Fundamentals of Venting and Ventilation

• Vent System Operation

• Sizing, Design and Applications

• Installation and Assembly

• Troubleshooting
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**Venting and Ventilation**

When man first began to burn fuel for warmth, he soon learned that the smoke, created during combustion, caused problems when it was allowed to collect at the source. His early caves were selected and later lodges were constructed with an escape for these unpleasant fumes. As he began to employ natural gas as a fuel, he continued to use what he had learned. Today, we still find that proper vent system operation is vital to safe and efficient furnace operation. In this manual, we will discover the things which are needed to provide this vent system.

We will also learn that a gas furnace requires a substantial amount of fresh air to operate properly. This is called ventilation air. This air is used in combustion and as a replacement for the air that a modern home loses through outward flow due to mechanical ventilation. Although we cannot control the loss of air, we can properly diagnose it if it becomes a problem and suggest cures.

The following topics are covered in this manual:

- How a natural draft (gravity) vent works.
- Fan assisted vent systems.
- Power venting.
- Sizing and designing vent systems.
- Supplying adequate amounts of fresh air for ventilation.
- Vent system installation.
- Troubleshooting.

Using the guidelines in this book can help to ensure safe and reliable vent performance for both natural draft and fan assisted furnaces.

Note: No two installations are alike! Take the time to study each application. Plan ahead, use good judgment, and always comply with national, state, and local codes.

**Never sacrifice safety for efficiency or ease of installation!**

**Motive Force in Vents**

What causes a natural draft vent to operate? Heat! As we all know, heat rises. This is because heated molecules have a tendency to become agitated and to move about. Because of all this motion, the molecules “bump” into each other creating more space in between them. See Figure 1. This makes the substance less dense - lighter. Referring to Figure 1: As heat is applied to the air inside the balloon it expands and becomes lighter. When enough heat is applied, the balloon will become lighter than the air around it and begin to rise. For this reason, gas furnaces are designed with the heat exchanger outlet located above the inlet. This allows the heated products of combustion to travel in a natural, upward path forming a natural draft!

To come back down, the balloonist in Figure 1 merely has to stop applying heat. Soon, the air in the balloon will begin to cool and become heavier. The balloon will then start dropping back to earth.

Heat drives the flue gasses out of the furnace because heat always moves from warmer areas to cooler areas. The hot flue-gases would much rather travel up the relatively cool flue pipe than to “back-track” to the much hotter main burner flame.

The final force, which results from the heat which is created, is the pressure difference found between the inside of the vent and the atmosphere around it. The combustion air entering the furnace is at atmospheric pressure which, at sea level, is about 14.7 PSIA (Pounds to the Square Inch Absolute pressure). The hot flue-gases rising out of the furnace are less dense, creating a pressure drop within the heat exchanger. This “gap” is continually being filled by the higher pressure entering air/gas mixture. So, in effect, the gasses entering the furnace are helping to “push” the flue gasses out of the furnace. See Figure 2.
Factors Affecting Vent System Design and Operation

There are many variables dictating how well a vent system will operate. They are: 1. flue-gas temperature 2. heat loss in the vent 3. vent height 4. vent system capacity 5. restrictions to flow and 6. the ambient temperature.

Flue-Gas Temperature

Flue-gas temperature affects vent operation because the hotter the gases are, the lighter they are. The design BTUH (British Thermal Units per Hour) capacity of the vent plus the furnace input and efficiency are factors affecting the temperature of the flue-gases. Higher BTUH furnaces produce higher flue-gas temperatures. On the other hand, the higher the efficiency of a furnace, the lower the flue-gas temperature. Two cases which can cause poor venting are the oversizing of the vent or reducing the BTUH input to an existing vent system. Either case will result in excessive cooling of the flue gases and a reduction of the vent forces.

Heat Loss

The amount of heat lost through the vent is based on two factors. They are: the ability of the vent pipe to transfer heat, and the temperature difference between flue-gases and the air around the vent. Single wall metal vents conduct heat well. Some non-metallic vent materials may absorb large amounts of heat. Double wall metal vents are often preferred because of their insulating qualities and the fact that the relatively thin inner walls do not absorb much heat.

Temperature differential affects heat loss because of heat flow-rate. The greater the temperature difference is on either side of a substance, the faster the heat will flow through the substance. For example, sections of vent pipe passing through an unconditioned space will lose heat more rapidly than vents within a conditioned space.

Figure 3

Vent Height

Where vent height is concerned, taller is better. As an illustration of this principle, refer to Figure 3. In 3A, the air leaving the heat source has only a short distance to travel before encountering atmospheric pressure. This retards the ability of the flue-gases to set up a good flow before encountering resistance. Figure 3B shows a taller vent pipe which allows the flue-gases to gather a little more momentum before exiting the vent pipe. Therefore, they have a better chance of overcoming the atmospheric pressure at the vent outlet. Sample 3C is even better still. Because of resistance in the pipe, gravity, and the cooling of the flue-gases, you can make the pipe too long. There will be a point where these factors counter-balance the momentum of the flue-gases. This limit is not usually reached.

Vent System Capacity

The volume of flue-gases produced by a furnace directly depends on the BTUH input of the furnace. The greater the BTUH input of the furnace, the greater is the amount of combustion products which need to be removed. Vent system design tables take into account, among other things, the volume of gases which will be produced by a furnace of a certain input.

If the input is greater than the capacity of the vent, then the vent will be unable to carry all of the flue products away.

Figure 4

As a result, flue products will spill out of the draft hood relief opening. Figure 4 illustrates some of the problems which may result from undersized vents.

We have traditionally relied on the adage “Bigger is better!” However, if the BTUH input is substantially below the capacity of the vent, the flue-gases will cool off before reaching the end of the vent. The fan-assisted furnaces are affected by this and the charts which apply to them have been re-written to reflect this concern. The reduction in the drafting forces can lead to condensation and acid formation within the vent. Acids and condensation are the greatest enemies of the gas appliance vent.
**Resistance to Flow**

Resistance in a vent pipe can come in several forms. Some examples are vent fittings such as elbows, tees, vent caps, and end screens. Other, more subtle, examples are wall roughness of the vent pipe, the shape of the vent pipe (round, oval, square, rectangular) and the configuration of the vent system. Resistance caused by fittings is unavoidable. The vent designer can only limit the number of fittings to the minimum necessary. Resistance pertaining to vent system configuration can be held to a minimum using good, commonsense design procedures.

Fittings such as elbows and tees cause the flue gases to change direction and result in a loss of momentum. Other fittings such as end screens and flue baffles take up space in the vent. This effectively reduces the area of the vent pipe and, therefore, reduces the capacity of the vent.

The shape of the vent does affect operation somewhat, but it is not as critical as the other factors mentioned. Gas flow through a round pipe is less turbulent than through a square or rectangular pipe. However, because we are talking about relatively low velocities, the effects of turbulence are minimal and are usually not considered.

Of significant importance is the configuration and installation of the vent system. Most charts allow two 90° bends in the vent as they are written. Added 90° bends in the vent system cause a 10% loss in vent capacity. An excessive number of bends in a vent can overcome the drafting action completely. Later, in the section on vent system design, the effects of friction losses from bends is covered in more detail. Also, since flue gases want to rise, horizontal (lateral) sections do not contribute to draft action. For this reason, lateral runs of vent pipe must have an upward pitch of one-quarter (1/4) inch of rise per every foot of run. This is not a great deal of slope, but it is necessary to help ensure the upward travel of the flue-gases. In the extreme, a lateral run with a slightly downward slope can actually act as a “trap” and prohibit the flow of flue products.

Two good rules to follow when designing and installing vent systems are: (1) avoid an excessive number of turns and bends (Figure 5) and (2) maximize rise; minimize run.

**Ambient Temperature**

Two ambients must be considered. First, consider the ambient temperature of the air around the vent pipe. As stated earlier, heat loss through the vent pipe walls can take away from the draft force. Heat flow rate through a substance is directly related to the temperature difference on either side of the substance. The greater the temperature difference, the greater the heat flow rate. Care must be taken when running vent pipes through unconditioned spaces such as a ventilated attic. It is a good idea to insulate vent pipe in unconditioned spaces.

On the other hand, when it comes to combustion air supply, a lower entering air temperature is better. The cooler a substance is, the more dense it is. Being more dense also means it is heavier. Cooler air gives us more “push” at the combustion air inlet. In the case of a unit which draws all of its combustion air from outside, the vent system will perform better on colder days when the difference in temperature is greatest.

**Satisfactory Operation**

Section 7.2.1 of the National Fuel Gas Code (NFPA54/ANSIZ223.1), under minimum safe performance, states that a venting system shall be designed and constructed so as to develop a positive flow adequate to remove all flue or vent gases to the outside atmosphere.

**Ventilation Requirements**

Any discussion of venting must include coverage of ventilation. Ventilation is the process of replacing the air which is required for the furnace operation. The amount of ventilation air supplied within the structure must equal all of the air requirements of all of the gas-fired equipment in the building plus any air quantities removed by range hoods, exhaust fans, etc. Whole house ventilation fans, sometimes called attic fans, are not considered because they are not usually in operation during the heating season.

A natural draft furnace’s combustion air supply is divided into four parts. Primary air is pre-mixed with the gas inside the burner and makes up only about 20% of the air required to completely support combustion. Secondary air completes combustion by entering the furnace through openings near the burners and mixing with the gas at the burner flame.

In order to ensure adequate air supply to the burner, most furnace designs have air openings sized to provide the burner with more than enough air for combustion. This extra air is called excess air and the furnace design will determine the amount of excess air which will be used.
This excess air supply ranges, by design, from 30% to 50% of the requirements for complete combustion. **Dilution air** is that air which is drawn in through the draft hood or draft diverter relief opening. Dilution air is a “side-effect” of the need to have a relief opening. The main purpose of the relief opening is to relieve negative pressure extremes in the vent which may cause pilot flame outages or “lifting” of the main burner flame. Fan assisted furnaces do not use dilution air.

Sometimes, dilution air is necessary to lower flue-gas temperatures to a less hazardous level. Figure 6 shows the hot flue gases exiting the heat exchanger in an upward motion. This motion creates a pressure drop in the area of the relief opening. Because of this pressure drop, the air around the draft hood/diverter is drawn into the flue. This is because the ambient air is at atmospheric pressure and will flow to any area under less pressure.

Just how much dilution and excess air is required? Consider a couple of facts. First of all, we realize that the air around the draft hood is at the same atmospheric pressure as the air going into the combustion air openings. Second, the draft force at the draft hood/diverter is equal to and possibly greater than the draft force at the combustion air openings. These facts can lead us to conclude that the dilution air supply is equal to or greater than the combustion and excess air supplies combined.

