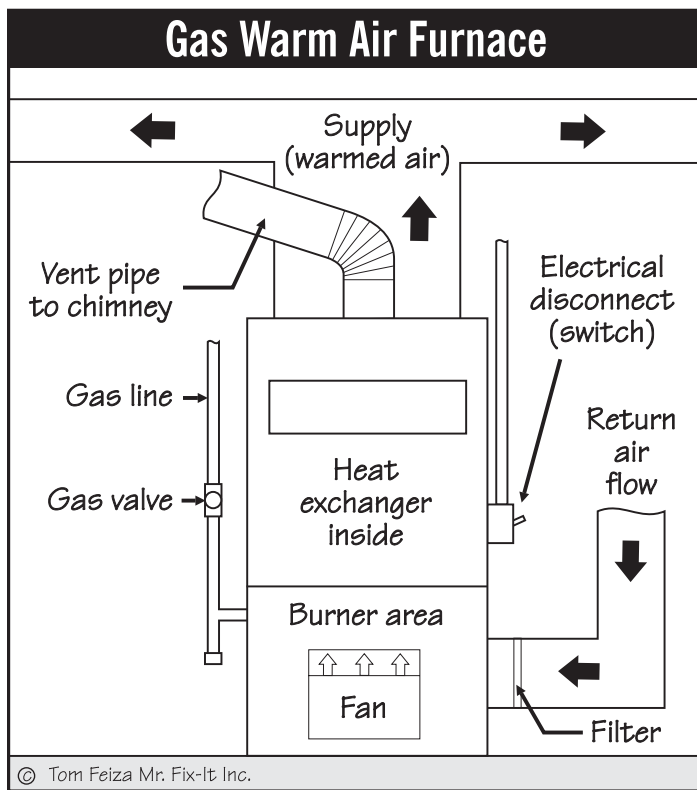


# REPLACE YOUR FURNACE

When it's time to replace your furnace, you will be faced with many confusing questions and no clear answers. Contractors will be happy to give you options and recommendations, but you will be left to make the decisions. Do you know that you must consider the chimney? What about efficiency, Btu rating, condensation and ease of maintenance? What is a Btu?

This article will provide the basic information you need to evaluate furnace replacement options and make smart decisions for your home. The information is based on a forced air (warm air) furnace replacement in a northern region of the U.S.



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H001

## UNDERSTANDING THE BASICS

Here are some basic terms used in the heating business:

**Btu – British thermal unit** – A unit of measurement for heat. A Btu is the amount of energy required to raise the temperature of one pound of water by one degree Fahrenheit. A Btu is approximately equal to the energy in one paper match burned end to end. A furnace rated 100,000 Btu input consumes 100,000 Btu per hour.

**AFUE – Annual Fuel Utilization Efficiency** – This percentage represents the average annual seasonal efficiency of a furnace or boiler. It shows how effectively the furnace converts gas into heating energy. An 80 percent efficient 100,000 Btu furnace provides approximately 80,000 Btu to your home.

**Ductwork or ducts** – This is a system of rectangular and circular metal tubes that carry heated or cooled air to the rooms of your home. Supply ducts move heated or cooled air into the rooms, and return ducts return air to the furnace. (Drawings H001, H004)

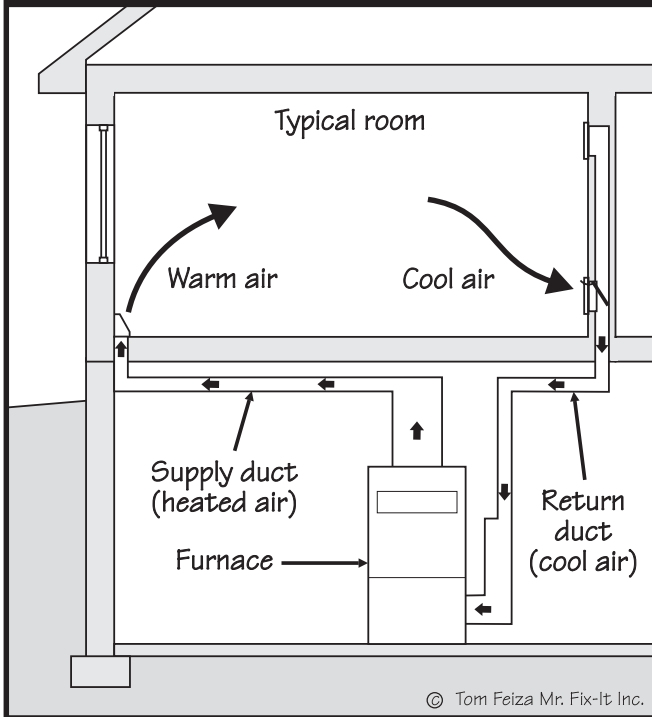
**Heat exchanger** – A heat exchanger transfers heat from the furnace flame into a metal container and then into the air moving outside the metal container through the ductwork in your home. Products of combustion from the flame are never mixed with the air heating your home.

