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INTRODUCTION

The purpose of a heating system in the North American climate is obvious. How well a heating system performs is not so obvious. A well designed heating system is large enough to provide adequate heat on the coldest day, is reliable, is inexpensive to install and to operate (efficient), is quick to respond to its controls, is able to heat all parts of the home equally or differentially, as the occupants desire, and is safe. There is no one heating system which performs all these functions to perfection. Every heating system is a compromise in one way or another, with low initial cost often being the predominant criteria for selection.

1.0 HEATING OBJECTIVES

Simply put, the goal is to generate bundles of heat, and to distribute them to the various parts of the building. Several fuels can be used to generate the heat. Some burn oil or gas, commonly referred to as fossil fuels, and others use the heat released by electricity flowing through coils. There are newer systems where existing heat is simply captured, stored and released in the home. This includes heat pumps and solar heating, for example. Decisions as to which fuel is the best are based on the fuel cost, how much of the heat generated can be used (the efficiency of the system), and the cost and durability of the equipment used to provide the heat.

The heat is often generated centrally, in a furnace or boiler, and is distributed throughout the house via air in ductwork or water in pipes. If the heat developed by the gas, oil, or electricity is transferred to air, the system is called a furnace. Where water is the heat transfer medium, this is a boiler. Any fuel can be used with either distribution system.

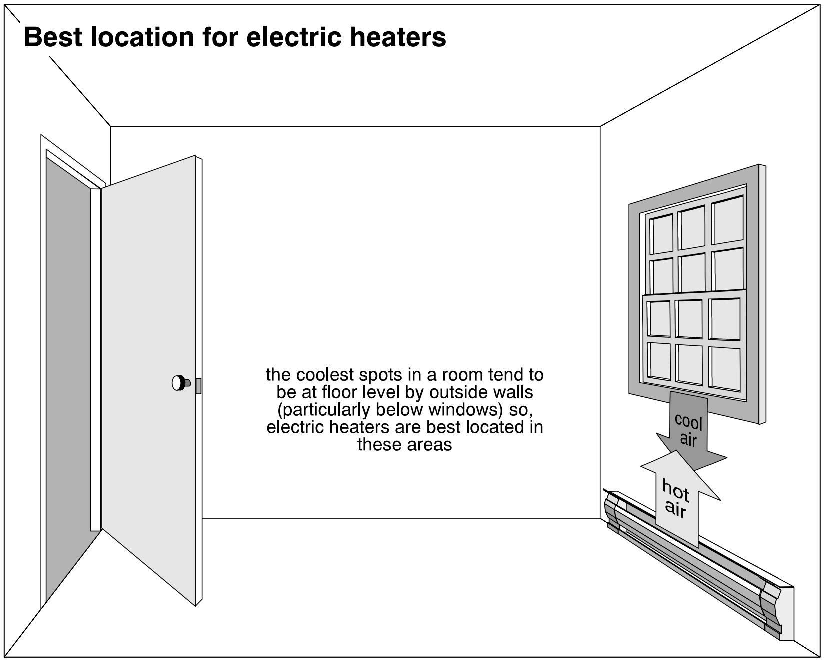
It is possible to generate some heat in each room and not bother with a distribution system. Old English castles with fireplaces in each room are examples of this approach, Another example is a house warmed with electric baseboard heaters. There are advantages and disadvantages to each approach, and these are discussed in this section.

2.0 UNITARY ELECTRIC HEATERS

Some houses are heated entirely by electric heaters while others employ electric heat as a supplement to the main heating source.

With the exception of electric furnaces and boilers (which are dealt with later in this section), electric heating systems are unitary rather than central. In other words, the heat is generated within the room or space which is to be heated, as opposed to a central system where the heat is generated in one location and then distributed through the house.

The most common type of electric room heater is the baseboard heater. The second most common type is the forced-air wall unit which contains a heating element and a fan.

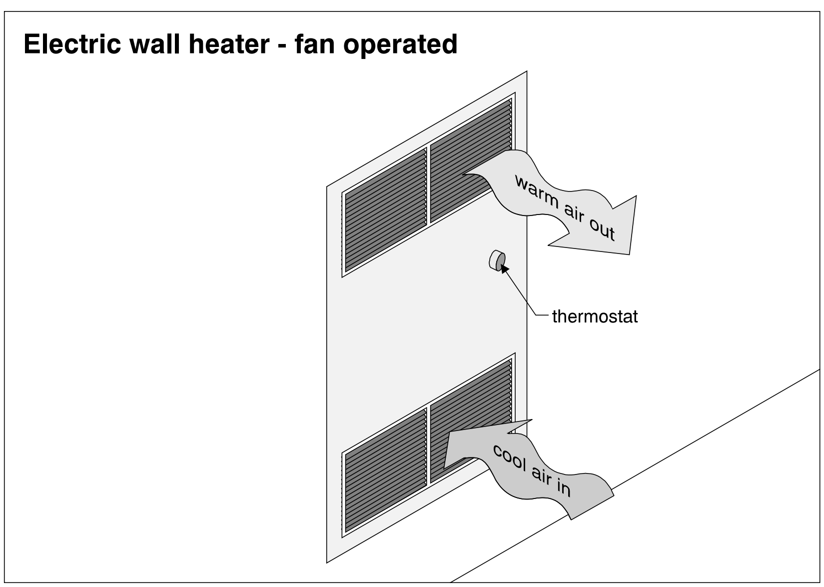


Thermostat

In either case, the controls can be directly on the units or wall mounted. These controls are simply thermostats. They control an individual unit or a particular area of the house which contains more than one heater. Wall mounted thermostats tend to be the preferred (and more expensive) method as they are easier to reach and, according to some, more accurate.

Floor Mounted

Some electric heaters are floor inserts. They are similar to baseboard heaters; however, they are installed directly in the floor. They are designed for locations such as in front of patio doors and floor length windows. These units may include a fan. Obviously, the controls for these systems are wall mounted.



Floor mounted heaters may be found covered with rugs or mats, particularly during the summer. Blocking the air flow may lead to overheating. It is common to find boots, mitts, et cetera, drying on floor mounted heaters. This is poor practice since the heater will rust.

Clearances

With electric heaters it is important to follow the manufacturer's recommendations for clearance from combustible materials. Draperies, for example, should be kept eight inches above the heaters. Alternatively, the drapes can be three inches in front of the heaters as long as they are at least one inch-above the floor.

Radiant Heating

There is one more type of unitary electric heating system - that being electric radiant heat. Electric radiant systems rely on large surface areas to heat up to the point where they radiate heat to a room. Electric radiant systems are almost always found in ceilings. They consist of wires which are embedded in the ceiling and spaced two to eight inches apart. Some systems employ pre-wired panels which fasten together. When operating, the ceiling will be warm, but not hot, to the touch.

If the distribution wire itself malfunctions (breaks), it is often difficult to locate the problem in the wiring. Some utilities have special equipment which can be used to locate the problem. In most cases, these systems are abandoned when they fail, and are replaced with electric baseboard heaters.

With any radiant heating system, care must be taken not to damage the system when drilling holes or mounting things such as light fixtures.

Special patching materials are available for treating cracks and other flaws in heated ceilings.

One common complaint about radiant heating systems is the shadow effect. Since radiant heat works the same way as sunlight, some people's legs feel cool if, for example, they are sitting at a dining room table for several hours. The table shades their legs from the direct radiant heat.

Advantages

There are several advantages and a few disadvantages to unitary electric heating. The advantages are:

1. Temperature can be controlled room by room or at least zone by zone.
2. The equipment is relatively inexpensive to purchase and install when compared to other forms of heating.
3. By the very nature of unitary heating, all of one's eggs are not in one basket.
4. Electric heating is quick to respond.
5. Electric heat is clean.
6. It can be used to supplement the primary source of heat within a house.
7. Electric heat takes up little room space and virtually no distribution space when compared to ductwork or hot water piping.
8. It requires no chimney and no combustion air.

Disadvantages

The disadvantages are:

1. In some areas, electricity is more expensive than other heating fuels.
2. The addition of several heaters to supplement an existing heating system may necessitate upgrading the electrical service. (It will require a large electrical service if the house is to be totally heated electrically.)
3. Unitary electric heating has no ability to filter, humidify or cool the air.

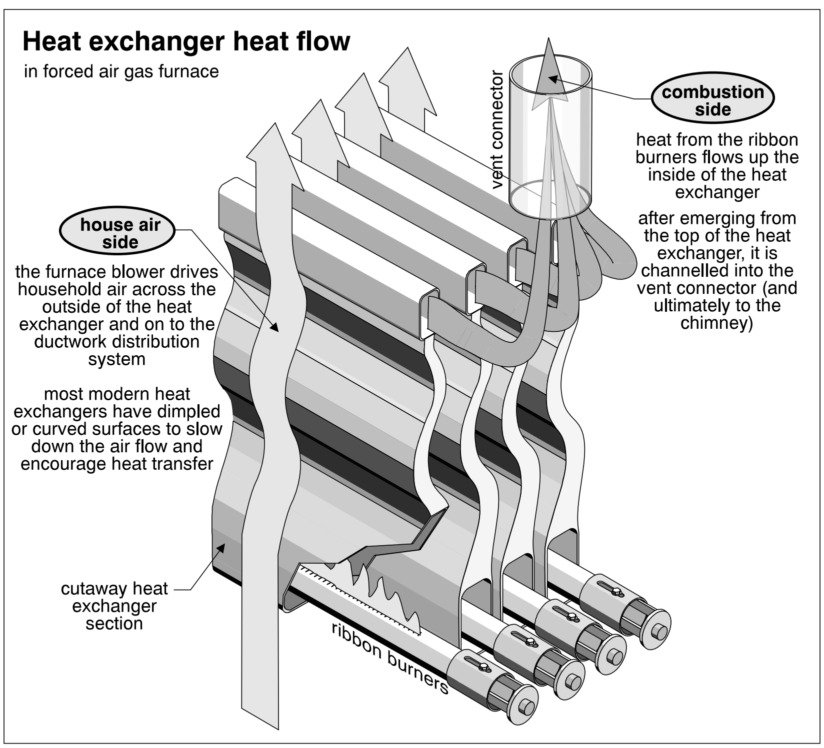
► 3.0 FURNACES (Forced-Air Systems)

Furnaces are central heating systems in that the heat is generated in one location and then distributed through the house.

With the exception of electric furnaces, all furnaces have three major components: a heat exchanger, a burner, and a blower.

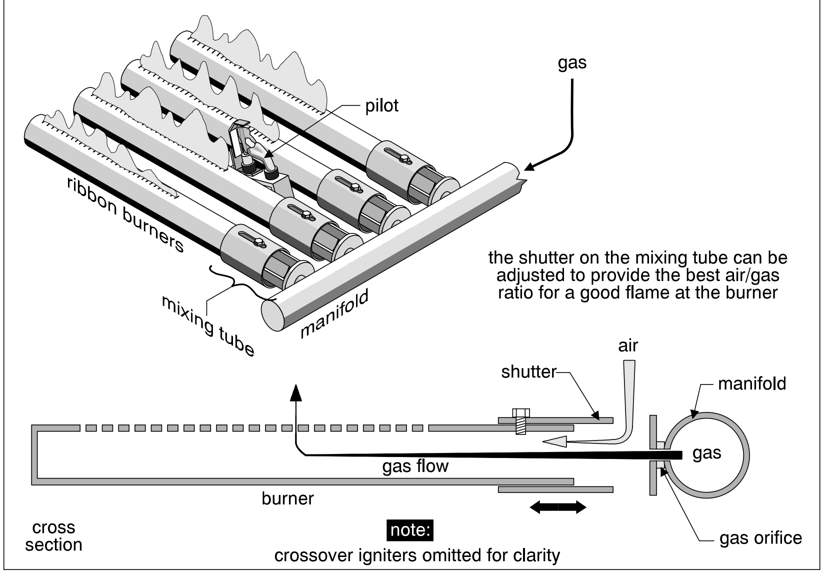
Heat Exchanger

The heat exchanger is the most critical component of a furnace. It separates the air which is being heated from the burning fuel. While the configuration of heat exchangers varies, a heat exchanger can be thought of as a metal box inside another metal box. The interior box has fuel burning in it. The heat from the burning fuel warms the interior box. Air is then passed through the outer box where it picks up heat from the hot walls of the inner box. In this way, the burning fuel never comes in direct contact with the house air. This is called an



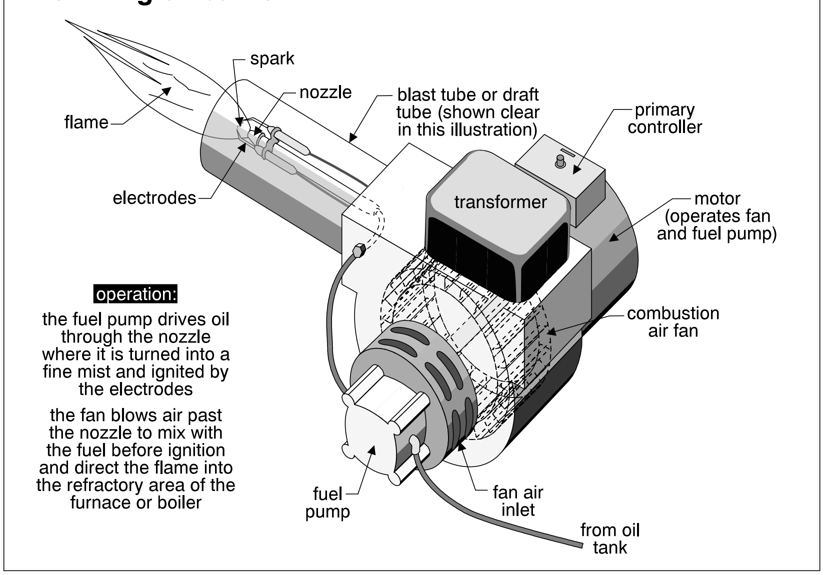
indirect fired heating system.

Gas burners



A gas burner is fed from a valve which allows gas to enter the burner where it is mixed with air and ignited. Gas burners can be of several shapes; however, the most common type is the ribbon burner which is not unlike the burner found on a gas barbecue.

Atomizing oil burner



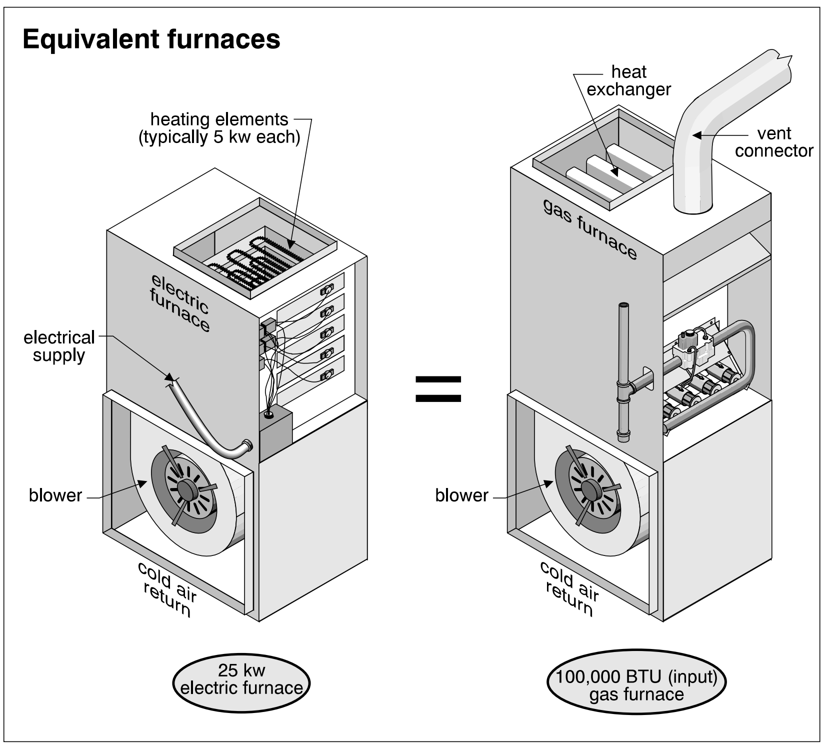
An oil burner is somewhat different since it is dealing with a liquid fuel rather than a gas. A pump is used to force the liquid fuel through a nozzle, causing it to atomize (break up into small droplets). A fan blows air through the burner to mix with the atomized oil. The mixture is ignited by a spark, creating combustion.

