Contents

6 Heating

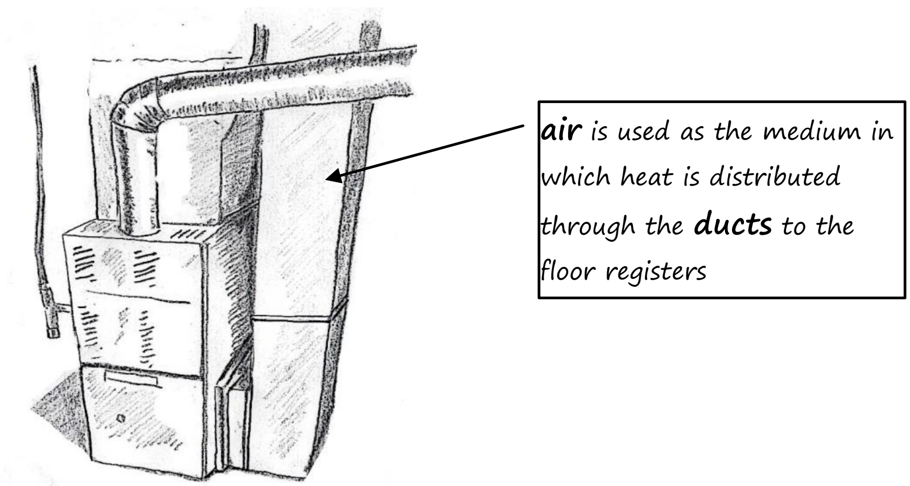
6.1 Description

The type of heating systems available for homes will vary significantly depending on the location, availability of fuel source, cost of fuel and preference of local. We have provided a brief description of the most common types of heating systems.

6.1.1 Forced Air Furnace:

As the name implies a forced air furnace employs ducts to distribute warm air to the rooms.

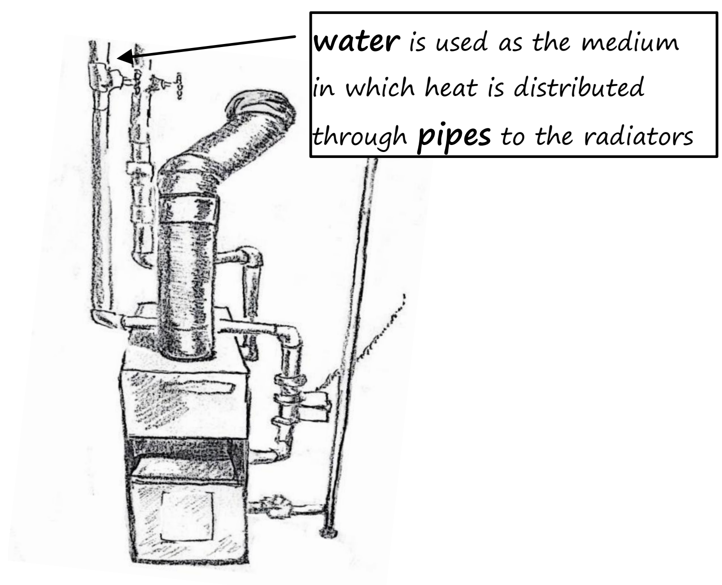
Fig. 6.1



6.1.2 Hot Water Boiler/Hot Water Radiant Heat:

This type of unit uses a pump to distribute heated water through pipes.

Fig. 6.2



6.1.3 Electric Heater(s):

Electric units are typically stand alone space heaters that service a space.

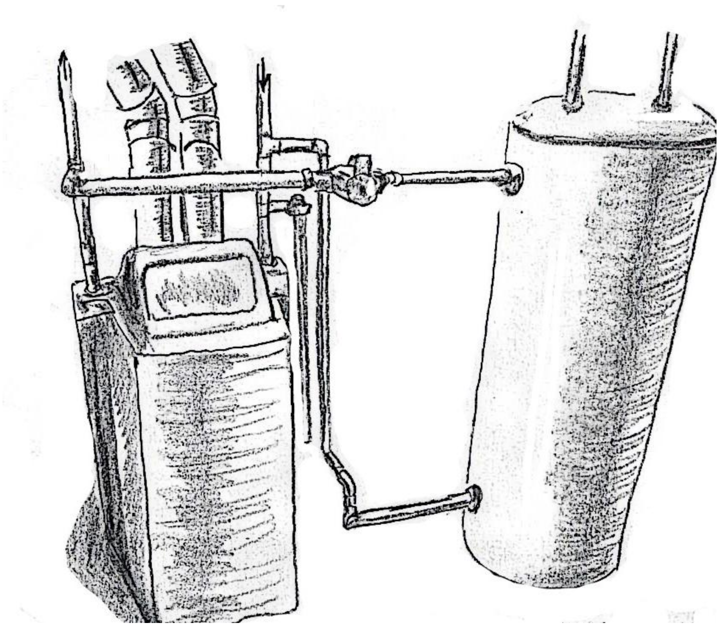
6.1.4 Electric Radiant Heat:

This type of system uses heated wires that are imbedded in floors and ceilings.

6.1.5 Combination System:

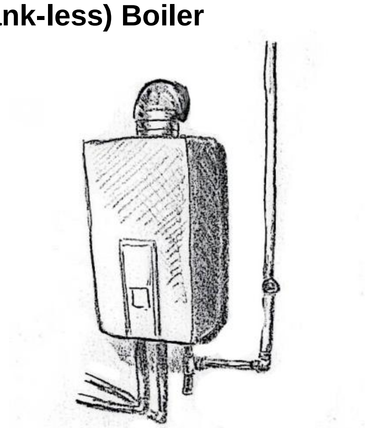
This type of system provides heating for the house and heating for domestic hot water use.