**Blower / Fan** – Both terms are used for the fan that moves air through the furnace and through your home. The blower re-circulates air in your home.

**Inducer – Inducer fan – Draft fan** – These terms are used interchangeably for the motor and fan that move combustion products through a higher efficiency furnace and out a vent or chimney.

**High and low returns** – Many modern duct systems have a "high" and a "low" return. The high duct return is open when central air conditioning is in use, allowing the system to capture hot air near the ceiling. The low return grill is open during the heating season, returning cold air from the floor to the furnace. (Drawings H004, H019)

## Warm Air Furnace and Distribution Ducts



H004

**Thermostat** – A thermostat senses the room’s temperature and turns the furnace on and off as needed to maintain the desired temperature.

## HOW A FURNACE WORKS

A typical forced air or warm air furnace burns a fossil fuel and distributes the warm air inside your home. The heat source is confined within a heat exchanger inside the furnace housing. Gas is burned below the heat exchanger. The hot products of combustion flow through the heat exchanger and up a chimney. Higher efficiency furnaces may use a draft fan to move the products of combustion, and the flame may be above or below the heat exchanger. (Drawings H001, H004)

When a thermostat senses that heat is needed in the home, it signals the furnace to turn on. The hot products of combustion warm the metal of the heat exchanger. After a minute or so, when the heat exchanger’s metal has warmed up, a limit switch or timer turns on the blower or circulating fan. The fan circulates air across the hot metal exterior of the heat exchanger.

The furnace re-circulates air in your home. It does not draw in outside air unless special provisions have been made for an outside air supply. The warm air flows through the supply ductwork to heat your home; cooler air returns to the furnace through return ductwork. Return air also passes through a filter in the ductwork before it reaches the furnace.

Duct systems for heated air circulation and ducting have changed through the years. An early “gravity” warm air furnace system (commonly called a octopus) did not use a blower fan. Warm air rose into the rooms.

In the 1950s, ductwork supplied air high on the inside walls using a blower. In the 1960s, ducts were moved low on the floor, below exterior windows.

Many forced air furnaces use natural gas. Other heat sources include oil, propane or even electrical resistance. This article will focus on natural gas furnaces because they are most common. Similar details pertain to propane and oil furnaces.

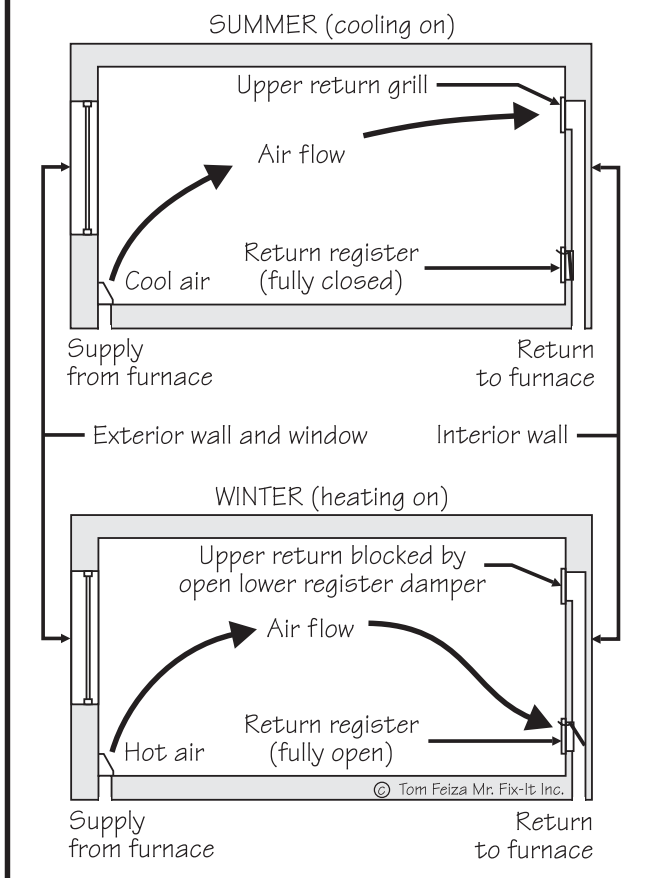
## TYPES OF FORCED AIR FURNACES

### Standard Efficiency Furnace

Houses built around 1970 or earlier typically use standard efficiency furnaces. These furnaces vent combustion gas up a chimney and provide an efficiency ratio of about 60 percent. This means that about 40 percent of energy

## High and Low Returns

### FORCED AIR FURNACE IN BASEMENT



H019

from the heat source is lost up the chimney. Since 1993, federal energy standards for new installations have required a minimum of 78 percent efficiency (AFUE).

