Study Guide

NORTH AMERICAN TECHNICIAN EXCELLENCE®

GAS FURNACES

GT71-01 Cat. No. 020-017

GAS FURNACES

1. This refresher course covers topics contained in the GAS FURNACES specialty section of the North American Technician Excellence (NATE) certification exam.

HEAT TRANSFER

British Thermal Unit is the Amount of Heat Required to Change the Temperature of One Pound of Water One Degree Fahrenheit.

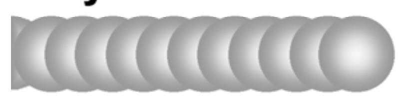
2. The **British Thermal Unit** or **BTU** is the amount of heat required to change the temperature of one pound of water one degree Fahrenheit.

Heat Transferred 3 Ways:

1. Conduction
2. Convection
3. Radiation

3. Heat can be transferred in three ways: conduction, convection and radiation.

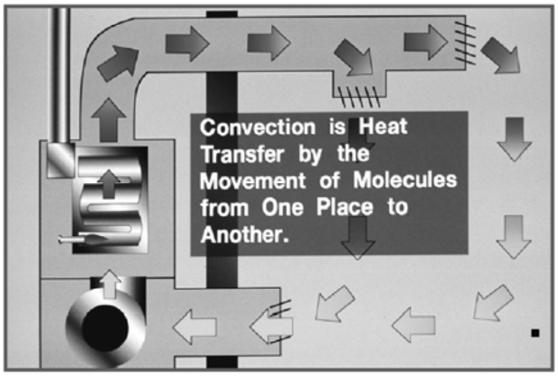
Conduction is the Transfer of Heat from Molecule to Molecule Through a Substance by Chain Collision.



4. **Conduction** is the transfer of heat from molecule to molecule through a substance by chain collision.

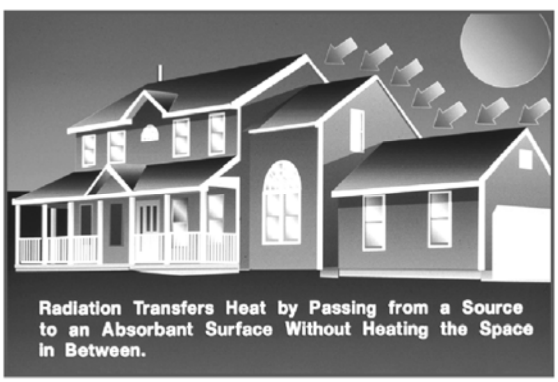
As heat is added to a substance, the temperature rises at that spot, causing the molecules to move more rapidly and start a chain reaction with nearby molecules, raising their velocity and temperature as well. As more heat is added, the chain reaction moves through the material.

While conduction does take place in gases and liquids, it works best when molecules are closely packed, as they are in solids.



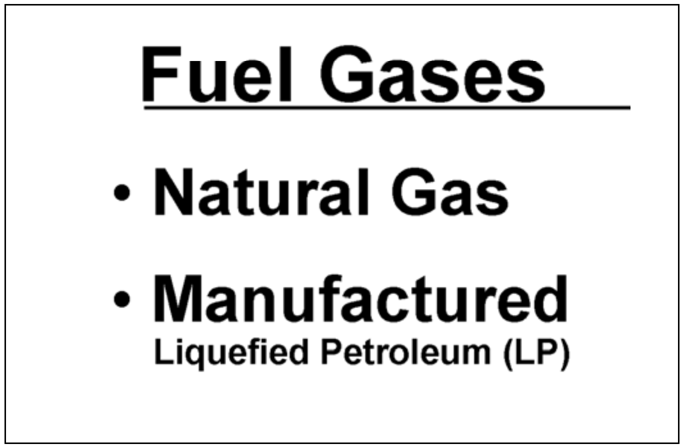
5. **Convection** is heat transfer by movement or flow of groups of molecules from one place to another. Heated molecules within a flowing medium, such as air or water, carry their heat to a new place.

In a forced-air heating system, for example, heat is carried by convection from the furnace heat exchanger through the flowing air in the duct system. On a smaller scale, hot combustion products carry heat along the inside surface of the heat exchanger, transferring heat to the cooler heat exchanger material by convection.



6. **Radiation** transfers heat by passing from an absorbent surface without heating the space in between. Radiation is the most common method of heat transfer because most of the Earth's heat energy comes from the sun by solar radiation. Radiant heat behaves like a waveform of energy, like light.

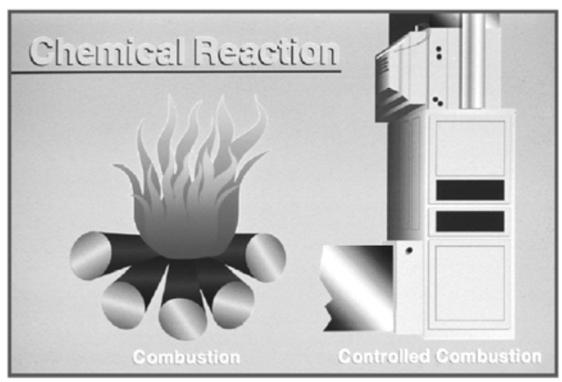
TYPES OF GAS



7. Two types of gas are used in gas furnaces: **natural gas** and **manufactured gas**.

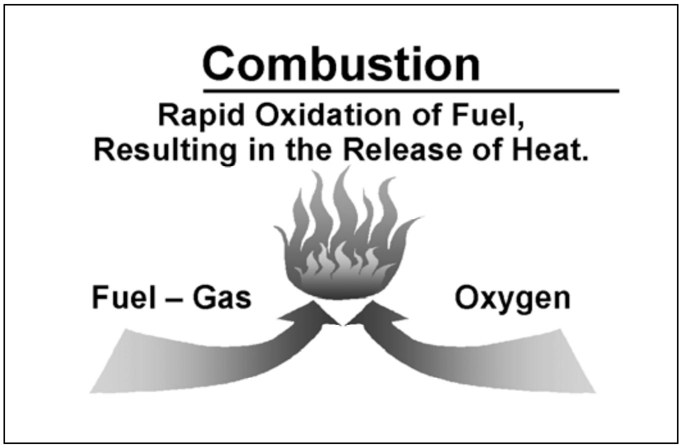
Natural gas occurs naturally in the earth and is composed of about 95% methane, with other gases such as ethane, hydrogen, carbon dioxide and nitrogen, making up the remainder.

Manufactured gases, such as liquid propane are man-made, created by combining gases in specific ratios. Propane, for example, is composed of three atoms of carbon and eight atoms of hydrogen.



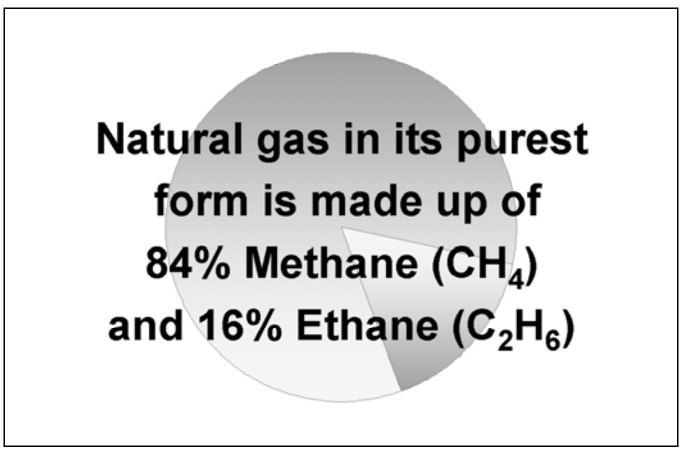
8. Most **chemical reactions** produce heat energy, resulting in a temperature rise equal to a quantity of heat. Combustion is a chemical reaction between fuel and oxygen in the air, resulting in a large temperature rise and producing a lot of heat.

A gas furnace harnesses this combustion reaction, transferring the high temperature produced by the combustion products to the furnace's heat exchanger, raising the heat exchanger's temperature, which then transfers that heat to the cooler circulating air.

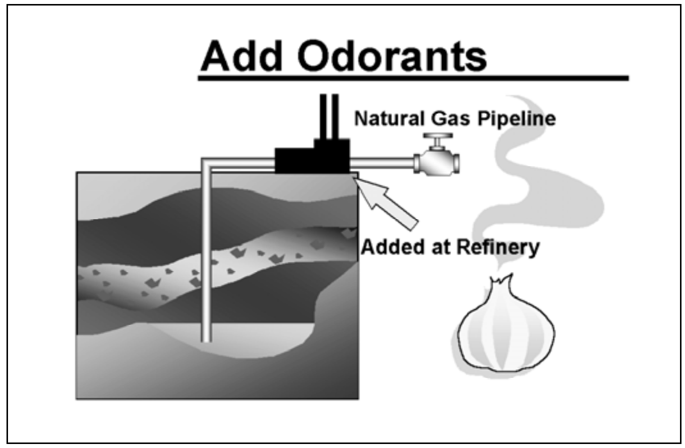


9. Simply put, **combustion** is burning. Technically, it is the chemical reaction between a fuel and oxygen. Specifically, combustion is the rapid oxidation of a fuel, which results in the release of heat and light.

Fuels must be in a gaseous state to burn and, with enough air present, gaseous fuels such as natural gas and LP gas will burn cleanly in their natural gaseous state.

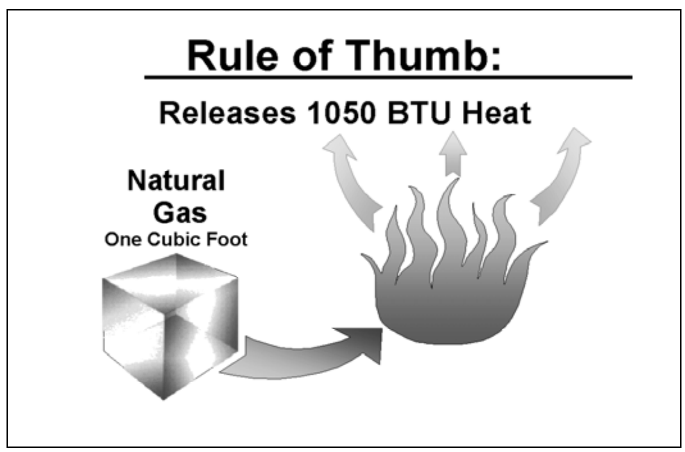


10. Natural gas in its purest form is made up of 84% Methane (CH_4) and 16% Ethane (C_2H_6).



11. Natural gas, propane and butane have no odor, color or taste. Though they are not toxic or poisonous by nature, they can create hazardous conditions in high concentrations both by displacing oxygen and causing suffocation or by creating a potential fire hazard if they accumulate in a closed room.

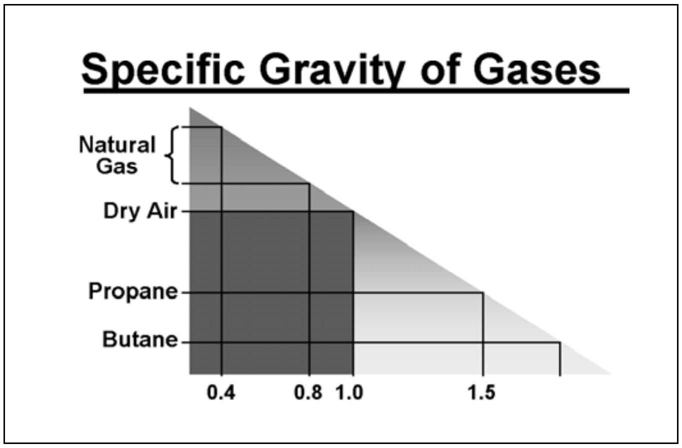
Odorants are added to these gases before distribution to help people detect leaks and avoid or correct unsafe conditions. Most odorants are compounds containing sulphur, called mercaptans that smell like garlic and are very powerful. These odorants are used in very trace amounts and the odor disappears when the gas burns.