Blower

Once heat has been created on one side of the heat exchanger, household air is blown across the other side of the heat exchanger to pick up the heat and distribute it through the house. All modern furnaces have a blower to draw air back to the furnace through the return air ductwork, blow the air through the furnace, and out the supply air ductwork. Older furnaces worked on gravity. They relied on the warm air generated in the heat exchanger to rise by natural convection through the ductwork in the house. Cooler, heavier air fell down the return ductwork by gravity.

Electric Furnaces

While all fuel burning furnaces are basically the same, electric furnaces are slightly different. They are very similar in operation to a hand held hair dryer. Since there is no actual combustion within the furnace, there is no need for a heat exchanger or a burner. These components are replaced by electric heating elements sitting directly in the air stream. The blower simply forces air across the heating elements, and the warmed air heads back to the rooms in the house via ductwork.



Fan/Limit Switch

In addition to the major components there are safety controls and minor components. Forced-air furnaces have a fan/limit switch. This switch has several functions. It tells the blower to come on when the furnace is up to temperature. The blower does not start automatically when the burner begins to fire because the air which would come out through the registers would be cool (and feel drafty). It waits until the temperature is high enough within the furnace to provide warm air at the registers. At this point, it comes on. The fan/limit switch does not shut off the fan when the burner is shut off. Since there is some residual heat in the heat exchanger, the fan keeps blowing until the temperature within the furnace drops to the point where the air coming out of the registers would feel cool. The last, and probably most important, function of the fan/limit switch is to shut off the burner if the temperature within the furnace gets too high.

Proving Ignition

Depending upon the type of furnace, there is also a safety device to verify ignition. Obviously, it would be unsafe to pour unburned gas into a furnace, without burning it. A potentially explosive condition would exist. Most gas furnaces have a pilot which ensures that the gas is ignited. A thermocouple (heat sensor) verifies that the pilot is running. If, for any reason, the pilot goes out, the thermocouple sends a message to the gas valve telling the gas valve not to open under any circumstances.

Newer gas furnaces do not have a continuous pilot. Instead, the pilot is ignited by a spark. Again, there is a sensor to ensure that the spark successfully ignited the pilot. If it does not, the gas valve will not open. A system called “hot surface ignition” is doing away with pilots on some furnaces. A silicon-graphite ignitor spins like a grinding wheel until it is white hot. It ignites the main burner. A sensor ensures that combustion occurs or it shuts the gas valve.

Some oil burners have a similar sensing device which ensures that ignition has occurred. Other oil furnaces have a device on the exhaust pipe (called the primary control) which measures the temperature of the exhaust gases. If the oil burner is pumping oil into the combustion chamber and the primary control senses that the exhaust pipe is still cold, it shuts off the oil burner because it realizes that the combustion chamber is being filled with unburned oil.

Exhaust Flue

There are other minor components found on most furnaces. With the exception of electric furnaces, all furnaces have an exhaust pipe to discharge the products of combustion. The exhaust pipe (exhaust flue or breeching) carries the exhaust gases from the furnace to the chimney.

Filters

Furnaces also have a filter to clean the air before it enters the furnace. This prevents the inner components of the furnace from becoming clogged with debris. The filter system also improves the quality of the air throughout the house.

Most furnaces have a conventional filter; however, electronic filtering devices are available. Electronic air filters have three stages. The first stage is a mechanical filter similar to a conventional filter. The second stage gives the particles which pass through the mechanical filter a magnetic charge. The third stage consists of collector plates of opposite polarity. The charged particles are attracted to these plates.

Humidifiers Many furnaces also have a humidifier. The humidifier simply adds moisture to the air, as the air within a house during the winter time tends to be drier than people would like. Some humidifiers are sophisticated while others are extremely simple. See 12.4 in this Section.

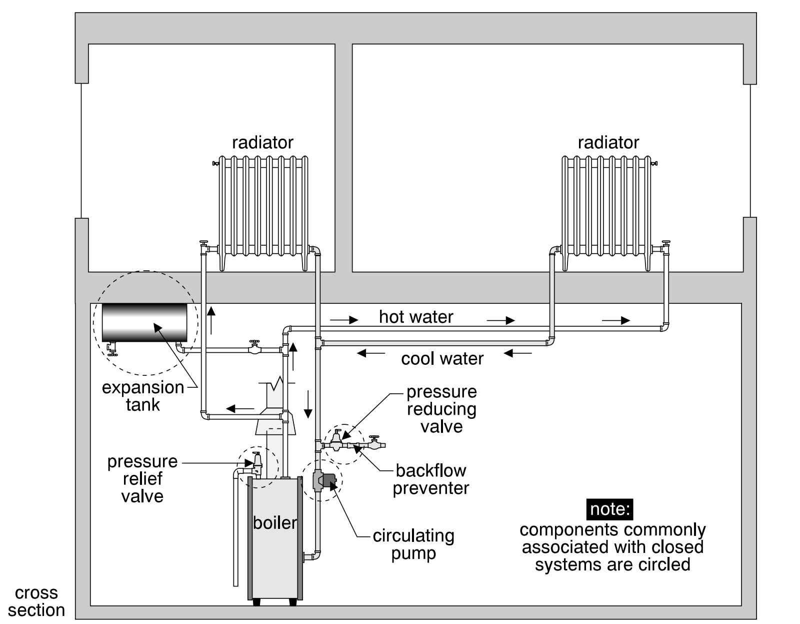
Ductwork In addition to the furnace itself, there must be a means of distributing the heat. Furnaces employ two sets of ductwork: ducts to supply the air to the various rooms in the house, and a return air system. Every room in the house should have at least one supply air register. Ideally, each room would have a return air register; however, most houses have fewer return air registers (which collect air from several rooms). Houses which were built with central air conditioning often have dual return air registers located near floor level and near ceiling level. The high level return air registers are designed to collect warm air during the air conditioning season while the low level registers collect cool air during the heating season.

► 4.0 BOILERS (Hot Water Systems)

Boilers are central heating systems in that the heat is generated in one location in the house and distributed via piping to the various rooms.

The word boiler is somewhat confusing in that hot water systems do not actually boil the water. They heat it to about 160 degrees F, typically. Some hot water (hydronic) systems have been converted from steam.

Closed hydronic system



Closed Systems

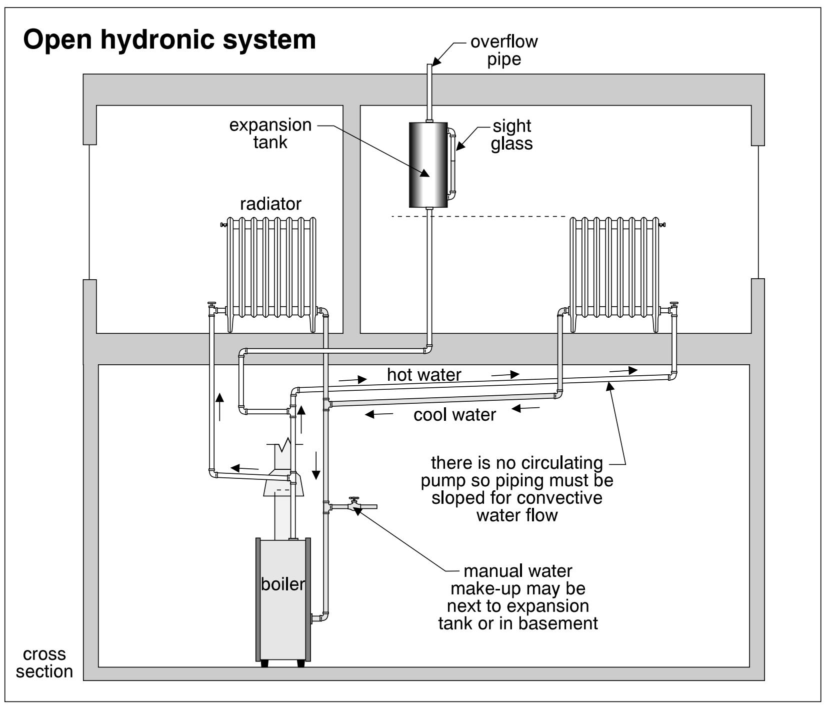
Modern boilers are "closed" systems. The water in the boiler, in the piping, and in the heat source within each room, is under pressure. The pressure within the system is normally a few pounds higher than what is required to force water up to the highest level within the house. In a typical house, this pressure would be twelve to fifteen pounds per square inch.

As the system heats up, the water expands and the pressure builds. An expansion tank, or cushion tank, normally located near the boiler, has air trapped in it. As the water expands, it begins to fill the expansion tank, compressing the air. This prevents excessive pressure build-up in the system as the water gets hotter.

Closed systems normally have a circulating pump to force the water through the system.

Open Systems

Before closed or pressurized systems, boilers were "open". The water within an open system is not under pressure. There is an expansion tank; however, it is not a pressure vessel. The expansion tank (or gravity tank) on open systems is located above the highest radiator within the house. It is normally found in a closet on the top floor. When the system is cold, the expansion tank has very



little water in it. As the system heats up, the water expands and begins to fill the tank. The tank is designed to easily handle all of the extra volume that is created by expansion. Expansion tanks on open systems usually have a sight glass on their exterior. This allows one to determine the level of the water within the system. If the system is low on water, it is simply added until the tank begins to fill, when the system is cold. If the tank is overfilled when the system is cold it will overflow as the system heats up. An overflow pipe emerges from the top of the expansion tank. It typically passes through the attic and discharges onto the roof, or down into a floor drain.

Open systems do not have circulating pumps. The water is moved through the system by gravity.

Heat Exchanger

With the exception of electric boilers, all boilers have two major components: a heat exchanger and a burner. The heat exchanger contains the burning fuel on one side and the water to be heated on the other. The flame heats up the metal and the metal in turn heats the water. Heat exchangers are made of cast iron, steel or copper.

Burners

To burn fuel within the heat exchanger, a burner is required. The most common fuels are natural gas and oil. The burners on hot water systems are very similar to those on warm-air furnaces discussed in the previous section (3.0 Furnaces).

Automatic Water Make-up

In addition to the major components, closed systems often have automatic water make-up devices to add water to the system as needed. On an open system, water is added manually by opening a valve on the pipe between the plumbing and heating system, until water is visible in the bottom of the expansion tank. On a closed system, a cold water plumbing pipe is connected to the boiler, with a special valve between. It is not a direct connection because the plumbing water pressure fluctuates and is too high for the heating system. Therefore, a pressure reducing valve is installed so that the pressure within the heating system does not exceed the right amount. If the plumbing system were ever drained, there would be the possibility of impure water from the heating system draining back into the plumbing system. Consequently, in recent years, automatic water make-up systems have contained a back-flow preventer.

Back-Flow Preventers

Safety Devices

There are also safety features built into a boiler. The first safety device ensures that ignition has taken place. Without proper ignition, the oil burner or gas valve, is shut down. (See Proving Ignition in Section 3.0.) The second safety device is a high temperature limit. Should the water within the system exceed a safe temperature (about 200 degrees F.), the system will shut down.

On closed systems, a pressure relief valve is provided. Should the pressure in the system exceed thirty pounds per square inch, the pressure relief valve will discharge water. Open systems do not require a pressure relief valve as they are not pressurized, and excess water simply overflows from the top of the expansion tank.

Low Cut Off

Some larger boilers have low water level safety devices to shut down the system if there is insufficient water in the boiler.

Radiators

Once the water in the boiler is heated, it is distributed through the house. Radiators are the most common form of hot water heating distribution. Radiators are constructed of cast iron. Most radiators have a control valve at one end.

This valve allows the water to the radiator to be shut off and, theoretically, it allows the amount of water flowing through the radiator to be adjusted so that the radiator gives off more or less heat. Seldom are radiator valves throttled down. They are normally wide open, and commonly leak if turned.

Bleed Valves

A small bleed valve is located near the top of the radiator. This allows air which is trapped within the radiator to be removed. This is normally done annually. It is not unusual to find this valve obstructed with paint.

Convectors

Hot water convectors are an alternative to radiators. Convectors are either cast iron or are tubing (usually copper) fitted with aluminum fins. Convectors take up less space because they are usually less than twelve inches high. Radiators are typically twenty-four to thirty-six inches high. However, convectors have to be longer than radiators to produce the same heat, and because they heat up and cool down more quickly than radiators, can result in uneven heating when installed in a home with radiators.

Radiant Heating

Some hot water heating systems employ piping buried in floors or ceilings. The piping heats the floor or the ceiling which in turn radiates the heat to the room. The pipes have traditionally been galvanized steel, black steel, or copper, although recently, flexible plastic tubing has been used. The pipes are usually buried about three inches below the surface and are eight to sixteen inches apart.

► 5.0 CONVERSION FROM HOT WATER TO FORCED-AIR

There are several reasons to consider conversion from hot water to forced-air heating. Among the more common are the ability to add central air conditioning, humidification and air cleaning, and the desire to get rid of the bulky radiators. To help make the decision easier, outlined below are some of the considerations.

Advantages of Hot Water Heat

a) Provide more even heat than forced-air systems.

b) No uncomfortable drafts from the distribution system.

c) Usually quieter than forced-air systems.

d) Does not circulate cooking odors through building (more important in two family homes).

e) A new boiler is smaller than a new furnace.

f) Piping requires less room in walls, floors and ceilings than ductwork.

Advantages of Forced Air Heat

a) Easy to add air conditioning, humidifying and air cleaning equipment.

b) Furnaces are less expensive to purchase than boilers.

c) There is a greater range of furnaces to choose from at each level of efficiency.

d) Heating registers do not occupy as much space in a room as radiators.

e) A leak in an air distribution system does not lead to water damage, as does a leak in heating pipes.

f) Ductwork is less expensive to install or relocate than piping.

Factors which make conversion appealing.

a) The boiler is old and may have to be replaced in the near future.

b) The house is a bungalow with an unfinished basement, or has a configuration which makes it very straightforward to install ductwork.

c) Central air conditioning is to be provided in any case (either independent or conventional).

d) There are plans to renovate extensively, so that opening up walls and ceilings is not a large additional expense.

Sample Situation

Assume that some or all of the factors listed above apply. Consider the following costs.

a) Replacement boiler (mid-efficiency)	$2,500 to $4,000
b) Replacement boiler (high-efficiency)	$5,000 to $9,000
c) Add independent air conditioning	$8,000 to $15,000
d) New forced air-furnace (mid-efficiency)	$1,500 to $2,500
e) New forced-air furnace (high-efficiency)	$2,500 to $3,500
f) Conventional central air-conditioning	$2,000 to $3,000
g) Remove radiators and piping, and install ductwork and registers	$9,000 to $17,000

Based on the writers' preferences, the choices would be either b) plus c), or e) plus f) plus g). Using the median costs in both scenarios, the cost would be roughly $18,500 in either case. One would financially be indifferent between the two choices in this example.