Fig. 6.3



6.1.6 On Demand (Tank-less) Boiler

Fig. 6.4



6.2 Efficiency

Whenever you burn fuel you will produce heat energy that is used to raise the temperature of a medium such as air or water. You also produce harmful gases that need to be removed safely through an exhaust flue. In so doing some of that energy will be lost through the exhaust flue. More advanced systems can use most of that energy and are therefore considered more efficient.

Note that for systems that use electricity as the fuel source the efficiency is 100% since no combustion is taking place and therefore no exhaust pipe required.

The efficiency of a heating system can be defined in two basic ways:

1. **Steady State Efficiency** which is simply the ratio of the Output vs. Input.

2. **Annual fuel utilization efficiency (AFUE)** which attempts to represent the actual, season-long, average efficiency of the system, including the operating transients. A higher AFUE means higher efficiency.

Generally we use the AFUE to define how efficient a heating system will be.

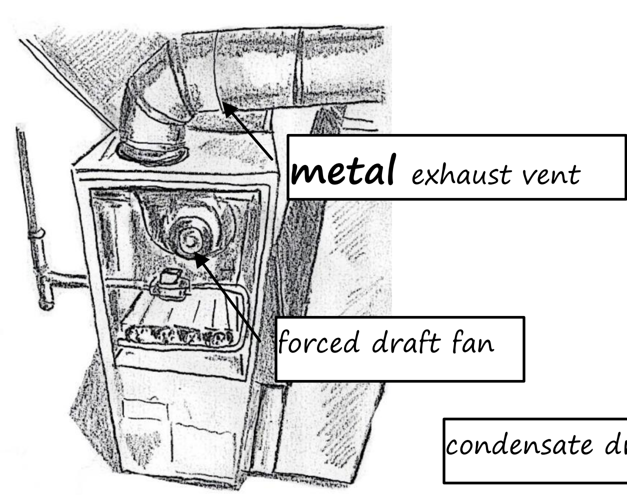
Table 6.1

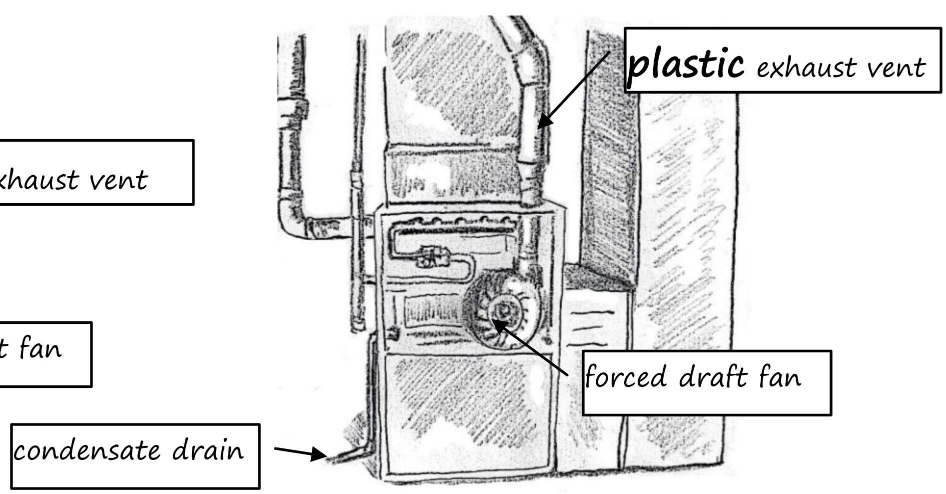
FUEL	Furnace/Boiler	AFUE
Oil	Cast iron (pre 1970's) Retention head burner Mid efficiency	60% 70-78% 83-89%
Natural Gas	Conventional (natural draft) Mid-efficiency High Efficiency (condensing)	55-65% 78-84% 90-97%
Electricity	Central or baseboard heating	100%
Propane	Conventional (natural draft) Mid-efficiency High Efficiency (condensing)	55-65% 79-85% 88-95%
Firewood	Conventional (natural draft) Advanced State-of-the-Art	45-55% 55-65% 75-90%

*table referenced from Wikipedia

How to determine if heating system is mid efficiency or high efficiency. The key difference is in the material used for the exhaust vent. Think of it like an automobile tail pipe.

Fig. 6.5 **Mid-efficiency Furnace** **High-efficiency Furnace**





6.3 Exhaust Vent Arrangement

When burning carbon based fuels (natural gas, oil and propane) the exhaust products must be removed in a safe manner. The following describes the various exhaust arrangements for the type of heating system.

Plastic Through-Wall Vent: This type of arrangement refers to **high-efficiency** furnaces and boilers. These systems are designed with heat exchanger(s) that absorb the majority of the heat energy from the combustion products. Therefore a plastic exhaust flue is adequate to remove the combustion products. The plastic flue vents directly through an exterior wall.

Metal Through Masonry Chimney: This type of arrangement refers to mid and low efficiency furnaces and boilers. The exhaust metal vent is inserted into the existing masonry chimney and continues through the top where it is capped with a rain cap.

Metal Vent Through Roof: This type of arrangement refers to mid and low efficiency furnaces and boilers. The exhaust metal vent runs through the house and continues above the roof where it is capped with a rain cap.

Metal Through-Wall Vent: This type of arrangement is usually employed by mid-efficiency boilers. The metal vent runs directly through the exterior wall.

Plastic Through Masonry Chimney: Similar to the plastic through-wall vent except it runs vertically through an existing masonry chimney. This is allowed as long as the vertical height does not exceed installation specifications.

Non-Applicable: This type of arrangement applies to electric furnaces and boilers. Since they do not emit exhaust products venting is not required.