To determine the total ventilation air requirement: **Example:** Input = 100,000 BTUH, 50% excess air

1. Obtain the minimum air required for complete combustion. **NOTE:** Approx. 10 cu. ft. per 1000 BTU
   
   \[\text{Calc: BTUH input} \div 1000 \text{ BTUH} \times 10 \text{ cu. ft.} = \text{cfh (cubic feet per hour)}\]

   Ex: 100,000 \div 1000 \times 10 = 1000

2. Multiply the result by the excess air percentage
   
   \[\text{Calc: Minimum requirement} \times \text{excess air \%} = \text{excess air}\]

   Ex: 1000 \times .5 = 500

3. Add the excess air to the minimum requirement
   
   \[\text{Calc: Min. req.} + \text{excess} = \text{primary \& secondary air}\]

   Ex: 1000 + 500 = 1500

4. Double this result to account for dilution air
   
   \[\text{Calc: Primary \& secondary air} \times 2 = \text{total}\]

   Ex: 1500 \times 2 = 3000 cfh or 50 cfm (cubic feet per minute)

**Vent Sizing and Design**

As mentioned previously, in order for a natural draft or gravity vent to work properly, it must have heat. **The proper amount of heat will be available only if the vent is sized properly.** Too small a vent will not have the capacity to carry all the combustion products outdoors. Too large a vent will allow excessive dilution air to mix with the combustion products and cool them so that a proper draft is not created. The vent must be made of a material that heats up quickly so that the draft will be established before combustion products spill into the room. Large, unlined masonry chimneys take so much heat to warm them that the venting may not take place properly for some time. Single-wall vents lose heat so fast that a proper heat level may not be established. In new construction, double-wall vents offer a good choice as a chimney liner for gas-fired appliances, if a lined chimney is to be provided. Before going on to detailed sizing instructions, a brief discussion of the types of products to be vented is in order.

**Furnace Categories**

In 1981 a task force from the American National Standards Committee was formed to develop recommendations for venting high efficiency gas appliances. One of the results of their work is the classification of gas appliances in relation to their venting characteristics. The two properties which are used for classification are the static pressure within the vent system and the temperature of the flue-gas entering the vent.

By static pressure in the vent, gas appliances are classified as positive or non-positive. A non-positive appliance vent will operate under zero or negative static pressures. Leakage in the vent system will flow into the pipe. A positive appliance will produce a positive static pressure within the vent. Because of this, measures to seal the vent against leakage must be taken when venting appliances classified as positive.

Where flue-gas temperature is concerned, the separation of categories is determined by whether or not condensation may occur inside the vent. A limit of 140°F (140 degrees fahrenheit) above the flue-gas dew-point was the value derived through testing and simulation. Appliances producing flue products with a temperature less than about 275°F (see Table 10 in the Appendix) have a high probability of
condensation forming in their vents. Vent systems for these appliances, found in Categories II and IV, must be constructed of a corrosion resistant material. Table 10 lists the different categories, the temperature and pressure attributes of each, and their venting requirements.

**Design Considerations for Venting the Separate Furnace Categories.**

**Category I**
Furnaces classified as Category I are non-positive with entering flue-gas temperatures greater than or equal to 140°F above their dew-point. This category includes all natural draft appliances and most induced draft or “fan assisted” appliances. Table 10 lists the venting requirements as being specified in Tables 1 through 6 or the National Fuel Gas Code (Figure 7). **A word of caution:** this category covers a wide range of products. Included in this category are the medium-high efficiency furnace models with efficiencies ranging from around 78% to just below 83% AFUE (Annual Fuel Utilization Efficiency). These primarily “fan assisted” furnaces produce flue products which are equal to or just above the 140°F above dew-point limit mentioned earlier. The title “fan assisted” refers to the gas combustion portion of the furnace, not the indoor blower for structure indoor air.

**Category II**
The vent systems for these forced-draft products are under positive pressure and must be leak-tight. Any leaks in these vent systems will be outward and will contaminate the atmosphere around the vent. See Figure 9. The venting material must be resistant to corrosion. See Figure 8. This is because there is a good chance that condensation will occur in the vent. It is also necessary that the vent material have a low heat transfer coefficient. There are currently some thermoplastic materials being used with these types of furnaces and gas appliances.

**Category III**
Category III furnaces are forced-draft furnaces with flue-gas temperatures greater than or equal to 140°F above dew-point. Because of the high flue-gas temperatures, condensation is not expected to occur in the vent systems for these products. Therefore, corrosion resistant vent materials are not specifically required. A special case is created when an induced draft furnace is to be vented horizontally. This will be covered later.

The vent sizing tables mentioned were originally designed on the assumption that entering flue-gas temperatures are above 360°F and have dilution air drawn into the vent system through the draft diverter. With furnace models in the efficiency range around 80% AFUE, flue-gas temperatures can be lower. With induced draft appliances, there is no dilution air. Accurate sizing of the vent systems for these models is critical. Later, in the section on sizing and design, proper venting of any Category I appliance or combination of these appliances will be covered using the latest release of these tables.

**Category II**
Category II furnaces are those non-positive furnaces which produce flue products less than or equal to 140°F above their dew-point. Because of the lower flue-gas temperature, the vent systems for these forced-draft products are under positive pressure and must be leak-tight. Any leaks in these vent systems will be outward and will contaminate the atmosphere around the vent. See Figure 9.
Types of Vents

Vent Classifications

Vents are classified by their construction, durability and resistance to heat and corrosion. The categories include: Chimneys, Type B vents, Type B-W vents, Type L vents, single-wall metal pipe, and plastic pipe.

A chimney is a vent constructed of masonry, reinforced concrete or metal. Masonry chimneys are the most common and were originally developed for use with coal or oil fired systems.

Special considerations are involved when using a chimney for venting a gas appliance. Chimneys used to vent Category I central furnaces must be either tile-lined or lined with a listed metal lining system. If a fan assisted furnace is to be used, the chimney must be internal to the structure and have another appliance, with natural draft, common venting into it or be lined with a Type B vent or a listed flexible metal lining system sized in accordance with the appropriate tables and notes. If one or more walls of the chimney are exposed to the outside of the structure, the chimney must be lined with a Type B vent or a listed flexible metal lining system. Masonry chimneys, which have been converted for gas after being used to vent coal, oil, or wood burning equipment must be lined with a suitable metal liner. Unlined masonry chimneys are prohibited.

Special attention must be given to the chimney's construction and location. Flue construction is especially important. The flue height and area affect the ability of the chimney to provide a good draft. Also, cracks and leaks in flue walls are a fire hazard.

Location of the chimney also affects venting. Chimneys located outside of the structure require a long warm-up period to establish adequate draft. See Figure 11. Chimneys on outside walls are more prone to condensation and therefore early deterioration.
**Type B** vents are widely used in new construction because of relatively low cost coupled with good performance. These vents can be made of aluminum, steel, or clay tile. Metal Type B vents employ double wall construction with an insulating air space. See Figure 12. When installed with specified clearances, excessive temperatures on surrounding combustible materials can be avoided.

**Type L** vents are also similar to Type B except they are higher in resistance to heat, fire, and corrosion. Type L vents have durability and resistance characteristics equivalent to fire-clay tile, cast iron or stainless steel. Other parts of the vent system which may be subject to condensation or contact with flue gases are constructed of the same materials and may include aluminum coated steel.

Type L vents are for use with oil and gas appliances listed as suitable for use with this type of vent. They can also be used as a substitute for a Type B vent or used for chimney or vent connectors. The use of type L vents is not common, although they are frequently selected for applications where heat and/or corrosion may be a problem.

**Single-wall metal** vents have limited applications. In some areas, local codes prohibit the use of this type of vent. Where permitted, vent material should be of at least 20 ga. galvanized sheet steel or at least 24 B & S gauge sheet copper or other non-combustible, corrosion resistant material.

The applications of single-wall metal vents are limited to runs from the appliance location directly through the roof or exterior wall. If, however, the vent is to extend back and upward through the eaves, the use of single-wall vents is not recommended. If a single-wall vent connector is adjacent to a cold outside wall, then it should be insulated. Another way to prevent the connector from losing too much heat to the wall would be to space it away from the wall. See Figure 14. Single-wall vents are not to be used for runs which pass through any concealed portions of a structure.

**Flexible metal** lining systems may be used in lining masonry chimneys. These liners are sized using the tables for Type B vents with the maximum rating reduced to 80% of the table rating. (Table maximum times 0.80 equals flex maximum.) The minimum rating is not affected.
**Plastic Pipe**
Due to the advent of higher efficiency furnaces, and therefore lower flue-gas temperatures, many manufacturers are specifying plastic vent pipes for their products. Plastic pipe has the advantages of corrosion resistance and leak-tight assembly. Two basic formulations are used: On 90+ AFUE furnaces, PVC and CPVC. For the 78 to 83% AFUE furnaces, a UL listed high temperature plastic pipe may be used. See the manufacturers’ installation instructions for details.

**Vent Materials**
A wide variety of materials are being used for vents today. Each of these materials has its own advantages and disadvantages.

Galvanized steel is low cost and fairly easily formed. Type B vents using galvanized steel have a good insulating quality and warm up quickly. This quick warm-up and insulating ability helps to establish a good draft early in the heating cycle. The disadvantage of galvanized steel is that it is not as corrosion resistant as some other materials.

The main advantage in stainless steel is its resistance to corrosion. The disadvantage is the higher cost.

Masonry, clay-tile, and concrete vents have a disadvantage of a prolonged warm-up period. Also, the mortar used in such vents is very susceptible to deterioration when condensation occurs in the vent. One advantage of these types of vents is they retain heat longer.

PVC vents have a high corrosion resistance and can be assembled with leak proof joints. However, this material is good only for applications where the flue-gas temperature does not exceed 180°F. CPVC has a higher flue-gas temperature rating than PVC but is also limited to those applications of 90+ AFUE high efficiency furnaces. Follow manufacturers’ instructions on application.

**Vent Design Configurations**
Each individual venting application has its own special considerations. The building structure, the orientation of the building, and the input of the gas appliances which the vent serves are just a few of the things which the vent system designer must consider. There are four basic categories of vent systems. The first category is the single appliance natural draft vent system. Then, there are two categories which cover the common venting of multiple appliances. One of these configurations is called manifold venting and involves multiple appliances on the same floor of a structure. The other method of common venting involves the use of individual connectors of each appliance sharing the vent and can be a single story or multi-story installation. The last category is special, covering power venting and direct venting.

**Single Appliance Natural Draft Vent System**
A natural draft or gravity type vent system relies only on the lifting force of the hot gases in the vent and does not rely on a blower or exhaust fan to assist the flow. An important fact to keep in mind is that the fan used in a fan assisted furnace, found in Category I and II, does not create a positive pressure. It only overcomes the natural resistance of the heat exchanger to the passage of flue gases. These furnaces are still classified as Fan Assisted, Category I, in their application. Typical single appliance venting systems are shown in Figure 15. The vent is the portion of the system where the gases normally begin their final ascent. The piping assembly that conveys the combustion gases to the vent is called the vent connector. It may have both vertical and horizontal sections where the vent is normally vertical only. Together the vent and vent connector make up the venting system.
When only this one appliance is operating, dilution air will also be drawn in through the draft hoods of the inactive natural draft appliances sharing the vent. This causes excess dilution, which leads to lower flue gas temperatures, which causes a reduction in draft. Figure 16 shows two examples of venting two appliances on the same floor of the building.

When using a common vent, the vent connector design is the key element. It is a good idea to treat each connector for each appliance as a vent in itself. Vent connector rise is critical. See Figure 17. Where overhead clearance inhibits adequate connector rise, it may be necessary to run the connector through the ceiling and then connect it to the common vent. See Figure 18.

Also, when venting two appliances, the vent connector from the appliance with the smallest heat input should enter the common vent at the higher point of the interconnecting tee. Vent connectors from separate appliances should never enter the common vent on the same horizontal plane. See Figure 19. In other words, don’t use the “Cross” of the “Tee” to connect appliances to the vent.

The inter-connecting tee should never be smaller than the size of the largest connector, see Figure 20, and should be as large as the common vent.

If the basic guidelines outlined in this section are followed, then common venting can be a safe, cost effective way
Type B vent manufacturers do supply tables with their recommendations. In general, adequate connector rise is essential to prevent spillage. Manifold length should be limited to 10 feet or 50 percent of the total vent height, whichever is greater.