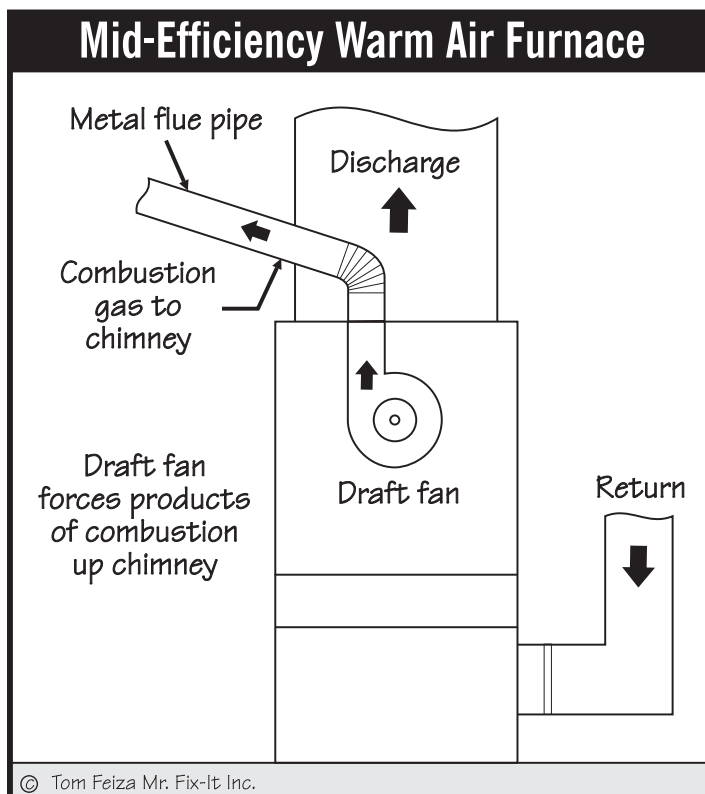
These furnaces have a standing pilot light and must be vented up a masonry or metal chimney. Some of these furnaces were improved with spark ignition systems and combustion vent dampers for energy efficiency. They must keep the products of combustion warm enough to rise naturally up the chimney.

These furnaces use simple systems, but they waste a lot of heat up the chimney. Some of the older systems have very sturdy burners and heat exchangers and will operate for many years. However, many of these furnaces installed after 1970 have very thin metal heat exchangers that are subject to failure through cracks and corrosion.

### Mid-Efficiency Furnace (80 Percent Furnace)

A mid-efficiency furnace utilizes about 80 percent of the energy from the fuel source. Actual efficiency may vary slightly but will usually average 80 percent. (Drawing H002)

This type of furnace requires a draft or inducer fan to move products of combustion through the heat exchanger and up the chimney. The heat exchanger is



H002

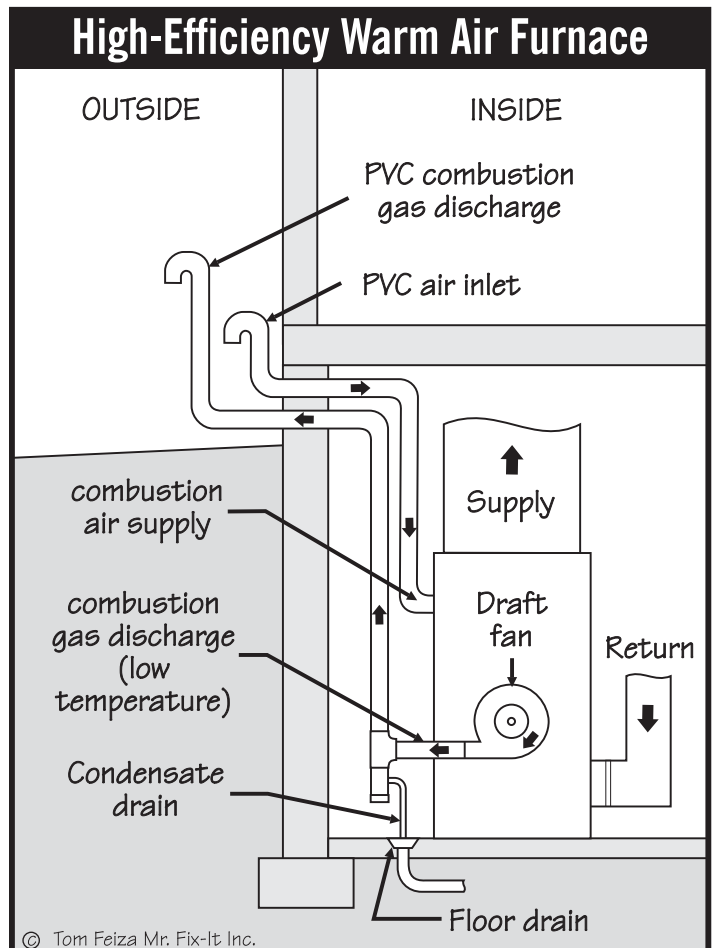
improved to utilize more heat from the products of combustion for heating your home. Typically, it has a hot surface or spark ignition device and does not have a standing pilot light.