Conclusion

In any given situation, one or more costs may vary dramatically from the set of figures above. As can be seen, several factors should be considered in making the decision to convert from hot water to forced air. The weight given each factor will vary from household to household, and the decision becomes subjective rather than right or wrong.

6.0 CONVERSION FROM OIL TO GAS

If one is planning to convert from an oil-fired heating system to a gas-fired system, a chimney liner may be necessary. (Please refer to 7.0 Chimney Liners and 14.17 Chimney/Chimney Liner).

If the present oil system is older, but still functioning, plans for conversion may be deferred. It may be prudent, however, to have a gas line installed in the near future. (The installation typically takes several weeks from the request date.) If the existing system fails during the heating season, a new gas system can then be connected quickly. In some locations, gas can be brought into the house at little or no cost if a gas appliance is connected (e.g. a rental water heater). Where this is not available, the cost may run $500 - $1,000. This discussion assumes, of course, that natural gas is available in the street. If the local gas company will rent a gas conversion burner, this may be the best option in the short term.

Mid or High Efficiency

One of the incentives for changing to gas is the much wider selection of furnace types. There are more mid and high efficiency gas furnaces than oil.

No Chimney

High efficiency and some mid efficiency furnaces do not need a chimney. They can discharge exhaust gases straight outside through the house wall. This can be an influence in the decision to convert, if the chimney for the oil furnace is in poor condition, or if a liner would be required on conversion to a conventional gas system.

7.0 CHIMNEY LINERS

Masonry chimneys may be lined or unlined. An unlined chimney simply has brickwork exposed on the interior. The brickwork on a lined chimney is protected. The liner may be a metal pipe, clay tiles, or asbestos cement pipe. Some experts feel clay tile liners are not ideal for gas heating systems.

As a general rule, oil-fired furnaces do not require a lined chimney because the products of combustion are not as corrosive to the chimney as the products of combustion from a gas-fired system. Since gas burns at a much lower temperature than oil, the exhaust gases are significantly cooler. As the exhaust gases travel up the chimney, they cool even more. Condensation can form on the inside of the chimney flue. When the furnace shuts off, the chimney cools and the condensation which has been absorbed into the brick and mortar freezes. This freeze/thaw action deteriorates the brick and mortar. This will eventually result in major chimney work being necessary.

If the debris falling to the bottom of the chimney is not cleared, it can eventually plug the furnace exhaust pipe causing the products of combustion to back up into the house. This is a very unsafe situation. Therefore, as a general rule, conventional and some mid-efficiency gas furnaces require a lined chimney flue. Most oil furnaces do not.

Metal Chimneys

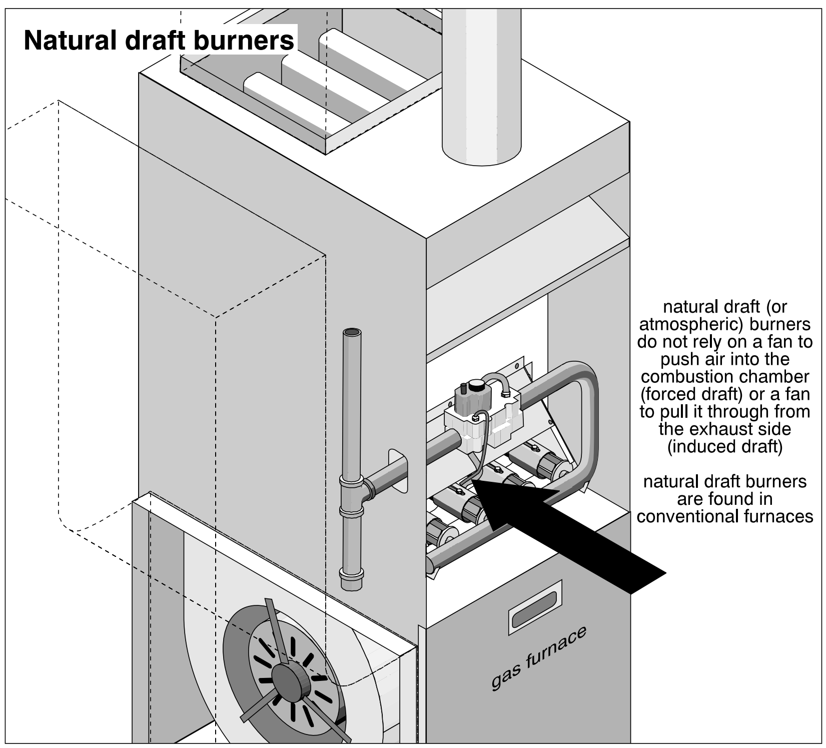
Metal chimneys do not require liners. In some cases the top sections corrode, and require replacement. The design of caps for metal chimneys has changed over the last fifteen years. New materials are also being introduced on metal chimneys to extend their life.

Electric furnaces, some mid-efficiency furnaces, and high efficiency furnaces are normally not connected to a conventional chimney and, therefore, a liner is not required for these units.

► 8.0 EFFICIENCIES

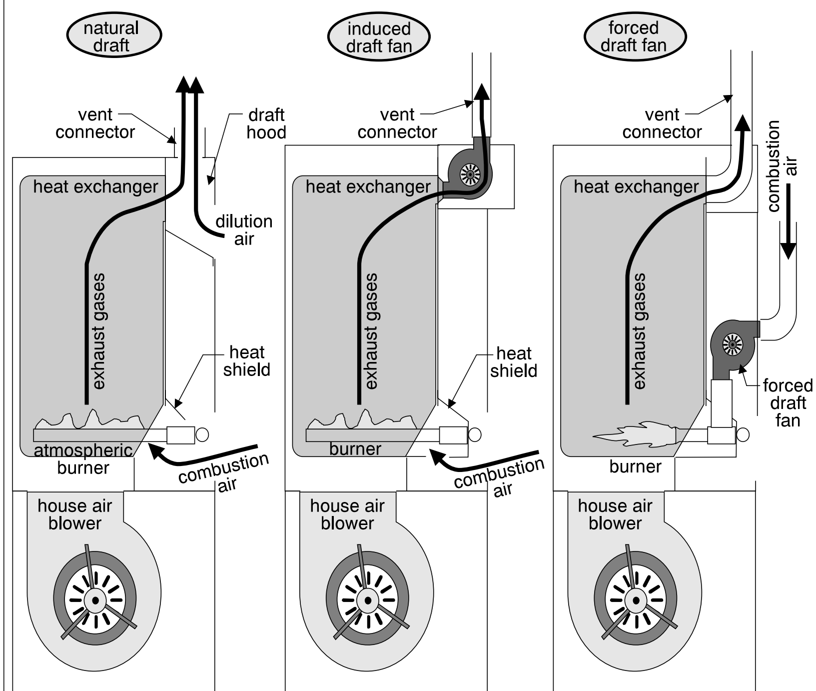
8.1 Conventional Systems: Both furnaces and boilers are classified by their efficiency. Until the mid 1970's, all systems were of similar design and efficiency. Almost all had an operating (steady state) efficiency of approximately eighty percent. In other words, when the furnace or boiler was operating, eighty percent of the heat that was produced from burning the fuel went into the house. The other twenty percent went up the chimney.

Since a boiler or a furnace has to be capable of providing enough heat during the coldest day of the year, it is capable of providing more than enough heat every other day of the year. Consequently, systems do not run perpetually during the winter. They simply come on when heat is called for by the thermostat and shut off when the house is at the desired temperature. In fact, most heating systems are oversized and do not even run continuously on the coldest day of the year.



Losses When a boiler or furnace is not operating, warm house air is escaping up the chimney. Even when the system is operating, a good deal of warm house air is lost up the chimney, just maintaining adequate draft for the exhaust gases. On gas-fired systems, some fuel is wasted keeping the pilot on. Also, when a boiler or furnace is starting up or cooling down, it is not operating at full efficiency. If you combine the off cycle losses with the start-up and cool-down losses, and add in the twenty percent losses during normal operation, the average seasonal efficiency of a conventional boiler or furnace is about fifty-five to sixty-five percent. With the advent of more efficient furnaces and boilers, the standard system became known as a conventional system. Conventional systems were phased out in the early 1990's.

Three kinds of draft



cross section of forced air gas furnaces

8.2 Mid-Efficiency Systems: Most mid-efficiency boilers and furnaces are essentially conventional units (although a few have a secondary heat exchanger) with some modifications to reduce off cycle losses. A motorized vent damper may be used in the exhaust pipe to prevent heat from escaping up the chimney when the system is shut down. Alternatively, the system includes an induced draft fan in the exhaust pipe which only operates when the system is on. Continuous pilots are replaced with spark ignited pilots. Their seasonal efficiency is not much lower than their operating efficiency. Therefore, most have a seasonal efficiency in the eighty percent range. These systems require annual maintenance, like any other.

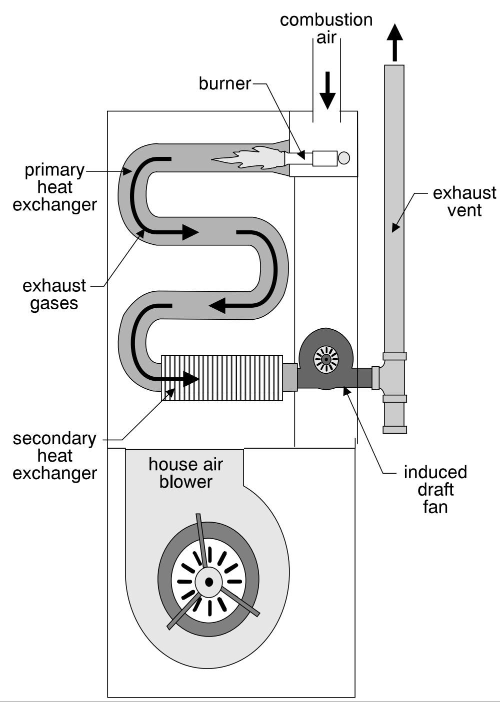
8.3 High Efficiency Systems: High efficiency furnaces and boilers go a step further, The main reason conventional systems are limited to eighty percent operating efficiency is condensation. If you burn gas, for example, and steal too much heat in the process. the exhaust gases will be so cool that condensation will form. (In the winter time, water often drips from the exhaust pipes of cars due to condensation in the exhaust system. Automobile exhaust is visible in the winter because the water vapor condenses when it hits the cold air.)

Condensing Systems

High efficiency furnaces and boilers are also known as condensing units. Their interior components are designed to withstand the corrosive condensate which forms (similar to the corrosion which rusts out your car muffler). High efficiency furnaces and boilers have a drainage system to get rid of condensate.

While a conventional furnace or boiler has a single heat exchanger, high efficiency units have more than one heat exchanger - some having three.

High efficiency furnaces have long heat exchangers

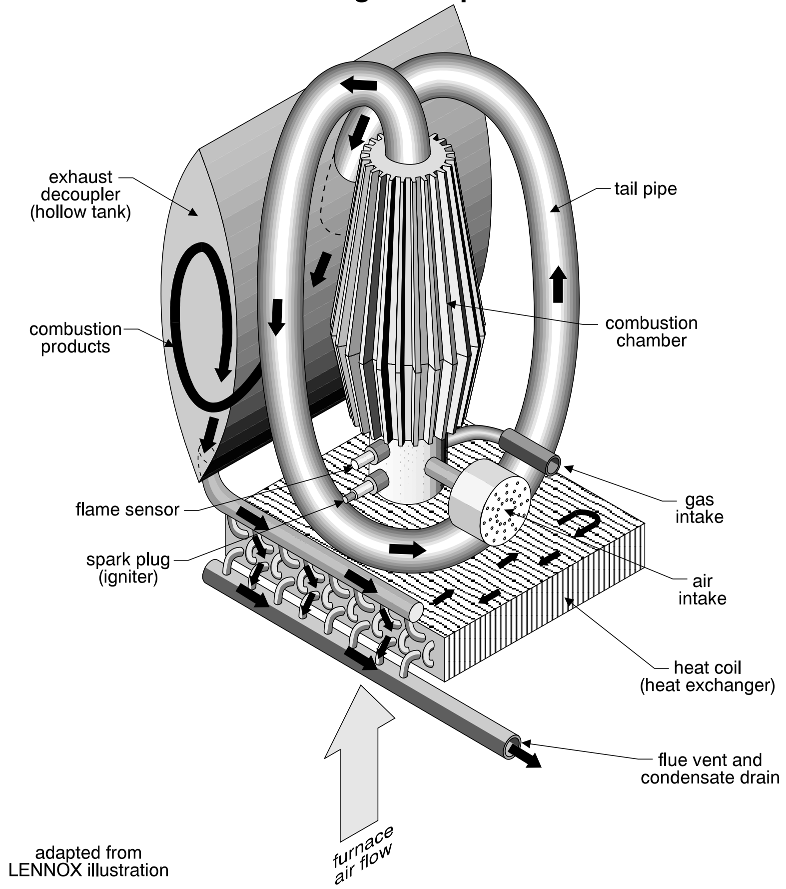


Pulse Systems

Some manufacturers of high efficiency systems employ an unconventional combustion system. This system relies on pressure waves to force products of combustion out of the combustion chamber. The pressure wave is reflected back and ignites the next gas/air mixture to continue the process. The "pulse" process becomes self perpetuating. The hot gases forced out of the combustion chamber pass across a heat exchanger where the heat is transferred. These systems tend to be noisier than most high efficiency systems.

High efficiency systems also incorporate features similar to mid-efficiency systems, to limit the off-cycle losses. They have a seasonal efficiency in the high eighty to high ninety percent range. Some reliability problems have been experienced with these systems, and some experts feel their higher maintenance costs over the life of the furnace may offset the efficiency advantages. Long term durability has yet to be proven.

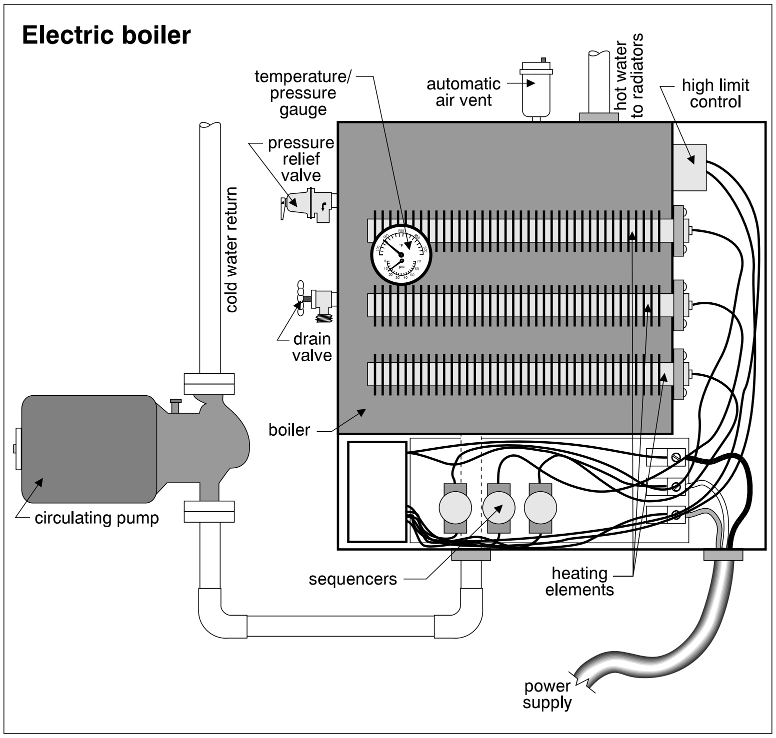
Pulse furnace heat exchanger components



Since there are more components in a high efficiency system, there is more to go wrong and, consequently, regular maintenance should be somewhat higher than a conventional furnace. At least annual servicing is required.