12. Natural gas is not pure methane. The important factor is that the presence of other gases affects the heating value of natural gas. Therefore, natural gas from different suppliers will have different heating values.

The heating value of natural gas ranges from about 900 to more than 1100 Btu per cubic foot, depending on the source. Pure methane has a heating value of 995 Btu per cubic foot.

A common rule of thumb is to use the figure of 1050 Btu per cubic foot for natural gas estimating, meaning that one cubic foot of natural gas releases 1050 Btu of heat. It is a good practice to check local gas suppliers to obtain the exact heating value of the natural gas supplied in your locality.



13. Because gases are quite light compared to liquids or solids, it is convenient to compare their weight to that of air. This ratio is called specific gravity. **Specific gravity** is the weight of one cubic foot of gas divided by the weight of one cubic foot of dry air at the same temperature and pressure.

Used as the reference gas, air has a specific gravity of 1.0. This value has no relationship with any physical property of air but is simply a comparative weight.

Natural gas has a specific gravity between 0.4 and 0.8. This means that a cubic foot of natural gas can weigh between 4/10 and 8/10 of the weight of a cubic foot of air, depending on the variation of the gases mixed with natural gas by suppliers. Propane has a specific gravity of 1.5 and butane's is 2.0.

Again, both measurements must be at the same temperature and pressure when compared.

Properties of Gas-Air Mixtures

Natural Gas

Gas in Air Mixture	Will It Burn?	Why or Why Not?
0 - 4.3%	No	Too Lean
4.3 - 15%	Yes	Proper Mix
15 - 100%	No	Too Rich

14. Not all gas-air mixtures will burn or explode. It is important to know the compositions of mixtures that do burn and those that are too lean or rich to burn or explode.

Mixtures with zero to 4.3% methane gas are too *lean* to burn. Mixtures of 4.3 to 15 percent methane gas in air can burn with a controlled flame *but can explode* if the mixture is allowed to collect before ignition. Mixtures with more than 15% methane are too *rich* to burn.

By-products of Complete Combustion include:

Carbon Dioxide

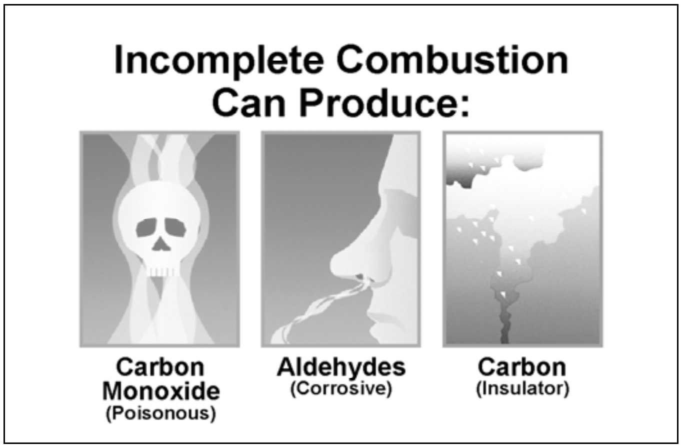
Water Vapor

Inert Gas

Light

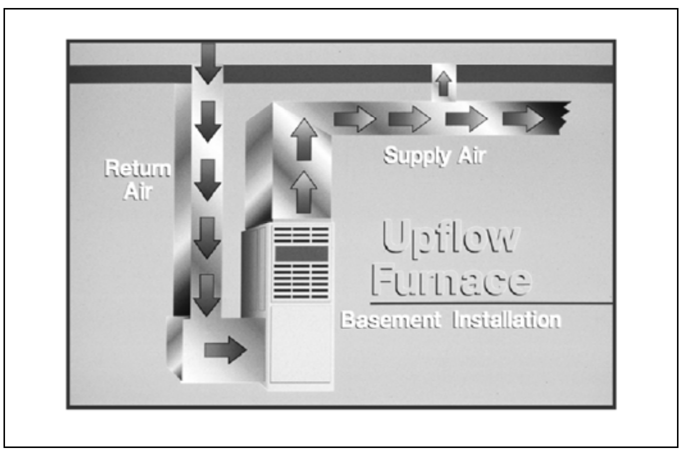
Heat

15. Some of the by-products of complete combustion include carbon dioxide, water vapor, inert gas, light and heat. To obtain complete combustion, enough air must be supplied to the gas furnace. This air must have a normal oxygen content and must be well mixed with the gas in the flame.



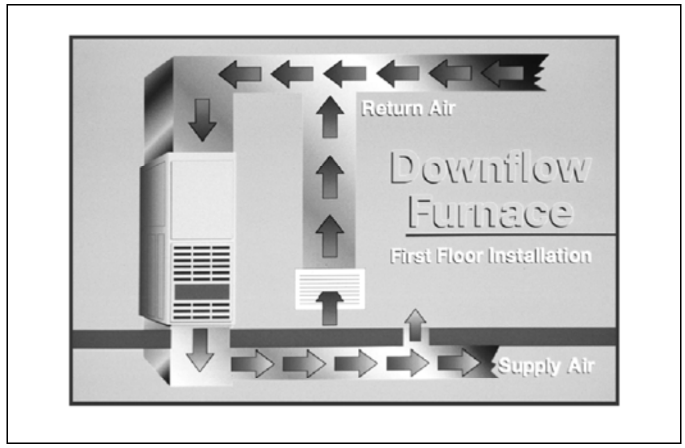
16. If insufficient air is supplied or if a flame strikes a cold surface that stops the combustion reaction, incomplete combustion results and other products are released. Some of these products are harmful, especially carbon monoxide and aldehydes. Incomplete combustion may cause soot to form on the inside of the heat exchanger, which in turn may harm equipment and reduce performance.

FURNACE CONFIGURATION



17. **Upflow furnaces** are the most widely used type of gas furnace and are generally installed in basements as well as in closets or equipment rooms.

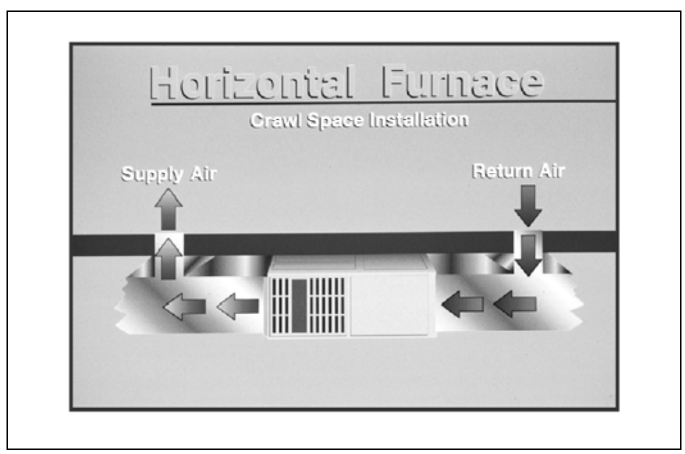
In upflow furnaces, return air enters through the bottom or lower side(s) of the furnace through a filter and is pushed upward through the heat exchanger by a blower. The heated air is then discharged into a plenum above the furnace to be delivered through the supply air system.



18. **Downflow furnaces** are often used in houses that are built with a crawl space or on a slab. This type of system might also be found in mobile homes and is more common in warmer climates where basements aren't as prevalent.

With a downflow furnace, the supply air system is installed in the crawl space, or in the slab, and the furnace is installed on the first floor. The operating components in a downflow furnace are arranged in the reverse order of the upflow, although certain upflow furnaces are designed and approved for rotation to downflow and horizontal applications. This is called multi-poise.

In a downflow furnace, return air enters the top of the furnace through a filter and is pushed downward through the heat exchanger by a blower. The air is then discharged into a plenum and the supply duct system located below the furnace.

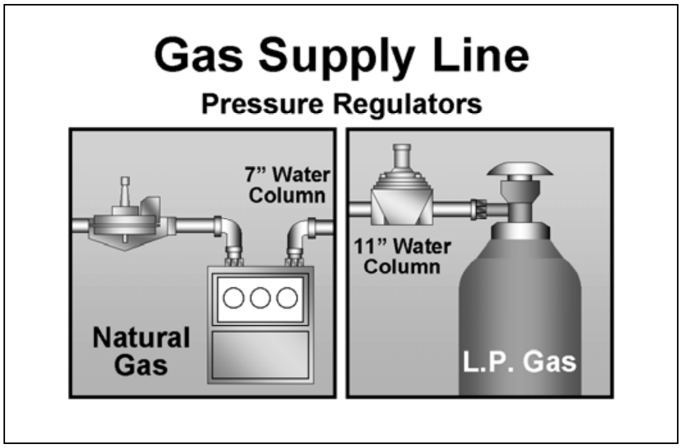


19. **Horizontal furnaces** can be installed in attics, under floors, in crawl spaces or suspended from ceilings, such as in garages. Certain upflow and downflow furnaces can be installed in the horizontal position for horizontal application.

In a horizontal furnace, air passes horizontally over the heat exchanger and is discharged into a supply air plenum located on the same level as the return air.

Whenever a furnace is installed in a closet, attic or crawl space, there must be adequate access to the furnace and room around it for servicing. In cases of attic installations, a platform should be built in front of the furnace on which the service technician can work and which will prevent him from stepping through the ceiling.

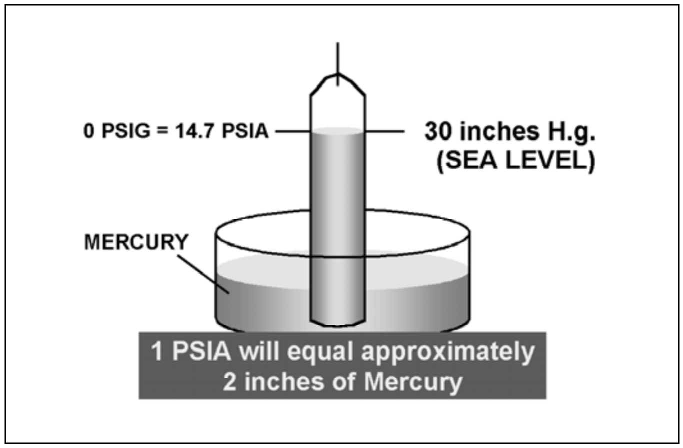
GAS PIPING



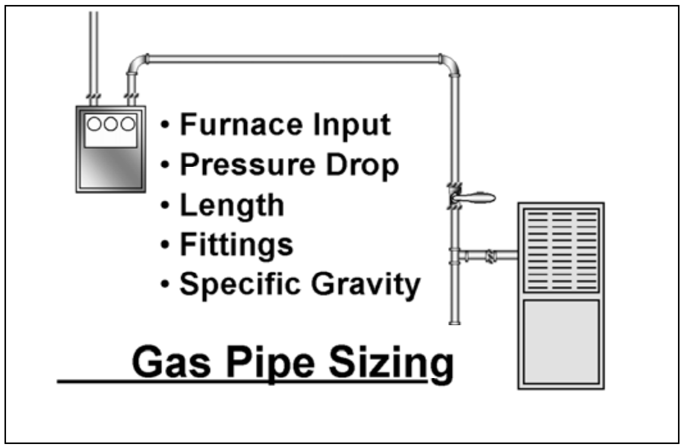
20. Variations in utility supply line pressure are common and pressures may be too high for direct connection to a gas furnace or other gas appliance. Therefore, a service regulator is required to reduce, adjust and maintain the pressure being supplied to the appliance in a building.