This type of furnace keeps the products of combustion warm enough to prevent condensation inside the furnace, but condensation can occur in the chimney if the chimney is not matched to the furnace.

### High-Efficiency Furnace (90 Percent Furnace, Condensing Furnace, Sealed Combustion Furnace)

A high-efficiency furnace, also called a 90 percent, sealed combustion or condensing furnace, provides about 90 percent efficiency in converting fuel to heat. It condenses the steam from combustion into water. (Drawing H003)

Steam? That's right. Water in the form of steam is a product of combustion. The "smoke" you see going up a chimney from a standard furnace actually is steam. The secondary heat exchanger allows this type of furnace to reduce the temperature of the products of



H003

combustion below the point of condensation. The steam that would otherwise go up the chimney is converted into water. The products of combustion leave the furnace at about 120 degrees, and most (90 percent) of the fuel's heat energy goes into your home.

In the secondary heat exchanger, steam is condensed back into water and releases about 940 Btu per pound of water. That can amount to several gallons on a cold day. The secondary heat exchanger must be protected from this water with a special coating or with stainless steel.

Because the products of combustion are at such a low temperature when leaving the furnace, they can be vented with a plastic pipe; no chimney is required. The vent pipe may be routed through the side of the home.

Many high-efficiency furnaces also utilize outside air for combustion. This lets the furnace use clean outside air and avoids drawing combustion air from inside your home, providing additional energy savings. Drawing outside air eliminates the possibility of contaminating the combustion process with chemicals from the basement.

Because this is a "condensing" furnace, water must be drained from it. The water or condensate is corrosive, and heat exchangers made of stainless steel or with special coatings must be protected from it. Condensate is often collected at several points in the system.

This furnace also uses an inducer or draft fan that must be designed for a damp, corrosive environment. It utilizes a hot surface or spark ignition device and does not have a pilot light.

### **High-Efficiency Plus Furnace (90 Percent Plus)**

I created the term "high-efficiency plus" because there is no standard, generic term for this type of furnace. It improves on the high-efficiency (90 percent) furnace by adding variable-speed fans and variable firing rates.

Some of these units fire or burn gas at two different rates, matching the performance of the furnace to the home's heating requirements. The lower rate is used most of the year. When it is very cold or when the home needs to be heated quickly, the furnace will fire at the higher rate.

The fan or blower circulates air at a rate matched to the burner. The lower fire and lower fan speed mean the furnace will be matched more closely to the needs of the home. The furnace runs longer, creating greater

comfort, because air is more evenly distributed through the home. This type of fan is also quieter. Variable speed fans consume significantly less energy than single speed fans.

### **FURNACE SIZING**

The "size" of a furnace is rated in input Btu per hour. A typical furnace is rated at 100,000 or 80,000 Btu per hour. A residential furnace can be as small as 40,000 or as high as more than 200,000 Btu per hour.

Be aware that an old 100,000 Btu furnace running at 60 percent efficiency delivers about 60,000 Btu/hour of heat to your home. A new 90 percent high-efficiency furnace rated 60,000 Btu will deliver about 54,000 Btu/hour of heat to your home.

You should understand that most furnaces installed more than 20 years ago are oversized. In many cases, a smaller furnace (with a smaller Btu rating) can be installed, and the smaller, properly sized furnace will provide better comfort. A furnace should be sized so that it runs almost continuously when the weather is very cold and windy.

You can quickly evaluate your furnace by clocking its operation during very cold weather. If the furnace runs 15 minutes on and 15 minutes off during extreme weather, the furnace is about double the size needed. Remember that it is very common to have an oversized furnace if it was installed prior to 1980.