Keep in mind, individual vents sized for a specific appliance will have more reliable performance. Also, common venting, with all of the necessary fittings, may actually be the more expensive route. Consider these things before deciding whether to vent separately vertical, horizontal or in a common vent.

**Manifold Venting**

In venting a group of appliances on one level, a manifold vent can be used. A manifold vent is a horizontal extension of the lower end of the common vent. The manifold portion will be attached to the vertical vent with an elbow or tee. As shown in Figure 21, the manifold may be graduated or of constant size. Different design procedures are used for each type. There are no hard and fast rules of design.

1. **Tapered Manifold**
   - Each section sized to handle input of combination of appliances attached

2. **Constant Size Manifold**
   - Entire manifold sufficiently large for all appliances attached – same size as common vent

As shown in Figure 22, a manifold may be either horizontal or sloped. Excessive slope does not improve venting and can cause problems. Many codes specify a slope of 1/4 inch per foot, sloped upward from the appliance to the common vent. Where local codes require sloped manifolds, all the appliance connectors must have the minimum acceptable rise for proper venting.

The designer of manifold vent systems must use careful judgment when selecting which type of manifold to use. There are not any “rules-of-thumb” regarding manifold type selection. Common sense and reasoning are a vent designer’s greatest assets.

For example, when manifolding medium efficiency furnaces (78% to 83% AFUE), a tapered manifold will work better than a constant size manifold. Less material means less heat loss. Second, there is less internal area, so there is less room for dilution when any of the furnaces are inactive. This prevents premature cooling and condensation of the flue products.

**Multi-Story Vent Systems**

Multi-story common vent systems are similar to manifold vents. However, each appliance may be on a different floor. Thus, as shown in Figure 23, they enter the common vent at different levels. The connector and vent must be designed so that they perform properly with only one appliance operating or any combination of appliances in operation. In design of multi-story vents, it is important to separate the gas appliances from occupied spaces. In this way, no flue-gases will enter the occupied space if the common vent were to become blocked at any level. In the remote case that blockage occurs, all appliances below the blockage will vent through the draft hood relief openings.
of the unit just below the blockage. Combustion products will be dumped into the space containing the appliances. Appliances operating at levels below the blockage could appear to be operating normally, when they may all be spilling combustion products at a higher level.

Even when appliances are isolated from the occupied area, air must be provided to each appliance. The air supply serves three major functions:

1. Combustion air for burning gas (primary, secondary and excess)
2. Draft hood dilution air (when required)
3. Ventilation air to avoid heat build-up

Relying on infiltration for ventilation air is a poor practice in multi-story applications. This is because the inner-most quarters within a structure will typically have fewer exterior doors and windows. Also, today's construction methods are producing much “tighter” buildings. The practice of locating gas fired equipment in a central hallway and using the hallway for ventilation should not be done. Figure 23 shows a practical method of locating appliances in a separate room with ventilation air grills on the outside wall.

Sometimes it is not practical to build a separate equipment room with an adjacent outside wall. If this is the case, the vent system designer should also design a duct system to supply outside air to the gas appliances. Several methods for supplying outside air are discussed in the section on ventilation air.

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**Figure 23**

- **OUTSIDE WALL**
- **OUTLET GRILL**
- **CLOSED SOLID DOOR OR ACCESS PANEL**
- **NOTE**
  - OUTLET PLENUM AND COLD AIR RETURN BOTH MUST BE ATTACHED TO FURNACE
  - EACH GRILL HAS 1 SQUARE INCH PER 4000 BTU TOTAL HEAT INPUT
- **INLET GRILL**
- **COLD AIR IN**
- **OUTSIDE WALL AIR SUPPLY FOR SEPARATED HEATING ROOM**
Sizing and Design

The section on furnace categories discussed the difference in the venting characteristics of the separate categories. This section on sizing and design covers first how to accurately size and design vent systems for Category I furnaces. Also in this section are some recommended procedures for venting Categories II, III, and IV.

**Category I**

Sizing vent systems for Category I furnaces is accomplished by applying known information to capacity tables developed by the AGA (American Gas Association) or the National Fuel Gas Code. Before referring to the capacity tables, the designer must do some planning and fact gathering.

The designer needs to know how and where the flue products are going to be expelled from the structure. Is the furnace going to be vented through a masonry chimney? Will there be a metal vent going through the roof? Is the chimney located on an inside wall or an outside wall?

The designer should also take into consideration the orientation of the building. Will the vent terminate on the side of the building which is exposed to prevailing winter winds? Are there any adjacent buildings which are taller than this one? These factors can have an effect on down-draft conditions.

The designer must also measure the distance from the furnace location to the vent or chimney location. This will be the lateral connector length. The height of the vent or chimney must be measured. Figure 24 illustrates the points where these measurements are made.

The last bit of information needed is type of the furnace (natural draft or fan assisted) and the BTUH input of the furnace(s) being served by the vent. Armed with this data, the designer can now use the capacity tables to size vents for Category I furnaces.

**Sizing For A Single Unit Using A Masonry Chimney**

When attaching a gas appliance to an existing masonry chimney, the size of the chimney must be checked to make sure the flow will not overload it. On the other hand, the chimney must not be too large. Use the formula \( \pi D^2 \times 7 \div 4 = \text{MAX} \) (3.1416 times the diameter of the flue collar squared times 7 divided by 4 = maximum area) to determine the upper limit of the flow area. Fortunately, the minimum and maximum limits are shown at the bottom of the Table listing the Masonry chimney sizes.

Table 6 (See Appendix for tables) is used to determine capacity of masonry chimneys serving a single appliance using a single-wall connector. Single fan assisted furnaces may not be installed in a masonry chimney without a metal liner. Table 8 gives values for chimney capacities with single-wall vent connectors serving two or more appliances. These tables contain a factor to allow two elbows used in the construction of the vent connectors. If more are required, reduce the maximum capacity by 10% for each added elbow.

Table 9 lists circular equivalents for masonry chimney liners. A fan assisted furnace may only be vented into a masonry chimney with a tile liner, provided the chimney is an internal chimney within the structure and there is another natural draft appliance also vented into the chimney.

As an example, consider the installation of a natural draft gas furnace with an input rating of 100,000 BTUH. The available chimney height is 20 feet, and the lateral for the connector is five feet. Table 6, (See Figure 25), shows that a five-inch
connector can be used and the chimney must have an internal minimum cross-sectional area of 28 square inches. Referring to Table 9, note that a 4 x 8 flue liner has only 12.2 square inches of equivalent area. An 8 x 8 liner has 42.7 square inches area, therefore, the liner should be a nominal 8 x 8 inch size to accommodate this furnace. Similarly, the size of masonry chimneys can be determined for two or more appliances using Tables 6 and 9.

Most often, the vent designer is not involved in the chimney construction. The designer and builder of the structure take care of that. The vent system designer’s responsibility is to check the chimney construction for proper size, suitable lining, and to make certain that the chimney cannot be used for any appliance which burns solid fuels. If the chimney once served a fireplace, the **fireplace opening must be permanently sealed**. If the owner of the building wants to keep the fireplace open for use, then the chimney must not be used to vent the gas furnace. A separate vent must be installed.

**Sizing a Single Appliance Type B Vent**

Category I furnace vent systems are designed using the capacity tables found in the Appendices of the National Fuel Gas Code (NFPA54/ANSIZ223.1).

Table 1 in this manual is used to size vent systems for a single Category I appliance using Type B vents and connectors. Table 2 is used for sizing vents for a single furnace using single-wall connector vent pipe material.

**How to use the Single Appliance Type B Vent Table** (Table 1). For this example, refer to Figure 24 on Page 11 and Figure 26.

**Values between Table values**

In many cases, the vent system will have total vent height (H) and total length (L) values in between the table values. To evaluate these situations, the fractional difference between the next largest and the next smallest is used.

**Example:** Heights and lengths in between table values.

Figure 27 represents a furnace for which we are to determine the proper vent size. The natural draft furnace input rating is 100,000 BTU with a 5 inch draft hood.

**Procedure** – (refer to Figure 28)

1. (H) = 20 feet and (L) = 13 feet.
2. Go down total vent height column to 20 feet.
3. Under 5 inch vent size, “Nat Max” 15 feet lateral shows 142,000
10 feet lateral shows 150,000
4. Since 13 is 3/5 of the way between 10 and 15, to

1. Determine the total height (H) and total lateral length (L) needed for the vent.
2. In Table 1, read down the (H) column to the proper total height.
* Go down total vent height column to 20 feet (Figure 26).
3. In the (L) space to the right of the correct (H), pick the proper lateral length (use zero for straight vertical vents which have no elbows).
* Read down the next column (L) to a length of lateral of 10 feet.
4. Read across the selected (L) row to the column which shows a capacity equal to or just greater than the appliance nameplate BTU input rating under “Nat. Max.” The reading will be in thousands of BTU’s per hour.
* Read to the right across (L) = 10 feet row until 150 is found. You are under the 5 inch vent size column.
5. 100,000 BTU equals to the furnace input. A 4 inch vent only has 89,000 BTU capacity – too small. A 6 inch vent has a capacity of 228,000 BTU – much too large. Use the five inch vent.

**Downsizing from the flue collar size**

Even though a flue collar provided on the furnace is a six inch diameter, a five inch vent can be used if the following conditions are met. **First, local code has to allow sizing vents smaller than the flue collar. Second, the total vent height must be ten feet or more. Third, if a fan assisted furnace is used, reduce the maximum rating by 10% (0.90 x maximum capacity).** A note of caution: Vents for equipment with a draft hood of 12 inch diameter or less should not be reduced more than one pipe size. A 12 inch to 10 inch reduction is one pipe size. **There is one case where downsizing a natural draft furnace vent should not be done. Never attach a three inch vent to a four inch flue collar. This does not apply to a fan assisted furnace.**
find the size for 13 feet of lateral, we take 3/5 of the difference:

\[ 8,000 \times \frac{3}{5} = 4,800 \]

... subtract the result from the 150,000 for 10 feet of lateral (we lose capacity with a longer lateral):

\[ 150,000 - 4,800 = 145,200 \]

145,200 BTUH is the table capacity for 13 feet of lateral and 20 feet height.

Therefore, a 5 inch vent would handle 145,200 BTUH input to the furnace.

Since the furnace input in this example is 100,000 BTUH, the 5 inch vent will do the job.

The same procedure would allow you to calculate heights which are not shown on the Tables. Remember that higher vents increase capacity.

**“Fan Assisted” Vent Sizing**

Throughout this manual the distinction between the “natural draft” and “fan assisted” furnaces has been stressed, although we have learned they are both Category I furnaces. Now, it is time to see what difference this design change makes in the vent sizing decision. We will examine the same example that was just used to select the vent size for the 100,000 BTUH natural draft furnace. This time we will select a “fan assisted” model.

**Procedure** – (Refer to Figure 28)

1. There is no change in the installation specifications. The height is the same, 20 feet, and the lateral distance is 13 feet.

2. Go down the total vent height column “H” to 20.

3. In the length of lateral “L” space to the right, find 15 feet. On this row, look under 4” vents. There are three ratings shown. The maximum “FAN” rating shows only 58. That’s only 58,000 BTUH. Not enough. But look closely, there is a minimum rating shown on that line also. The minimum is 34,000 BTUH. Each fan assisted furnace will show both a maximum and minimum rating in order to help control condensation in the vent pipe.