For natural gas, this regulator is usually provided by the gas utility and is installed upstream of the gas meter. It should be adjusted by the utility to supply a pressure of approximately 7 inches of water column at the inlet of the furnace when the furnace is operating. The pressure supplied to the furnace should **never exceed the maximum pressure on the furnace rating plate**, which is about 13.5 in. w.c. Also, the pressure supplied to the furnace should not be less than the minimum of 4.5 inches to assure that the furnace can be fired at rated input.

LP gas service regulators are installed at the gas storage tank by the supplier and set at 11 in. w.c. ***They should only be adjusted by the gas supplier***.

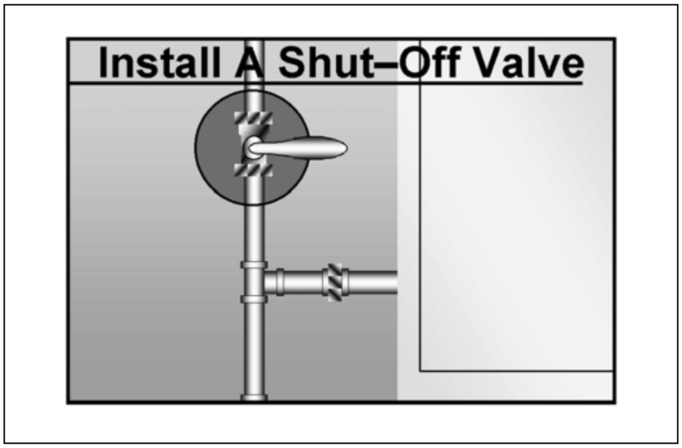


21. Remember that when we determine compression ratios, 0 PSIG (pounds per square inch gauge) is equivalent to 14.7 PSIA (pounds per square inch absolute) at sea level. That same pressure is equivalent to 30 inches of mercury at sea level. Therefore, 1 PSIA will equal approximately 2 inches of mercury.

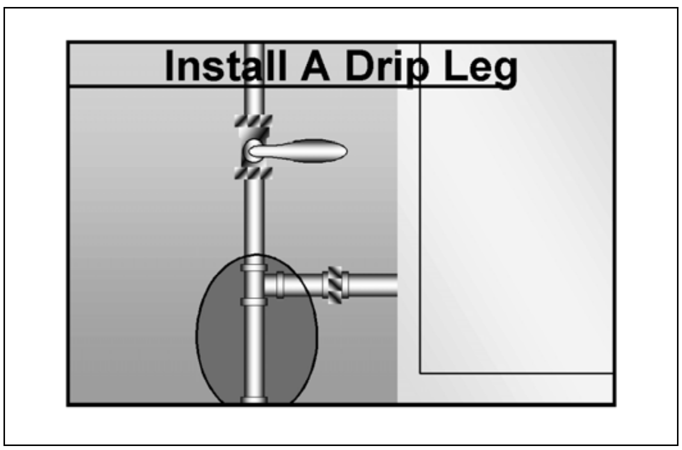


22. Gas piping is sized so that the required quantity of gas will be supplied to the furnace without excess pressure drop. The size or diameter of the piping depends on the amount of gas to be consumed, the allowable pressure drop, the length of the piping run, the number of fittings, and the specific gravity of the gas.

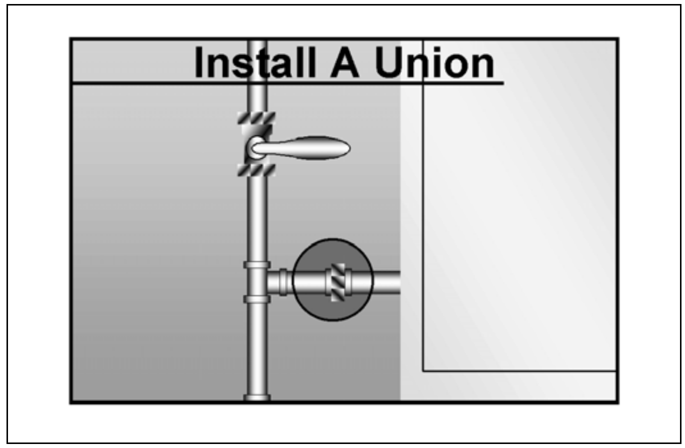
Piping length can also be measured, with 3 equivalent feet added for each fitting (elbow, tee, etc.) in the run.



23. Almost all local codes require a **manual shutoff valve** ahead of the furnace which allows the furnace to be isolated from the gas source and any other gas appliance in case service is required. This valve must be both visible and accessible from the furnace to quickly and easily turn off the gas in case of emergency.

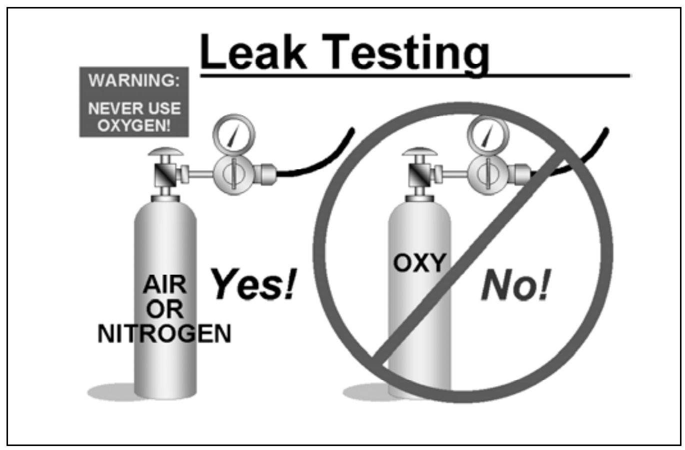


24. **Drip legs** should be installed wherever condensate may collect in the piping, but they should not be located where the condensate could freeze.



25. Codes also require a ground **union** to be installed between the manual shutoff valve and the furnace. This is a very practical requirement since it makes it easy to disconnect the furnace from the gas line for service or replacement of the gas valve or furnace.

This union should not be installed inside of the cabinet of the furnace.



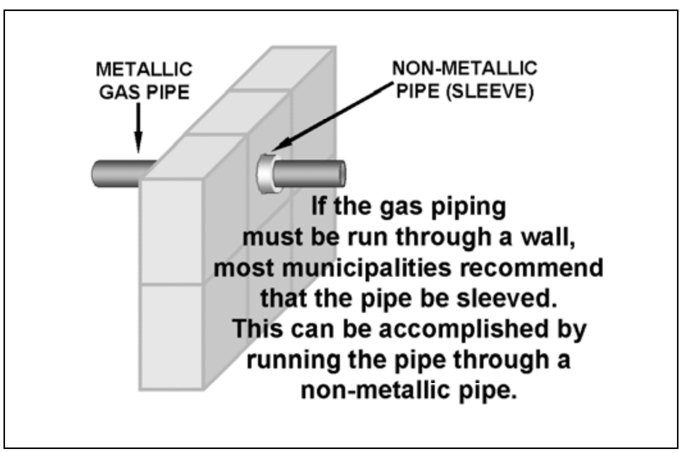
26. All gas piping systems must be **leak tested** before they can be used. Pressure testing may be done with air or any inert gas such as dry nitrogen. Fuel gas can be used in piping systems operating at pressures of 0.5 psig.

Warning: NEVER use oxygen to leak test.

27. Use a soapy water solution or a commercially available, non-corrosive leak detection fluid to find leaks in gas piping. If leak detection fluids are not approved as non-corrosive, rinse the pipe after testing. If a leak is found, it must be repaired and the pipe retested.

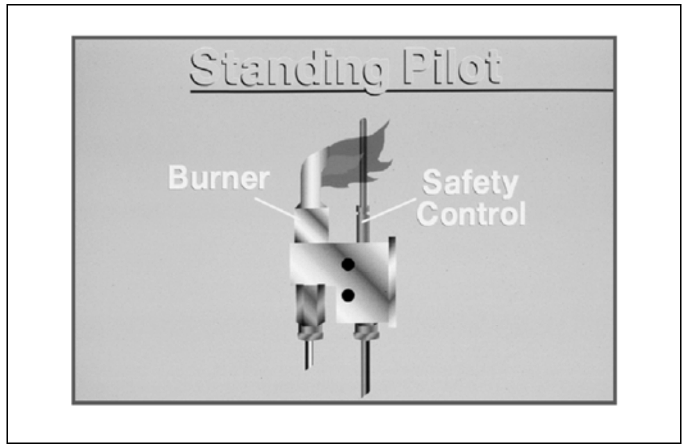
Electronic leak detectors are also designed to detect the presence of combustible gas. Most of these types of leak detectors will measure in parts per million. They need to be calibrated from time to time. Care must be used because they can detect minute leaks that are less than that allowed by code. Also, electronic leak detectors should not be used in windy conditions.

Warning: NEVER use a flame to locate a leak.



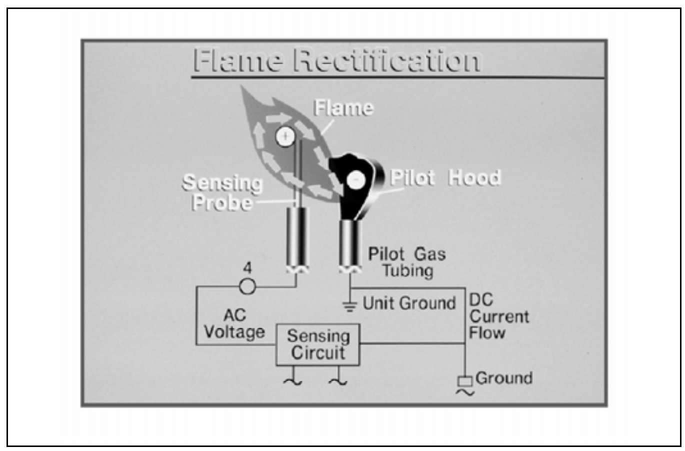
28. If the gas piping must be run through a wall, most municipalities recommend that the pipe be sleeved. This can be accomplished by running the pipe through a non-metallic pipe.

IGNITION DEVICES



29. A furnace has an ignition system to light the gas at the main burners each time there is a demand for heat. A **standing pilot** is the most common ignition device. After being lit initially, it burns continuously, whether the main burner is on or off.

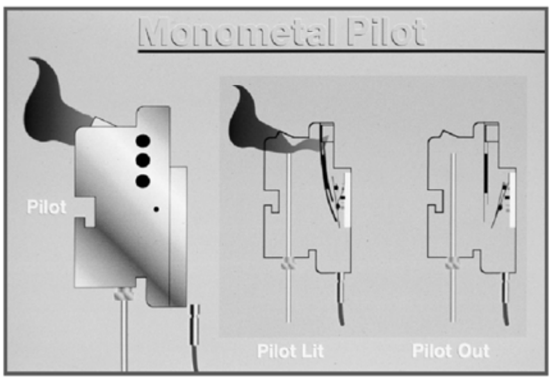
A standing pilot has two components: a gas burner and a safety control.