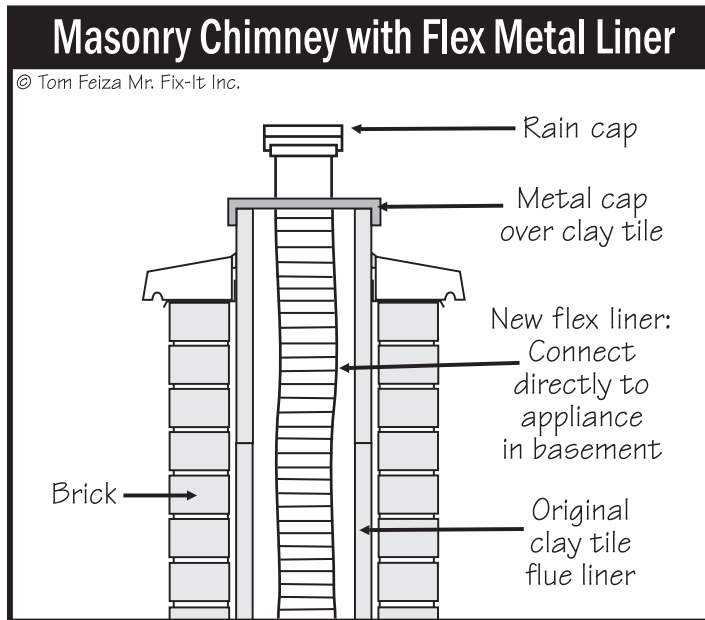
Trust your contractor to size the new furnace correctly. Contractors are responsible for selecting the correct type and size. They can check the existing furnace, and chances are they have already installed a replacement furnace in a home just like yours. They can also perform a heat loss calculation to determine the correct furnace size for a home with complicated heating needs.

The size of the furnace will depend on square footage, type of home, number of stories, windows, insulation, orientation, and exposure to the sun.

### **CHIMNEY ISSUES**

If your furnace vents through a masonry chimney, the chimney must be evaluated. Your contractor should automatically address the chimney; if not, you may face additional costs down the road or when the furnace is installed or damage to the chimney becomes evident.

An 80 percent furnace puts much less heat up the chimney than does an older 60 percent furnace. When there is a lack of heat in a masonry chimney, combustion gas can condense in the chimney flue. This will ruin the liner and eventually ruin the structure of the chimney. In many cases, a thin metal liner must be installed inside a masonry chimney. (Drawing F012)

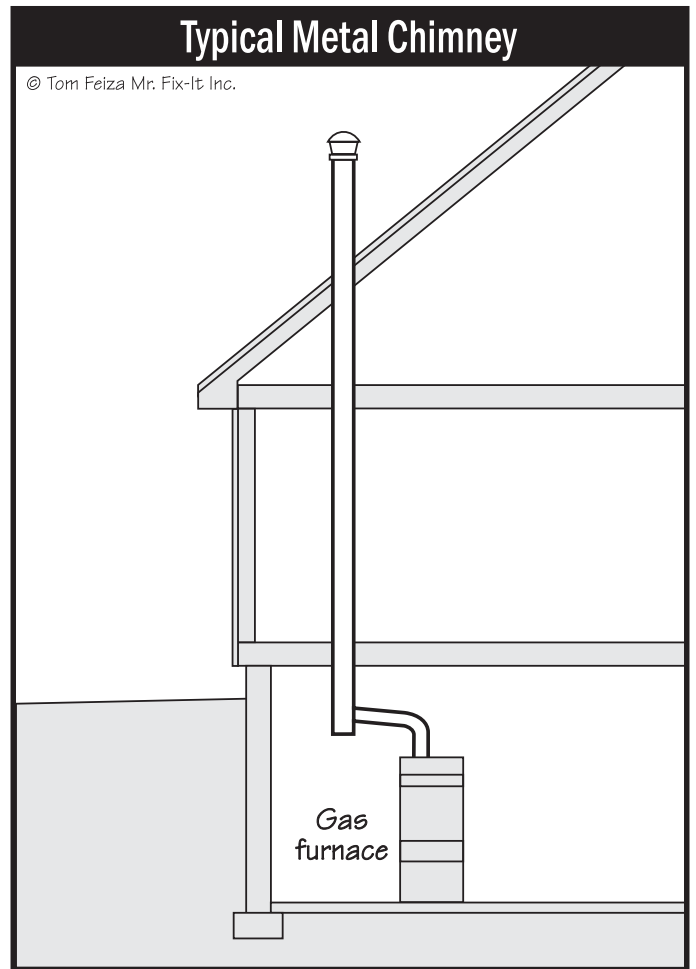


F012

An 80 percent furnace venting up an existing metal chimney usually does not represent a problem, but it still needs to be evaluated. If the original masonry chimney is inside the structure of your home and the clay tile is very small, there is a chance the chimney can be used. In this case, the structure of the home surrounds the chimney and helps keep the chimney warm. (Drawing F003)

For a 90 percent furnace, combustion gases are vented with a plastic pipe and no gases are vented up the chimney. If the chimney is used only by the furnace, no problem—cap the flue tile. If the chimney liner was shared by the original furnace and an existing gas water heater, you have a problem. The water heater will not warm the chimney, so you must have a small flexible liner installed. (Drawing F012)

If there is a significant chimney problem and the chimney needs to be rebuilt, consider installing a high-efficiency furnace and a direct vent water heater that does not need a chimney. That will eliminate the use of the chimney and avoid the possibility of a major rebuild. Simply remove the chimney to the roofline.