Electric Heating

Electric boilers, furnaces and room heaters do not have the same problems as fossil fuel burning systems. Since there are no products of combustion there are no exhaust gases to deal with and consequently, no condensation. No heat is lost outside through a chimney, because no chimney is needed. At first glance, one would assume that electric heating systems are one hundred percent efficient. This is almost true. Electric heating systems do have some minor losses. When an electrical heating element is hot enough to glow, for example, some of the energy is lost as light. Electric heating works out to be about ninety-eight percent efficient.



► 9.0 CAPACITY

Ratings Capacity refers to the amount of heat the system can generate. Heating systems which burn fossil fuels have an input and an output rating. The output rating is a percentage of the input rating. The percentage will depend on whether the system is a conventional, mid-efficiency or high efficiency system. The ratings are given as BTU's per hour. A BTU. is a British Thermal Unit and it represents the amount of heat required to raise the temperature of one pound of water by one Fahrenheit degree.

Electric heaters are rated in kilowatts. One kilowatt is equal to 3412 BTU/hr.

Heat Loss Heating systems are sized by calculating the heat loss from the house. The heat loss is dependent upon the size and configuration of the house, the construction, the amount of insulation, the type, size and orientation of the windows, as well as several other variables. Without doing full heat loss calculations, it is not possible to accurately determine the required heating system size. Most houses, however, should have systems with output ratings of 30 to 60 BTU per hour per square foot of house. Many older house heating systems are higher. In energy efficient new homes and in attached housing (where there are fewer exterior wall surfaces), the figures may be lower.

Smaller Sizes Current philosophy dictates that systems should be sized so that they run for longer periods of time to keep the house warm. The longer a furnace or boiler is running, the more efficient it is. A unit which comes on for a very short period of time and shuts off suffers considerable start-up and cool-down losses. There are also losses with conventional systems, when they are not operating, from such things as heat escaping up the chimney.

If the system appears to be undersized, it is best to take a "wait and see" attitude. Remember that heating systems are sized for the coldest day of the year. It is better to supplement the heating than replace the furnace or boiler. A cold section of a house may be the result of poor distribution, rather than a furnace or boiler that is too small.

► 10.0 FAILURE PROBABILITY

Every boiler or furnace contains several components which, if they fail, will cause the boiler or furnace to stop operating. For example, if a ten dollar thermocouple fails on a gas-fired furnace, the pilot will shut off. With the pilot shut off, the furnace will not operate. The intent of providing a failure probability is not to guess when one of several minor components might break down.

Heat Exchanger

The failure probability is intended to give an indication of how likely the furnace or boiler is to fail in a way in which it must be replaced. For most systems, failure by this definition, means a crack or a hole in the heat exchanger. Since most of the heat exchanger is not visible, the actual condition of the heat exchanger cannot usually be determined during a home inspection. Because a home inspection is not technically exhaustive, the likelihood of failure is based on probability rather than testing or furnace tear down. A conventional gas-fired furnace, for example, contains a heat exchanger which has an average life expectancy of twenty to twenty-five years. A nine year old furnace of this type would have a low failure probability. Furnaces between ten and seventeen years would have a medium failure probability while furnaces above seventeen years of age, would have a high failure probability. There are, however, manufacturers of gas-fired, forced-air furnaces whose heat exchangers have a reputation for failing in ten to fifteen years. Therefore, the failure probability might be considered high on one of these manufacturers' eight year old units.

Retrofit

Most high efficiency furnaces require more air flow across the heat exchangers than conventional furnaces. Older, smaller ductwork and/or an air conditioning coil can restrict air flow which increases the temperature rise within the furnace. This can result in premature failure of the heat exchangers and void the warranty. This condition may not be identified in a home inspection.

Most copper and steel boilers have a life expectancy of twenty to twenty-five years, although some are notorious for their ten to fifteen year lives. Older style cast iron boilers last much longer than conventional furnaces and a thirty year old unit may only have a medium failure probability. The condition of the unit may also affect the estimate. A unit which shows considerable corrosion, for example, may have a shorter than average life expectancy. See 13.1 in this section.

Electric Systems

Electric furnaces do not have a heat exchanger. Instead, they contain electric heating elements and controls for the elements. Every single component can be replaced. With age, however, electric systems can get to a stage where replacement of the entire unit makes sense, due to lost reliability and a lack of available replacement parts. Electric boilers have a water jacket which will eventually rust. Although there are not great statistics on these units, a life expectancy of twenty to twenty five years may be reasonable.

With unitary electric heating (an independent heater in each room), failure probability is meaningless as all of one's eggs are not in one basket. Electric heating elements are like automobile headlights. Their life expectancy is not well defined.

► 11.0 GAS PIPING

Gas piping in a house is commonly black steel or copper. Leaks can create an explosion hazard and should be treated as emergencies. The house should be vacated immediately without operating anything which may cause a spark including switches, telephones or doorbells. More information on gas piping can be found in Plumbing, Section 4.0.

► 12.0 WARM AIR HEATING SYSTEMS

12.1 Furnace (Heat Exchanger): The condition of a furnace hinges on the condition of its most critical component, the heat exchanger. (Some furnaces have more than one heat exchanger.) It separates the flame and exhaust gases from the air in the house. The hot gas on one side of the heat exchanger never comes in direct contact with the air which is being circulated over the other side of the heat exchanger. A heat exchanger fails in one of two ways - it rusts through or it cracks. With either condition, the products of combustion escape through the hole in the heat exchanger and into the air supply to the house. When this happens, a new heat exchanger is necessary. A crack or hole in a heat exchanger is usually not visible, and typically will not be identified during a home inspection.

Life Expectancy

Heat exchangers have an average life expectancy of twenty to twenty-five years. If the furnace is nearing this age, other components are also beginning to wear and consequently very few heat exchangers are replaced. Pulling a furnace apart and replacing the heat exchanger costs almost as much as replacing the whole furnace. In most cases, the entire furnace is replaced.

Humidifiers

Defective humidifiers, leaking condensate trays from air conditioning systems or extremely damp basements can cause heat exchangers to rust prematurely.

Corrosive Environments

There are some environments where chemicals in the air are also corrosive to a heat exchanger. Swimming pool chemicals, paint strippers and the chemicals commonly found in hair dressing shops, for example, will rust out a heat exchanger very quickly. In a corrosive environment, a furnace with a specially protected heat exchanger is recommended.

Manufacturing Defect

Some manufacturers have a reputation for heat exchangers with short life expectancies. With some of these units, the manufacturer will replace the heat exchanger; however, in many cases, the furnace has to be replaced at the owner's expense.

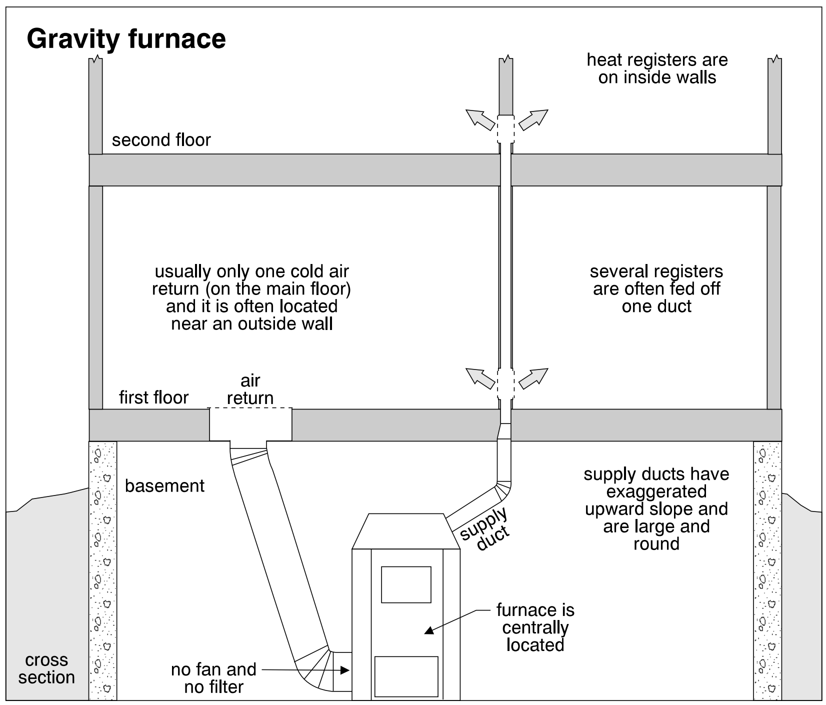
Improper Fuel Conversion

When conversion from oil to gas became popular, there were some oil furnaces which should not have been converted but were. These are oil furnaces with a secondary heat exchanger. These systems worked well on oil, as the secondary heat exchanger, located above the blower, preheated the return air from the house before it went into the main portion of the furnace.

Unfortunately, since gas burns at a lower temperature than oil, this arrangement tended to cause condensation inside the heat exchanger above the blower. This section would rust out, allowing exhaust gases to be drawn into the air supply for the house. These furnaces should be replaced with furnaces designed for gas. Other furnaces are not suitable for conversion to gas for other reasons. Where there is any doubt, a qualified service representative should be consulted.

12.2 Gravity Warm Air Furnace: Gravity furnaces are often known as "octopus" furnaces because of the large round ductwork that emanates from the body of the furnace.

The mode of operation of an octopus furnace is similar to a conventional furnace except there is no fan to draw house air to the furnace, blow it through the furnace, and push it out of the air registers in the house. Instead, the system works on gravity (convection) relying on warm air to rise through the supply ducts and cool air to settle back through the return duct to the furnace.



Almost all gravity warm air furnaces are obsolete and even if the heat exchanger has not failed (which would require immediate replacement of the furnace) a good argument can be made for replacing the unit because of the inefficiency of the system. Reduced heating costs would pay for a new furnace in a few years.

Ductwork Modifications

Octopus furnaces are usually located in the middle of the basement. The large round ducts have to slope up from the furnace to the supply registers, allowing the warm air to rise by convection. Ductwork is modified when an octopus is replaced because the old round ductwork which takes up a lot of space is not necessary with modern furnaces. New furnaces are more compact and can be located along a wall, usually close to the chimney. Since a fan forces air through the ducts, the ducts can be smaller, rectangular and run along the ceiling horizontally, opening up the basement space.

12.3 Blower/Blower Motor: The air movement section of a furnace consists of a blower and motor. This section of the furnace is responsible for drawing return air back from the house to the furnace, pushing the air past the heating section of the furnace and back out the supply air registers within the rooms. The most common problems with these components are burned out motors and worn bearings.

On some newer systems, the motor is mounted within the blower and drives it directly. On older systems, however, the motor is external to the blower and drives it via a pair of pulleys and a belt. Belts and pulleys are often in need of adjustment.

If furnace filters have been missing for some time, blowers get extremely dirty. A dirty blower moves less air, making the furnace work harder and the house less comfortable. Dirt build-up can also cause the blower to get out of balance. This will cause excessive noise and vibration. Sometimes, vibration causes the entire blower unit to become loose. In other cases, the blower bearings may fail.

12.4 Humidifier: Most central humidifiers are relatively inexpensive pieces of equipment added to forced-air furnaces. Their purpose is to raise the humidity levels within the house during the heating season. If too much humidity is added, however, condensation forms on windows and on other relatively cool house surfaces. Condensation can also form inside wall and ceiling cavities, causing rot and deterioration.

Humidity Levels

Unfortunately, the ideal humidity level for the house is not the same as the ideal humidity level for people. People tend to appreciate higher levels than are desirable from the house's perspective. To prevent condensation and mildew, the following should be observed:

Outside Temperature	House Humidity Level
-20 degrees F.	15%
-20 to -10 degrees F.	20%
-10 to 0 degrees F.	25%
0 to +10 degrees F.	35%
+10 and above degrees F.	40%
Summer months	Off

Humidifier Types

There are several different types of humidifiers. The most inexpensive type consists of a tray with evaporative pads. Some of these units are designed so that the tray sits inside the plenum, immediately over the heat exchanger, while others are designed so that the tray sits outside the plenum beside the furnace. These are generally low quality humidifiers that allow for no control over humidity. When the furnace is on they are humidifying; when the furnace is off, they are not. The units that sit inside the plenum are particularly troublesome, in that they tend to leak and drip onto the heat exchanger. This can cause premature rusting of the heat exchanger and failure of the furnace.

Location

Drum type humidifiers are perhaps the most common type. They should be mounted on the return air ductwork with a bypass duct to the supply plenum. These units have controls and the previously recommended humidity levels should be followed.

Adjustment Drum type humidifiers have several common problems. The water level often requires adjustment. Without proper adjustment, the tray overflows which can cause damage to the furnace. The tray sometimes overflows because mineral deposits foul the automatic water supply valve, causing it to stay open, even when the tray is full. The drum pad itself tends to clog up with mineral

Leaks deposits seizing the drum, which in turn burns out the motor. Replacement parts for these humidifiers are readily available. The water supply connection to the supply plumbing pipe is a common leakage point.

Duct Damper Where central air conditioning is found, a humidifier duct damper should be present. This damper should be kept closed during the cooling season to prevent air conditioner coil ice-up.

Trickle Atomizing And Steam Humidifiers Trickle (cascade) type humidifiers that allow water to fall over a special pad are usually high quality units. The water that is not evaporated is collected and flows to a drain. Atomizing humidifiers and steam generating units are also high quality and are rarely seen residentially. These higher priced units tend to work well; however, they are expensive to install. Due to their design, the inner workings cannot be inspected during a visual examination.

12.5 Conventional Air Filter: There are several different types of conventional air filters; however, they all perform the same function - to filter the air before it travels into the furnace and out through the registers. Conventional air filters sit in the return air plenum, just upstream of the blower. Some are cleanable while others are disposable. Regardless of the type, they should be checked monthly.

Conventional air filters are inexpensive. It is a wise practice to replace or clean them regularly. Clean filters improve the comfort of the home and help to reduce heating costs.

Non-combustible filters should be used in furnaces where the exhaust pipe passes through the return air portion of the furnace.

12.6 Electronic Air Filter: Electronic air filters clean the air to a much greater extent than conventional mechanical filters. Because they help to remove pollen and cigarette smoke particles, these are good units for people who suffer allergies. The units have a preliminary mechanical filter to remove larger airborne debris. The smaller particles which get through the filter are electrically charged and then collected on plates of opposite polarity. When one hears an intermittent sparking or crackling noise, the unit is functioning properly.

Cleaning Because electronic air filters are extremely efficient, they get dirty quickly. They should be checked or cleaned once a month. The manufacturer's cleaning directions should be followed carefully. (Some can be placed in the dishwasher.) Care should be taken when removing the components from the ductwork as there is potential for an electric shock due to the electrical charge which is built up within these units. The power to the unit should be turned off about thirty seconds before opening the filter compartment. The furnace fan should also be turned off before servicing the filter.

When the removable components are put back in the ductwork, care must be taken to ensure that they are installed in the right orientation. An arrow indicating air flow should point toward the blower. Approximately ten percent of the filters noted during inspections have been installed backwards.

Activated charcoal filters to help absorb odors are sometimes added to electronic air filters. These are usually in a metal frame, just downstream of the electronic filter collector plates.