Look under the 5” column. The rating jumps to 217,000 but the minimum is still below our furnace input of 100,000. We could use this size of vent. Is it a good choice? Not if you must pay the bill for the vent. Let’s see what the 4” vent size will handle. The largest furnace that it could serve is 124,000 BTUH. That’s more than we need. The minimum is 46,000 BTUH and we have more than that. We’re almost through.

4. To determine the size for an 13 foot lateral:

13 is 3/5 of the difference between 10 and 15.

Go down the “H” column to 20 feet. In the “L” space, find 10 feet. On this row, look under 4” and see 133 Fan max.

Find the difference between the rating for 10 and 15 feet.

\[ 133,000 - 124,000 = 9,000 \]

Since 13 is 3/5 the difference between 10 and 15, then we find 3/5 of 9,000.

\[ 9,000 \times \frac{3}{5} = 5,400 \]

Subtract the result from the 133,000

\[ 133,000 - 5,400 = 127,600 \]

127,600 BTUH input is the maximum capacity of a 4 inch
vent having 20 feet of height and 13 feet of lateral. The minimum could be figured in the same way.

Since the furnace input in the example is 100,000 BTUH, the 4 inch vent will work on this type of furnace. In this example when compared to natural draft, the result was changed from 5 to 4 inch vent pipe. By trying other combinations of height and lateral offset, you will soon see that the result could have been quite different.

For appliances with more than one input rate, the minimum vent or connector (Fan Min.) capacity determined from the tables shall be less than the lowest appliance rating and the maximum vent or connector capacity determined from the tables shall be greater than the highest appliance input rating.

**Multiple Appliance Vent Systems**

Any vent system, venting two or more appliances on the same floor into a common vent, is a multiple or combined appliance vent system. The minimum (shortest) total height is the vertical distance from the highest appliance draft hood outlet to the top of the vent. This dimension is the same regardless of the number of appliances. The vent connector rise for any appliance is the vertical distance from its draft hood outlet to the point where the next connector joins the system. The common vent is the portion of the vent system above the lowest interconnection. The sizes of the individual connectors are found from Table 4a and the size of the common vent from Table 4b. See Figure 30.

**How to Size A Multiple Vent System**

The Tables relating to common venting were constructed with an assumption which you must remember. They assume the connector leading to the vent will never exceed a length greater than the connector diameter in inches times one and one half feet. In other words, for each inch of connector diameter, the length must not exceed 18 inches. A four inch diameter connector must not be longer than six feet. (4 x 18 = 72 inches = 6 feet)

What happens if you go beyond this length? Does the vent quit working? NO! You must just remember to de-rate the connector’s capacity, that’s all. Each time you add on, up to the connector’s original length, take away 10% of the maximum capacity. For 7 to 12 feet of 4” connector, use only 90% of maximum capacity. For 13 to 18 feet, de-rate by 20%, as you have three times the original length. As you have always been told, keep it as short as possible.

First, determine size of each vent connector.

1. Determine the minimum (shortest) total height of the system. See Figure 29 for measuring points.
2. Determine the connector rise for each appliance.
3. Using Table 4a, find the vent connector size for each appliance. Enter the table at the selected minimum total height. Read across to the connector rise for the first appliance and continue across the proper connector rise row to the appliance input rating. Read the vent connector size at the top of the column with the correct input rating.

4. Repeat Step 3 for each appliance.

**Determining Size Of Common Vent**

As we look at the common vent tables, there are three columns under each heading. They are: “Fan + Fan”, “Fan + Nat” and “Nat + Nat”. The numbers reflect the maximum input combination of fan assisted and natural draft appliances which may be used. If you must use an existing natural draft water heater with a new fan assisted furnace, choose the center column. Two natural draft products, use the right hand column, etc. If the letters “NR” appear, that choice of vent and product are not recommended.

1. Add together the input ratings of all appliances in the multiple vent system.
2. Enter the common vent Table 4b at the total height value used above.
3. Continue across to the first value that equals or exceeds total input ratings.
4. Read the size of the common vent needed at the top of this column.
5. **CAUTION:** Regardless of the result, the common vent must always be as large as the largest connector. If two or more vent connectors are the same size, the common vent must be at least one size larger.
3. Since 52,000 BTUH is in excess of the water heater input rating, it is not necessary to find the maximum input rating for an 18 foot minimum total vent height.

Use a four inch vent connector.

(B) Determine Furnace Vent Connector Size
See Figure 29B.

Procedure:
1. Refer to Vent Connector Table 4a.
2. There is no Total Vent Height column for 18 feet; therefore, work from 15 foot and 30 foot columns.
3. Read down Total Vent Height column to 15 feet; read across 2 foot Connector rise line. 5 inch vent size shows 97,000 BTUH, or less than furnace input. Repeat step, using 30 foot column, 2 foot Connector rise line. Here the 5 inch vent size shows 106,000 BTUH.
4. 18 feet is 1/5 the difference between 15 feet and 30 feet. The difference between 97,000 and 106,000 is 9,000. 1/5 of 9,000 is 1,800. Add 1,800 to the 15 foot figure (97,000) = 98,800 BTUH.
5. 98,800 BTUH is the maximum input for 18 foot minimum total vent height.
6. A 5 inch connector would be the correct size for the furnace, providing the furnace had a 5 inch or smaller draft hood outlet.

(C) Determine Common Vent Size
See Figure 29C.

Procedure:
1. Refer to Common Vent Table 4b.
2. There is no Total Vent Height column for 18 feet; therefore, work from 15 foot and 20 foot columns.
3. The total input to the vent is 145,000 BTUH.
4. 15 feet maximum BTUH for 5 inch vent is 140,000 20 feet maximum BTUH for 5 inch vent is 155,000.
5. 18 feet is 3/5 the difference between 15 feet and 20 feet. The difference between 140,000 and 155,000 is 15,000. 3/5 of 15,000 is 9,000. 140,000 + 9,000 = 149,000 BTUH, which is greater than total input to common vent.
6. Therefore, the common vent can be 5 inch diameter pipe. See Figure 30.

Multi-Story Vent Systems
Multi-story vent systems of any height can be sized using the multiple appliance vent Tables 4a and 4b. These tables are best suited to appliances separated from occupied areas such as boilers on porches or furnaces and water heaters in closets. The system will function satisfactorily when any one or all appliances are operating.

When designing a multi-story vent system, the following principles should be applied:
1. The overall system should be divided into smaller, vent systems for each level, each using a total vent height for each level as shown in Figure 31 on page 18. Principles of design of multistory vents using vent connector and common vent design table.
2. Each vent connector from the appliance to the verti-
cal common vent should be designed from the vent connector table, as in multiple appliance vent systems.

3. For sizing of the vertical common vent, the common vent table is used. The vertical common vent for each system must be sized large enough to accommodate the accumulated total input rating of all appliances discharging into it, but should never be smaller in diameter than the largest section below it.

4. The vent connector from the first floor or the lowest appliance to the common vent is designed as if terminating at the first tee or interconnection. The next lowest appliance is considered to have a combined vent which terminates at the second interconnection. The same principle continues on to the highest connecting appliance with the top floor appliance having a total vent height measured to the outlet of the common vent.

5. The multi-story system has no limit in height as long as the common vent is sized to accommodate the total input rating.

**Precautions in Designing Multi-Story Vent Systems**

1. The common vent portion of the system must be vertical with no offsets to use the values in the Tables without de-rating.

2. Common vent height must always be computed as the distance from the outlet of the draft hood to the lowest part of the opening from the next interconnection above.

3. If the vent connector rise is inadequate, increase vent connector size, always making use of maximum available vent connector rise.

4. Be sure that the ventilation air supply to each appliance is adequate for proper operation. A furnace must be enclosed in a separate room from the living area and a permanent provision for outside air supply is necessary.

5. If an air shaft or chase is used for installation of the common vent, be sure that sufficient space is provided for fittings, clearance to combustibles and access for proper assembly.

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### Common Vent Calculations – Four Floors

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Total Input to Common Vent</th>
<th>Available Connector Rise</th>
<th>Total Vent Height</th>
<th>Connector Size</th>
<th>Common Vent Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90,000</td>
<td>10’</td>
<td>10’</td>
<td>5”</td>
<td>5”</td>
</tr>
<tr>
<td>2</td>
<td>180,000</td>
<td>1’</td>
<td>10’</td>
<td>6”</td>
<td>7”</td>
</tr>
<tr>
<td>3</td>
<td>270,000</td>
<td>1’</td>
<td>10’</td>
<td>6”</td>
<td>8”</td>
</tr>
<tr>
<td>4</td>
<td>360,000</td>
<td>1’</td>
<td>6’</td>
<td>6”</td>
<td>10”</td>
</tr>
</tbody>
</table>

**Table A**

### Common Vent Calculations – Separate Top Floor

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Total Input to Common Vent</th>
<th>Available Connector Rise</th>
<th>Total Vent Height</th>
<th>Connector Size</th>
<th>Common Vent Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90,000</td>
<td>10’</td>
<td>10’</td>
<td>5”</td>
<td>5”</td>
</tr>
<tr>
<td>2</td>
<td>180,000</td>
<td>1’</td>
<td>10’</td>
<td>6”</td>
<td>7”</td>
</tr>
<tr>
<td>3</td>
<td>270,000</td>
<td>1’</td>
<td>16’</td>
<td>6”</td>
<td>6”</td>
</tr>
<tr>
<td>4</td>
<td>90,000</td>
<td>8’</td>
<td>6’</td>
<td>5”</td>
<td>5”</td>
</tr>
</tbody>
</table>

**Table B**

---
6. The capacity tables apply only when the entire system is constructed of listed double-wall Type B Vent materials.

Example: Figure 31 shows a typical example of a multi-story vent system.

1. Assume Figure 31 represents a 4-story apartment.
2. Each appliance has a 90,000 BTUH input rating.
3. Each appliance has a 5 inch draft hood.
4. Total vent height is 10 feet for each of the three lower floors.
5. Total vent height is 6 feet for the top floor.
6. Use Table 4b for sizing common vent.

Table A shows the calculation for venting all four floors into the common vent.

However, if the furnace on the top floor is vented separately, Table B shows the results of increasing the minimum total vent height of the third floor appliance to 16 feet and decreasing total input to common vent to 270,000 BTUH. Table B indicates the economics of venting the top floor separately. This eliminates the larger sizes of vent pipe and the use of extra, costly fittings.

Vents in High Altitude Locations

Vent systems should be designed on the basis of the sea level input rating. For multiple appliance inputs, design the vent using the greatest possible sea level input rating.

When a gas appliance is derated due to altitude, the volume flow of fuel gas required will be less than at sea level. However, the volume of air required for furnace operation is not that much less. This is because the air becomes less dense as the altitude increases. Because of the lower density, a higher ratio of air to gas is required to supply enough oxygen.

Power Venting

If the steps outlined in the previous sections are followed carefully, the vent will perform well. Sometimes, however, there are factors which cannot be overcome, such as extremely high prevailing winter winds. Also, especially in retro-fit applications, sometimes it isn’t convenient or even possible to redesign an improperly sized vent. Sometimes the furnace may be poorly located, requiring several elbows. Power venting is a good solution to many venting problems.

A power assisted vent system has a fan, blower, or booster, see Figure 32, located within the vent system. The power assist (draft inducer) can be located anywhere in the vent, but locating it at the vent outlet is preferable. If the furnace is “Fan Assisted”, a barometric relief damper must be installed at the appliance flue outlet to prevent the power vent from pulling the products of combustion through the heat exchanger. With a negative vent pressure, any leaks in the vent will be inward. The air around the vent will be pulled into the vent rather than the flue-gases being forced out of the vent.