F003

## SELECTING A CONTRACTOR

Many good furnace brands exist. The key to a successful furnace replacement is to work with a good contractor. How do you find one? Ask neighbors and friends, and check with the local builders' or remodelers' group. Consider the contractor who services your furnace. Don't depend on those who place big advertisements. Ask for several references and check them out. The contractor should make a visit to evaluate your home and establish the requirement for the new furnace.

Make sure your contractor is covered by workers' compensation and liability insurance. The contractor should automatically offer this information. Find a contractor who has been in the business for several years and who works with a quality furnace brand. Check out the salesperson's approach to the project. Will the salesperson automatically check the chimney, the thermostat, local permits, electrical and ductwork, and listen to your concerns?

Because this is a large and important purchase, you should check out two or three contractors.

## PERMITS

Call your local municipal building inspection department and ask whether you need a permit for furnace replacement and related electrical work. The department may also have requirements for the chimney and furnace venting.

## ELECTRICAL

In most areas, electrical codes will require a separate circuit for the new furnace. This is not required by all municipalities, but it is common. The heating contractor should be able to do a basic evaluation and determine whether providing a separate circuit presents a problem.

## THERMOSTAT

As part of the project, consider a new electronic set-back thermostat. This type of thermostat is more accurate than the older mercury bulb thermostat. It is also easy to program so you can save energy by setting back the temperature at night or when your home is not occupied.

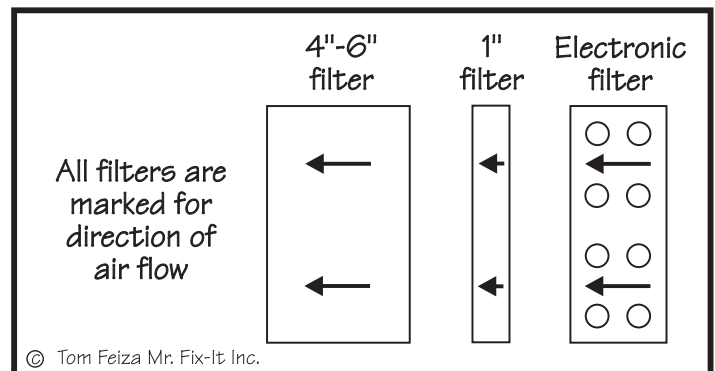
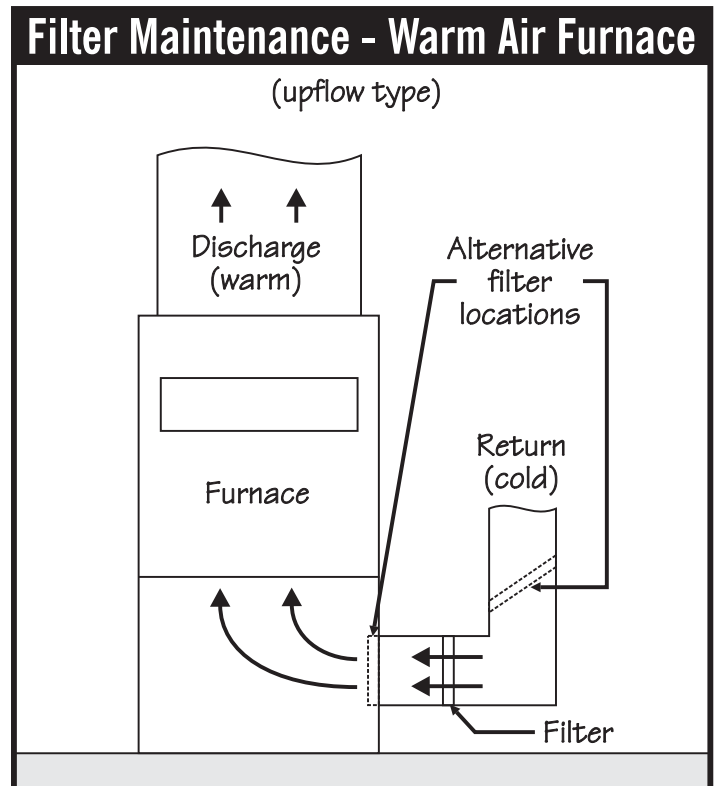
## FILTER

Now is your chance to improve your furnace air filtering system, particularly if you are not happy with your current system. The standard arrangement will be a slot for a 1-inch-thick throwaway or washable filter. While this meets minimum requirements for the furnace, it doesn't remove small particulates from the air. You can improve on the standard 1-inch fiberglass filter by using a pleated paper filter. (Drawing H009)

A frame for a 4- or 6-inch-thick pleated paper filter is a great improvement over the basic filter and will remove much smaller particulate matter from the air. This type of filter has a very small opening spread over a very large surface area. Normally a replacement filter costs about \$25, and the filter lasts about a year.