30. The **flame rectification** circuit of the spark generator senses a change in the electrical conductivity to detect the presence of the pilot flame. When the pilot flame is ignited, the hot ionized gas in the flame becomes a conductor of electricity, and, in effect, shorts out the spark to ground. When the flame rectification circuit detects the increased current flow to ground, it will turn off the spark and the spark will remain off as long as the pilot is lit.

On some types of spark ignition systems, if the pilot flame does not ignite, the spark may continue until service is provided. On others, if the pilot does not ignite within a prescribed time (usually 15 to 90 seconds), the spark ignition circuit will turn off the spark and gas. Other systems may try another ignition cycle after a time delay of a minimum of 5 minutes.

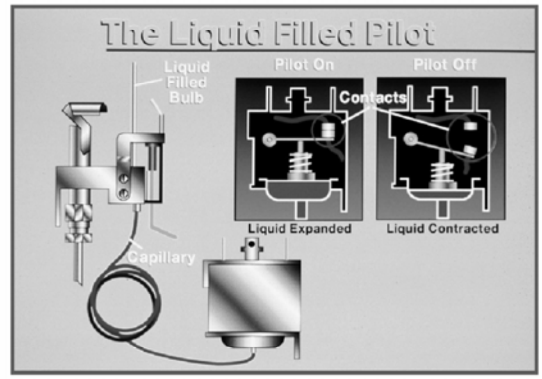
Depending on the system, if ignition does not occur after one or more cycles, the system will lock out, requiring a service technician to manually reset the system. The cause of the pilot ignition failure must be determined before resetting.



31. Another type of pilot is the **monometal** or **bimetal** pilot. The monometal element consists of two strips of stainless steel anchored to the pilot frame at the upper end, separated by a small air gap and joined together at the lower end.

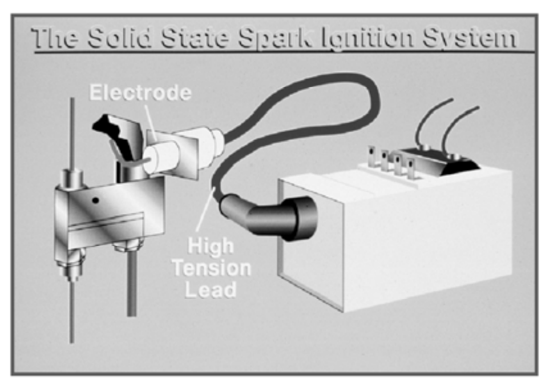
The pilot flame plays on the nearest strip, heating and expanding it more than the other, causing it to warp. This warping action actuates the electrical safety switch, closing a set of electrical contacts. Should the pilot light go out, the monometal element cools and returns to its original shape, opening the safety switch contacts.

The bimetal pilot works similarly but is not as common.



32. Yet another type is the liquid-filled pilot, which is similar in action to the monometal pilot. A liquid-filled sensing bulb, located in the pilot flame is heated by the flame, causing the liquid inside to expand. The displaced liquid flows through a very small diameter capillary tube into a diaphragm element in a remote safety switch, pushing the diaphragm out and closing a set of electrical contacts in the safety switch. When closed, the switch contacts, which are in the main gas valve, enable the gas valve to be energized if there is a demand for heat.

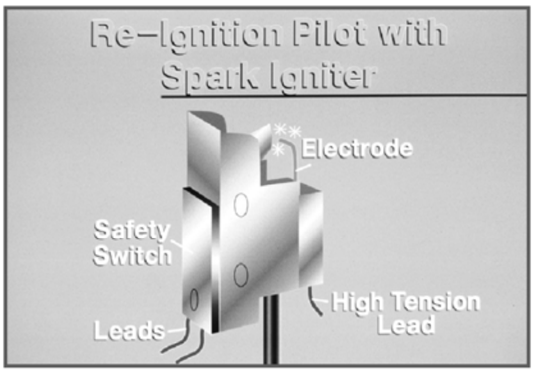
If the pilot goes out, the bulb cools, contracting the liquid into the bulb and returning the diaphragm to its initial position. This opens the switch contacts, preventing the main gas valve from being energized.



33. One of the most common types of pilot re-ignition now in use on gas furnaces is the electronic **spark ignition system**. While there are many different types and designs on the market, all operate with the same basic principles.

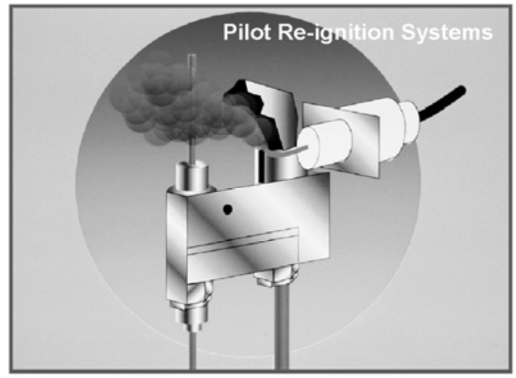
These systems use flame rectification for detecting the presence of a pilot flame, along with a thermally actuated pilot safety switch for controlling the main gas.

Spark ignition systems for residential furnaces are usually 24-volt input but are also available for 120-volt input. In any case, a network of electronic components in the spark generator converts the supply voltage to a high voltage potential of approximately 15,000 volts at the output terminal, which is conducted to the pilot electrode by the high-tension cable.

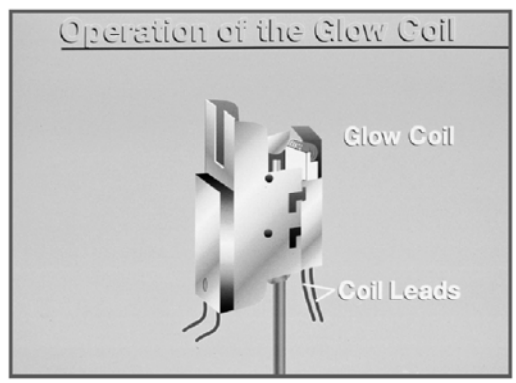


34. **Re-ignition pilots** enable the pilot gas to be shut off during the furnace off-cycle. This is an effective way to save energy. Furnaces with vent dampers or inducer fans generally use re-ignition pilots.

When there is a demand for heat, the pilot gas is turned on and must be re-ignited before the main gas to the burners is turned on. Glow coils or spark ignition systems are commonly applied to standing pilots with bimetal or liquid-filled safety switches for automatic re-ignition. The safety switch must prove the pilot flame before the main gas is turned on. Thermocouple-type pilots are not suitable for re-ignition because they must be manually reset after pilot outage.

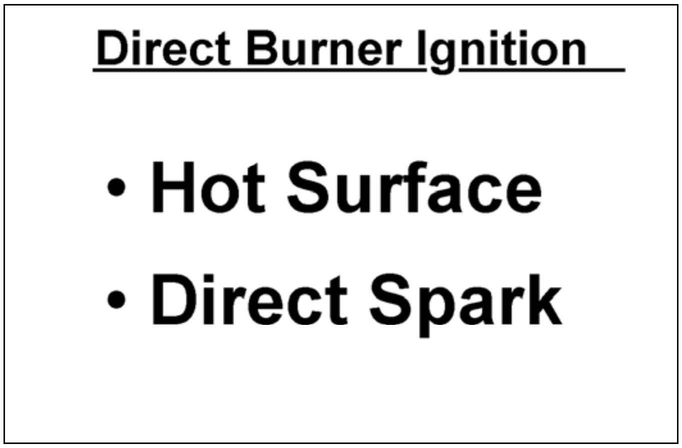


35. The electrode is positioned near the pilot burner to provide a spark gap between the electrode and the pilot burner through which the pilot gas must pass. When the spark generator is energized, the high potential at the electrode tip will create an electric spark across the gap to the grounded surface of the pilot. The spark will continue firing until the gas flowing through the gap is ignited.

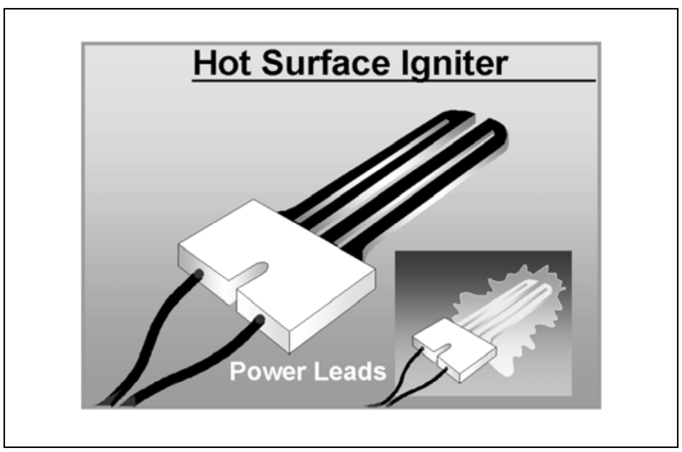


36. In the glow coil type of pilot re-ignition system, the **glow coil** is constructed of platinum wire wound into a tight coil. It operates on low voltage, approximately 12 volts. When current passes through the glow coil, the electrical resistance heats the coil wire to the ignition temperature of the gas. When the fuel gas passes over the coil, it ignites.

Because of its very high temperature, the glow coil cannot remain energized continuously without risk of burning out. A time delay circuit de-energizes the glow coil after about 15 seconds to prevent coil damage. Usually, this provides plenty of time for ignition to take place.



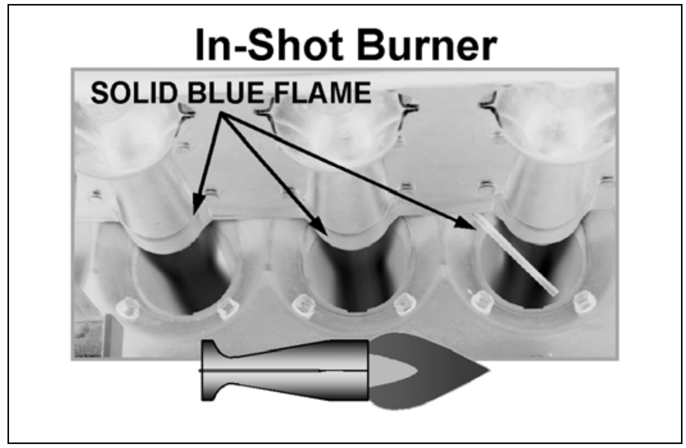
37. Direct main burner ignition systems do not involve a pilot flame. There are two types being used: the **hot surface ignition system (HSI)** and the **direct spark ignition system**. The basic principles of operation for each type are similar to the re-ignition systems applied to pilots.



38. The **hot surface igniter** is an electric resistance-heating element made of silicon carbide. This material is electrically conductive and extremely stable at high temperatures. When energized, the heating element glows white hot, with a surface temperature above the ignition temperature of the gas.

