a good seal to prevent pressure imbalances.

6. Cut the listed insulated pipe to the appropriate length.

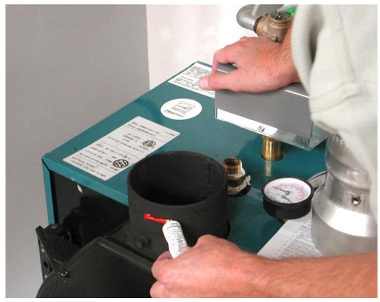
7. Place the collar on the back of the tee.

8. Place the cover sleeve onto the flue pipe.

9. Attach the pipe onto the tee.

10. Apply sealant to the cover pan around the inner pipe, joints and tee assembly.

11. Seal or tape the joints from the termination to the tee assembly.



12. Apply a bead of sealant to the appliance collar.

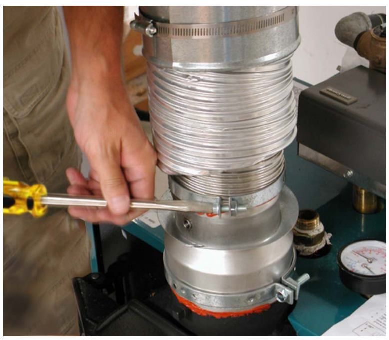
13. Apply a bead of sealant to the inside of the adapter.

14. With a twisting motion, assemble the adapter to the appliance collar.

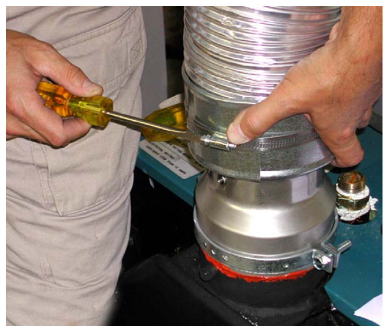
15. Drive the adapter onto the appliance using a mallet and block of wood.

16. Install adapter clamp onto adapter.

17. Attach flue pipe to adapter.



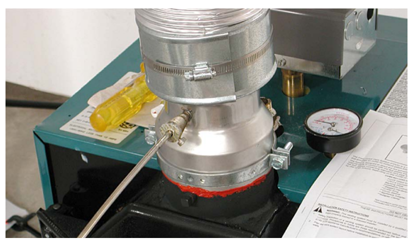
18. Adjust clamp until both halves are 1/8" apart.



19. Fasten cover sleeve.

20. Install elbow into bottom of tee and run intake air pipe to burner location.

21. Install VRV close to the air inlet of the burner and adjust for proper flow.



22. *Inspect the assembled unit and ensure that the burner is working properly*. Perform combustion tests using the port provided. Apply sealant and install port plug screw.

Chapter 4

Venting Systems for Condensing Appliances

Condensing appliances require special venting systems that differ from those used with non-condensing appliances.

To understand the venting process, it's important to understand that condensing appliances achieve their higher efficiencies by extracting almost all of the heat from the combustion gases before they pass through the venting system and are emitted to the atmosphere.

Condensing appliances don't offer more efficient combustion than non-condensing appliances; they simply extract more heat from the combustion gases than non-condensing appliances.

In a non-condensing appliance, water vapor (one of the by-products of combustion) travels through the appliance and escapes through the venting system to the outside atmosphere, where it cools and condenses.

In a condensing appliance, the flue gases pass through the heat exchanger(s) for a longer period of time, allowing the appliance to absorb more heat. The gases condense in the appliance and as they cool, water vapor drips out of the heat exchanger instead of passing to the outside through the venting system.

Because the flue gas temperatures of condensing Oilheat appliances are so low, the venting systems differ from those described in Chapters 2 and 3.

The Condensate

Flue gas condensate drains from the appliance into a trap (Figure 1) which must be piped to an appropriate drain location.