A power assist installed in a vent can increase the capacity of the vent up to four times. The amount of capacity increase depends on the strength of the assist and the size of the vent. Exact sizing information for power assists can be obtained from the manufacturer.

Category II

As mentioned earlier, Category II furnaces are classified as non-positive with flue-gas temperatures less than or equal to 140°F above their dew-point. Extreme care must be taken when designing vents for these furnaces. There are several special considerations involved.

Flue-Gas Temperature

The temperature of the flue-gases from a Category II furnace can be expected to be somewhere around 275°F or less. Existing vent sizing tables are based on the assumption that the flue-gases entering the vent are at a temperature of 360°F or higher. Because Category II furnaces produce lower temperature flue-products, existing tables may not apply. The volume of gases being produced by these products will be less than in lower efficiency models; therefore, the vent pipe size could possibly be smaller than indicated by existing sizing tables.

Until research yields specific tables for these types of products, the furnace manufacturer’s instructions are the only basis available for designing vents for Category II products.

Condensation

Because of the lower temperature flue-gases produced, there is a good chance condensation will occur inside the vent. As a result, the National Fuel Gas Code suggests the use of a corrosive resistant vent material such as stainless steel or aluminum coated stainless steel.
While the piping may be more expensive initially, it will be less expensive than several repairs on a less corrosive resistant material.

It is also recommended that a “drip Tee” be placed in the vent connector at a location near the furnace. If proper slope is maintained on the lateral sections of the vent, condensate will drain into the “drip Tee” and can be drained via a hose to a nearby drain approved by local authorities.

“Drip Tee’s” or “drain Tee’s” are available through many vent pipe manufacturers.

Power Venting

The designer of vents serving Category II furnaces should probably consider the use of some kind of power assist in the vent. Because of the lowered flue-gas temperatures, the draft forces produced by these furnaces are also reduced. There is no room for error with these furnaces. A vent system of a “marginal” size and design will often operate improperly.

If power venting is chosen, there are a couple of recommended procedures. First, the draft inducer should be located at or near the vent outlet. Installing it at the outlet causes the vent to operate under negative pressure. In this way, any leaks in the vent will be inward. The air around the vent will be pulled in rather than the flue-gases being pushed out. Secondly, no matter where the power assist is located, the vent system should be sealed. Seams and joints can be sealed either using a high temperature, silicone-rubber sealant or with pressure-sensitive, foil-backed tape.

Generally, good common sense practices will go a long way toward successful venting of Category II furnaces. If the designer will maintain proper slope, limit the number of elbows, insulate the vent in cold spaces, the additional steps outlined in this section can help to ensure proper vent performance.

Category III

Category III furnaces are distinguished by positive vent pressure and flue-gas temperatures greater than or equal to 140°F above their dew-point. Getting the flue-products to the outside of the building is really no great problem. The positive pressure classification means that the combustion by-products will be “pushed” out of the vent. Furnace manufacturers accomplish this through the use of blowers attached to the heat exchanger outlet or by the use of pulse combustion systems. A special case is created when 78 to 83% AFUE induced draft furnaces are vented horizontally.

The higher flue-gas temperature minimizes the danger of harmful condensation occurring inside the vent. Therefore, there is no need for a special corrosion resistant vent pipe material. However, if UL listed high temperature plastic is used in the vent, a drain Tee must be installed due to the high heat loss and subsequent condensation. This will occur when venting 78 to 83% AFUE induced draft furnaces horizontally.

The prime consideration when venting Category III furnaces is the positive vent pressures. In order to prevent leakage of flue products into the indoor atmosphere, the vent system should be assembled in a leak-proof manner. Again, the recommended sealing method is with high temperature silicone rubber. In some cases, foil-backed tape may be used. Check the manufacturers instructions and local codes.

Sizing

Because these furnaces are forced draft, sizing of the vent pipe is not usually left up to the vent designer. The furnace manufacturer normally includes information which will be used to determine the vent design. Usually, the vent pipe will be the same diameter as the flue connector/adapter of the unit. The design information will cover the maximum amount of lateral run which is allowed when a certain number of elbows are used.

Termination

Positive pressure furnaces such as Category III and Category IV furnaces are suitable for termination through a wall. The vent should not, however, terminate through a wall which is directly exposed to the prevailing winter wind. If the wind is strong enough, it may overcome the draft produced by the forced draft blower or pulse combustion system. Also, the terminal should not be located where there is no wind. “Dead corners” allow the vented flue-gases to accumulate.

When venting through a side wall, care must be taken to ensure that the flue-products cannot reenter the building. It is also necessary to locate the vent terminal above the normal level of snow or ice accumulation. Be wary of the possibility of snow drifts on the leeward side of a building.

![Diagram of sidewall terminal location for condensing model furnaces.](image-url)
than or equal to 140°F above their dew-point. These are super high efficiency models which condense water vapor from the flue products in order to recapture heat. Venting these furnaces is very similar to venting Category III products with a few small differences.

**Vent Pipe**

The vent pipe for these products must be corrosion resistant. Although the furnace condenses water vapor out of the flue gasses, not all of the water vapor is condensed. Many manufacturers are recommending the use of PVC or CPVC plastic pipe. This pipe may be used because of the low flue-gas temperatures. If metal pipe is desired, Allegheny Steel type AL29-4C stainless steel pipe is recommended. Type AL29-4C stainless steel is a high quality metal formulated specifically for resistance to acids.

**Condensate**

Category IV furnaces usually include, in the design, some method of removing and draining the condensed water vapor. Because of this, it should not be necessary to provide any kind of “drip Tee” or “drain Tee” in the vent. However, it is vital that all vent pipe slope toward the furnace. Any condensate, which may form inside the vent, will run back to the furnace. The furnace condensate disposal system can then take care of it. Also, it is important that the vent pipe be installed with the male ends of the pipe and fittings toward the “lip” formed where the pipe is inserted into couplings and fittings.

**Vent Design**

Consult local authorities or the owner of the building on matters such as snow accumulations.

Figure 33 illustrates clearances for side-wall terminals used near entrances into a building.

Figure 34 is a diagram showing two methods of side-wall termination above the expected level of snow accumulation.

**Category IV**

Category IV furnaces - “90+” AFUE models - are characterized by positive vent pressure and flue-gas temperatures less than or equal to 140°F above their dew-point. These are super high efficiency models which condense water vapor from the flue products in order to recapture heat. Venting these furnaces is very similar to venting Category III products with a few small differences.

**Vent Pipe**

The vent pipe for these products must be corrosion resistant. Although the furnace condenses water vapor out of the flue gasses, not all of the water vapor is condensed. Many manufacturers are recommending the use of PVC or CPVC plastic pipe. This pipe may be used because of the low flue-gas temperatures. If metal pipe is desired, Allegheny Steel type AL29-4C stainless steel pipe is recommended. Type AL29-4C stainless steel is a high quality metal formulated specifically for resistance to acids.

**Condensate**

Category IV furnaces usually include, in the design, some method of removing and draining the condensed water vapor. Because of this, it should not be necessary to provide any kind of “drip Tee” or “drain Tee” in the vent. However, it is vital that all vent pipe slope toward the furnace. Any condensate, which may form inside the vent, will run back to the furnace. The furnace condensate disposal system can then take care of it. Also, it is important that the vent pipe be installed with the male ends of the pipe and fittings toward the furnace. This prevents the possibility of the condensate collecting at the “lip” formed where the pipe is inserted into couplings and fittings.

**Vent Design**

Consult local authorities or the owner of the building on matters such as snow accumulations.

Figure 33 illustrates clearances for side-wall terminals used near entrances into a building.

Figure 34 is a diagram showing two methods of side-wall termination above the expected level of snow accumulation.

**Category IV**

Category IV furnaces - “90+” AFUE models - are characterized by positive vent pressure and flue-gas temperatures less than or equal to 140°F above their dew-point. These are super high efficiency models which condense water vapor from the flue products in order to recapture heat. Venting these furnaces is very similar to venting Category III products with a few small differences.

**Vent Pipe**

The vent pipe for these products must be corrosion resistant. Although the furnace condenses water vapor out of the flue gasses, not all of the water vapor is condensed. Many manufacturers are recommending the use of PVC or CPVC plastic pipe. This pipe may be used because of the low flue-gas temperatures. If metal pipe is desired, Allegheny Steel type AL29-4C stainless steel pipe is recommended. Type AL29-4C stainless steel is a high quality metal formulated specifically for resistance to acids.

**Condensate**

Category IV furnaces usually include, in the design, some method of removing and draining the condensed water vapor. Because of this, it should not be necessary to provide any kind of “drip Tee” or “drain Tee” in the vent. However, it is vital that all vent pipe slope toward the furnace. Any condensate, which may form inside the vent, will run back to the furnace. The furnace condensate disposal system can then take care of it. Also, it is important that the vent pipe be installed with the male ends of the pipe and fittings toward the furnace. This prevents the possibility of the condensate collecting at the “lip” formed where the pipe is inserted into couplings and fittings.

**Vent Design**

Consult local authorities or the owner of the building on matters such as snow accumulations.

Figure 33 illustrates clearances for side-wall terminals used near entrances into a building.

Figure 34 is a diagram showing two methods of side-wall termination above the expected level of snow accumulation.

**Category IV**

Category IV furnaces - “90+” AFUE models - are characterized by positive vent pressure and flue-gas temperatures less than or equal to 140°F above their dew-point. These are super high efficiency models which condense water vapor from the flue products in order to recapture heat. Venting these furnaces is very similar to venting Category III products with a few small differences.

**Vent Pipe**

The vent pipe for these products must be corrosion resistant. Although the furnace condenses water vapor out of the flue gasses, not all of the water vapor is condensed. Many manufacturers are recommending the use of PVC or CPVC plastic pipe. This pipe may be used because of the low flue-gas temperatures. If metal pipe is desired, Allegheny Steel type AL29-4C stainless steel pipe is recommended. Type AL29-4C stainless steel is a high quality metal formulated specifically for resistance to acids.

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**Vent Design**

Consult local authorities or the owner of the building on matters such as snow accumulations.
Since these furnaces incorporate some kind of forced draft system, the pipe sizing is done by the manufacturer. The vent designer must stay within the limitations of lateral lengths and number of elbows which are contained in the furnace installation instructions.

**Combustion and Ventilation Air**

As previously mentioned, gas furnaces require a substantial amount of fresh air for proper operation. In the past, this air would make its way to the furnace by way of infiltration. Older construction methods allowed a considerable amount of air leakage around doors, windows, etc. With today’s increasing energy efficiency awareness, buildings are being built “tighter”. Caulking, weatherstripping, and otherwise sealing a structure has been the first major step toward making it more energy efficient. These practices reduce the likelihood of enough air infiltrating into the building.

The following guidelines present design considerations and procedures for ensuring an adequate air supply to the gas furnace.

The method of supplying air to the furnace is just as important as supplying enough air. Makeup air for exhaust fans should not come from the same space in which the furnace is located. For example: If the furnace is located in a ventilated basement or crawl space, the building’s makeup air supply should come from elsewhere. Otherwise, the furnace and the makeup air system may have to compete for the air in the basement. This may cause “starvation” of the furnace. A negative pressure condition may even arise in the basement. The furnace draft will be affected resulting in spillage of combustion products at the furnace draft hood.

Since the makeup air supply comes from the basement, in this example, flue products may also be pulled into the building’s conditioned air supply. The scenario could “snowball” with incomplete combustion occurring, condensation in the vent, and corrosion.