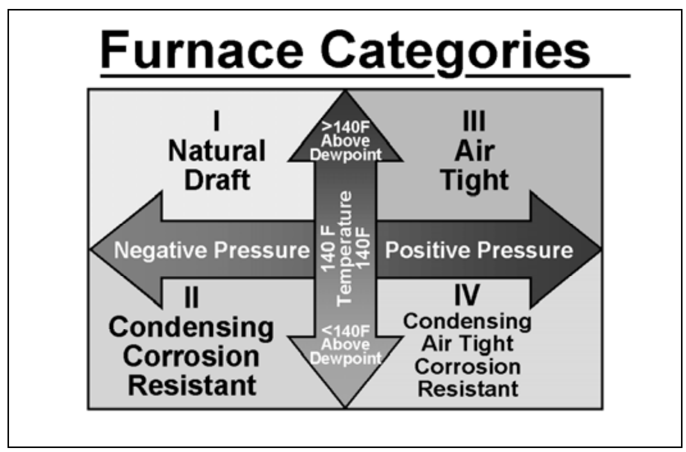
Residential systems usually use 120-volt igniters, which assure more accurate surface temperature control than 24-volt igniters. Always check the installation instructions to verify voltage before working with the system.

The igniter is mounted adjacent to an end burner and positioned so that the heater element is in the gas flow path of the carry-over port. A flame sensor is located at the opposite end burner to detect that a safe burner flame has been established all the way across the burners. It senses the flame through the same flame rectification principle discussed under spark re-ignition systems.



39. Gas flow velocity and burning speed are the primary characteristics that determine flame stability in gas burners. The design of the in-shot (or mono-port) burner allows it to burn efficiently, characterized by a **solid blue flame**.

VENTING

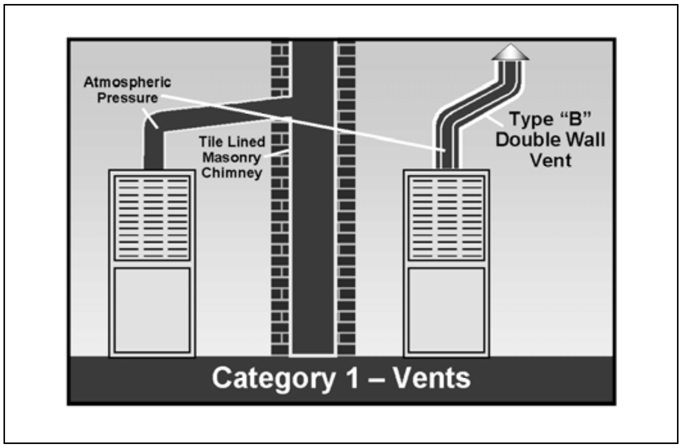


40. Vents are classified in four categories. Category I and IV vents are most common.

Category I and II vents operate at a negative pressure and depend on natural draft to remove flue gases and must have flue gas temperatures at least 140°F above the dew point to avoid condensation.

Category III and IV vents are allowed to be cooler and operate at positive pressure, requiring a fan-powered, airtight vent to remove flue gases. Condensation may occur in them.

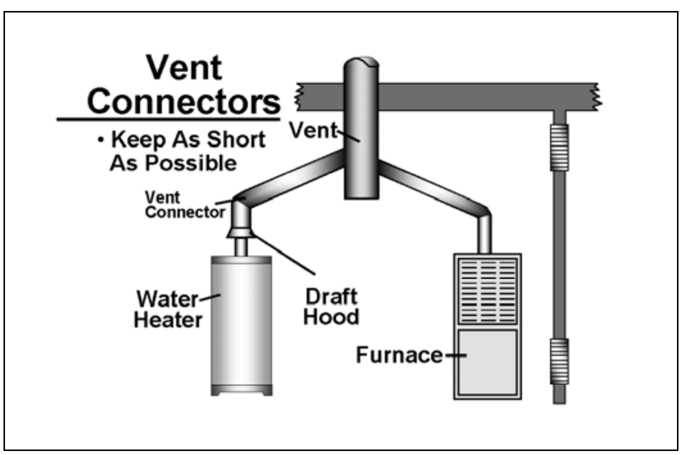
Recognition that properly designed venting systems for gas-fired appliances are vital for safety and reliability led to the adoption of venting and combustion requirements by the **National Fuel Gas Code** and by local code authorities.



41. The vent system is an integral part of a furnace application and must be carefully matched to the furnace. Induced-draft furnaces use either Category I natural-draft vents or Category III powered vents.

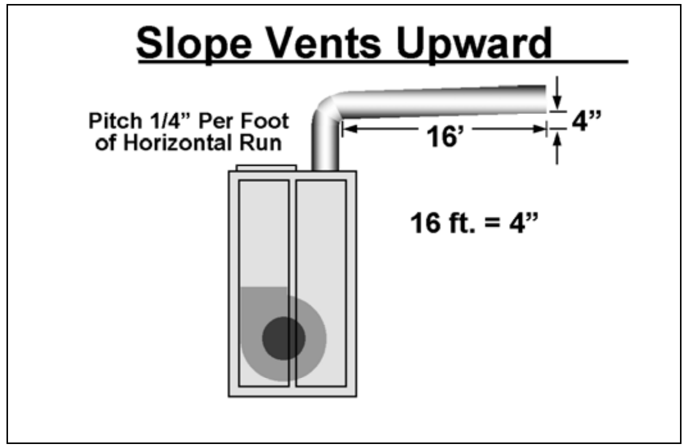
When using Category I vents, care must be taken to avoid condensation. Type "B" double-wall metal pipe or lined masonry chimney construction should be used. Vents for induced-draft furnaces must be exactly sized for furnace heating capacity.

Care must be taken when using existing chimneys, vents and vent connectors to be sure they meet size requirements and are in good condition.

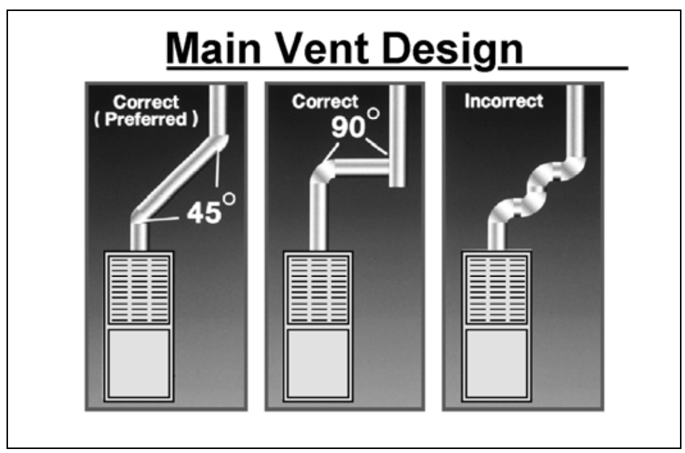


42. The **vent connector** is that portion of the venting system that links the appliance to the main vent. In all cases, vent connectors should be kept as short as possible.

Because of its increased installation versatility, Type "B" double wall vent pipe is recommended for connectors to minimize heat loss and avoid condensation, especially when the connector is located in or passes through an unheated space, such as an attic.

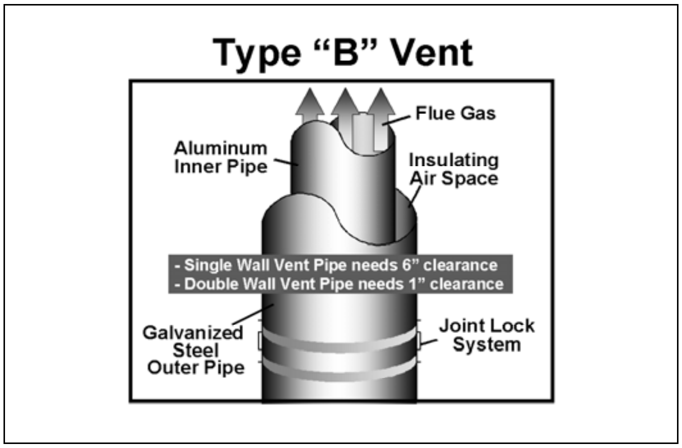


43. Since hot flue gases rise, horizontal runs of vent connectors should always slope upward. They should be pitched upward at least 1/4 inch for each foot of horizontal run. Again, flue pipes should be rigidly supported with hangers and straps to insure against movement after installation.



44. Keep the number of elbows to a minimum. Since it is almost always impossible to complete a vent system without elbows, vent-sizing tables are generally tabulated assuming two 90-degree elbows between the appliance and the main vent.

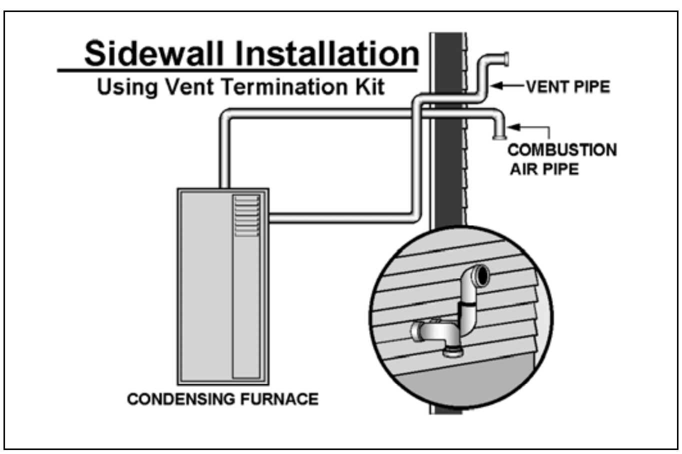
Elbows add resistance within the vent system, with one elbow equivalent to the resistance of a horizontal pipe 20 diameters in length. Since two 45-degree elbows are equivalent to one 90-degree elbow, use 45-degree elbows whenever possible to reduce restriction.



45. Both single wall and double wall metal vent piping materials can be used for venting gas appliances. The most common and effective gas vent material, however, is **Type "B" double wall pipe**, which was specifically developed for gas furnaces.

The inner wall is aluminum to resist corrosion and the outer wall is galvanized steel for strength, with an air space between the walls to prevent condensation inside the pipe.

Single wall vent pipe requires a 6-inch clearance while double wall vent pipe requires 1-inch.



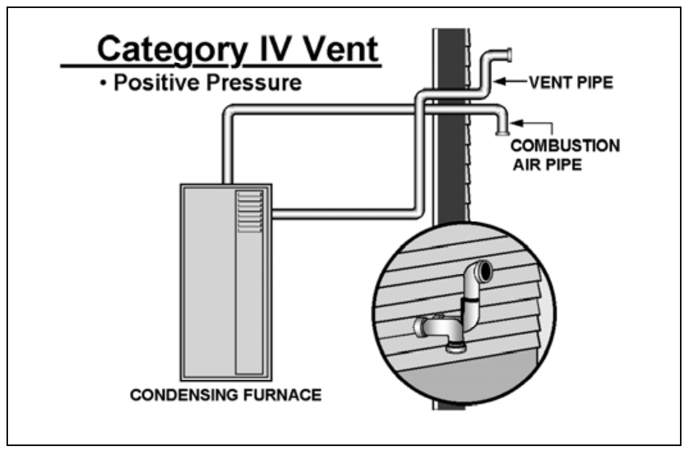
46. In 2-pipe condensing furnace systems, the vent and combustion air pipes must terminate in the same general outdoor area so that they are in the same pressure zone to avoid problems like flame rollout or furnace cycling.

Vent and combustion air pipes can terminate on a sidewall or a rooftop as specified by the manufacturer and following specified clearances.