Cement Liner Through Chimney: A masonry chimney may have a cement liner. This is often installed later to provide a safer flue.

Clay Liner Through Chimney: Masonry chimneys will usually have a clay liner for homes built from about the 1950's and onward. This was done to provide a flue with a better seal and smoother interior walls which are easier to clean.

Masonry Chimney Without a Liner: Homes with masonry chimneys built prior to the 1950's usually do not have liners. The inside walls of the chimney are bare brick. The metal exhaust vent from the furnace or boiler was simply connected to the chimney. This type of arrangement is now considered unsafe since the exhaust products can migrate through the mortar joints or other gaps into the house.

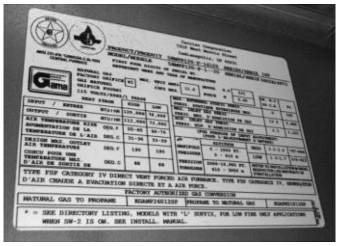
6.4 Rated Input/Output

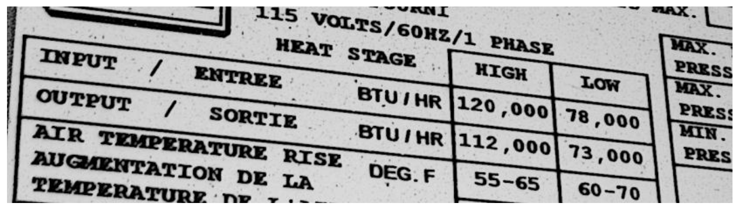
The rated **Input and Output** refers to the amount of energy put into a system versus the energy we get out of the system. There is always some energy lost. We can therefore conclude the greater the output versus the input the more efficient a system will be. See 8.2 Efficiency.

A heating system is designed to provide an adequate amount of **heat capacity** for the size of house. This can be determined by heat loss calculations performed by a qualified specialist.

The Input and Output rating can be found on the data plate usually located on the cabinet or front cover of the system.

Fig. 6.6





General we measure the rating in two ways:

British Thermal Units: The **British thermal unit** (**BTU** or **Btu**) is a traditional unit of energy equal to about 1055 joules. It is the amount of energy needed to cool or heat one pound of water by one degree Fahrenheit.

In science, the joule unit (SI from French:*Système International d'Unités* translated as International System of Units) of energy, has largely replaced the BTU.

Kilowatt Hours: When an object's velocity is held constant at one meter per second against constant opposing force of one newton the rate at which work is done is **1 watt**.

$$\mathrm{W} = \frac{\mathrm{J}}{\mathrm{s}} = \frac{\mathrm{N} \cdot \mathrm{m}}{\mathrm{s}} = \frac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^3}$$

In terms of electricity, one watt is the rate at which work is done when one ampere (AMP) of current flows through an electrical potential difference of one volt (V).

$$\mathrm{W} = \mathrm{V} \cdot \mathrm{A}$$

The **kilowatt hour** (**kWh**) is a unit of energy equal to 1,000 watt-hours.

6.5 Age/Life Expectancy

The manufacturing date is required to determine the age of the heating system and therefore the life expectancy. Often the serial number will contain the date of manufacturing though this requires some experience to interpret. Technical reference manuals are also available. A tag or sticker will sometimes provide the date of installation

The table below provides **typical life expectancy of the heat exchanger** which is essentially the main component of the system. When the heat exchanger is damaged it usually means the entire system requires replacement but there are exceptions. Of course many smaller components that make up a heating system may not last as long.

Table 6.2

System Type	Typical Life Expectancy
Furnace	20-25 yrs.
Boiler — Copper Tube	20-25 yrs.
Boiler — Cast Iron	25 yrs. and up
Combination	15-20 yrs
Electric Heaters	25 yrs. and up

6.6 Fuel

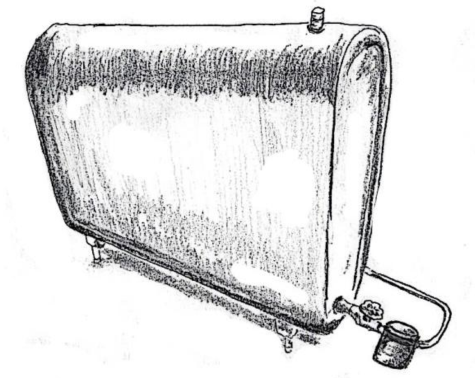
The following describes the various types of fuels used to power a heating system. The type of fuel used often depends on the resources available in the area and the cost.

Natural Gas: Natural gas consists mostly of methane with several other gases including propane, butane and ethane. Natural gas is delivered to homes via vast infrastructure systems. Heating systems that utilize natural gas are often very efficient.

Propane: Propane is extracted from natural gas. Propane when burned makes twice more energy per unit than does natural gas. Therefore less volume is required and is considered a more cost effective way to heat a house. Propane is stored in storage tanks under high pressure and in liquid form.

Oil: Many people prefer oil heat and in some areas it is very common because of the low cost and availability. Oil heat provides more heat per BTU than other heating fuels. Oil is stored in storage tanks under normal atmospheric pressure and in liquid form. Since oil will not easily burn in liquid form it is atomized (turned into a vapour) by the burner located at the furnace (or boiler) before igniting.

Fig. 6.7



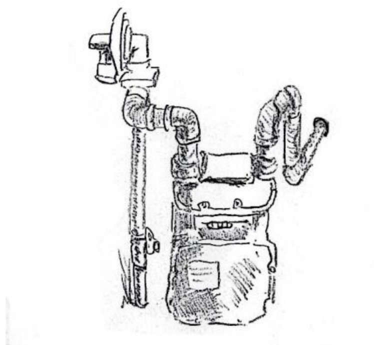
Electricity: Since a house is already provided with electricity it is easy to install an electrically fueled heating system. Electricity does not emit combustion products so is considered a cleaner from of energy. However this will highly depend on the source of electricity. For example if it comes from a coal powered plant then it may not be the best way to heat your house (especially if you are concerned about the environment).