For the same reasons, air returning for re-heating should never be pulled from the same space as the furnace combustion air supply. Installations where the furnace is centrally located, as in a hall closet, require the return air to be ducted to the furnace from a location outside of the closet. It is also a good idea, in such installations, to provide a method of bringing fresh, outside air directly to the furnace.

As a matter of fact, recent studies indicate it is always a good idea to supply fresh, outside air for combustion on any installation. There is a very good reason for this. Contaminated combustion air can cause serious corrosion problems within both the furnace and the vent system. Some states have now included the requirement for outside air in their state codes.

Elements such as chlorides and fluorides produce highly corrosive acids when burned and then condensed. If the water vapor in the flue products condenses with these elements in the combustion air, hydrochloric acid or hydrofluoric acid may be a result. These chlorides and fluorides can be found in abundance in any building. They can be found in bleaches, detergents, cleaning solutions, solvents, spray can propellants, cements, adhesives, and halogenated refrigerants. It is evident that it would be almost impossible to eliminate all of these contaminants from the atmosphere. Therefore, supplying fresh, outside combustion air should be considered for every installation.

**Confined Spaces**

The National Fuel Gas Code contains recommendations to supply outside air anytime the room containing the equipment falls under the heading of being a confined space. A confined space is a room whose volume is less than 50 cubic feet per 1000 BTUH of total input to all appliances installed in the room. For example, a room contains a gas water heater with 40,000 BTUH input and a furnace with 80,000 BTUH input for a total of 120,000 BTUH. At 50 cubic feet per 1000 BTUH input, 6000 cubic feet (120 x 50) is required to preclude the space being classified as a confined space.

If the equipment room was 12’ x 20’ x 8’ (1920 cu. ft.) for instance, such a room would be considered a “confined space.”

For the installation depicted in Figure 36 to be valid, the rooms on the other side of the openings must constitute a total volume which meets the requirements for an unconfined space. For instance, in the previous written example, the equipment room had a volume of 1920 cubic feet. The total input to the appliances within the room was 120,000 BTUH. 6,000 cubic feet or more of volume is needed to constitute an unconfined space. So, in Figure 36, the room connecting through the openings would have to make up the balance of the required 6,000 cubic feet.

\[
6,000 - 1,920 = 4,080
\]

4,080 cubic feet of free space would be needed on the other side of the ventilation air openings. That might be a room with eight foot ceilings which measured 510 square feet. Also, this 510 square foot area cannot, by any means, be reduced. If, for example, a hall and adjacent room are being used for this 510 square feet then there cannot be any doors or curtains between them.

Figures 36, 37, 38, and 39 illustrate four acceptable methods.
shown in Figures 36 through 39, one opening should be located within 12 inches of the floor and the other within 12 inches of the ceiling. Even for short appliances, the space between the louvered openings should never be less than 3 1/2 feet. If connected with ducts, the cross-section area of the duct shall not be less than the free area of the louvered opening.

**Unconfined Spaces**

Unconfined spaces will normally have enough natural infiltration of air. If the construction is unusually tight, air from outdoors will be needed. The minimum dimension of rectangular air ducts shall be not less than 3 inches. Screening to cover the openings to the outside should not be smaller than 1/4 inch mesh and shall not be capable of closure. Insect screening and louvers reduce effective area.

In calculating the free area of air openings, consideration shall be given to the blocking effect of louvers and grilles. If the free area through a design of louver or grille is known, it should be used in calculating the size opening required to provide the free area specified. If the design and free area is not known, it may be assumed that wood louvers...
will have a 20 to 25 percent free area and metal louvers and grilles will have a 60 to 75 percent free area. Louvers and grilles shall be fixed in the open position or interlocked with the equipment so that they are opened automatically during equipment operation. Ref: National Fuel Gas Code Section 5.3.5. The return air, circulating for reheating by the furnace should be isolated from the air supply coming from the outside through these ducts.

**General Installation**

Specific instructions for installing vent systems are usually available through vent and furnace manufacturers. Also, national, state, and local codes cover many of the specifications such as vent type, vent materials, and installation practices. In all cases, the code authority having jurisdiction will have the final say over any installation. This section covers some general guidelines which have been “time” tested. There are also some additional procedures which have proved reliable in the field. Many of these additional measures have been adopted by some manufacturers and are included in their installation instructions.

**Vent Fittings**

Figure 40 depicts different fittings which are used in a vent system. The use of many of these fittings is self explanatory. It is recommended that Underwriter’s Laboratories listed vents and fittings be used. Some of the fittings require a little explanation.

**Roof flashing** - The roof flashing should fit tightly over the hole in the roof. It should also mesh with the roof shingles. Notice there are two kinds of roof flashings illustrated.

**Storm collar** - The storm collar is a counter flashing for the roof flashing. Its purpose is to keep out snow and rain. The storm collar should fit tightly around the vent pipe and above the roof flashing. The area where the storm collar wraps around the vent pipe should be caulked with plastic cement or high temperature RTV silicone.

**Firestops** - A firestop assembly should be installed where the vent passes through a floor or ceiling. The purpose of the firestop is to close up the opening made to allow clearance for the vent pipe. This prevents a “chimney” effect from occurring through the opening in the event of a fire.

---

**Figure 40**

1. Round Pipe  
2. Tall Cone Roof Flashing  
3. Draft Hood Connector  
4. Reducer  
5. 90° Adjustable Elbow  
6. Cover-All Face Plate  
7. Wall Bracket  
8. Storm Collar  
9. Standard Tee  
10. Wall Thimble  
11. Adjustable Roof Flashing

**Figure 41**

Figures 41 and 42 show a typical firestop and ceiling support. Either one can serve as a firestop. Either can also be used to center the pipe to allow specified clearance from combustibles. When installing a sheet metal firestop such as in Figure 41, the firestop should be attached to the joists.
and to framing cross members. This is to ensure that no spaces will exist which will allow the accumulation of combustible materials around the vent.

**Joint Connections** - All joints must be secure and leak tight. If a joint leaks, air may be pulled into the vent (in a natural draft vent) and further dilute the flue gases. The result would be a reduction in the draft force. Pipe with locking connections should be pressed together until it locks. Pipe without locking connections should be assembled with sheet metal screws and then sealed.

**Vent Terminals** - There are many different types of vent terminals, as illustrated in Figure 43. In general, the vent terminal (or vent cap) should be the same size as the vent terminal connections intact. The furnace flue collar is not designed to provide support of vertical vents or vent connectors.

Figure 44 illustrates a well assembled vent system. Support lateral vent connectors as near the flue collar as possible and every three feet from there. Lateral supporting is usually accomplished with metal hanging straps. Vertical supporting can be done using the ceiling support which was shown in Figure 42.

**Lateral runs** - Lateral runs should be avoided, if possible. When lateral runs are necessary, the length should be kept as short as possible. Also, avoid an unnecessary number of turns and bends. Remember, each 90 degree elbow in excess of two causes a 10% reduction of the vent capacity. To explain it differently, each 90 degree elbow causes resistance equivalent to a lateral length of pipe 40 times the pipe diameter. A six inch elbow is the same as 240 inches or 20 feet of 6 inch pipe. The maximum length of lateral vent pipe can not exceed 75% of the total height of the vent. An upward pitch of at least 1/4 inch per lateral foot should be maintained.
**Obstructions** - Internal obstructions reduce the effective internal area of the vent and, therefore, reduce the capacity of the vent. Where vent connectors attach to a common vent or chimney, they should be installed flush with the inside surface at the point of entry. Accessories such as vent dampers also cause some restriction. The amount of restriction will depend on the design of the damper. Sometimes, foreign objects such as bird's nests, mice, ice, snow, etc. have been known to get into a vent and block it. The proper use of bird screens and vent caps will combat these "uninvited guests."

**Clearance Requirements** – Vent pipe clearance from combustible materials must comply with national, state, and local codes. This clearance is usually six inches for single-wall vent pipe and one inch for Type B double-wall vent pipe. These clearance requirements can be maintained by the use of straps, non-combustible spacers, wall thimbles, fire-stop spacers and ceiling supports.

Plastic pipe vents, where allowed by code, are used for furnaces which have relatively cool flue-gas temperatures. Also, plastic pipe (PVC or CPVC) does not readily conduct heat. Because of these two facts plastic pipe vents, where allowed by code, can be installed with zero clearance. The special high temperature plastic pipe, used with 78 to 83% AFUE furnaces, has clearance requirements. See the installer's guide for the furnace you are installing.

**Pipe Orientation** – Most Type B vent pipe will have flow arrows stamped or embossed on the side of the pipe. When venting lower efficiency (high flue gas temperatures) furnaces, the vent should be installed with the flow arrow pointing away from the furnace. When installed in this manner, the male end of the pipe will be pointing away from the furnace. See Figure 45. This allows the flue-gases to "slip" through the joint more easily.

When venting higher efficiency furnaces, the removal of condensate from the vent is an area of prime concern. Figure 46 shows a vent installed with the male ends pointing toward the furnace. Also shown is a drain "Tee" with trapped drain line. Installation with the male ends toward the furnace allows the condensate to run more freely down the vent and into the drain. Obviously, this installation will have a slight effect on the travel of the flue-products up the vent pipe. For this reason, and also to prevent condensate leaks, it is necessary to seal these joints.

In installations where condensation is likely to occur, it is a good practice to install vent pipe with the linear seams on top. Actually, it is a good idea for all installations. This will also help to prevent leakage of any condensate which may form in the vent.

**Terminal Location** – The vent terminal, whether it is a masonry chimney or metal-pipe vent, should not be located where positive wind pressures occur. Positive pressure zones may be found due to eddy currents of air swirling...
over the top of a structure (Figure 47) or where a wall faces the prevailing winter wind (Figure 48). Vent termination in these areas can result in down-drafts. These down-drafts may cause flue gas spillage and/or pilot outages.

Wind tunnel tests have yielded guidelines for chimney and side-wall termination are dissipation of flue-gases, re-entry of flue-gases into the building, damage to surroundings, and furnace operation. Side-wall vents should not terminate through a wall, exposed to prevailing winter winds. Excessive vent pressures created may adversely affect furnace operation. Side-wall terminals should not be located in "dead corners" where the flue-products may accumulate. Care should be taken to avoid venting onto plants. The acidic nature of the flue-gases may be harmful to plants. Condensation which may form at the vent outlet can cause unsightly damage to the sides of the building. For this reason, manufacturers specify a minimum amount of vent pipe protruding from the wall. Some even recommend a corrosion resistant shield or flashing around the vent terminal.

Last, but in no way least, is safety. Vent terminals should be located high enough above pedestrian and vehicular paths to prevent the flue-gases exhausting on passers-by. Some manufacturers even prohibit installation above pedestrian walkways.

The manufacturers’ installation instructions for side-wall termination should contain clearances from possible air entry points into the building. It is important that side-wall terminals be either above or at a safe lateral distance from doors, windows, etc. Figure 33 diagrams the clearances specified for venting through a wall.

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### Safeties and Accessories

#### Vent Safety Shut-off

On November 1, 1987, a national standard went into effect requiring a vent safety shut-off to be located in the draft hood or draft diverter of listed gas-fired equipment. The vent safety shut-off (sometimes referred to as a “spill” switch) is a thermal cut-out located in the draft hood/diverter. It will close the gas valve in the event of the flue-product spillage at the draft hood/diverter. In retro-fit applications, the shut-off should be located in a position where it will not affect the normal operation of the furnace. It must be wired into the furnace controls so that the gas valve will not open unless the shut-off switch is in the closed position, (in series with the gas valve solenoid).