From a visual inspection it is not possible, in all cases, to determine whether a unit is malfunctioning or simply in need of cleaning. In some cases, the power supply has been interrupted and simply needs to be reactivated.

Settings

12.7 Fan/Limit Switch: The fan/limit switch is essentially a temperature sensor. It measures the temperature of the air within the furnace above the heat exchanger. For normal operation, it is designed to turn the blower on and off at pre-set temperatures. When the furnace is operating in the autornatic" mode, it will not blow cold air through the registers because the fan/limit switch won't turn on the blower until the air in the furnace is up to temperature (130 - 150 degrees F.). It will also continue to blow after the burner has shut off as long as the temperature in the furnace is relatively high (90 - 110 degrees F.). In this way, residual heat in the furnace is distributed through the house. (Some modern furnaces use a simpler control for the fan, which times it to come on two or three minutes after the burner, and shut down two or three minutes after the burner.)

Override

Most fan/limit switches have a manual override button which allows for continuous fan operation. In houses with central air conditioning or a heat pump, this manual override function is often abandoned as this can be accomplished by a switch on the thermostat.

High Limit

The most important function of the fan/limit switch is to shut down the furnace if the temperature of the air gets too high (170 - 200 degrees F.). This may be due to an inoperative fan or crack in the heat exchanger, for example. In this sense, it is a safety device. Some units have a separate high limit switch.

Problems

Sometimes, fan/limit switches are out of adjustment, causing the furnace or the blower to short cycle (turn on and off at short intervals). If this is the case, the unit should be adjusted. Other causes of short-cycling include thermostat and heat exchanger problems.

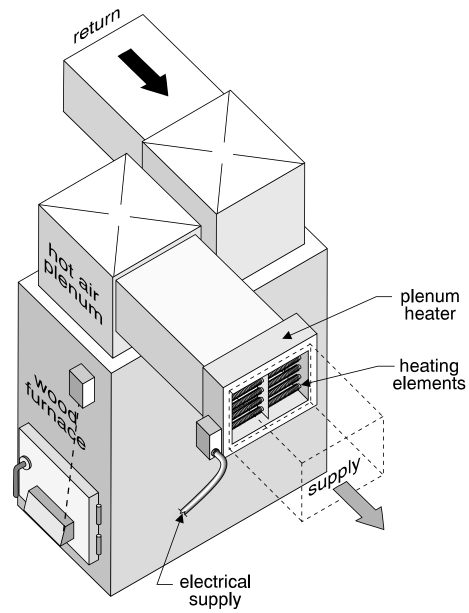
If the limit setting is too high, or the switch is defective, the furnace can overheat. In some cases, this can cause a fire by igniting dust inside the ductwork or combustible materials nearby. This system should always be checked during regular furnace servicing.

12.8 Electric Plenum Heater: Some forced-air fuel burning furnaces are equipped with an auxiliary electric plenum heater. Electric plenum heaters are not designed to work in conjunction with the furnace. Normally, they are arranged so that the electric plenum heater will first try to satisfy the heating demands of the house. If it cannot keep up, the plenum heater will switch off and the furnace will come on. Electric plenum heaters are most commonly found on oil-fired furnaces. Much like electric furnaces, heating elements can burn out. These can be replaced.

In houses with small (60-amp) electrical services, electric plenum heaters (typically 9 kilowatts and 37.5 amps) may be controlled by a device which will shut them down if there is a high demand for electricity in other portions of the house.

An inoperative plenum heater may be due to a burned out element, malfunctioning controls, or may simply be shut down by the device which senses the use of too much electricity in other parts of the house (in which case it is not malfunctioning). If the furnace is operating, the heater cannot be tested.

Plenum heater



► 13.0 HOT WATER HEATING SYSTEMS

13.1 Boiler (Heat Exchanger): It should be noted that while hot water heating systems are called boilers, they do not actually boil the water, they only heat it to about 160°F., typically (steam heating systems, discussed in 17.0 of this section, actually do boil the water). Some hot water boilers have been converted from steam. This may not be determined during a home inspection. A boiler consists of a burner and a heat exchanger. The burner simply generates heat within a combustion chamber. The heat exchanger allows the heat from the flame to pass through it and heat the water on the other side of the heat exchanger. The heat exchanger is the most critical component of the boiler. When a heat exchanger fails, it rusts through or cracks and allows leakage into the combustion chamber or leakage through the exterior casing of the boiler.

Heat Exchangers

Heat exchangers in boilers can be made of a variety of materials. Some are cast iron, while others are copper or steel. Heat exchangers in old, heavy cast iron boilers have a life expectancy of thirty-five to fifty years, although there are exceptions which last up to eighty years. It is not possible from a visual inspection to determine how many years of life remain in these boilers. They do not fail like clockwork.

Most newer, lighter boilers, regardless of the material used in the heat exchanger, have an average life expectancy of twenty to twenty-five years. There are exceptions to this rule and some steel boilers have life expectancies of only ten to fifteen years.

In some cases, a rusted heat exchanger which is leaking can be repaired; however, in most instances this is not the case, and a new boiler is needed.

13.2 High Temperature Limit: The high temperature limit is a safety device which is intended to shut off the boiler if the water within the system reaches a temperature of approximately 200 degrees F. The word boiler is actually a misnomer as boilers do not raise water temperature to the boiling point (unless it is a steam system). The high temperature limit prevents the boiler from boiling. Boiling water builds up pressure which may rupture the boiler or piping. One common problem with these units is leakage at the point where the high temperature limit is mounted. Secondly, the unit itself can require recalibration or repair.

Closed Systems

13.3 Expansion Tank: (For an explanation of open and closed systems, refer to 4.0 in this section.) When heat is applied to the water in a heating system, the water expands. The expansion tank or cushion tank provides space for the water to expand into. Under normal circumstances, the expansion tank is partially filled with water. The remainder of the tank contains trapped, compressed air. As the water in the system beats up and expands, it consumes some of the space occupied by the air, by simply compressing the air further. Air is easily compressed, water is not. The expansion tank is normally mounted in the basement, above the boiler.

Tank Waterlogged

If the expansion tank has no air in it, (in other words, the tank is waterlogged) it has no capacity to accept more water. When the boiler comes on and the water in the system is heated up, the pressure in the system rises to the point that the pressure relief valve operates. Therefore, a leaking or dripping pressure relief valve may mean a waterlogged expansion tank.

Since the air in an expansion tank eventually gets absorbed into the water, expansion tanks have to be drained periodically to prevent them from becoming waterlogged.

Some modern expansion tanks have a diaphragm in them, which prevents the water from coming in direct contact with the air. Therefore, the air is never absorbed into the water and unless the diaphragm fails, the tank will theoretically never become waterlogged.

Open Systems

On some older heating systems, the expansion tank is located on the top floor of the house, above the level of the highest radiator. In these systems, the expansion tank is commonly found in a closet. These systems are called "open" systems and are not pressurized. The top of the expansion tank has a pipe which should discharge to the building exterior or floor drain. If the system overflows, the expansion tank simply discharges water out of the pipe (often onto the roof).

On some of these open systems, the pipe from the expansion tank to the building exterior has been disconnected. They often terminate in the attic. If the system should overflow, a considerable amount of water damage can occur in the house.

With the exception of periodic draining, expansion tanks are maintenance free. Some expansion tanks, however, do require replacement when they rust through and leak.

13.4 Pressure Relief Valve: The pressure relief valve is a safety device which prevents the pressure within the system from exceeding a pre-set limit (usually thirty pounds per square inch). Because the water which could discharge from a pressure relief valve in an emergency situation would be extremely hot and under relatively high pressure, the discharge from the pressure relief valve should be piped down to a distance of approximately six inches above the floor. This reduces the risk of scalding anyone nearby.

Pressure relief valves often leak. Sometimes this is due to a defective valve seat or debris caught on the valve seat. These problems are easily rectified. Often, a leaking pressure relief valve is reflective of nothing more than a waterlogged expansion tank. (See Expansion Tank above).

Sometimes, pressure relief valves which leak chronically are blocked off. This should never be done, as the relief valve is an essential safety device.

Pressure relief valves are not found on "open" hot water systems.

13.5 Pressure Reducing Valve: On older systems, water has to be added manually from time to time to compensate for leakage, evaporation, and air absorbed from the expansion tank. On modern systems, water is automatically added through a pressure reducing valve. The pressure reducing valve allows water to fill the system on an as-needed basis. It connects the boiler to the plumbing system. It is typically set at approximately fifteen pounds per square inch (higher in some three storey houses). If the pressure within the heating system drops below fifteen pounds, the pressure reducing valve simply adds water from the plumbing system.

The most common problems with pressure reducing valves are leakage and improper adjustment.

Most boilers have pressure gages on them. If the boiler is cold, the pressure gage on the boiler should indicate roughly the same pressure as the pressure reducing valve (12 - 15 psi). If the two numbers are not the same, it could indicate a pressure reducing valve which is out of adjustment or a defective pressure gage. There may also be a closed valve between the valve and gage. If no water discharges after opening a radiator bleed valve on the top floor, this indicates a similar problem.

13.6 Back-Flow Preventer: A back-flow preventer works in conjunction with a pressure reducing valve as part of the automatic water make-up system. The back-flow preventer stops water in the heating system from backing up into the plumbing system. For example, if the water in the plumbing system was drained to repair a faucet, it is conceivable that pressurized water in the heating system could back up into the plumbing system. This would present a health hazard. The back-flow preventer only allows water to flow into the heating system. It allows no water to flow out.

These are not found on all systems, although many municipalities now require them on new or replacement installations. The most common problem with back-flow preventers is leakage.

13.7 Low Water Cut-Out: The low water cut-out is a safety device which shuts off the boiler if the amount of water within the boiler is insufficient. Unfortunately, this device cannot be functionally tested without draining the heating system.

Like most safety controls, the most common problem is leakage. Typically, larger residential systems have low water cut-outs.

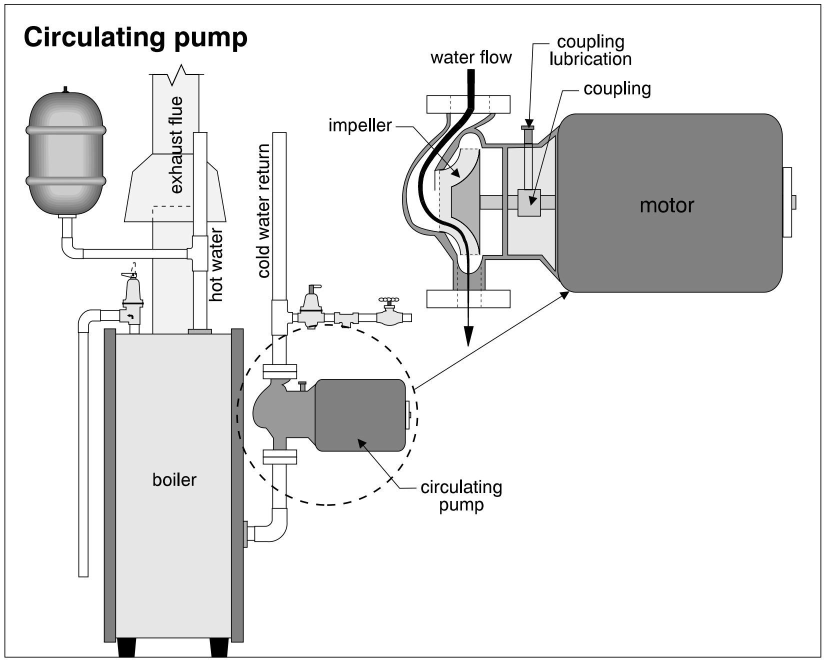
13.8 Isolating Valves: Isolating valves are simply valves for the water leaving the boiler which, if turned off, shut off water to a portion of the house. These valves are not very different than valves in a plumbing system. Most are manually operated, although sophisticated multi-zoned houses with more than one thermostat may have electrically operated valves.

The most common problems are leakage and seizing. Since the valves are not used often, they tend to seize. These valves are not functionally tested during an inspection as the first time a valve has been turned, after sitting for any length of time, it is prone to leakage.

13.9 Circulating Pump: The circulating pump on a hot water heating system is the equivalent of the blower on a forced-air system. Its responsibility is to move the heated water through the house. On older systems, this is done by gravity (convection); however, on newer or updated systems, a circulating pump moves the water more efficiently. "Open" systems do not employ circulating pumps. (Open and closed systems are discussed in 4.0 of this section.)

Depending upon the type of boiler, the circulating pump is designed to run continuously, or intermittently when the water in the boiler is above a certain temperature. Others operate only when the boiler is operating. This last arrangement is the least desirable.

The most common problems associated with circulating pumps are leakage, worn pump bearings, burned out pump motors and defective temperature sensors which control the pump.



Many modern boilers (e.g. copper tube boilers) have a safety interlock that prevents the boiler from operating unless the pump is running. These boilers would quickly overheat if water was not flowing through them.

► 14.0 GENERAL

Physical Condition

14.1 Exhaust Flue: The exhaust flue on any heating system is designed to carry the exhaust gases to the chimney from the furnace. They are typically a single wall galvanized steel pipe, six inches to ten inches in diameter. They should not be aluminum. Sections should be screwed together. Problems include poor connections, corroded metal, and improper slope. Flues should not extend into the chimney far enough to obstruct the flow of gases out of the flue and up the chimney.

Length

Depending upon the location of the heating system relative to the chimney, some exhaust flues are too long. Exhaust flues from oil furnaces should be no more than ten feet in length.

Slope

Because exhaust gases are warm, it is important that the exhaust pipe has a proper slope to promote the flow of exhaust gases toward the chimney (minimum of one-quarter inch per foot).

Draft Air

Exhaust Gases

Most furnaces need air to maintain draft up the chimney, in excess of the air needed for combustion. Where this is not available, exhaust gases may not go up the chimney. Exhaust gases spilling from the exhaust flue, draft hood or burner area, may present a life threatening situation. This problem requires immediate action.

Clearance to Combustibles

Exhaust flues become extremely hot. Exhaust gases can be 300-700 degrees F. They are often too close to combustible surfaces. A minimum of nine inches clearance should be provided for oil furnaces and special collars should be used where the exhaust flue passes through a combustible material. Gas furnace flues should be at least six inches from combustibles.

High Efficiency Systems

Exhaust from high efficiency boilers and furnaces is handled quite differently. The exhaust gases have a much lower temperature (roughly 140 degrees F.) and are usually discharged through a plastic pipe to the building exterior. Most high efficiency heating systems have induced draft which means there is a fan drawing the exhaust gases out of the furnace.

Mid-Efficiency Systems

Some mid-efficiency furnaces also discharge exhaust gases out through the house wall. These gases are relatively hot, and combustible clearances (six inches) must be maintained on stainless steel exhaust flues. These flues can run as much as forty feet inside a house, depending on manufacturer's recommendations.

High Temperature Plastic Venting

Some mid-efficiency furnaces and boilers use high temperature plastic venting. In some jurisdictions, the sale of these materials, namely Plexvent, Ultravent and Sel-Vent, has been prohibited due to cracking and separation of joints. Some home owners have been forced to replace the entire furnace because no approved replacement vent pipe was available.

14.2 Gas Burner: The most common gas burners are point source burners, ring burners and ribbon burners. Burners get dirty and the small orifices (particularly on ribbon burners) plug with debris. Burners also become misaligned and the flame does not point in the right direction. Burners can also rust.

Dirty Misaligned Rusted

Incomplete Combustion

The air supply can be restricted if the burners are in a small closed room or if the burners are dirty or incorrectly adjusted. This results in incomplete combustion, higher heating costs, and, in some cases, condensation problems. In severe cases, carbon monoxide poisoning may occur. See Section 14.5. This is a life threatening situation.