6.7 Fuel Shut Off

The main shut off valve should be identified in order to turn the fuel source off in case of emergency or during maintenance. In addition to the main valve there is a valve located beside the appliance.

Natural Gas Meter: The meter can be located on the interior of the house though is more commonly found on the exterior. The main shut off valve is located beside the meter.

Fig. 6.8



Oil Tank Valve: This valve is located at the front base of the oil tank with the filter that connect to the oil supply pipe.

Electrical Panel: Electrically fueled systems are shut off by disconnecting fuses or breakers which are located at the electrical panel.

6.8 Limitations

The Inspecting of a **heating system** will have **limitations** as described below.

Heat Exchanger: This is essentially the main component of a Furnace or Boiler System where the heat from the combustion vapours is transferred through to the heating medium such as air or water.

A visual inspection of the heat exchanger may not be possible.

Since this component is located inside the cabinet **visibility is limited** and **often not visible** especially with high efficiency systems.

Data Plate: The data plate provides the general information of the heating system of which the following might used by the Home Inspector:

- Manufacturer
- Date of Manufacturing
- Heating capacity
- Combustible Clearances
- Temperature rise limits
- Maximum boiler pressure
- Maximum boiler temperature

The following provides some data plate conditions that may limit the information required by a Home Inspection.

Missing: Sometimes the data plate may have been removed or fallen off over time.
Not Legible: Usual due to wear and tear over time.

Incomplete: Relevant information may not be listed though this is unlikely.
Not Found: Sometimes located on the unit where it is not visible or accessible.

Additional Limitations

System Shut Off/Inoperative: Sometimes the system will be in the off position in which case it cannot and/or should not be tested. This may be due to safety reasons not disclosed to the Home Inspector.

A/C Presently Operating: This will typically apply to forced air systems. Since the evaporator coil will be in the cooling mode switching to heating may cause undue stress to the coil. The evaporator coil must first be allowed to return to room temperature.

Summer Test Procedure: The system is usually allowed to turn on briefly for observation but not allowed to warm up the house.

Radiator/Zone/Safety Devices Not Tested: These devices are not tested since they usually require a specialist's attention and may interfere with the proper operation of the system.

Circulating Pump Not Tested: Typically unless the system is running the pump will not be engaged.

Oil tank Not Visible: These can be located behind walls or inaccessible rooms or possibly underground.

Chimney clean-out Not Opened: Often sealed depending on the type of exhaust vent arrangement.

Heat Loss Calculations Not Done: Although it can be estimated if the heating capacity is adequate calculations are not performed to verify. This requires a specialist with proper equipment and software.

6.9 Observations/Recommendations

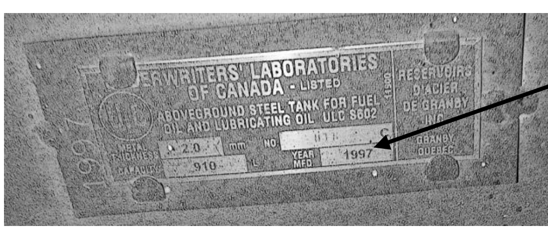
6.9.1 Fuel

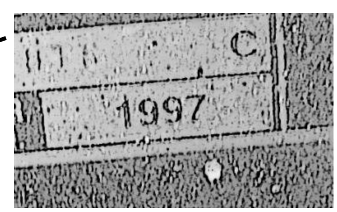
Defects identified require immediate attention by a qualified technician.

Gas Piping/Meter: Should be properly supported and not located in areas where prone to damage. Rusting components should be replaced. Gas can be distributed with copper piping which must be labelled or sheathed with a yellow jacket. Meters located in the driveway require collision barriers.

Oil Piping/Tank: Older oil tanks will require replacement especially for insurance purposes. The age can be determined by the data plat located on the top of the tank . If a date is not given or the data plate missing it is a good indication the tank is older.

Fig. 6.9





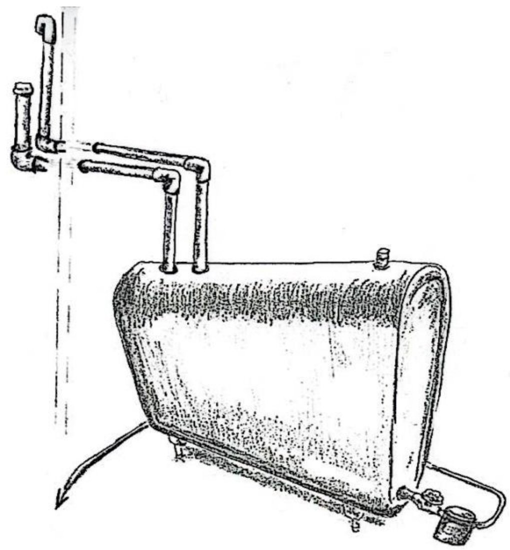
The support legs of a tank should be free of corrosion.

Tanks that have been abandoned should be removed and the pipes removed or sealed with concrete.

Valves and filters require annual maintenance. In the past oil pipes were buried in the basement concrete floor. This piping should be abandoned. New oil piping is installed above ground and sheathed with an orange/red jacket.

A **leaking** oil tank or piping can become a **serious environmental issue**. Remediation can be very expensive.