The condensate is acidic, with a pH of about 3.5. Continual exposure to condensate may injure plants and can damage certain building materials, including metal, wood, stone, and concrete. Some local codes require that an acid

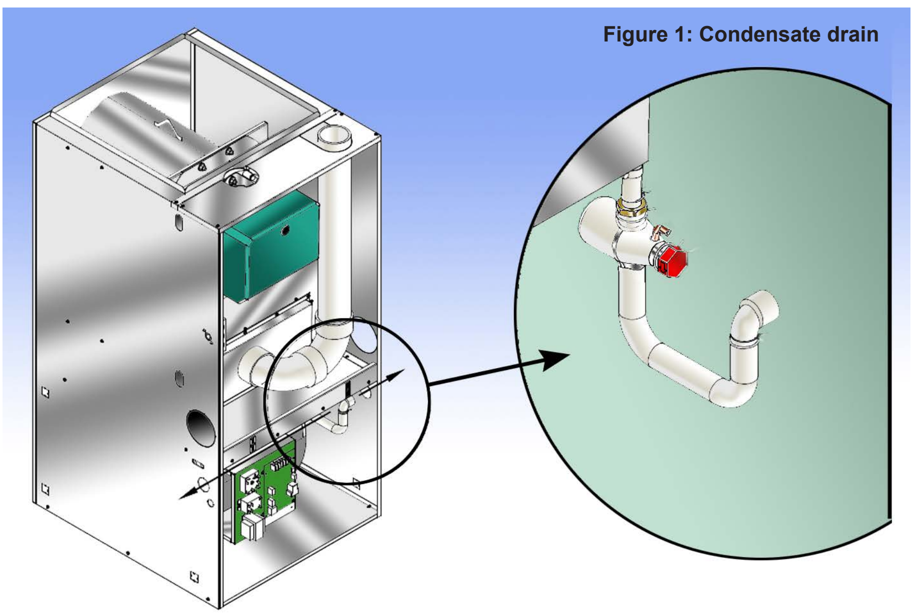


Figure 1: Condensate drain

neutralizing kit be connected to protect pipes and sewer systems.

Some condensing appliances are equipped with a blocked drain switch (Figure 2) to prevent the unit from operating in the event of a blocked or slow-draining drain. This switch is wired in series with the primary control's T & T circuit and opens if the condensate level gets too high.

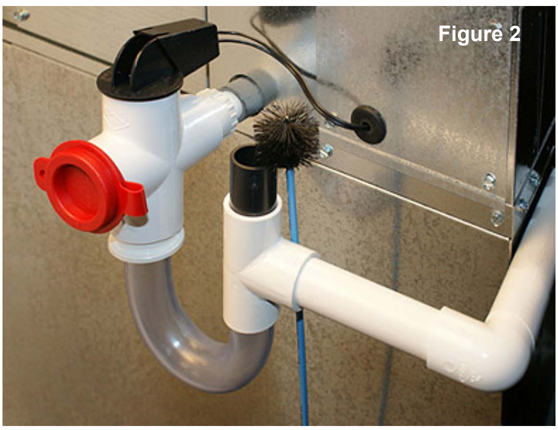


Figure 2

A condensate pump may be needed to remove the condensate to a safe place when:

- a suitable drain is not present at the appliance;
- the drain is above the trap outlet level on the appliance;
- the drain line cannot be sloped downward for its full length to the drain.

The condensate piping in the appliance and the drain system should be flushed regularly, at least once each year.

PVC vs Stainless Venting Systems

PVC piping is normally used as the venting material for condensing furnaces. However, since PVC starts to soften and lose its shape at about 150°F and condensing boilers can have flue gas temperatures between 190°F and 300°F, polypropylene or stainless steel must be used for venting hydronic appliances.

PVC Venting Systems—Furnaces

There are a number of requirements that must be met when venting with PVC and the specific manufacturer's instructions must always be followed. In general, manufacturers agree that:

- Vent size reduction is not permissible.
- Horizontal runs must be supported every 3–5 feet to prevent sagging, joint separation or pipe blockage.
- The vent system must slope upward from the appliance to allow proper drainage of condensate.
- Vent pipes passing through unheated areas must be insulated.

and there are significant differences in a number of areas, including:

1. Pipe—some manufacturers specify rigid Schedule 40 PVC only while others also accept ABS.
2. Fittings – some specify DWV and some accept Schedule 40.
3. The minimum and maximum length of piping.