Accurate vent sizing is critical to avoid nuisance tripping of the vent safety shut-off. A vent which is undersized or restricted will cause spillage at the draft hood/diverter, causing the shut-off to open. Over-sized vent systems are prone to excessive heat loss within the vent. This heat loss will cause the flue-gases to lose momentum. In this case, the flue-gases can “linger” in the area of the draft hood/diverter long enough to cause the shut-off to open. In grossly oversized vents, the heat loss can overcome the momentum of the flue-gases completely resulting in spillage. This is another reason why accurate sizing of vent systems can’t be over emphasized.

#### Vent Dampers

The purpose of a vent damper is to reduce the cost of heating by closing off the vent during the furnace off-cycle. This
helps the furnace heat exchanger to retain heat which would normally be lost through the vent. The amount of savings, if any, depends on the installation. Listed automatic vent dampers may be installed on an existing appliance if the appliance has a history of safe, satisfactory operation and it is equipped with a draft hood or draft diverter. Manually operated vent dampers shall not be installed in the vent connectors of a gas appliance. Electrically operated vent dampers must be connected to the furnace controls to prevent the firing of the main burners with the damper in the closed position.

Thermally operated automatic vent dampers require heat from the burners to activate them. It is obvious then that the control sequencing mentioned above cannot apply. Most thermal vent dampers are bi-metal vane designs which rely on the “warping” of the bi-metal to open. Until enough heat is applied to the thermal vent damper, the flue-products will have to go somewhere else. For this reason, automatic vent dampers can only be installed on gas appliances which have a draft hood or draft diverter. The relief opening in a draft hood/diverter provides a path for the flue-products in the event of a down-draft or flue blockage. If the equipment room is properly ventilated, then there should be no danger from the spillage which may occur.

**Draft Inducers**

When installing a power assisted draft inducer, it is always best to install it at the outlet of the vent. When installed in this manner, the flue-products will be “pulled” through the vent and discharged to the outside atmosphere. There is a margin of safety, so any leaks will cause ambient air to be drawn into the vent. If the draft inducer were to be installed at the inlet to the vent, positive vent pressures would mean that any leaks would be outward. Installation of a power assist at the vent inlet requires a sealed vent.

The draft inducer must be wired into the furnace controls so that the burners will not be fired unless it is operating. This is usually accomplished through the use of a normally open “sail” switch. The flow established by the draft-inducer will cause the contacts of the sail switch to close, proving the operation of the draft inducer. The sail switch would be wired in series with the room thermostat and gas valve or ignition controls.

**Protection Against Fire Hazards**

The proper installation of vents in accordance with manufacturers’ instruction is aimed at eliminating fire hazard conditions. Type B-W vent, which is used for venting recessed heaters, must be installed with a solid header plate to serve as a firestop. A firestop spacer is also to be placed at each point where the vent passes through a floor or ceiling.

**Prohibited Installations**

There are some installations that are prohibited by codes and local authorities. There are others which represent potentially unsafe situations. If it is possible to recognize these types of situations, serious problems may be avoided.

**Single-walled pipe is not recommended for outside vents**
The National Fuel Gas Code suggests several installation practices to avoid. It should be consulted for description of these cases, but briefly they are as follows:

No portion of the venting system shall extend into or pass through any circulating air duct or plenum. By adhering to this practice, the chance of flue product leakage into circulating air streams will be minimized. See Figure 51.

The use of uninsulated single-wall pipe is not recommended for use outdoors in cold climates. Such use may cause condensation and corrosion of the vent system. See Figure 52.

Wind flow over roof structures often causes localized pressure disturbances. The vent termination must be placed where these effects are minimized.

Termination of the vent must be at least 1 foot above the highest point where it passes through a roof on a flat to 7/12 pitch roof and at least 2 feet above the highest part of the roof within 8 feet, provided the termination is 12 inches in diameter or less. Except for direct vent appliances, the vent should not terminate adjacent to a wall or below eaves or parapets. See Figure 53.

The height of Type B vents must not be less than 5 feet in vertical height above the highest connected draft hood.
For Type B-W vents, the minimum height must be at least 12 feet, from the base of the heater. See Figure 54. If vents are less than these minimum heights, spillage may occur.

Do not exhaust a clothes dryer into a vent or chimney. The power exhaust system of the dryer often overloads the vent resulting in unsatisfactory operation of other appliances. The moisture-laden air is almost certain to result in condensation when the vent is cool. Furthermore, lint may accumulate causing blockage.

**Troubleshooting**

Problems with venting systems are not usually reported by the building’s occupants unless they smell something. Sometimes a “no heat” complaint due to chronic pilot flame outages is a result of improper venting. It is important that installers and service technicians be observant and know the signs of poor vent performance.

**Pilot Outage or Lock Out**

More often than not, pilot outages are caused by malfunctions in the pilot system. Dirty pilot orifices or improper thermocouple/pilot-flame orientation are some causes for chronic pilot outages. Sometimes, however, pilot outage can be traced to the vent system. The first thing to look for is the vent cap. Make sure the cap is present and securely fastened to the vent. The cap should also be checked to see if the design will reduce the effects of wind. Sometimes, changing the vent cap to a more suitable wind-baffling design may solve the problem.

The problem could also be improper terminal location. If the terminal is located in a high pressure area, down-drafts may blow the pilot flame out. The solution would be to either relocate the vent terminal or to raise the vent height to get the terminal out of the positive pressure area. If the pilot outage problem is not very frequent, the down-drafts may not be very strong. Even in these cases, steps to prevent down-drafts should be taken. As a possible alternative in this situation, installation of some type of intermittent pilot ignition system might be considered.

**Vent System Testing**

When an existing furnace is removed from a venting system serving other appliances, the venting system is likely to be too large to properly vent the remaining attached appliances.

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 system are in operation:

a. Seal any unused openings in the common venting system.

b. Visually inspect the venting system for proper size and horizontal pitch. Determine that there is no blockage or restriction, leakage, corrosion or other deficiencies which could cause an unsafe condition.

c. Insofar as it is practical, close all building doors and windows and all doors in between the space where the appliances remaining connected to the common vent system are located and the rest of the building. Turn on clothes dryers and any gas-burning appliances 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 the fireplace dampers.

d. Follow the lighting instructions. Place the appliances in operation. Adjust the thermostat so the appliance will operate continuously.

e. 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.

f. After it has been determined that each appliance remaining attached to the common venting system properly vents when tested as outlined, return doors, windows, exhaust fans, fireplace dampers and any other gas-burning appliance to their previous condition of use.

g. If improper venting is observed during any of the tests, the common venting system must be corrected according to the standards set forth in the National Fuel Gas Code, ANSI Z223.1.

**Spillage**

Spillage of flue-products from the draft hood/diverter is usually detected by an unpleasant odor. There are many reasons for spillage to occur. One cause might be an undersized vent. If the vent is too small, it will not have the physical capacity to move the volume of combustion products being produced. The solution is to replace the vent with a larger diameter vent. Another solution might be to increase the overall height of the vent. The section in this manual on Factors Which Affect Vent Operation pointed out why an increase in height increases the capacity of a vent. The capacity tables found in this manual and also in the National Fuel Gas Code can be used to determine the feasibility of this solution. If neither of the previously mentioned solutions are acceptable, then power venting should be considered.

On the other hand, oversized vents can also result in spillage. This is because the larger area results in a loss of velocity or momentum. The problem is compounded because the flue-gases are given more time to cool. They also have a greater mass of metal to surrender heat to. This cooling results in a reduction of the draft force. Increasing vent height will only aggravate this situation as the vent capacity is already too great. Two solutions to the problem of oversized vents are: install the correct size vent or install a draft inducer.

Another cause of spillage can be an undersized vent cap. Usually, if the vent itself is correctly sized, a vent cap the same size as the vent will perform satisfactorily. The solution is to insure that the vent cap is not highly restrictive and is at least the same size as the vent. Again, power venting...
is possible solution.

Spillage can also be caused by excessive resistance due to poor vent system design or installation. This excess resistance may be due to an excessive number of elbows, exceedingly long lateral runs, or improper pitch in lateral runs. The number of elbows in a vent system should be kept to a minimum. Vent capacity tables already take into account two elbows.

Each 90 degree elbow, in excess of two, decreases vent capacity by 10%. As a general rule, lateral length should be limited to 75% of the total vent height. This rule may not apply, however, to vent systems with several elbows.

Installations with several elbows and long horizontal runs will perform poorly. Proper slope must be maintained in lateral runs. The pitch should be at least 1/4 inch per lateral foot of run. In the extreme case, a downward pitched horizontal pipe may even form a trap, possibly resulting in spillage.

Resistance to flow in a vent may also come in the form of restrictions. These restrictions may be caused by the presence of foreign objects such as bird’s nests, rodent nests, or insect nests, etc. Vents should be periodically inspected for the presence of obstructions. A screen on the vent outlet may be necessary.

Restrictions can also come in the form of accessories such as dampers, draft regulators or inoperative induced-draft blowers. Faulty accessories must be replaced. Control of these accessories must be integrated with the combustion system to prevent firing of the furnace in the event of a malfunction. Vent systems should be inspected for damaged or deformed pipe. A sizeable dent in a vent pipe may also be a restriction.

Flue-gas spillage may occur when the combustion and dilution air supplies are under negative pressures. If a structure contains other devices which exhaust air, close attention must be paid to the ventilation air supply. Range hoods, bathroom and kitchen exhausts are examples of such devices. The air supply for a furnace should never come from the same immediate area where these appliances are located.
### VENT TABLES

**Capacity of Type B Double-Wall Vents with Type B Double-Wall Connectors Serving a Single Category I Appliance**

<table>
<thead>
<tr>
<th>Height (Inches)</th>
<th>Appliance Input Rating in Thousands of BTU Per Hour</th>
<th>Fan and Connector Diameter - D (Inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fan Nat</td>
<td>ISSN</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>152</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
<td>197</td>
</tr>
<tr>
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<tr>
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<td>28</td>
<td>288</td>
</tr>
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<td>4</td>
<td>35</td>
<td>340</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>398</td>
</tr>
<tr>
<td>6</td>
<td>47</td>
<td>452</td>
</tr>
</tbody>
</table>

Note: D is the diameter of the vent and connector. ISSN stands for Input Sensitivity to Natural Gas. Fan Nat refers to the natural gas setting of the fan. This table provides the capacity of the vent system for various input ratings and diameters, ensuring proper gas flow and safety in gas fireplaces and stoves.
# Table 1 (Continued)

Capacity of Type B Cables: Will Work with Type B Cables at Full Connections

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>100V</th>
<th>125V</th>
<th>150V</th>
<th>250V</th>
<th>300V</th>
<th>375V</th>
<th>500V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Detailed values are provided in the table.*
## VENT TABLES

Capacity of Type B Double-Wall Vent with Single-Wall Connectors

Serving Two or more Category I Appliances

### TABLE 4

<table>
<thead>
<tr>
<th>Vent Diameter - D (inches)</th>
<th>2&quot;</th>
<th>3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
<th>8&quot;</th>
<th>10&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliance Input Rating Limits in Thousands of BTU Per Hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VENT CONNECTOR CAPACITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Common Vent Capacity

<table>
<thead>
<tr>
<th>Common Vent Diameter - D (inches)</th>
<th>2&quot;</th>
<th>3&quot;</th>
<th>4&quot;</th>
<th>5&quot;</th>
<th>6&quot;</th>
<th>8&quot;</th>
<th>10&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VENT CONNECTOR CAPACITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### TABLE 6