Fig. 6.10



Buried Oil Tank: Also called UST (underground storage tank). Generally no longer in use for homes due to the high potential for environmental damage. Since the tank is not visible it is difficult to determine if present. There might be clues such as pipes with valves protruding from the interior of a foundation wall. Or a fill and vent pipe that protrude from the ground. If a buried oil tank is suspected a specialist should be contacted for further evaluation. If a buried oil tank is present removal is usually required following strict guidelines. Testing is required to determine if the soil is contaminated. Remediation is very expensive if soil contamination discovered.

Oil Burner: Since oil will not easily burn in its liquid form it is atomized (turned into a vapour) by the burner before igniting. Older units should be replaced. Noisy or leaking burners require repair or replacement.

6.9.2 Exhaust Venting

Defective or inadequately installed exhaust venting can lead to carbon monoxide inside the house with deadly consequences.

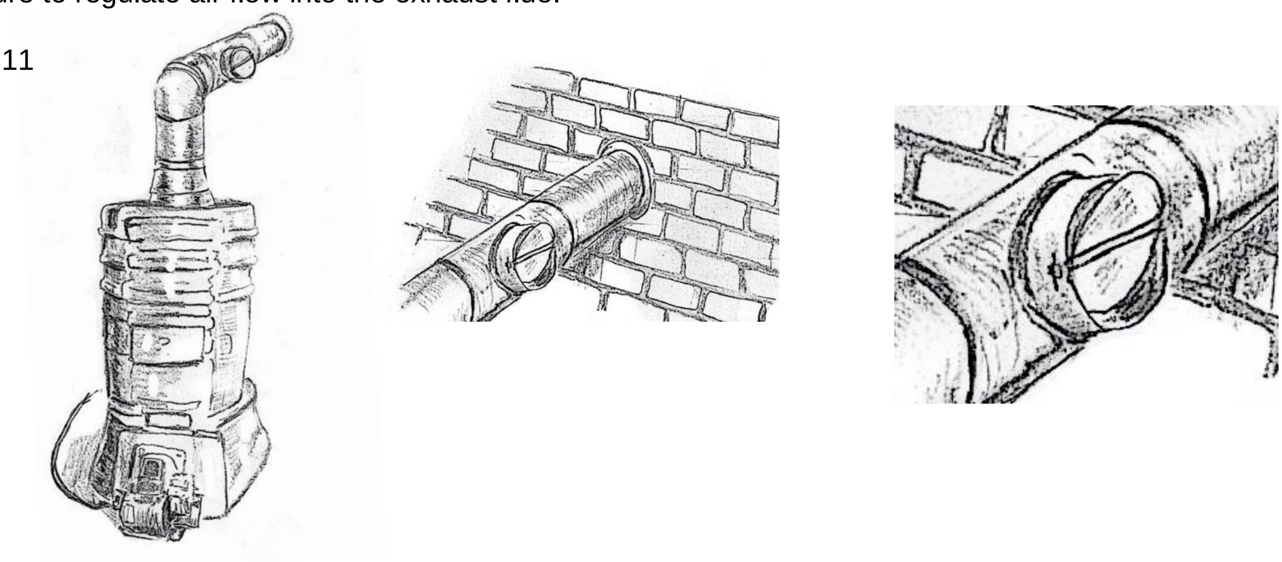
Since there is always some risk a house should have at least **one carbon monoxide detector per level**.

Combustion Air/Draft: Gas and oil fired systems require air since flames require oxygen to burn. It is therefore important to provide proper combustion air to the system. For systems located in isolated rooms (i.e. furnace room) this can simply be a hole with a grill on the interior wall. The size of the hole will depend on the capacity of the system and we must not forget to include the capacity of a water heater if applicable. Generally 1 square-inch is required per 1000 Btu's. A pipe can also be installed from the isolated room to the exterior.

Inadequate combustion air can make the system work harder and become less efficient. It can also cause back-drafting which can lead to high levels of **carbon monoxide inside the house with deadly consequences**.

Barometric Damper: This component is connected to the exhaust vent. It will open or close depending on air pressure to regulate air flow into the exhaust flue.

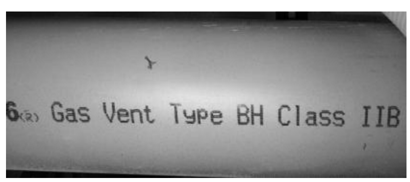
Fig. 6.11



Chimney Liner: A metal liner is required when replacing a heating system. Of course this does not apply to high-efficiency units which use plastic through wall vents. Metal exhaust vents were originally single wall. Presently double wall vents are used labelled Type B Gas vent.

Exhaust Vent/Pipes: Should be properly sealed, slope upward (1/4 inch per foot) and depending on length will require support (every 3 feet). Connections and seams should not be leaking.
For high-efficiency systems the plastic vent piping should be rated for combustion appliances (labeled- gas vent pipe BH). Originally these systems were being installed with plumbing grade plastic pipes (labeled DWV -drain waste vent). It was soon discovered that the heat from the exhaust fumes would prematurely degrade the plastic pipe or its connections.

Fig. 6.12



6.9.3 Thermostat

A heating system is controlled by a thermostat which regulates the house temperature. A basic thermostat will indicate the temperature at the location of the thermostat and the temperature setting. The thermostat is **typically located in the main level central part of a house** where an overall mean temperature is expected.

Older types of thermostats are now being replaced with electronic units that are programmable which can help moderate the house temperature more efficiently. For example the setting for heat can be lower when the house is not being occupied (i.e. during work hours) or at night when sleeping. Some newer thermostats can now be linked to smart phones and controlled remotely.

Some boiler systems will employ two or more thermostats - multi zone controls. This requires a separate pump for each thermostat.

6.9.4 FORCED AIR FURNACE

The furnace requires annual servicing by a qualified technician (i.e. Gas Fitter).