Since there are major differences in the installation procedures for both boilers and furnaces, the only way to ensure that a system is properly installed is to follow the appliance manufacturer's instructions.

Stainless Steel or Polypropylene Systems—Boilers

The same situation exists with the venting of boilers as with furnaces—there are a number of requirements that must be met and the specific manufacturer's instructions must always be followed.

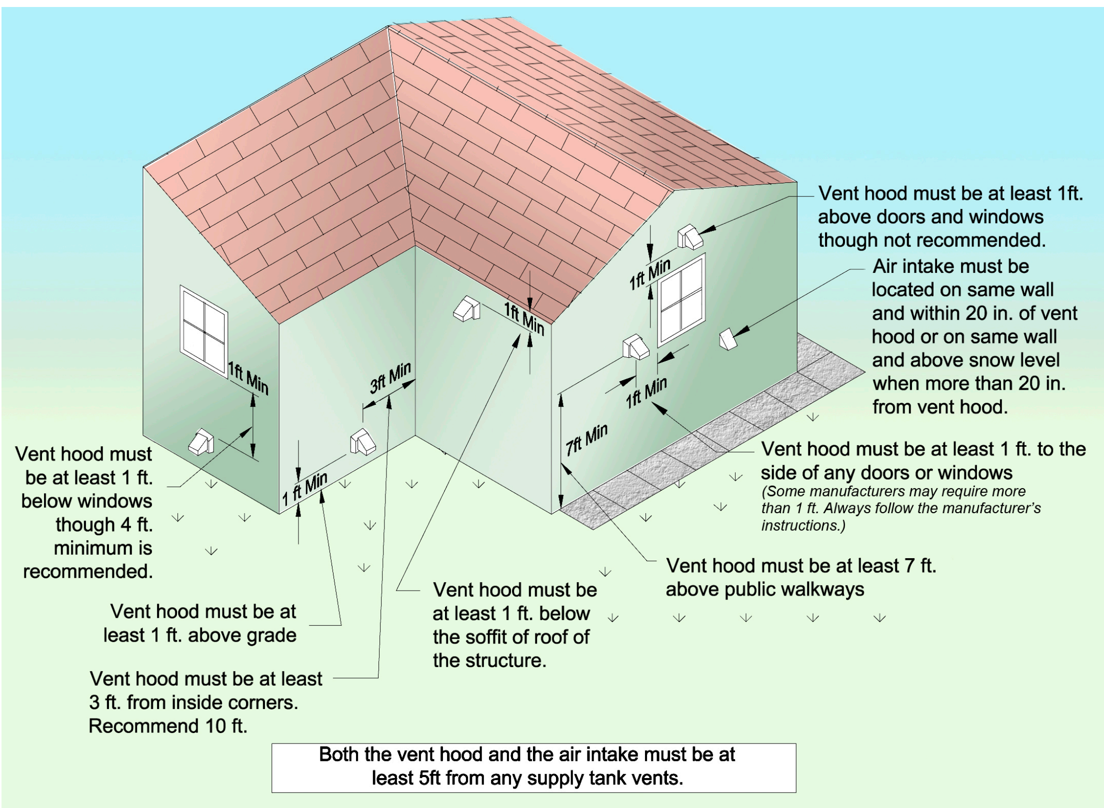
There is no "standard" set of instructions; different models of the same boiler have different allowable vent lengths.

Terminal Location

The terminal location requirements for condensing appliances are similar to those for power vent systems.

Because the appliance is likely to produce a visible plume due to condensation, surfaces close by will be coated with water vapor. The exhaust vent should be located in an area where the condensation will not cause an unsafe condition as, for example, under a deck where icing could result.

Figure 3 shows recommendations by some manufacturers for terminal locations specific to condensing appliances.



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