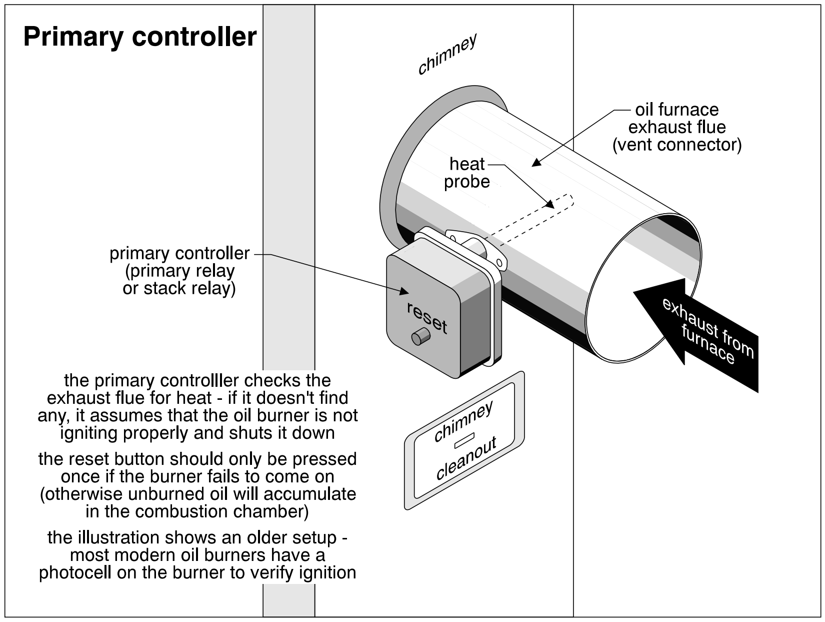
Flashback

On some heating systems (particularly with ribbon burners) "flashback" is a common phenomenon when the system first starts up. While this is not a problem with the burners themselves, the resultant damage is caused by the burners. In a flashback situation, some of the ignited gas spills out of the front of the heating system. Heat shields, provided on most systems, prevent any serious damage under these conditions; however, in extreme cases, control wiring and other components of the heating system have been badly burned. If there is any evidence of scorching or burning outside the combustion chamber, a specialist should be contacted.

14.3 Oil Burner: Oil burners consist of a fan to force air into the combustion chamber, a pump to force oil into the combustion chamber, a nozzle to convert the oil to a fine mist, and an ignition system to ignite it. During a visual examination of a heating system, very little of the oil burner can be inspected, due to its design. Problems can occur with any of these components and a specialist should be contacted.

Even burners which are working may be burning very inefficiently, and heating costs will rise. Oil burners should be serviced annually. Old systems should have an annual efficiency test. Efficiency cannot be tested during a home inspection. Burners starved for air will be costly to operate and may generate dangerous carbon monoxide gas.

14.4 Primary Control: The primary control is found on most oil-fired heating systems. It is a device which is mounted on the exhaust flue in most cases. The primary control is a safety device which senses the temperature in the exhaust flue. Its purpose is to verify combustion. If the oil burner is pumping oil into the furnace and the primary control senses no heat in the exhaust pipe, it concludes that the oil being pumped into the furnace is not being ignited and it shuts off the pump. Most primary controls have a reset button on them. It should



be pressed only once if the furnace fails to ignite. Pushing the reset button several times could allow an unsafe accumulation of oil in the combustion chamber. Some newer oil burners use a cadmium sulfide “eye”, or photocell, on the oil burner that verifies ignition.

Combustion and Draft Air

14.5 Combustion Air:

All fuel burning systems need air to mix with the fuel. Therefore, if the furnace or boiler is in an enclosed room, ventilation should be provided. Draft air is also needed to ensure the exhaust gases will be carried up the chimney. As a rough rule, fifteen cubic feet of combustion air and fifteen cubic feet of draft air are required to safely burn one cubic foot of natural gas. This is normally accomplished by providing grilles in the furnace room door. Two square inches of ventilation should be provided for every 1,000 BTU’s (input capacity). Ideally, half the ventilation is near the floor, and half is near the ceiling.

Outside Air

Some heating systems use combustion air brought in from the exterior. This is done so that the air burned during the combustion process is cold outside air, rather than air which has already been heated. Using air which has been heated is wasteful, since it costs money to warm the air, and cool air actually burns better. Houses which are tightly sealed to improve energy efficiency may require outside combustion air, to prevent starving the burner for air.

With most of these arrangements, the furnace room becomes cold during the winter and freezing pipe problems can occur if there is any plumbing in the furnace room. Freezing heating pipes can also be a problem, if the heating system should happen to malfunction.

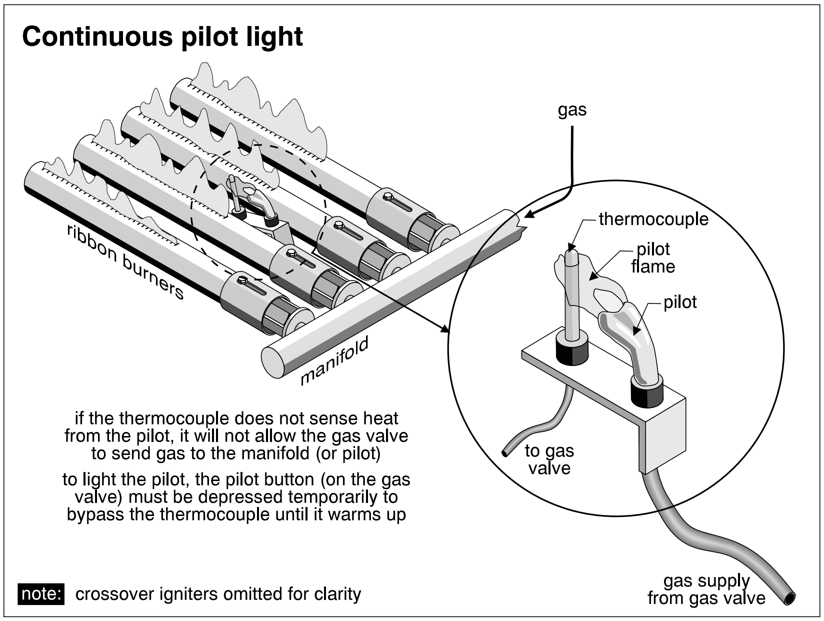
Furnace rooms which bring in outside air should be well insulated to keep the rest of the basement comfortable.

High Efficiency Furnaces

Some high efficiency furnaces bring outside air directly into the burner through a closed pipe. This avoids the cold furnace room problem. An adequate supply of air is verified by the pressure sensors in the furnace, before the burner is allowed to fire.

14.6 Pilot/Thermocouple: Many gas-fired heating systems have a continuous pilot. The pilot lights the burner when the gas valve opens. In conjunction with the pilot is a thermocouple which simply proves ignition. If the thermocouple is not satisfied, the gas supply to the pilot is shut off, and the main gas valve will not open. Thermocouples are prone to failure, but are easily replaced by a heating specialist.

There is great debate over whether a continuous pilot should be left operating during the summer time. One school of thought suggests that the heat from the pilot provides some warmth for the system and prevents condensation in damp basements, thereby extending furnace life. The other school of thought is that a pilot running all summer long is a waste of energy. The debate continues.

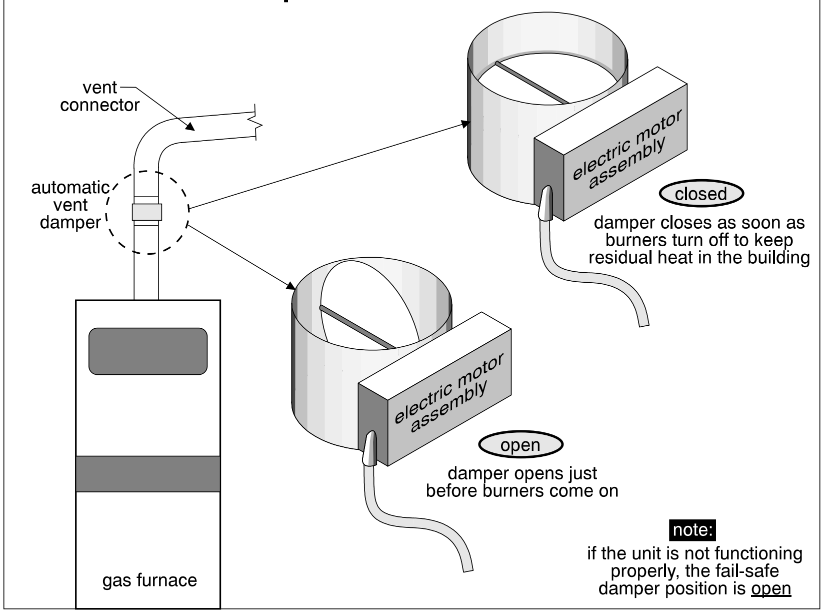


Some newer heating systems have an intermittent pilot which is ignited by a spark plug. Pilot ignition is then verified by a thermocouple. On some systems, if the pilot does not light after a few attempts, the whole system shuts down. This can create problems if the house is vacant as freezing pipe problems can ensue. Adjustment of the pilot or thermocouple will usually rectify this problem.

14.7 Pilotless Ignition: Oil-fired systems and some mid and high efficiency gas systems do not have a pilot. On these systems, a spark or hot surface ignition system (a spinning "grinding wheel" which glows white hot) is used to ignite the fuel when heat is called for. These systems contain a safety device which shuts down the entire heating system if ignition is not proved after a certain amount of time. Depending upon the arrangement of the system, some will try again after a certain period, while others will not. This can pose a problem in an unattended house as the heat can be off for long periods of time until the problem is discovered.

14.8 Motorized Vent Damper: Vent dampers are commonly found on mid efficiency gas-fired heating systems. The vent damper closes off the exhaust flue when the heating system is not in use, to prevent warm air from the house escaping up the chimney. This does not affect the steady state efficiency but

Automatic vent dampers

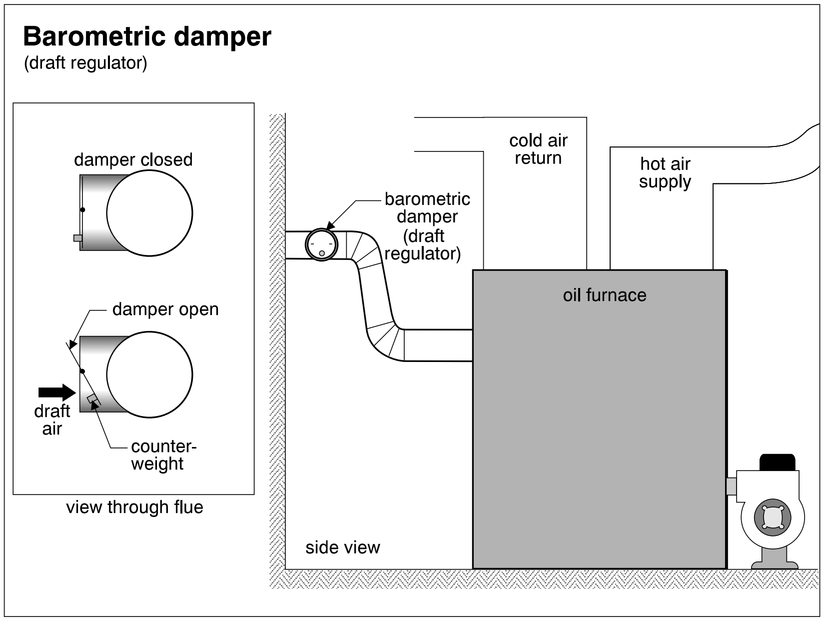


improves the seasonal efficiency. These systems are designed to be fail-safe. In the event the vent damper does not open, the furnace or boiler will not come on (if it did come on, all of the exhaust gases would end up in the house).

Vent dampers spend their time in a corrosive environment and therefore are prone to failure. They should be checked annually. Some experts suspect that their life expectancy can be as short as three years. Vent dampers cannot legally be retrofitted onto existing heating systems. They are approved for gas furnaces only, in some areas.

14.9 Induced Draft Fan: Some mid-efficiency and most high efficiency systems employ an induced draft fan on the exhaust side of the furnace or boiler to pull products of combustion through the unit. This helps to ensure good draft, and reduces heat loss during off cycles, because the fan, at rest, restricts the flow of air to the outside. Again, because of their working environment, these fans have a high failure rate and should be serviced annually.

14.10 Barometric Damper: Barometric dampers are found on oil-fired systems and forced draft gas systems. The barometric damper allows for constant draft in the chimney when the system is on. Air from the basement is drawn into the exhaust flue, but exhaust gases are not allowed to escape out of the flue. The barometric damper is mounted on the exhaust flue and looks like a round swinging door. Barometric dampers are often corroded, out of adjustment, or simply inoperable. They are inexpensive items which are easily repaired; however, they should be maintained in good condition.



14.11 Clearance From Combustibles: The exhaust pipes on conventional oil heating systems should be a minimum of nine inches from combustible surfaces. A six inch clearance is required on gas furnaces. B-Vents (insulated flue pipes) require a one inch clearance. Three inches of air space should also be maintained between the plenum (supply ductwork section immediately above the furnace) and combustible surfaces. Clearances are also required from the sides and rear of the heating plant itself. These clearances vary from unit to unit. On modern systems, the information is given on a plate attached to the boiler or furnace.

14.12 Refractory (Fire Pot): Refractory is found in some boilers and furnaces. It may be a similar material to firebrick found in fireplaces and, in some cases, is firebrick. Its purpose is to protect the other components from direct contact with the flame. Refractory deteriorates with time and exposure to flame and requires repair or replacement from time to time. It is often not visible without dismantling the system or breaking a mortar seal.

14.13 Condensate Line: On high efficiency heating systems, the products of combustion are cooled to the point where condensation forms. This condensate (water) must be collected and must flow to a drain. Sometimes, the drain lines are plugged or poorly installed.

Some cities require the condensate to be neutralized before it goes into the drains. (It is somewhat acidic and some local authorities fear it may deteriorate some types of city drain piping.) Neutralizing kits are available through furnace manufacturers.

14.14 Condensate Pump: If a condensate line (Refer to 14.13 in this section) cannot flow by gravity to a drain, a condensate pump must be installed. The pumps are relatively inexpensive; however, they are a high maintenance item as they tend to fail with great regularity.

14.15 Gas Valve: On gas-fired heating systems, the main gas valve is one of the Most important components. It contains most of the brains of the heating system. Its operation is simple. It is designed to open and allow gas into the combustion chamber; however, it uses feedback from several safety devices to determine whether it is safe or appropriate to allow gas into the combustion chamber. The reliability of gas valves is high. Replacement is neither difficult nor terribly expensive.

White-Rodgers 36B

A particular White-Rodgers gas valve has been known to cause overheating problems as a result of an intermittent malfunction. The valve in question is a White-Rodgers 36B series. Valves which are date coded 7630 through to 7752 are the ones which are considered to be problematic. If any Model 36-B gas valve is present, a heating contractor, the furnace manufacturer, or the valve manufacturer should be contacted.

14.16 Heat Shield: A heat shield is found on some conventional forced-air furnaces. It is located at the point where the ribbon burners project into the heat exchanger. In many cases, the heat shield is loose, rusted, or missing. If this is the case, it should be repaired or replaced. The heat shield is not normally removed during a home inspection.