The best filtering system for removing smoke and pollen particles is an electronic filter. This type of filter uses electronically charged plates and wires to attract particulates. The filter plates must be washed every so often in the tub or the dishwasher. (Drawing H029)

Finally, there are 1-inch-thick electrostatic filters and ultraviolet light air cleaners. Neither of these is very common, and I don't believe in experimenting with most new products until they have been tested and proven in the marketplace for a significant time.



H009

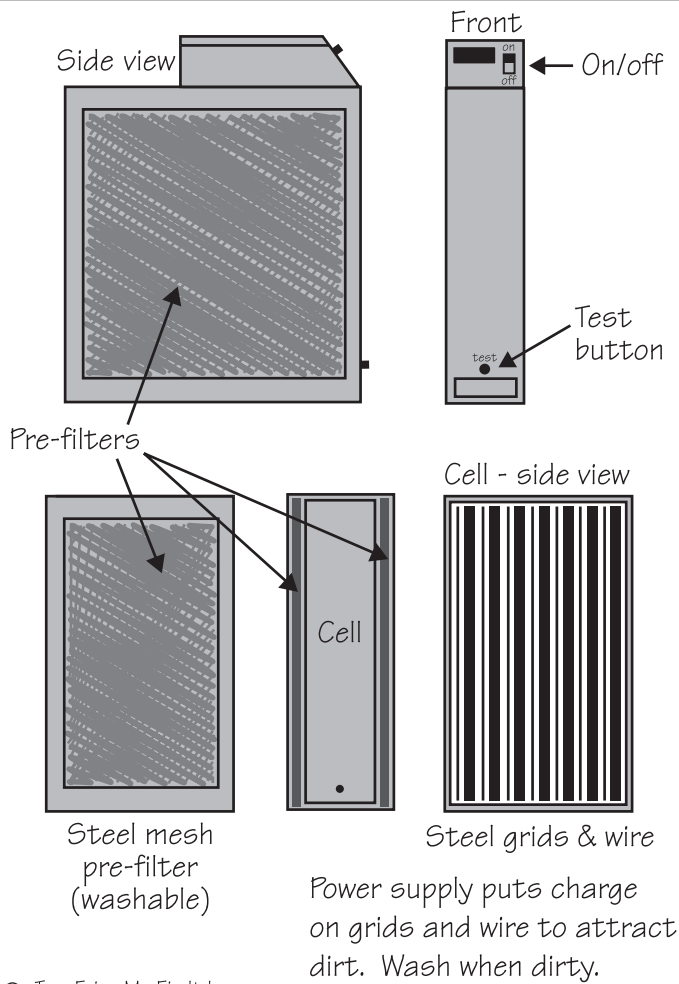
## HUMIDIFICATION—NOT

In most cases, you should consider eliminating any humidification system. You can always add it later if needed. Newer furnaces draw less air from your home for combustion and do not create a constant flow up a chimney. This eliminates some of the ventilation or air leakage into your home. With less air loss, there is less air infiltration through leaks. With less infiltration, a newer furnace does not dry out your home.

## GAS VALVE

The gas valve should be updated with the new furnace. (Drawing P076)

## Electronic Air Filter

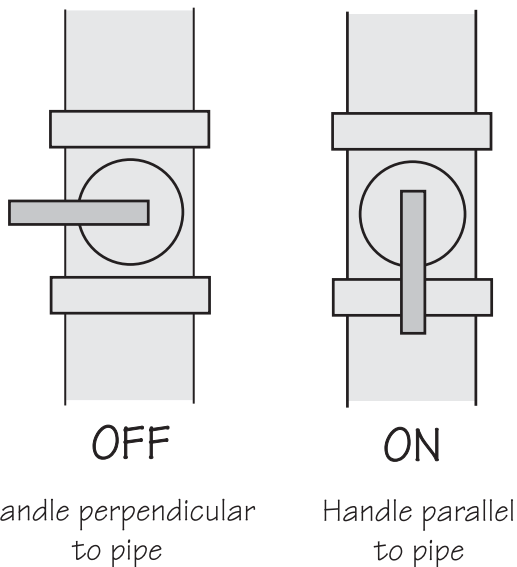


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H029

## Gas Shutoff Valve - Typical

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P076

## EVALUATING DUCTWORK

If your home was built before 1960, the ductwork needs a critical review. In some cases the ductwork and returns may be too small for a modern furnace and additional ductwork must be added. Some older systems have 4-inch round supply ducts that don't allow for proper flow. With an undersized duct system, the furnace will not operate properly and you will not have a comfortable home.