Older natural draft furnaces require annual carbon monoxide testing.

Heat Exchanger: The life expectancy of a furnace is typically measured by the serviceability of the heat exchanger (typically 20-yrs). This important component contains the combustion gases. Air is passes over and around the heat exchanger to absorb the heat before being distributed to the house registers.
Since the heat exchanger is located inside of the furnace cabinet accessibility is minimal or usually not visible at all especially for high efficiency furnaces.
Corroded or cracked heat exchangers require further evaluation by a specialist.

Draft Fan: Mid and high-efficiency furnaces will have a draft fan (this should not be mistaken for the blower which distributes air through the house). The draft fan mechanically removes the combustion products. This is in part what makes the furnace more efficient.
Noisy or damaged draft fans require repair or can be replaced. Leaking of condensate may also occur with high efficiency furnaces also require repair

Condensate Line/Pump: This condensate line is used for high efficiency furnaces to remove the water (condensate) accumulated from the combustion products. The condensate line is drained into a nearby floor drain. Since the water is acidic (corrosive) a neutralizer should be installed.

When a floor drain is not near the furnace we must remove the condensate with a pump located beside the furnace. The pump line then drains into the closest drain or laundry sink for example.

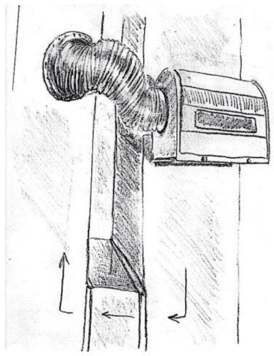
Condensate lines that do not remove water adequate may cause corrosion to the furnace which may reduce the life expectancy of its components. Crimped, leaking or damaged condensate lines should be repaired.

Filter: The air that passes through a furnace requires cleaning with a filter. There are countless filter products available with claims of fine dust removal and allergen reduction. In addition to keeping the house air clean the filter is meant to keep the walls of the heat exchanger clean which makes for a better transfer of heat. The two basic types of filters are mechanical and electrical. Mechanical filters are typically disposable units. As the name implies an electronic filter produces an electrostatic field that charges air particles which are collected. A good analogy is when we comb our hair and can then attract bits of paper to the comb.

Blower: The blower is located at the base of the furnace. it is essentially a fan that forces the house air through the duct system. Older blowers are belt driven and all new furnaces are equipped with direct driven units. High efficiency furnaces typically have a two stage capability.
Noisy and dusty blowers require maintenance. The motor that drives the blower can be replaced easily if it fails.

Humidifier: A humidifier is attached to the return plenum (duct) that provides moisture to the house air. It is controlled by a humidistat typically located near the humidifier. Older humidifiers that have a tray of standing water should be abandoned (and/or replaced) with flow- through units. The standing water can produce harmful bacteria which is absorbed by the house air. An example is legionnaires disease which can lead to respiratory problems or even death.

Fig. 6.13



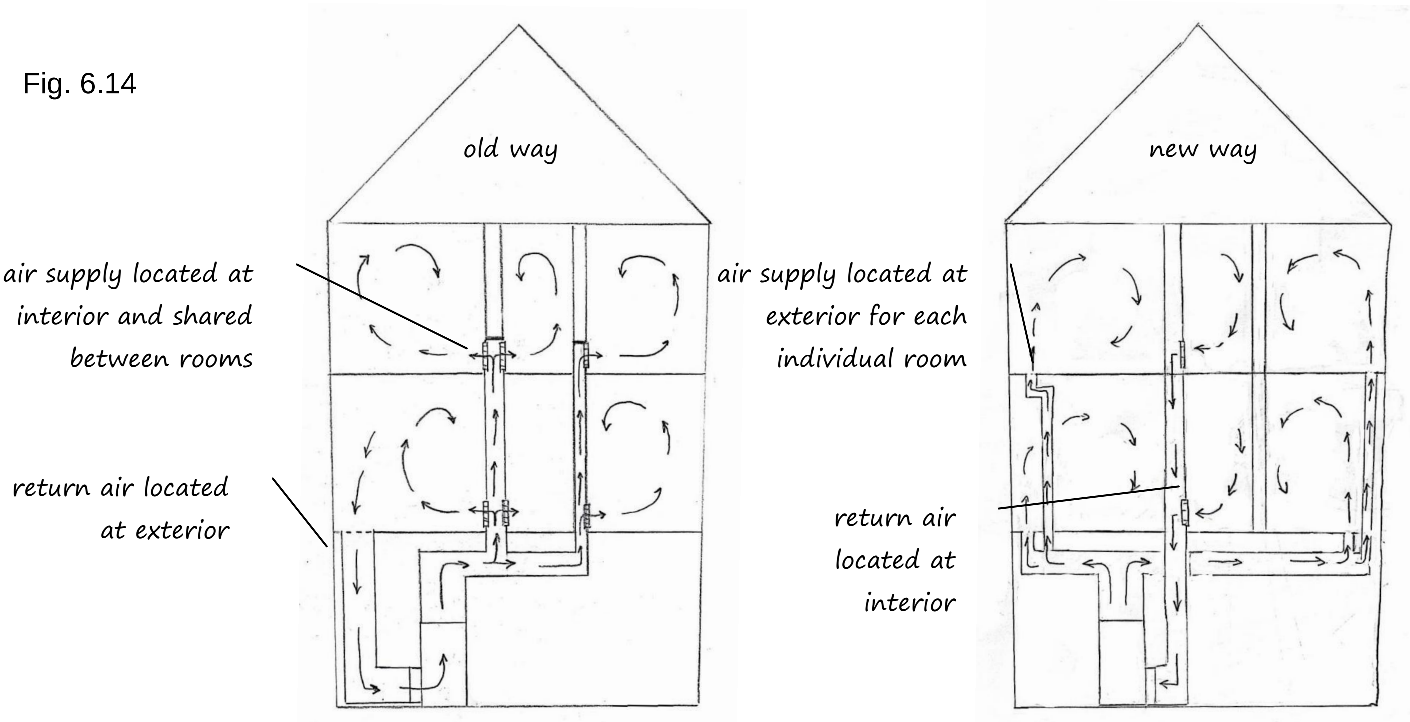
Too often the humidistat is not adjusted as required in accordance with the outside temperature. During colder outside temperatures the moisture in the house air can migrate to the colder spaces (i.e. wall cavities, roof space, etc.). This condenses and may cause mould.