**Capacity of Masonry Chimney with Single Wall Vent Connectors Serving a Single Category I Appliance**

<table>
<thead>
<tr>
<th>Connector Diameter (D) (inches)</th>
<th>Appliance Input Rating in Thousands of Btu Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>120</td>
<td>6</td>
</tr>
<tr>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>180</td>
<td>5</td>
</tr>
<tr>
<td>210</td>
<td>5</td>
</tr>
<tr>
<td>240</td>
<td>5</td>
</tr>
<tr>
<td>270</td>
<td>5</td>
</tr>
<tr>
<td>300</td>
<td>5</td>
</tr>
<tr>
<td>330</td>
<td>5</td>
</tr>
<tr>
<td>360</td>
<td>5</td>
</tr>
<tr>
<td>390</td>
<td>5</td>
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<tr>
<td>420</td>
<td>5</td>
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<tr>
<td>450</td>
<td>5</td>
</tr>
<tr>
<td>480</td>
<td>5</td>
</tr>
<tr>
<td>510</td>
<td>5</td>
</tr>
<tr>
<td>540</td>
<td>5</td>
</tr>
</tbody>
</table>

**Minimum Internal Area of Chimney:**
- \(12\) square inches
- \(19\) square inches
- \(26\) square inches
- \(33\) square inches
- \(50\) square inches
- \(53\) square inches
- \(71\) square inches
- \(95\) square inches
- \(132\) square inches

**Maximum Internal Area of Chimney:**
- \(49\) square inches
- \(88\) square inches
- \(137\) square inches
- \(198\) square inches
- \(369\) square inches
- \(392\) square inches
- \(444\) square inches
- \(558\) square inches
- \(792\) square inches

*Note 2: Numbers followed by an asterisk indicate the possibility of common combustion, depending on locality. Consult appliance manufacturer and serving gas supplier for authority having jurisdiction.*
Glossary

AFUE – The Annual Fuel Utilization Efficiency (AFUE) is a ratio of annual output of useful energy delivered to the heated space to the annual fuel energy input.

ATMOSPHERIC PRESSURE – The pressure exerted on the earth’s surface by the weight of the atmosphere above it. At sea level this is approximately 14.7 pounds per square inch, 760 mm of mercury.

BAFFLE – An object placed in appliance to change the direction of, or retard, the flow of air, air-gas mixtures, or flue gases.

CHIMNEY – (Also see Gas Vents) A vertical shaft enclosing one or more flues for conveying flue gases to the outside atmosphere.
   b. Masonry Chimney. A chimney of solid masonry units, bricks, stones, listed masonry units or reinforced concrete, lined with suitable flue liners.
   c. Metal Chimney. A field-constructed chimney of metal.

CHIMNEY FLUE – (See Flue)

COMBUSTIBLE MATERIAL – As pertaining to materials adjacent to or in contact with heat producing appliances, vent connectors, gas vents, chimneys, steam and hot water pipes, and warm air ducts, shall mean materials made of or surfaced with wood, compressed paper, plant fibers, or other materials that will ignite and burn. Such material shall be considered combustible even though flame-proofed, fire retardant treated, or plastered.

COMBUSTION – Rapid oxidation of fuel gases accompanied by the production of heat, or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen.

COMBUSTION AIR – Air supplied to an appliance specifically for the combustion of fuel.

COMBUSTION PRODUCTS – Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inerts but excluding excess air.

COMMON VENT – The portion of a vent system into which the flue gases from two or more appliances flow.

CONDENSATE (CONDENSATION) – The liquid which separates from a gas (including flue gas) due to a reduction in temperature.

CUBIC FOOT (Cu. Ft.) OF GAS – The amount of gas which would occupy 1 cubic foot when at a temperature of 60°F, saturated with water vapor, and under a pressure equivalent to that of 14.73 pounds per square inch absolute.

DENSITY – The weight of a substance per unit volume. As applied to gases, the weight in pounds of a cubic foot of gas at standard pressure and temperature.

DEW POINT – The temperature at which a vapor starts to condense into a liquid. In undiluted flue gases it is about 140°F. In diluted gases in the vent it is approximately 100 to 105°F.

DILUTION AIR – Air which enters a draft hood or draft regulator mixes with the flue gases.

DOWNDRAFT – A flow of air downward in the stack caused by excessively high air pressures created at the outlet of the chimney or vent cap or by negative pressure at the inlet of the vent system.

DRAFT HOOD/DRAFT DIVERTER – A device built into an appliance, or made a part of the flue or vent connector from an appliance, which is designed to (1) provide for the ready escape of the flue gases in the event of no draft, back draft, or stoppage beyond the draft hood; (2) prevent a back draft from entering the appliance; and (3) neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance.

DRAFT HOOD CONNECTOR – A transition fitting for connecting double-wall pipe to the single-wall flue collar or draft hood outlet of the appliance.

DRAFT REGULATOR – A device which functions to maintain a desired draft in the appliance by automatically reducing the draft to the desired value.

EXCESS AIR – Air which passes through the combustion chamber and the appliance flues in excess of that which is theoretically required for complete combustion.

FIRESTOP – A blockage placed in a hollow wall or opening in any other part of a building structure to halt upward progress of fire through the wall or opening.

FIRESTOP SPACER – A component of a vent system which serves to secure a vertical vent and at the same time serve as a firestop for the opening made for the vent through a floor, ceiling or wall.

FLUE – The general term for the passageways in an appliance and vents through which combustion products pass to the outside atmosphere.
   1. Appliance Flue – The flue passageways within an appliance.
   2. Chimney Flue – The vertical conduit for conveying combustion products delivered to it by a vent connector to the outside atmosphere.

FLUECOLLAR – That portion of an appliance designed for the attachment of the draft hood or vent connector.
FLUE EXHAUSTER – A device installed in and made a part of the vent which will provide a positive induced draft. *(Draft Inducer)*

FLUE GASES – Products of combustion plus excess air in appliance flues or heat exchangers (before the draft hood or draft regulator. *(See Vent Gases).*

FLUE OUTLET – The opening provided in an appliance for the escape of the flue gases.

FLUE PRODUCTS – *(See Flue Gases)*

GAS VENTS – Factory-built vent piping and vent fittings listed by a nationally recognized testing agency, that are assembled and used in accordance with the terms of their listings, for conveying flue gases to the outside atmosphere.

  a. Type B Gas Vent. A gas vent for venting gas appliances with draft hoods and other gas appliances listed for use with Type B Gas Vents.
  b. Type B-W Gas Vent. A gas vent for venting listed gas-fired vented wall furnaces.
  c. Type L Venting System. A venting system composed of listed factory-built components assembled in accordance with the terms of listing for venting appliances listed for use with Type L venting systems. They may be used also where Type B gas vents are permitted.

HALOGENATED HYDROCARBON – Any number of compounds composed of carbon and hydrogen which has a chlorine, fluorine or bromine constituent.

HIGH EFFICIENCY APPLIANCE – An appliance which operates at an AFUE value above about 83 percent. These appliances normally use a power burner, induced or forced draft blower or pulse combustion to vent the flue gases. The appliances also require special consideration of condensate. Between 83 and 90 percent AFUE condensate may occur in the vent system during cycling. If the AFUE value is above 90 percent condensate will occur in the appliance and vent system during cycling and steady operation.

LISTED – Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

MAKE-UP AIR – Air supplied to a space to replace air exhausted or otherwise removed from the space.

MULTIPLE APPLIANCE VENT – *(See Vent)*

NATURAL DRAFT – The motion of the flue gases through an appliance generated by hot flue gases rising in a chimney or vent.

PRIMARY AIR – The air introduced into a burner which mixes with the gas before it reaches the port or ports.

RELIEF OPENING – The opening provided in a draft hood to permit the ready escape to the atmosphere of the flue products from the draft hood in the event of no draft, back draft, or stoppage beyond the draft hood, and to permit inspiration of air into the draft hood in the event of a strong chimney updraft.

RETURN AIR – Air returning through ductwork to be reheated by a forced-air furnace after circulation through the heated space.

ROOF FLASHING – Metal used to waterproof roof joints or openings where vents emerge from the roof.

SECONDARY AIR – The air externally supplied to the flame at the point of combustion.

SLIP JOINT – Joints of metal vents so fabricated that vent sections can be secured to each other without tools by sliding the parts together manually.

SPACE, CONFINED – A space whose volume is less than 50 cubic feet per 1000 Btu per hour of the aggregate input rating of all appliances installed in the space.

SPACE, UNCONFINED – A space whose volume is not less than 50 cubic feet per 1,000 Btu per hour of the aggregate input rating of all appliances installed in that space. Rooms communicating directly with the space in which the appliances are installed, through openings not furnished with doors, are considered a part of the unconfined space.

SPILLAGE – Combustion products flowing from the appliance air openings or draft hood relief openings due to a malfunction of the venting system.

STORM COLLAR – A cone-shaped metal piece providing a waterproof transition from a vent pipe and a roof where the pipe emerges from the roof.

THIMBLE – A metal device penetrating a wall with a hole for a vent pipe to pass through. The thimble secures the pipe, seals the wall opening and insures that the hot vent is isolated from combustible wall material. A ventilated thimble has holes which allow air to pass freely between the vent and the thimble thereby keeping the thimble cool.

UPDRAFT – An increase in the upward velocity and volume of the flue gases caused by excessively low atmospheric pressures at the outlet of the chimney or vent cap.
VENT – *(See Gas Vents)* A device, such as a pipe, to convey flue gases from an appliance to the outdoors.

VENT CONNECTOR – That portion of the venting system which connects the gas appliance to the gas vent or chimney.

VENT DAMPER DEVICE, AUTOMATIC – A device intended for installation in the venting system, in the outlet of or downstream of the appliance draft hood, of an individual automatically operated fuel-gas burning appliance and which is designed to automatically open the venting system when the appliance is in operation and to automatically close off the venting system when the appliance is in a standby or shutdown condition.

a. Electrically Operated. An automatic vent damper device that employees electrical energy to control the device.

b. Mechanically Actuated. An automatic vent damper device dependent for operation upon the direct application or transmission of mechanical energy without employing any type of energy conversion.

c. Thermally Acutated. An automatic vent damper device dependent for operation exclusively upon the direct conversion of the thermal energy of the vent gases into mechanical energy.

VENT GASES – *(Flue-Gases, Flue-Products)* Products of combustion from gas appliances plus excess air, plus dilution air in the venting system above the draft hood or draft regulator.

VENT TERMINAL (VENT CAP) – The fitting at the end of a vent pipe that directs the flue gases into the outside atmosphere and keeps out rain, snow, debris and animals.

VENTING – The process of removing the gases produced by combustion.

VENTILATION (VENTILATION AIR) – Air brought into or allowed to enter the space occupied by an appliance to replenish air used in combustion, excess air, and draft hood dilution air or to provide replacement of the air in a space by fresh air.

VENTING SYSTEM – The gas vent, chimney or single-wall metal pipe, and vent connector if used, assembled to form a continuous open passageway from the gas appliance to the outside atmosphere for the purpose of removing vent gases.

WATER COLUMN – Abbreviated as W.C. A unit used for expressing pressure. One inch water column equals a pressure of 0.578 ounces per square inch.

‘Y’ FITTING – A tee fitting modified in shape to reduce flow resistance.
Note: This publication is general in nature and is intended for INSTRUCTIONAL PURPOSES ONLY. It is not to be used for equipment selection, application, installation, or specific service procedures.