14.17 Chimney/Chimney Liner: Not all heating systems require a chimney. Electric heating systems do not as there are no products of combustion. High efficiency, and some mid-efficiency heating systems have an exhaust pipe which does not connect to a chimney.

Metal

The majority of heating systems are, however, connected to a chimney. The chimney can be metal or masonry. Modern houses often have metal furnace chimneys (which are actually Class B vents). With time, the corrosive exhaust gases can deteriorate a metal chimney. Metal chimneys more than ten years old should be inspected carefully. Other problems with metal chimneys include poor connection of sections, poor support for the chimney, missing rain caps, and inadequate clearance from combustibles (one inch is required for Class B vents). Rain caps for metal chimneys have changed over the last fifteen years. Newer designs are less susceptible to corrosion. The metal itself is also changing on newer systems.

Masonry

Masonry chimneys can be lined or unlined. An unlined masonry chimney simply has brick or concrete block on the interior. While this is suitable for most oil furnaces, it is not suitable for the vast majority of gas furnaces. Most gas furnaces require a chimney liner to protect the masonry from the exhaust gases. The liner can be metal, clay pipe, or asbestos cement pipe.

Shared Chimneys

In attached housing, it is common for two houses to have one chimney. Each home has one flue, typically. When repairs to the masonry are required, the cost is often shared. Where this situation exists, the neighbor should be consulted prior to starting chimney work.

Shared Flues

A furnace and a fireplace, for example, should not share a single flue in a chimney. For more information, see 8.9 in the Interior Section.

Safety

14.18 Chimney Clean-Out: Chimney flues without metal liners should have a clean-out door at the base of the chimney to remove debris. If debris is allowed to build in the bottom of the chimney, it could eventually block off the exhaust flue for the heating system, and cause exhaust gases to back up into the house. This is an unsafe situation. The frequency of cleaning will depend on the rate of accumulation of debris in the base of the chimney.

Liner

If a considerable amount of debris consisting of mortar, sand and small pieces of brick continue to accumulate in the base of the chimney, a liner should be considered to prevent further chimney deterioration. A specialist should be consulted.

14.19 Thermostat: The function of a thermostat is to turn on the heating system when the temperature near the thermostat is lower than the desired thermostat setting, and shut the system off when the desired temperature is reached.

Location

The location of a thermostat is critical. It should not be placed in areas where there are drafts, a heat source such as a fireplace, or a heating duct in the wall behind the thermostat. It should not be placed behind doors, on outside walls, or in areas where it is likely to receive a considerable amount of direct sunlight. All of these factors can fool the thermostat into thinking the house is warmer or cooler than it actually is. Relocating a thermostat is not a difficult job.

Set-Back Feature

Many modern thermostats have set-back functions which allow the temperature to be lowered during periods when the occupants are away or sleeping. As a general rule of thumb, the maximum set-back employed should be no more than nine degrees Fahrenheit as cooler temperatures create higher relative humidity levels which can result in condensation problems. Also, some heating systems (particularly hot water systems) are not capable of returning the house to its original temperature in a reasonable amount of time if the set-back is too large.

Blower Control

Some thermostats have a control for the blower on forced-air systems. They allow for the blower to work automatically (coming on only when the furnace is on) or continuously. Continuous operation is normally used when an electronic air filter has been provided, as it allows for a constant cleaning of the air within the house.

Problems

Thermostats can function improperly if they are dirty, not level, or improperly calibrated. They can also suffer mechanical damage. Most thermostats contain an anticipator which is a device which prevents overshoot. Overshoot occurs when the heating system heats the house to a higher temperature than the thermostat is calling for. The anticipator must be calibrated to the specific furnace or boiler. If it is not, overshoot or short cycling may occur.

Location

Leaks

Abandoned

14.20 Oil Tank: Oil tanks should be 10 feet from burners. Oil tanks are usually maintenance free; however, leaks can occur in the tank, filter and oil line leading to the burner. Leaking filters and lines can be easily repaired or replaced; however, repairing a leaking tank is seldom done. Most are replaced. Some tanks are located outdoors underground. Inspection of these is not possible during a home inspection.

Condensation

Leakage from tanks is usually the result of rusting which occurs due to water in the tank (from condensation). It settles to the bottom of the tank as it is heavier than oil. This is where most of the rusting occurs. It is best to keep the tank full during the summer months to keep condensation to a minimum.

14.21 Electric Elements/Wiring: Most electric furnaces and boilers have multiple heating elements. The average size for a single element is roughly five kilowatts. Heating elements in electric systems are much like car headlights. They burn out from time to time, however, it is impossible to predict when this will happen. Most electric furnaces and boilers are designed with a sequencer to turn on the heating elements one by one, so that they don't all come on at once and create a large electrical surge. Sometimes, sequencers or relays malfunction which may lead one to believe that an electrical element is burned out when in fact it is not. Therefore, this should be checked by a qualified technician.

The wires leading to heating elements and various controls sometimes overheat in electric furnaces. Any burned wires or components should be replaced.

14.22 Fuses/Breakers: Most electric furnaces and boilers have built-in fuses or breakers. Under normal circumstances, these should not trip or blow. If they do, a specialist should be consulted. The main fuses or breakers at the electrical panel may also cut off power to the furnace or boiler.

14.23 Electric Heaters: Some houses are heated entirely by electric heaters, while others employ electric heat as a supplement to the main heating source. Electric heaters are much like automobile headlights. It is impossible to tell when one is likely to burn out. Fortunately, most are easily replaced.

Electric heaters can be missing, undersized, damaged, rusted, dirty or wired incorrectly. The thermostat can also be defective. Heaters designed to operate at 240 volts can be incorrectly wired at 120 volts. They will not work as efficiently as they should. This will not normally be picked up on a home inspection.

Many basements with warm air furnaces have heating supply registers overhead. These areas often prove to be cool since warm air rises. The heat from these registers lingers near the ceiling level and escapes up to the main floor. One of the common cures is to add electric baseboard heaters to augment the supply. Similar improvements can be made in houses with hot water heating, where some rooms have no radiators, or rads on the ceilings. Relocating the main heat source down to near floor level is another approach.

14.24 Heat Recovery Ventilators: Heat recovery ventilators are also known as air-to-air heat exchangers. They are typically used in houses where increased ventilation is required and there is a desire to recover some of the heat from the air which is being discharged from the building.

UFFI

Heat recovery ventilators are often used in houses which have been insulated with urea formaldehyde foam insulation, in order to increase the number of air changes in the house. Sometimes, the house is kept under positive pressure to help expel formaldehyde gases.

In Energy Efficient Houses

They are also used in energy efficient houses where the number of natural air changes is so low that mechanical ventilation must be provided. Normal minimum requirements call for one third to one half air change per hour.

Indoor Pools Heat recovery ventilators are commonly used with indoor swimming pool heating systems because many air changes are needed to reduce humidity.

Principle of Operation One or more blowers move air across a heat exchanger transferring heat from the air being exhausted to the incoming air.

Connections The fresh air duct should not be directly connected to the return air duct of the furnace unless recommended by the manufacturer. A gap between the fresh air duct and a grill on the return air duct should be maintained to avoid unbalancing the airflow and to allow for tempering of the cool air. This may not be needed if the fan is kept on at high speed.

Intake and Exhaust Hoods The intake and exhaust hoods on the exterior should be at least six feet apart and three feet from the corner of the building. The intake hood should be at least eighteen inches above grade and at least three feet away from driveways, gas meters or any exhaust vents. The exhaust hood should be at least eight inches above grade.

Problems Blowers and motors will wear out. Filters can be clogged or missing, resulting in clogging of the heat exchanger. Defrosting cycles can go awry, condensate trays and lines can plug or leak. In corrosive environments, damage can occur to the heat exchanger unless it was specifically designed for that environment.

► 15.0 DISTRIBUTION

Register Location **15.1 Supply Ducts/Registers**: Every habitable room should have at least one supply register. Supply registers should be located near exterior walls, below windows. However, it is often not cost-effective to relocate existing registers.

Problems Common problems with supply ducts and registers are air leaks, disconnected or obstructed ducts, dirty ducts, ducts sized adequately for heating but inadequate for air conditioning, ducts sized for conventional furnaces, but inadequately sized for high efficiency systems, and unbalanced ductwork (too much air coming through one register and not enough air coming through another). Rooms without return registers may be cool if the door is closed. Supply ductwork adds warm air until the room is pressurized. Then the flow stops. Cutting 3/4 inch off the door bottom allows the air to circulate.

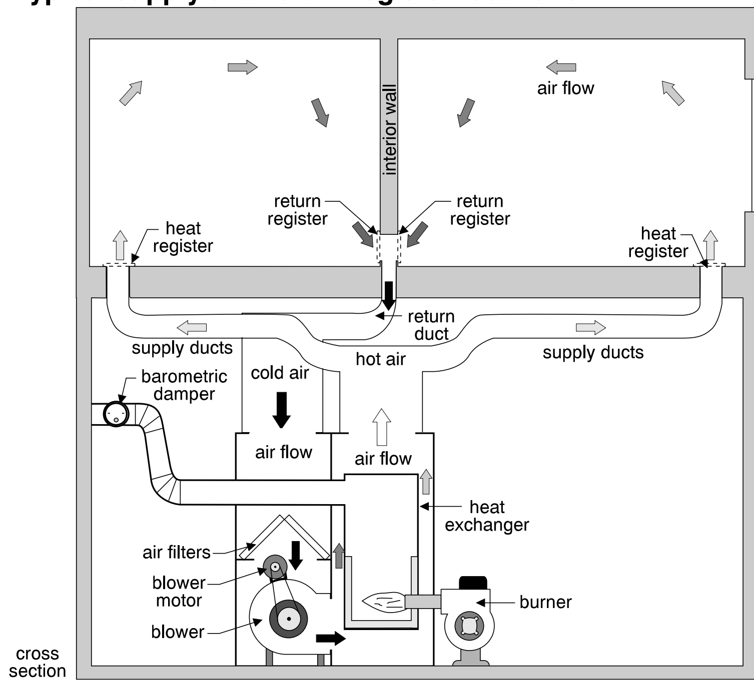
Undercut Doors

Registers Air registers are often missing, broken, or painted shut. They are easily replaced. Supply registers should not be located in garages, since automobile fumes may enter the house when the system is not operating. Many basements have supply registers at the ceiling level only. If the basement is to be finished, it is best to relocate the registers near floor level, since heat rises. If this is not done, the room can feel cool during the winter. An alternative is to provide auxiliary electric baseboard heat.

Gravity Furnace Ductwork modifications are required when replacing a gravity warm-air furnace with a modern furnace.

Heating Ducts in Concrete Slab-on-grade houses with forced-air heat often have heating ducts embedded in the concrete foundations and slab. Sometimes the ducts are partially collapsed during the concrete pouring process. Moisture in and around the slab can flood the ducts and rust the metal duct walls. The water standing in the ducts can become a health hazard. Rusted duct walls can come loose and collapse. Any of these will restrict at least some air flow through the system. Ductwork in poured slabs and foundations is, of course, difficult to inspect and repair.

Typical supply and return register locations



15.2 Return Air Registers: Ideally, every room which has a supply register should have a return air register; however, this is almost never the case. In many older homes there are one or two centrally located return air registers. Rooms which have supply air registers and no return air registers should have doors which are undercut somewhat, so that air can escape from the room back to the return air register, if the doors are closed. The total supply register area should be equalled by the total area of the return air registers. It is common in older homes to find inadequate return air.

High and Low Levels

In sophisticated and high quality installations, there are often high level and low level return air registers, in some rooms. These systems are set up for air conditioning and heating. During the air conditioning season, return air is taken back to the air conditioning system from high registers, collecting warm air at ceiling height. During winter months when heating is required, floor level cooler air is drawn back for heating. A damper on the lower return air register dictate which register will be in use. Compromise systems in modern houses often have low level returns on the first floor and high level returns on the second.

Return air ductwork is often in need of cleaning as large floor mounted return air registers seem to be a collection place for debris. Older return grills in floors are often broken and may not be safe to walk on, or place furniture on.

Location

Ideally, the supply registers should be located on an outside wall below a window, and the return register should be located on an opposite wall. In some houses, return air registers were provided near the supply air registers. Some of these systems short circuited themselves in that the warm supply air is simply drawn back into the return air register, with little heat going to the room itself. Sometimes, simply blocking off the poorly located return air register will improve heating in a specific room considerably.

Return air registers should not be provided in garages, since automobile fumes may be drawn into the house.

Supply and return registers will not perform if the air flow is obstructed. Carpeting and furniture should be kept clear of air flow paths.

15.3 Radiators/Convectors: At least one radiator or convector should be provided in each habitable room. Most radiators are of cast iron construction. They are heavy and take a considerable amount of time to heat up. By the same token, they take a long time to cool down and, consequently, tend to produce even heat. Convectors, on the other hand, are normally much lighter weight and are designed to transmit heat quickly to the surrounding air. Therefore, the heating within a room containing convectors is likely to be more cyclical than a room containing radiators. This does not pose a problem except in systems where only some radiators have been replaced by convectors. In this situation, uneven heating can be encountered.

Removal

In some houses, radiators or convectors have been removed to allow for changes (to make room for kitchen cabinets, for example). As a general rule of thumb, they are not cost-effective to re-install. It is much easier to install an electric baseboard heater than a radiator. The same is true if one is planning on relocating a radiator. It is probably best to simply remove it and replace it with electric heat.

Radiators and convectors respond more slowly if air movement around them is obstructed. Reflective materials (aluminum foil, for example) behind radiators help direct heat into the living area.

Problems

If air is trapped in a radiator, it will not heat properly. The air can be released through the bleed valve (see 15.5 in this section).

If the radiators on the top floor of a home are not filled with water because there is not enough in the system, the rads will be cold. Correction on an open system means opening the valve to the plumbing system to add more water. The same procedure is used on a closed system without an automatic make-up valve. Where a make-up valve is present, it may be clogged, or the pressure may be set too low.

Other problems include leaks, usually at the control valves (see 15.4 in this section), and cracking, if the water in the system freezes.

15.4 Radiator/Convector Valves: Most radiators or convectors have a valve controlling the water flow through the unit. These valves are used infrequently and, consequently, when they are used, they often leak. These valves are not operated during a home inspection.

Even valves which are left undisturbed are prone to leakage over time. While the valves are relatively inexpensive to replace, the damage from a leaking valve can be extensive. Consequently, they should be inspected on a regular basis. Ideally, repairs should be undertaken during the summer months, as the work requires draining the heating system.

15.5 Bleed Valves: Radiators and most convectors have a small valve at the top to “bleed” off air which gets trapped in the unit. Trapped air reduces the amount of water in the radiators or convectors, reducing its ability to generate heat.

Radiators or convectors should be bled at least annually. The valves are delicate and easily broken. The very small valve openings can be obstructed by dirt or paint. They are prone to seizing or leaking; however, they are easily replaced. This requires at least partial draining of the system.

If no water comes out of the bleed valve after the pressurized air is released, more water has to be added to the system. See 15.3 in this section.

15.6 Piping: The piping on most hot water heating systems is black steel (not galvanized); however, some modern systems have copper piping. Steel piping corrodes, however, the rate of deterioration tends to be slow as the water within the heating system is rarely replaced. Eventually, it becomes chemically inert and, consequently, the rusting process is stopped. Draining the water from a heating system every summer is not recommended, since the pipes will deteriorate more quickly. On occasion, corroded pipes and connections are discovered. They should be replaced on an as-needed basis.