Duct System: The ducts collect air from the house return registers and distribute the heated air to the supply registers. Over the years duct arrangements have been modified to improve efficiency.

Generally the location of the supply vent and return vent has been switched as demonstrated in the figure below. Also additional return vents have been installed and supply vents are not 'shared' between rooms.

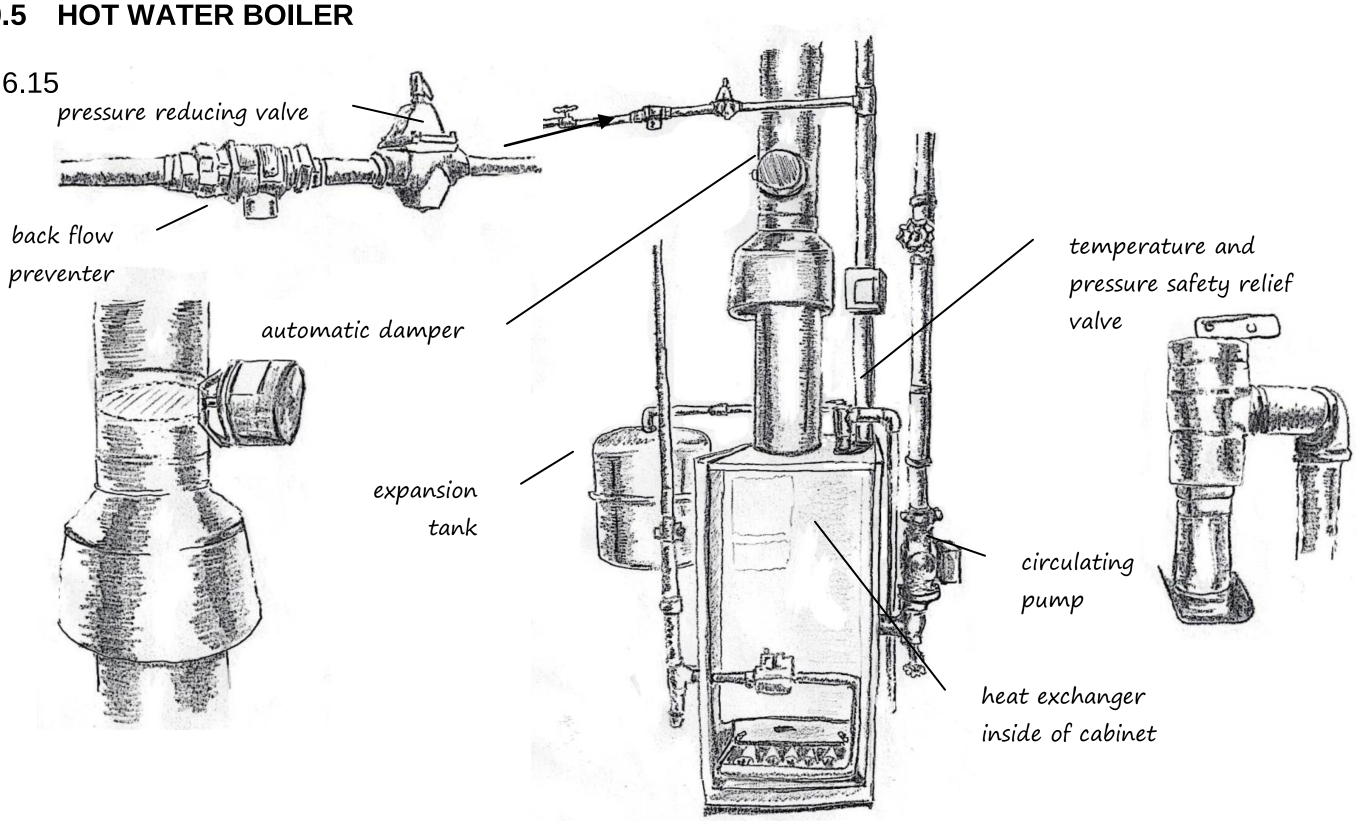
Old Duct Arrangement compared to New Duct Arrangement

Fig. 6.14



6.9.5 HOT WATER BOILER

Fig. 6.15



Heat Exchanger: The life expectancy of a boiler is typically measured by the serviceability of the heat exchanger (typically 20-yrs). This important component contains the combustion gases. Water passes over and around the heat exchanger to absorb the heat before being distributed with pipes to the house radiators. Since the heat exchanger is located inside of the boiler cabinet accessibility is minimal or usually not visible at all especially for high efficiency boilers.
Corroded or cracked heat exchangers require further evaluation by a specialist.

Pump: The pump circulates the water to the boiler and through the pipes to the radiators. Old systems did not have pumps but instead relied on the hot water rising to the radiators before returning to the boiler.

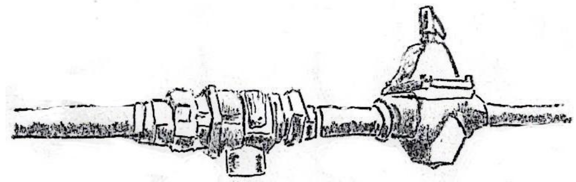
A home may have more than one pump controlled by individual thermostats. This is referred as zone heating and can make for a more controlled environment.