## CLEANING DUCTWORK

Should your ductwork be cleaned as part of a furnace replacement? If you have a pre-1950 home, consider cleaning your ductwork. You should also consider cleaning if someone in your home is sensitive to dust and dirt.

Often, a new furnace moves more air through the duct system. When more air is moved, it flows at a faster speed. This may tend to dislodge and push additional dirt into your home.

## FURNACE BRAND

All the furnace brands you recognize produce high-quality products. There was a period during the 1970s and '80s when some furnaces were poorly designed, but now all the major brand furnaces perform well. Consider the type of heat exchanger material and the warranty when making your replacement decision.

## BIDS / QUOTES

You must receive a written quote that identifies at least the following items: brand, type, size, efficiency, Btu rating, and warranty information. The contract should state how venting and the chimney will be handled. The contractor should remove the old furnace and clean up afterward. Building permits and fee should be included.

Make sure the quotations give you all the information you need to compare apples to apples between the bids. They must quote the same type of furnace (same efficiency). Be careful of a very low quote; something may be left out. You can expect to pay a portion of the price when the furnace is ordered and to make the final payment when the furnace is installed and working properly.

## WARRANTIES

Because furnaces often are so similar to one another, consider choosing the furnace that provides the best

warranty. Pay special attention to the warranty for the heat exchanger—it is the most expensive part of the furnace and is subject to heat and corrosive conditions.

## HOW MUCH CAN YOU SAVE?

You may ask the contractor to estimate the energy and cost savings for the replacement furnace.

You can also take an educated guess at the savings by evaluating your current heat costs. Gather up your gas bills for a one-year period. Total the costs for the six-month heating period. Then total the costs for the six-month spring and summer period. The summer bills will establish the base cost of gas service excluding heating cost; base cost includes the meter charge and gas used by the water heater, clothes dryer and stove. Subtract the summer total from the winter total, and you'll see your approximate heating cost.

Once you know your heating costs, look at the efficiency of your current furnace and of potential replacements. Increasing efficiency from 60 to 90 percent will save you about 30 percent in heating costs. This is not a precise calculation, but it will give you an idea of the savings.

You also need to consider the additional cost of moving from a 90 percent to a 90 percent plus furnace. You will save a little on gas and electricity. The payback may be minimal for the additional cost, but the comfort of your home will improve.

## NOISE

The only furnace that will have a significant difference in operating noise will be the 90 percent plus. Its variable-speed, slow-start motors will be very quiet. When the furnace runs on low fire, there will be less fan noise.

## INTERIOR COMFORT

All of the furnaces will provide excellent comfort, providing the duct system is adequate or improved. You

will notice that the higher efficiency furnace moves more air—that is, more velocity at the grills. The discharge temperature will also be lower than that of a standard efficiency furnace.

When a furnace is properly sized, it will run more often and for a longer period of time, providing a more uniform temperature in your home. The 90 plus furnace can provide more comfort because it will often run at the lower fire rate and lower fan speed for longer periods.

## MANUALS AND INSTRUCTIONS

Make sure the contractor walks you through the system and explains the operation of the system and the thermostat. The contractor should give you the detailed instructions provided by the manufacturer. Ask the contractor to identify emergency shut-offs for gas and for the furnace system and to walk you through filter maintenance.

## FURNACE REPLACEMENT WITH OR WITHOUT AIR CONDITIONING

Today, most forced air systems also function as central air conditioning with the addition of an exterior compressor and interior coil and piping. If your home has an older air conditioning system or you are considering adding air conditioning, do it when the new furnace is installed, or at least plan for coil installation in the ductwork above the furnace.

## SUMMARY

The key to a successful furnace replacement is finding a good contractor and understanding the basics of a furnace project. Focus on the quality of the contractor, not on the price. Review this article to ensure that all details are covered, and don't forget about the chimney for any furnace you buy.

## HOME TIPS

See Tom's book [How To Operate Your Home](#) (ISBN 0-9674759-3-7) for great information on "operating" a home.

Written by Tom Feiza

The book is available at [www.amazon.com](http://www.amazon.com) or through Tom at: [www.howtooperateyourhome.com](http://www.howtooperateyourhome.com) or [www.htoyh.com](http://www.htoyh.com) 262-786-7878.



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