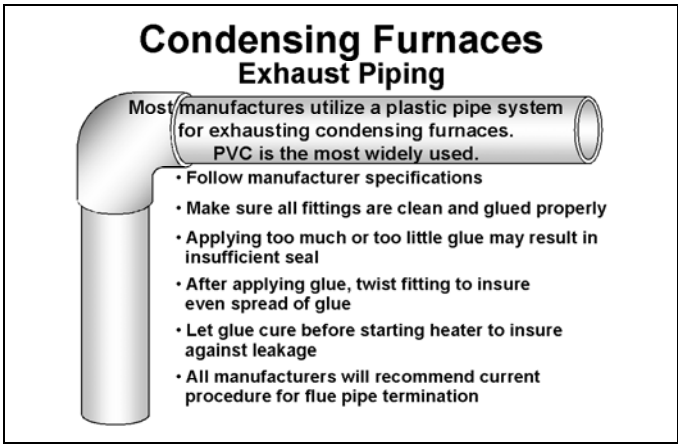
If piping terminates on a sidewall, locate it to avoid damage to shrubs or siding materials and to avoid drawing contaminated air into the furnace. Be careful around swimming pools, to avoid drawing chlorine-contaminated air and provide plenty of clearance around clothes dryer vents to avoid moisture and freeze-ups.

If piping on a rooftop, avoid the possibility of vent gases entering the building by allowing plenty of clearance of building ventilation air inlets.

Finally, the condensing furnace vent pipe cannot be common vented or run into the chimney with other vented appliances.



47. Most condensing furnaces use a direct vent system. A Category IV direct vent system operates under positive pressure with respect to the atmosphere. This type of furnace cannot be connected to an existing natural-draft vent or chimney. This is a sealed system powered by an inducer fan.

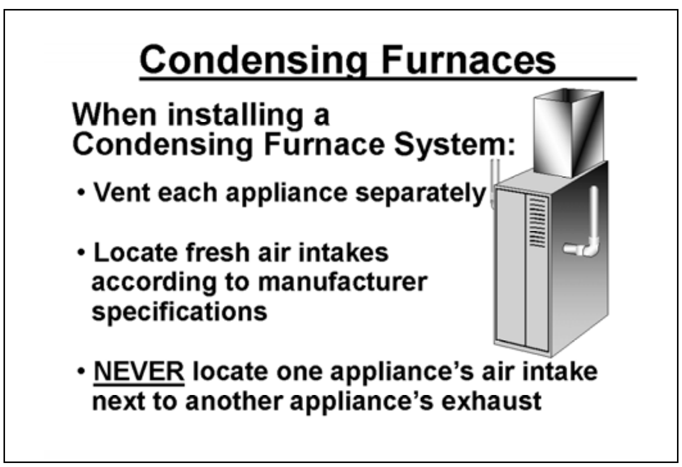


48. For condensing furnaces, most manufacturers utilize a plastic pipe system. PVC is the most widely used. It is necessary to follow the manufacturers' specifications when exhausting with PVC pipe.

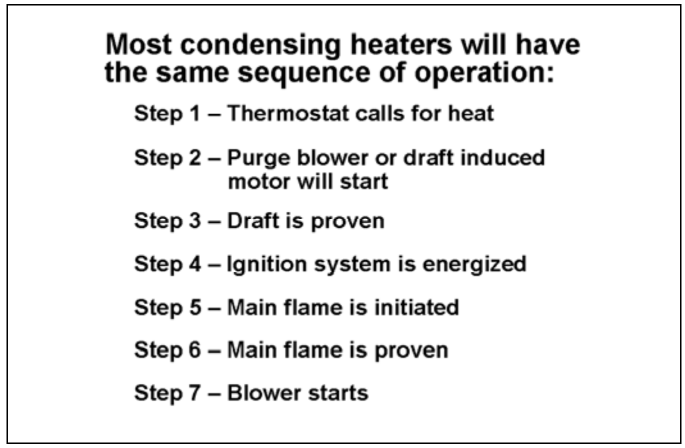
Make sure that all fittings are cleaned and glued properly. Applying too much or too little glue may result in having an insufficient seal.

Once the glue has been applied, twist the fitting to insure that the glue has been spread evenly. Let the glue cure before starting the heater to insure against leakage.

All manufacturers will recommend the correct procedure on how the flue pipe should be terminated outside of the structure.

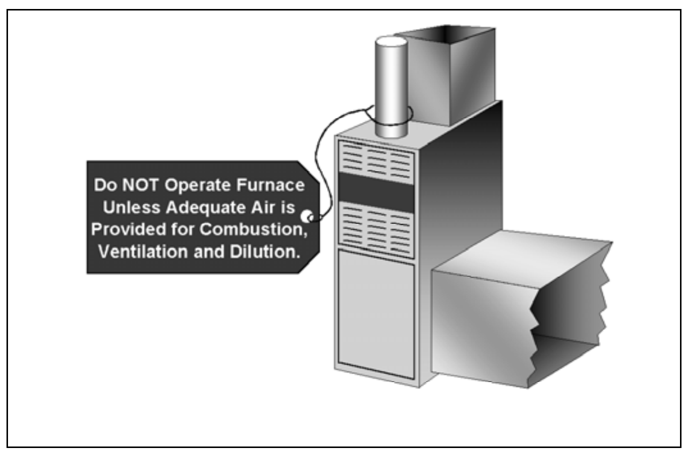


49. When installing a condensing furnace system, each appliance should be vented separately, making sure that fresh air intakes are located according to manufacturer's specifications. NEVER locate one appliance's fresh air intake next to another appliance's exhaust.



50. Most condensing heaters will have the same sequence of operation:

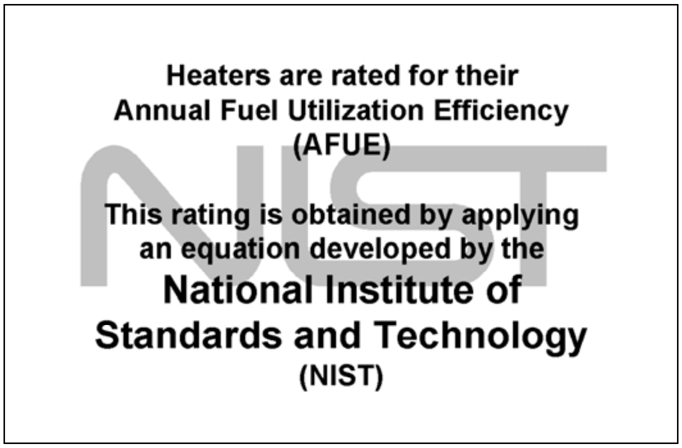
- Thermostat calls for heat
- Purge blower or draft induced motor will start
- Draft is proven
- Ignition system is energized
- Main flame is initiated
- Main flame is proven
- Blower starts



51. Venting and combustion air are a vital part of total heating system design and require the same early-stage planning as furnace selection and duct sizing.

The furnace and vent should be considered a package and installed accordingly, making sure to follow the changing requirements for venting and combustion air systems and following local and national codes.

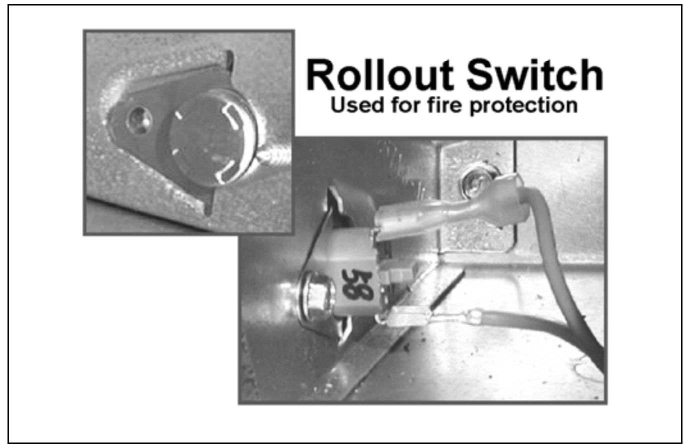
RATING



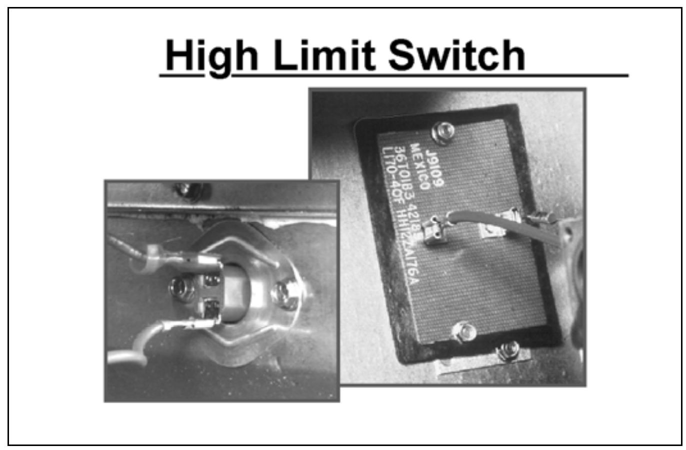
52. Heaters are rated for their **Annual Fuel Utilization Efficiency** or **AFUE**. This rating is obtained by applying an equation developed by the **National Institute of Standards and Technology** (NIST).

53. The **American Gas Association** (AGA) establishes the minimum construction safety and performance standards.

SAFETY SWITCHES



54. The **rollout switch** is designed to protect against fire caused by flames flowing backward out of the heat exchanger. The switch senses the flame and shuts down the flow of gas.



55. The **high temperature limit control** or limit switch is a thermally actuated switch that senses when the furnace heat exchanger exceeds a safe operating temperature due to malfunctions. Simply put, the **limit switch** shuts off the burners if discharge air temperatures become excessive. High temperature limit controls are required on all gas-fired furnaces.

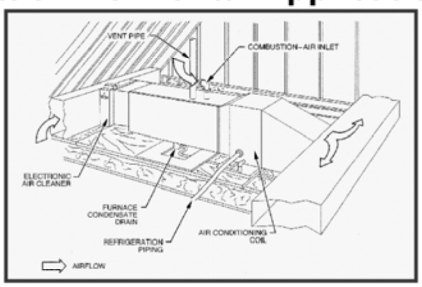
Most limit switches are *automatic reset*, meaning that the contacts will automatically close when the furnace drops below the reset point. The gas valve will re-open and the burners will re-ignite. Auxiliary high temperature limit switches are sometimes added on downflow or horizontal furnaces where reverse airflow will change the position where the limit switch is needed.

In the case of the automatic reset switches, continuous re-tripping of the switch indicates a continuing malfunction and, therefore, a need for service. After resetting a manual reset limit switch, find out what caused it to open and correct the problem before considering the service call complete.

NEVER try to alter these switches in any way or change their settings. **NEVER** replace them with a switch that has not been approved by the manufacturer.

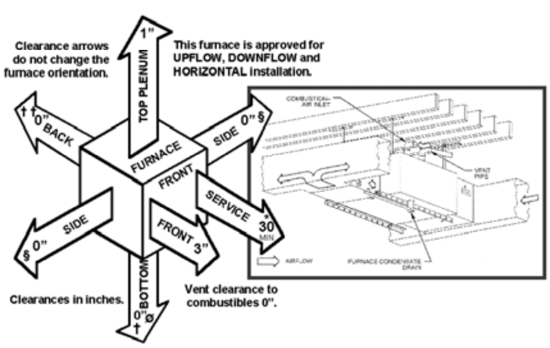
INSTALLATION TIPS

Attic - Horizontal Application



When installing a furnace on wood rafters, a zero clearance furnace or an add on non-combustible base must be used.