Expansion Tank: When water is heated it expands. Since water is relatively incompressible it puts a lot of force on the system. We there install a 'cushion' tank filled with air that absorbs this force. All boilers require expansion tanks. In old systems they were installed in the ceiling above the boiler and in new systems located beside the boiler.

Pressure Reducing Valve: Water to the boiler is provided from the domestic water supply which has a pressure between 30-40 psi (pounds-per-square-inch). Since the boiler typically operates at 10-20 psi the pressure must be reduced.

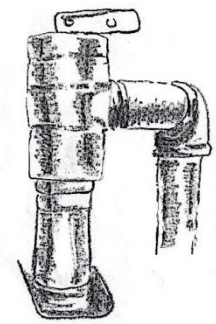
Backflow Preventer: The water that is used to heat the house must be kept separate from the domestic water. A backflow preventer will allow 'feed' water to enter the boiler system but not flow back. This is necessary since once the water enter the boiler system it is no longer considered potable.

Fig. 6.16



Pressure Relief Valve: Boilers are built to operate under design pressures and temperatures. However since components may fail a pressure relief valve is installed to release dangerous pressure and/or temperature conditions. The tube connected to this valve must be extended close to the floor and free of obstructions.

Fig. 6.17



Distribution Piping: In the past boiler piping was exclusively steel (black iron pipe). More recently copper and plastic piping is used to distribute hot water to the radiators. Both must be manufactured for this purpose. Typically copper piping must be Type L or Type K which are more durable. Plastic piping must also be rated for this purpose and can be identified by the stamped labeling (PEX - cross linked polyvinyl .

When two different metals come in contact they will corrode over time. Sometimes a steel pipe is connected to a copper pipe. This is acceptable as long as a special connector called a 'dielectric union' is used that prevents the metals from being in contact.

Piping must be properly supported to avoid undue stress.

Problem Piping: It was discovered that a certain brand of plastic piping installed between 1995 and 2007 had defective brass connections and prone to degradation due to the heat. It can be identified by the Label Kitec®. This requires further evaluation and may require replacement. Please refer to the Kitec Settlement website. Aquapex® also is a concern as above though more important regarding potable systems.

www.kitecsettlement.com

Radiator(s): As the name implies radiators (or 'rads' for short) transfer heat to the air.

They are typically equipped with a valve to control the flow of hot water (at the bottom) and a bleed valve (at the top) to remove air that can enter the system and inhibit proper flow.

Control valves on older systems should be inspected before use by a technician since they are prone to leaking. Bleed valves should be bled (removal of air) annually.

Over the years design improvements have made radiators more energy and space efficient.

Convectors: This is a 'type of radiator' in which a hot water pipe has many metal fins attached to it. The sum of the fins makes for a large surface area where by heat is transferred to the air. As the name implies warm air rises and is replaced by cool air creating convection currents.
Some convectors are short and long and located along the base of a wall. These are often mistaken for an electric baseboard heater.

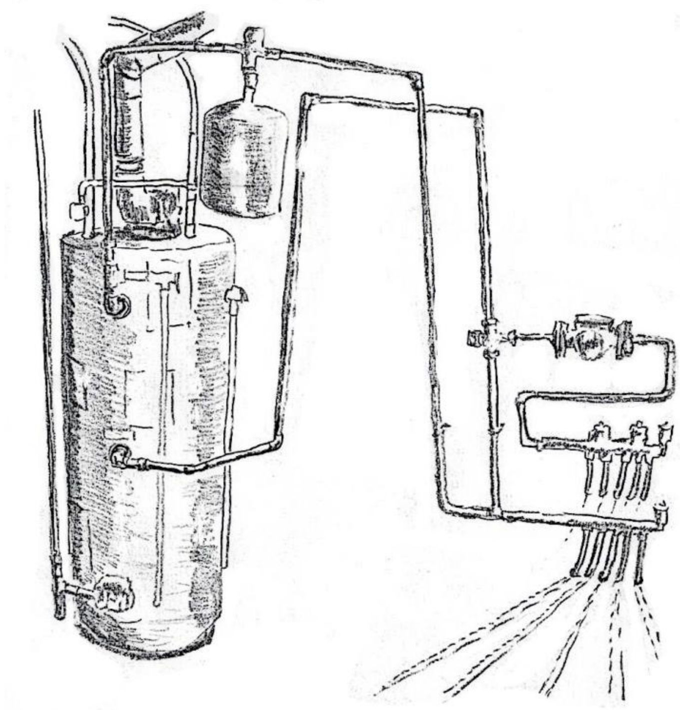
6.9.6 Hot Water Radiant Heat:

This type of arrangement employs a system of hot water pipes that are imbedded in the floor. Most commonly the concrete basement floor will have hot water radiant heat. The pipes heat the otherwise cold floor and this radiates up into the space. It also makes for a more comfortable walking surface since the heat is instantly transferred to the soles of your feet. They are also commonly used for washroom floors.

6.9.7 Combination System

Fig. 6.18

gas fired hot water tank provides heating for hot water domestic use and hot water for radiant floor heating



6.9.8 ELECTRIC HEATERS(s)

A house may fully or partially depend on electric heat. Often this will depend on the cost of electricity. The most common types are baseboard electric heat which are individually controlled by a thermostat. The thermostat can be located at the unit or on the wall.

Wall mounted units with fans to distribute the heat are also common.

6.9.9 Electric Radiant Heat:

This type of system employs electric coils that are imbedded in the floor or ceiling.