15.7 Motorized Dampers: Some sophisticated warm-air heating systems are zoned. Thermostats in various areas of the house control dampers which open and close, directing air to the areas where heat is needed. As a general rule, motorized dampers in residential installations tend to be neglected and often break down. In many systems, they are abandoned or removed. It is not possible during an inspection to verify the proper operation of zoned systems.

15.8 Zone Valves: On some sophisticated hot water heating systems different areas of the house are controlled by different thermostats. These thermostats will operate motorized valves which open and close to direct hot water to the areas of the house that require heating. As a general rule, maintenance on these valves tends to be neglected and they are often abandoned. It is not possible during an inspection to verify the proper operation of zoned systems.

Another way to get zone control of a hot water system is with multiple circulating pumps. The thermostats control different pumps, directing water to specific zones, on demand.

15.9 Hot Water Radiant Heating: Radiant heating systems rely on large surface areas heating up to a point where they radiate heat to a room. Most radiant heating systems are found in ceilings; however, some radiant systems are installed in floors. Surface temperatures remain relatively low; however, they should be warm to the touch when the system is operating.

On hot water radiant systems there are several potential problems: one is pipe blockage which prevents the flow of water through the system, rendering it inoperative. While this type of problem is not found frequently, it is difficult to locate the blockage. A more common problem with hot water radiant systems is leakage. When a leak occurs, however, it is usually easily located due to the obvious water damage. (This is not true if the leakage is below the basement floor.)

Heating pipes can be buried too deep (more than three inches) in concrete floors, resulting in slow response to the thermostat and some heat loss. There may be unwanted fluctuations in temperature. Hot spots and cold spots may be noted if pipes are too far apart (more than eight to sixteen inches).

These systems are susceptible to building settlement, and especially with steel or copper, the pipes can be broken as the house moves.

With any radiant heating system, care must be taken not to damage the system when drilling holes or mounting things such as light fixtures. Special patching materials are available for treating cracks and other flaws in heated ceilings.

On systems where only a part of the house is heated radiantly, the lower temperature operation requires mixing valves and the long runs of small diameter pipe require separate pumps due to friction loss.

15.10 Electric Radiant Heat: A description of electric radiant heat can be found on Page 5 of this section. If the concealed wires break, it is often difficult to locate the problem. Some local utilities have special equipment that can locate the problem. In many cases, these systems are abandoned in favor of baseboard heaters. As with hot water radiant systems, care must be taken not to damage the system by drilling holes in the ceiling or by mounting light fixtures. Surface finish cracks are common with electric radiant systems. Special patching compounds are available for repairing cracks.

► 16.0 LIMITATIONS

16.1 System Shut Off/Inoperative: If the power supply to a system, or the pilot light for a system is off, the system cannot be tested.

16.2 Summer Test Procedure: During the portion of the year when the heating system is not normally operating, the heater, furnace or boiler is tested by turning up the thermostat. This will result in a partial test of the heating unit; however, the adequacy of the distribution system and amount of heat cannot be ascertained. Problems which may only show up during long term operation of the heating system may go undetected.

16.3 Air Conditioning/Heat Pump Operating: A furnace will not be tested if the central air conditioning or heat pump system is in operation. This would put unnecessary stress on the system.

► 17.0 STEAM BOILERS

Steam boilers are not installed residentially today except as replacements on older steam systems, but may be found in older homes. The boiler itself is similar to a hot water boiler, typically made of cast iron or steel. As with hot water boilers, the cast iron systems last longer than steel. Generally speaking, a hot water boiler may be expected to last slightly longer than a steam boiler made of the same material. The fuel can be coal, gas or oil, similar to a hot water boiler.

Identification

A steam boiler may be distinguished from a hot water boiler by the presence of a water level gage (sight glass or gage glass). This is a vertical glass tube which indicates how much water is in the boiler. The boiler is typically three quarters filled with water. If water cannot be seen in the glass tube, the boiler should not be operated. Similarly, the water level in the tube should not fluctuate wildly during operation.

Operating Pressures

Steam systems in houses operate at 1/2 to 5 psi steam pressure. This is lower than hot water systems (12 to 20 psi). Steam pressures which are too high can affect the boiler water level and steam delivery to the radiators.

The radiators, piping and top section of the boiler are filled with air when the boiler is at rest. When the boiler comes on and steam is generated, the steam moves through the system displacing the air. The air is released through air vents on the rads or on the piping system. As the steam hits the relatively cold surface of the radiators, it condenses giving up its heat to the rads. The heat is transferred from the rads into the room, similar to a hot water system. The condensed water flows back to the boiler to be reheated.

One-pipe Systems

A one-pipe steam system has a single pipe attached to each radiator. Steam moves through this pipe to the rad, and the condensate flows back to the boiler through the same pipe. The pipe is sloped (at roughly one inch every ten feet) so that the water can drain back. This type of system typically has an air vent at each rad. The one-pipe system cannot be converted to a hot water system without the addition of a second pipe.

Two-Pipe Systems

The two-pipe system has one pipe for carrying steam to the rad, and a smaller pipe for returning condensate water to the boiler. Radiators on a two-pipe system typically do not have air vents on the rads themselves. On the return line (condensate line) there is a steam trap which allows water and air to pass through, but closes when confronted with steam. This keeps the steam in the piping and radiator system where it can heat the building effectively.

Air is vented out of the system by a main air vent. The two-pipe system can be converted to hot water, which may yield more efficient heating, and better control of the heating. Conversion can be tricky, and problems can be encountered if the work is not done professionally. A specialist should be consulted.

Generally speaking, two-pipe systems are considered somewhat more economical to operate than one-pipe systems.

Radiators

The radiators are typically provided with a supply valve that can be opened or closed, and may have an air vent. The supply valves can be opened or closed part way on a two-pipe system, but should be either fully opened or fully closed on a one-pipe system. Sophisticated and relatively expensive supply valves are thermostatically controlled, to allow zone control of the heating.

Air vents may have an adjustable air opening. This is used for balancing the system, so that the air vents close to the boiler can be throttled down, causing air to be released more slowly. Ideally, all radiators become fully charged with steam at the same time. In practice this rarely occurs.

Wet Return or Dry Return

Depending on whether the return line joins the boiler above or below the boiler water level, the system is described as wet return or dry return. In a wet return system, a “Hartford Loop” should be provided to prevent a leak in the return piping from allowing water to leak out of the boiler. Since there is a great deal of piping, the possibility for leakage is high. If the water leaks out of the boiler, this will at best leave the house without heat, and at worst will crack the boiler.

Controls

The steam boiler has three primary safety controls.

1) A high pressure limit will shut off the boiler if the pressure is too high. This system is usually connected to the boiler with a pig tail piping configuration. The pig tail is filled with water, so the steam won’t corrode the control.

2) A low water cut-out is set to shut off the burner if the water level in the boiler drops below a given level. Some of these are located inside the boiler, but the majority are mounted externally. An external low water cut-out has a blow-off valve or bleed valve which should be operated weekly. When water is released from this valve, the burner should shut off. It is not unusual for this to be neglected.

3) A pressure relief valve is usually set at 15 psi to relieve pressure which may build up in the boiler as a result of a malfunction.

Other controls include water level and pressure gages to monitor the operation of the system. There is also a manual or automatic water make-up valve so that water can be added to the system. Many service people recommend not relying on an automatic water make-up valve to ensure adequate water supply.

Strengths of Steam Systems

Steam systems are simple with a gravity circulation system. No pumps or fans are required. If heat is lost in a building, there is no danger of freezing pipes or radiators. (The boiler itself can freeze, of course.) In order to work on the system, it is not necessary to drain water out of pipes and rads as is the case with the hot water system..

Weaknesses of Steam Systems

They are slow to respond compared to hot water and are not generally as fuel efficient as hot water systems. Steam radiators can be very hot and this can be somewhat dangerous if there are young children in the house. The boiler must be at a lower elevation than the radiators to provide steam to each rad, unless there is a pump on the return water (condensate pump). Poorly tuned steam systems can be very noisy. Since they are not common, there are few qualified people to work on them in most areas.

Operating Problems

Since steam boilers are for the most part older, the availability of parts can be a problem. Obstructed air vents will prevent the system from heating up. Air vents stuck in the open position will be inefficient and can be dangerous as steam is released directly into the room.

If the water level in the system drops, the boiler may crack as it overheats. If the system floods with water, the piping and radiator systems may allow water to leak out.

If the blow-off for the low water cut-out is not tested regularly, the cut-out may not operate properly and may fail to shut the boiler off in a low water situation.

If the pipe slope is incorrect due to poor installation or building settlement, this system can be very noisy and heat distribution can be very uneven.

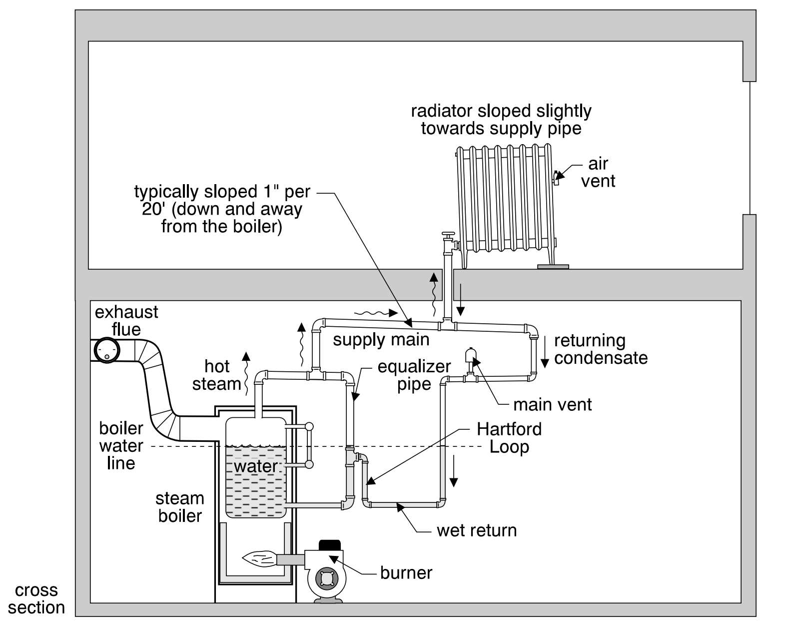
If the steam trap fails in the open position, the system will be inefficient and the house will be uncomfortable. Similarly, if the steam trap is clogged, steam may be unable to move properly through the pipes and rads.

These are only the common problems associated with steam systems. The list is by no means exhaustive.

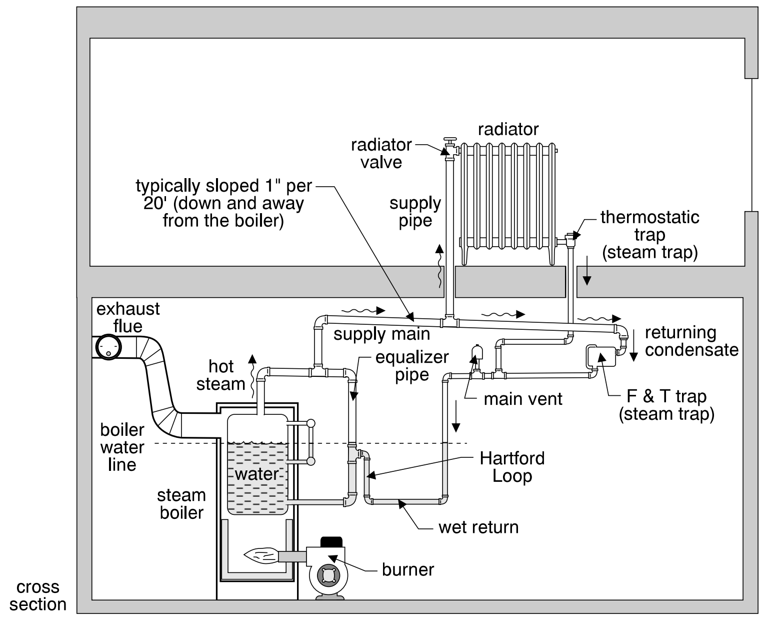
Summary

A steam boiler should be fully serviced by a specialist upon taking possession of the home. It is important that the homeowner know how to maintain the system and that the maintenance procedures be followed. If it is a two-pipe system, consideration can be given to conversion to hot water. Again, a specialist should be consulted.

One pipe parallel flow system



Two pipe system



► 18.0 Combination Heating Systems

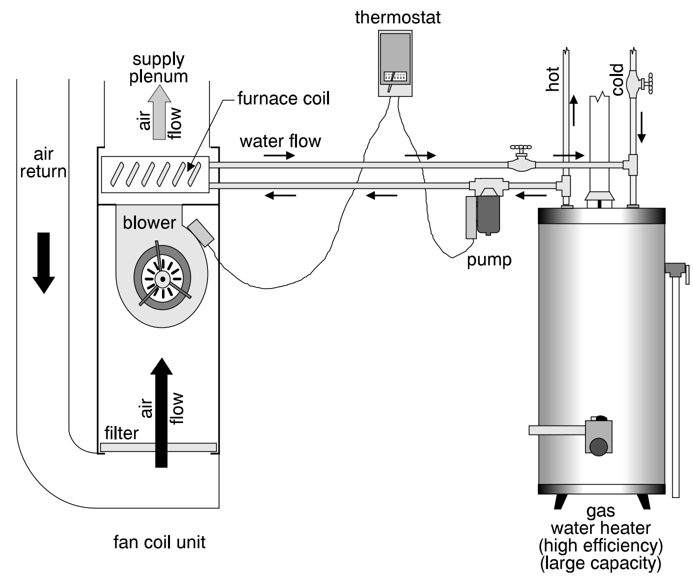
Description

Combination heating systems provide domestic hot water as well as heating the house. In simple terms the heat source is a special water heater. It has conventional connections to be hooked up to the plumbing system. It also has an extra inlet and outlet connection intended for a fan coil unit. The water heated within the tank can flow to the plumbing system or it can flow to the fan coil unit. The fan blows air across the coil, picking up heat. The warm air is distributed throughout the house via ductwork.

The concept is not new. Years ago, many boilers had a loop coming from the boiler to heat domestic water. These older systems relied on a heat exchanger within the water tank so that the water used for heating never came in contact with the potable water.

These older systems used the boiler to heat the water in the house. New combination systems work the other way around. They use the water heater to heat the house. The principal difference is that the water flowing through the fan coil unit is potable water which is returned to the water tank and will eventually end up in the plumbing system. It is for this reason that new combination systems cannot be connected to older radiator systems. They can only be connected to brand new fan coil units, connected to the system with new piping.

Combination furnace/water heater system



Problems Combination systems tend to have modest capacity. Generally speaking, the systems are not larger than 75,000 BTU's/hour. Early experience has indicated that some systems are undersized for heating. As a result, homeowners have turned up their domestic water temperature to as high as 160/170°F. This has resulted in scalding situations and pressure relief valves leaking. If the units

Mixing Valves are to be operated at such high temperatures, mixing valves to cool the domestic hot water are required.

Some jurisdictions are insisting that the systems be designed so that the water temperature can be no more than 140°F and the design water temperature of the air handler is 130°F. This means that more airflow is needed to heat the house. The ductwork in many houses is not designed to handle higher volumes of air. Therefore, these systems would appear to be most practical in climates where the heating demand is relatively small compared to the domestic hot water demand.

New Technology With respect to reliability and problems, the systems are too new to forecast. Some manufactures are using high quality stainless steel for the tank, combustion chamber and exhaust flue. These units are suspected to have a long life expectancy.

The fan coil units are not necessarily made by the same manufacturer. Consequently, quality and life expectancy can vary.

NOTES