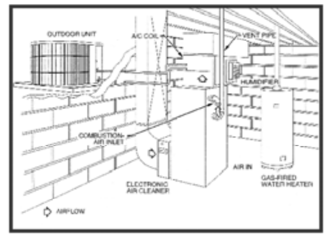
56. When installing a furnace on wood rafters, a zero clearance furnace or an add-on non-combustible base must be used.



All correct service clearances must be observed. These clearances are set by the manufacturer of the equipment.

57. All correct service clearances must be observed. The manufacturer of the equipment sets these clearances.

HEAT PUMP CONNECTED TO A GAS FURNACE



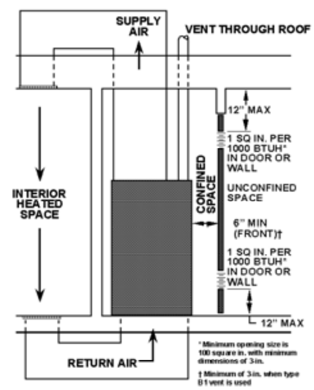
- **NEVER run units at the same time.**
- **Connect the <u>first stage</u> of the thermostat to the heat pump.**
- **DO NOT USE temperature rise method of calculating CFM, since the compressor's capacity varies with the outdoor temperature.**

58. If a heat pump is being connected to a gas furnace, the installer must insure that both units never run at the same time. The first stage of the thermostat should be connected to the heat pump. Since the compressor's capacity varies with the outdoor temperature, the temperature rise method of calculating CFM should not be used with this type of system.

Supplying Inside Air to a Confined Space

Sizing Air Openings

Furnace Input (Btuh)	Free Area per Opening (Square Inches)
44,000	100
66,000	100
88,000	100
110,000	110
132,000	132
154,000	154



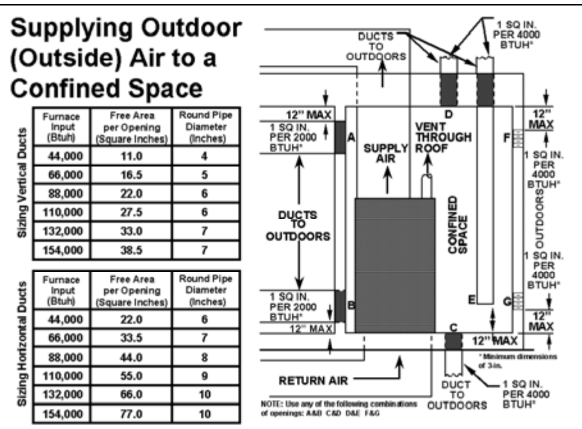
59. Whether the furnace is installed in a confined or unconfined space, adequate air must be made available for combustion. In older, loosely constructed homes, adequate air can be supplied by infiltration. If the home is newer and of tighter construction and/or infiltration cannot supply adequate air, the air must be brought in from the outdoors.

By code, the combustion air requirements for all gas furnaces are the same. Only the sizes of the ducts, grille openings, etc. differ based on the specific model of furnace and its input Btuh.

Confined spaces are defined as those having less than 50 cubic feet per 1,000 Btuh of input. A confined space must have two permanent openings, one within 12 inches of the ceiling and the other within 12 inches of the floor. Grilles or louvers installed over openings must be permanently open.

When supplying inside air for combustion and ventilation from an adjacent unconfined space to a confined space, we must follow specific requirements. Each opening must have at least one square inch of free area per 1,000 Btuh of the total input for all equipment in the confined space, but not less than 100 square inches per opening (see table above). When used, screens must not be smaller than 1/4-inch mesh.

If a furnace is installed on a raised platform to provide a return air plenum, and return air is taken directly from the hallway or space adjacent to the furnace, then all air for combustion must come from the outdoors.



Sizing Vertical Ducts

Furnace Input (Btuh)	Free Area per Opening (Square Inches)	Round Pipe Diameter (Inches)
44,000	11.0	4
66,000	16.5	5
88,000	22.0	6
110,000	27.5	6
132,000	33.0	7
154,000	38.5	7

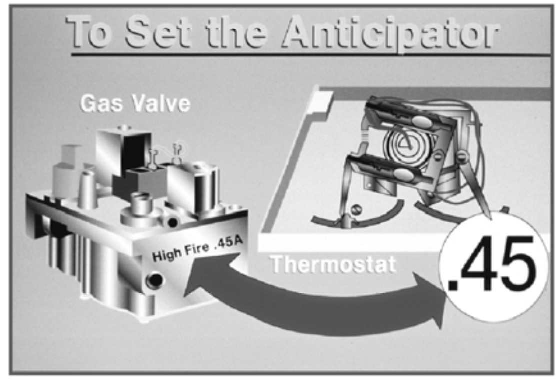
Sizing Horizontal Ducts

Furnace Input (Btuh)	Free Area per Opening (Square Inches)	Round Pipe Diameter (Inches)
44,000	22.0	6
66,000	33.5	7
88,000	44.0	8
110,000	55.0	9
132,000	66.0	10
154,000	77.0	10

60. Supplying outdoor or outside air to a confined space also has specific requirements. If combustion air is brought in through vertical ducts, the openings and ducts must have at least one square inch of free area per 4,000 Btuh of the total input for all equipment within the confined space (as shown in the above table labeled "Sizing Vertical Ducts").

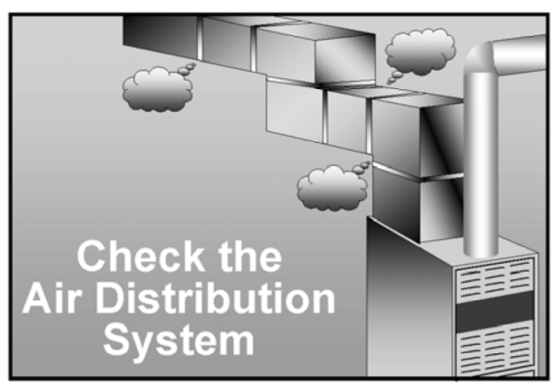
If combustion air is brought in through horizontal ducts, the openings must have at least one square inch of free area per 2,000 Btuh of the total input for all equipment within the confined space (see table labeled "Sizing Horizontal Ducts").

The cross sectional area of any vertical or horizontal duct must be equal to or larger than the free area of the opening to which it connects. Rectangular duct must not be less than three inches high.



61. Proper adjustment of the **heat anticipator** is important. To set the anticipator, you must determine the current or amp draw of the furnace control circuit. On models that only have a gas valve in this circuit, the amp draw rating may be found printed on the gas valve or in the installation instructions. **The anticipator adjustment pointer should be set to the corresponding number of amps on the anticipator scale**.

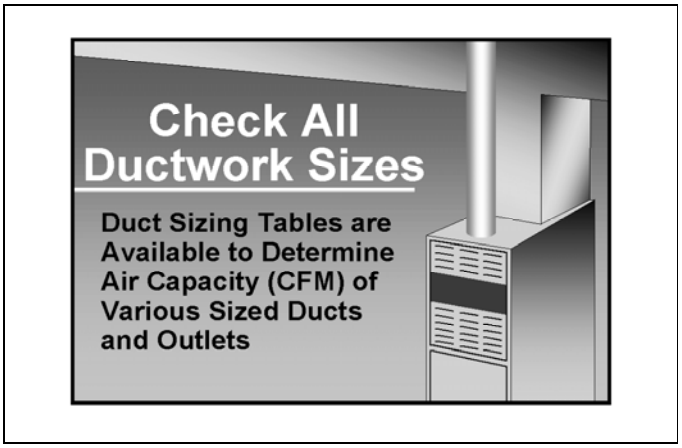
Use an ammeter to measure the current draw, using the multiple pass method to generate enough current strength to get an accurate reading.



62. A well-designed and properly installed **air distribution system** is the key to a successful furnace installation. Check the system, including the supply air plenum and ducts, the room air outlets, the return air ducts, and the return air grilles.

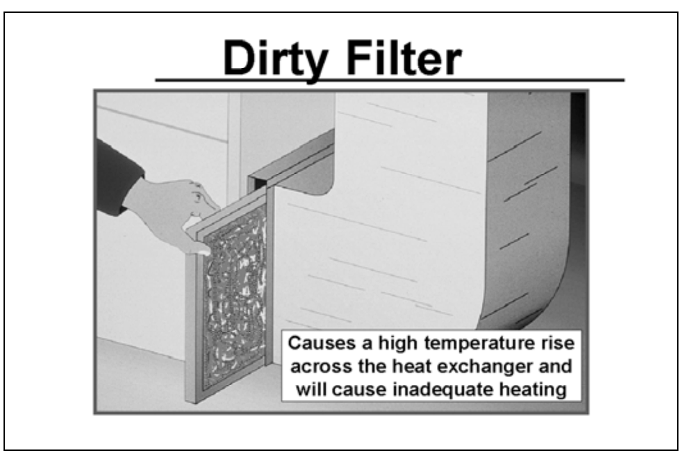
If the air distribution system is undersized, it will require more fan horsepower to move the air, leading to poor air distribution and more noise. This is particularly a problem when replacing a system designed to handle the heating CFM with a heating and cooling system that must deliver more CFM for cooling.

Existing duct systems may contain restricted runs and leaking joints, resulting in poor air distribution and hard-to-heat rooms. These duct systems must be corrected to insure customer satisfaction. A good duct system will have dampers in each run for fine-tuning the airflow.



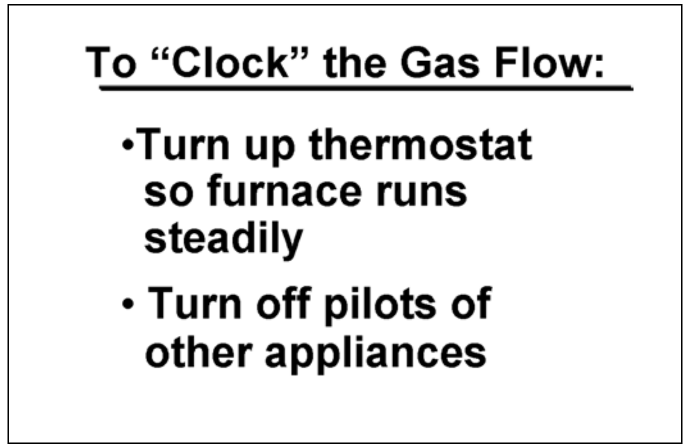
63. Duct sizing tables are available to determine air capacity (CFM) of various standard-sized ducts and outlets. For replacement jobs, the width and depth of the main supply and return header ducts should be measured and checked against sizing tables for the proper air quantity. If the main ducts extend in more than one direction, check each one individually. Inadequately sized headers must be replaced or supplemented.

Sizes of all runout ducts to individual rooms should be checked to see if they meet their room air quantity requirements. If they are inadequate, they must be changed or additional runouts added.



64. When the limit switch senses excessive discharge air temperatures, it trips, shutting off the burners. Excessive temperatures can be caused by a number of things. The most common cause, and the simplest to correct, is dirty air filters.

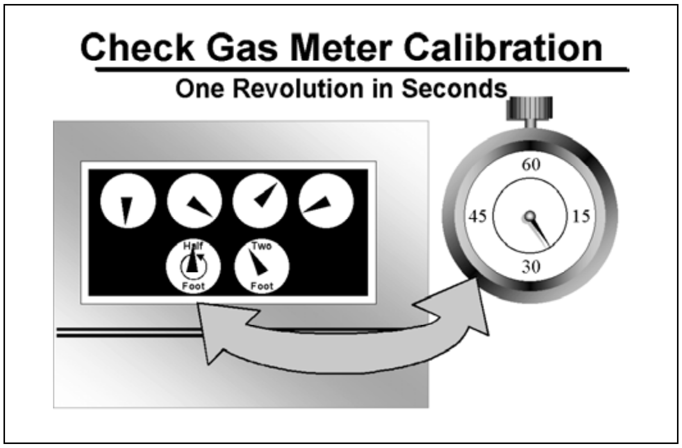
If the filter is dirty, replace it or clean it if it is washable. Filter maintenance is a simple task that homeowners can do themselves.



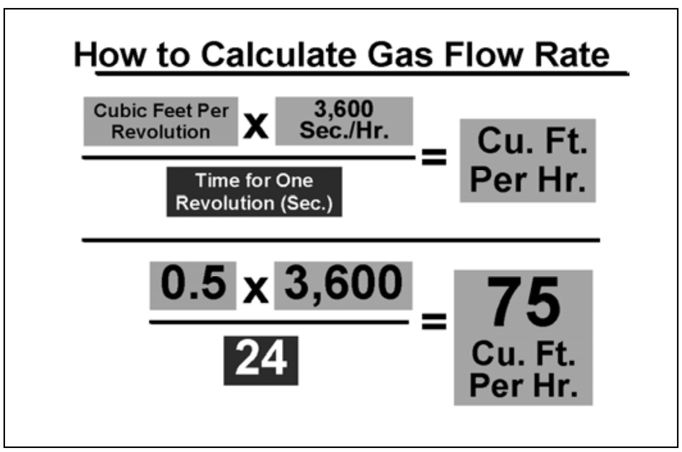
65. In troubleshooting gas furnace problems it is necessary to check the gas input. Check the size of the orifices and the manifold pressure, adjusting the latter, if necessary.

When it has been determined that the orifice sizes and manifold pressure are correct, the furnace input should be checked by measuring the gas flow to the furnace. This is done by "clocking" the gas flow through the meter. To assure an accurate gas flow rate measurement, be sure that the gas supply to all other gas appliances is turned off when the measurement is taken.

Note: Remember to turn other gas appliances back on after all measurements and adjustments have been made.



66. To determine gas flow, the furnace must be on and operating steadily. Clock the gas meter to determine the number of seconds required to burn a given quantity of gas. Check the gas meter calibration to see how many cubic feet are consumed in each revolution of the dial.



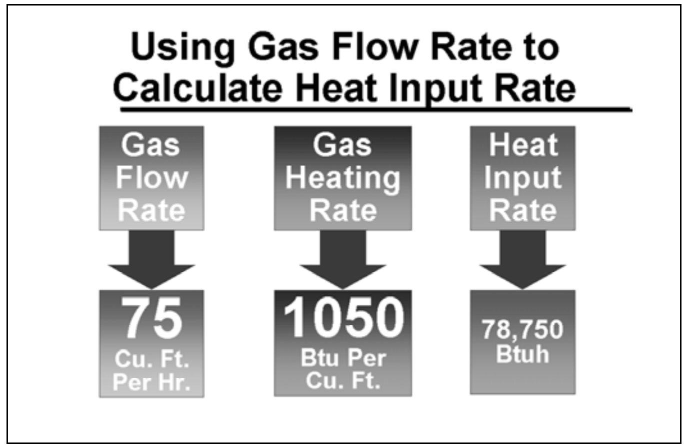
67. The equation for gas flow in cubic feet per hour (CFH) is:

$$\frac{\text{Cubic Feet/Revolution} \times 3{,}600 \text{ Seconds/Hour}}{\text{Time for One Revolution in Seconds}}$$

For example, a gas meter is calibrated for 0.5 cubic foot per one revolution of the dial. Using a stopwatch, we determine that it took 24 seconds for the 0.5-cubic-foot dial to make one revolution. What is the gas flow to the furnace in cubic feet?

Substituting the values of the example into the equation given previously, the gas flow is:

$$\text{CFH} = \frac{0.5 \text{ cu. ft.} \times 3{,}600 \text{ sec./hr.}}{24 \text{ seconds}} = 75 \text{ cu. ft.}$$

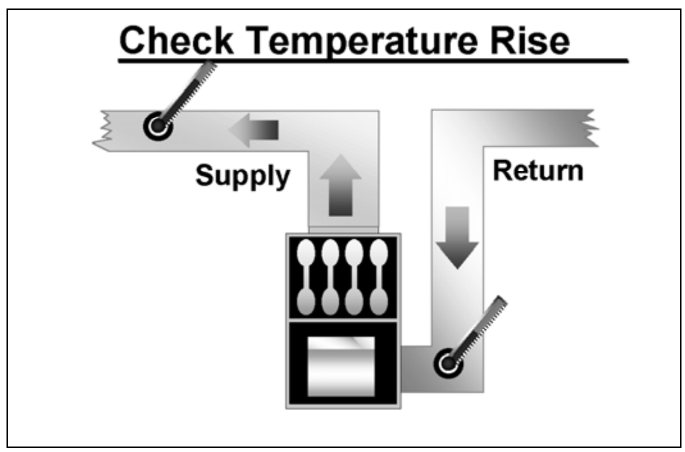


68. Once the flow rate has been determined, it is simply a matter of multiplying the flow rate by the heating value of the gas to obtain the heat input to the furnace. The heating value of the gas must be obtained from your local supplier.

Example:

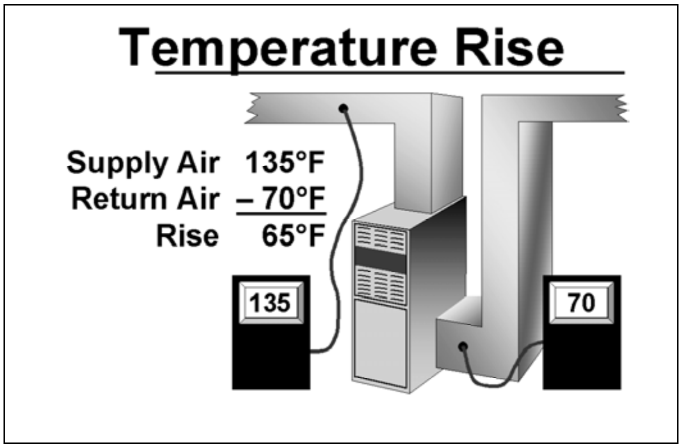
Flow Rate × Heating Value = Heat Input

75 cu. ft. × 1,050 Btu's = 78,750 Btuh



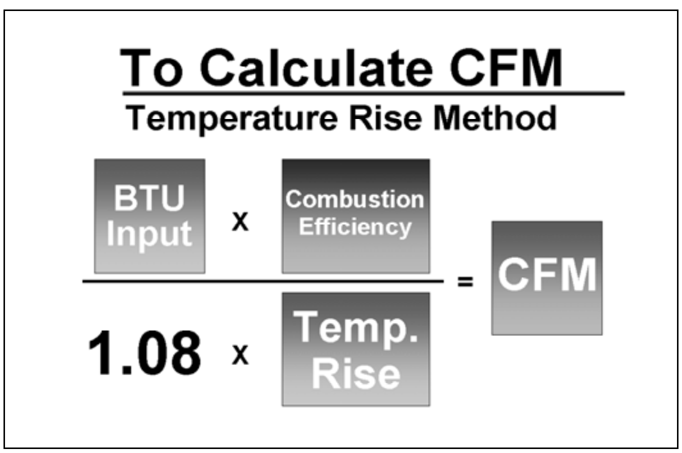
69. During start-up procedures, the temperature rise through the furnace should be checked. The range of the temperature rise for the furnace is listed on the rating plate. **Do not operate the furnace outside this range**.

The temperature rise can be measured by thermometers in the return and supply air streams. Drill a hole in the return duct near the furnace and another in the supply duct out of the line-of-sight to the heat exchanger to prevent radiant heat from affecting the reading. Make sure the furnace is fired at 100% of the rated input and that the filter is clean. All supply and return registers should be open and unrestricted.



70. Let the furnace run for at least 5 minutes until the readings stabilize. The temperature can be determined by subtracting the return air temperature from the supply air temperature. The temperature rise can be adjusted by adjusting the blower speed. Increase the blower speed to reduce the rise. Decrease the blower speed to increase the rise.

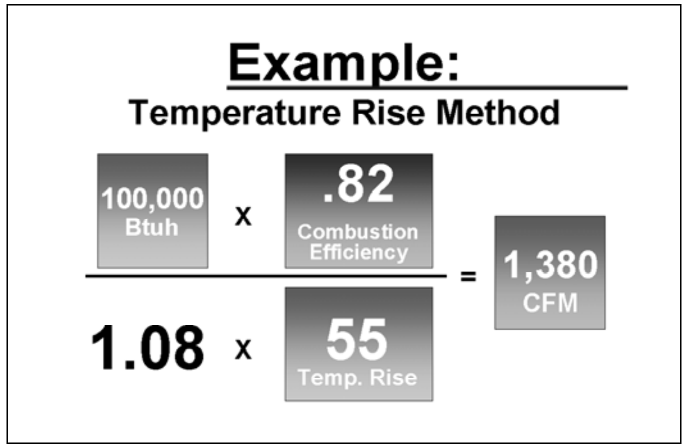
For example, the rating plate temperature rise of a furnace is listed at 45° to 75°F. You measure a 135°F supply air temperature and a 70°F return air temperature. The difference is a 65°F rise. This is slightly above the 60°F midpoint, but is well within the listed range. No adjustments to the blower speed are necessary.



71. When the temperature rise has been determined, it can be used to calculate the actual airflow rate in cubic feet per minute (CFM). The airflow rate can be useful in determining the adequacy of the ductwork or whether to change the fan speed. The formula for CFM is:

$$\text{CFM} = \frac{\text{Input (Btuh)} \times \text{Efficiency (\%)}}{1.08 \times \text{Temperature Rise (°F)}}$$

For efficiency, use the listed AFUE of the furnace. For furnaces prior to AFUE, use 75% steady-state efficiency. AFUE is the seasonal efficiency and is somewhat lower than the steady-state efficiency. When used in this formula, it will result in a slightly lower CFM, but will be satisfactory for our purposes



72. For example, the furnace in the previous example was operating at an input of 100,000 Btuh when we measured its temperature rise of 55°F. It is listed with an AFUE of 82%. How much air is being supplied to the home? First, convert the AFUE to 0.82 efficiency.

$$\text{CFM} = \frac{100{,}000 \text{ Btuh} \times 0.82}{1.08 \times 55°\text{F}} = 1{,}380 \text{ CFM}$$

Checking the 1,380 CFM against the fan performance data in the product literature indicates whether there is a duct pressure drop problem or whether the fan speed needs to be changed. It also helps to determine whether there is a potential problem with overheating due to insufficient air. If there is a duct pressure drop problem, more air may be obtained by increasing the fan speed. However, higher fan speed may result in unacceptable noise levels.

Unfortunately, the only real solution to undersized ducts, grilles, and returns is replacement. It is important that this type of problem be recognized and faced early on. Attempting to push more air through undersized ductwork is rarely a satisfactory solution. If the ductwork is too small, it should be replaced.

Carrier Corporation
Syracuse, New York
800-644-5544
www.training.carrier.com

GT71-01

Cat. No. 020-017