Heating

There are many types of heating systems that HVAC technicians must be familiar with. Heating systems can burn fossil fuels such as oil or natural gas to produce heat or use electricity to energize electrical heaters. Heating systems that circulate warm air are the most common.

Before you can understand heating systems, you must first understand the terms and processes used in heating.

Heat transfer takes place when there is a temperature difference between two objects.

Heat can be transferred by conduction, convection, or radiation.

Conduction is the flow of heat from one object to another by direct contact. In a gas furnace, the burners transfer heat to the heat exchangers by conduction.

Convection is air motion caused by warm air rising and cooler air falling. Convection heating occurs when hot water baseboard heaters warm the air, causing it to rise.

Radiation is heat transfer through space by wave motion. Heat from the sun is radiant heat.

Humidity can affect heat transfer. The body feels more comfortable and loses heat slower when humidity is higher. That is why humidifiers are often installed on forced air heating systems.

Temperature is a measure of heat or cold on a numerical scale. In the United States, the Fahrenheit scale is used. The rest of the world uses the Celsius scale.

The measurement of heat in HVAC work is the British thermal unit (Btu). Furnace heating capacity is stated in Btus per hour.

Combustion is the burning of fuel to create heat. For combustion to take place, there must be a fuel such as oil or gas, an ignition source such as a spark or flame, and oxygen.

Complete combustion takes place when the fuel is completely burned, leaving only carbon dioxide and water as byproducts.

Incomplete combustion occurs when the fuel is not completely burned, usually the result of not having enough oxygen available. Carbon monoxide, soot and aldehydes are byproducts of incomplete combustion.

Carbon monoxide and aldhydes are toxic. The formation of these substances can be eliminated by providing from 5% to 50% excess air to the furnace.

Combustion efficiency is a measure of how much of the fuel is used to heat the structure and how much is lost out the chimney or vent. An 80% efficient furnace would lose 20% of the heat produced.

Furnace efficiency is expressed as Annual Fuel Utilization Efficiency (AFUE). The higher the AFUE, the more efficient the furnace.

The highest efficiency gas furnaces are condensing furnaces with AFUEs over 90%. They extract latent heat from the flue gas to achieve the higher efficiency.

Oil burners burn with a yellow flame, while gas burners burn with a blue flame with a slight orange tip. A yellow flame on a gas burner can indicate incomplete combustion.

Incomplete combustion can be avoided by providing adequate primary air and secondary air to the burner.

Fuel for furnaces is available in liquid and gaseous forms. Heating values of the different fuels vary.

Gaseous fuels include natural gas, manufactured gas, and liquefied petroleum or LP gases such as propane and butane. Of all the gaseous fuels, butane has the highest heat content.

Fuel oils are available in six grades. The higher the grade number, the higher the heat content.

Grade 1 fuel oil (kerosene) is used in vaporizing-type oil burners. Grade 2 is used in pressure-type oil burners. Both types of burners are used in home heating applications.

In a forced-air furnace, fuel is burned to warm a heat exchanger. Then a blower takes air from the home and moves it over the heat exchanger where it picks up heat. The heated air is then distributed throughout the house through air ducts.

There are four forced-air furnace types. The upflow furnace discharges air upward. It is usually located in a basement, but can be located in a closet or utility room with ducts above the ceiling.

The horizontal furnace is installed in an attic or crawlspace. Return air enters one end and heated air exits the other end.

The low-boy is an upflow furnace designed for basement installation where headroom is limited.

The downflow or counterflow furnace receives return air in the top and discharges it downward into a duct system below the floor. Many manufacturers now offer a multi-poise furnace that can be installed in some or all of the above listed configuratrations.

Combustion takes place inside the metal heat exchanger. Heat exchangers come in a variety of styles, depending on the application.

Condensing furnaces contain a secondary heat exchanger that removes latent heat from the flue gas by condensation. This can boost efficiency to over 95%.

Motor-driven fans circulate air in forced air systems. An induced-draft fan is used in higher efficiency furnaces to draw combustion air into the burners and to purge the products of combustion.

The blower circulates conditioned air throughout the structure. A belt-drive blower contains an adjustable pulley that varies the diameter of the drive pulley to change the speed of the blower.

Direct-drive blowers have the blower directly attached to the motor shaft. The motor speed is changed to adjust the blower speed. Increasing blower speed increases air delivery.

Air filters are located in the return air side of the furnace to remove dust and other particles in the circulating air. Filters must be cleaned or replaced on a regular basis.

An automatic vent damper is an energy-saving device that blocks the escape of heat up a chimney or vent during the burner off-cycle.

Vent dampers can be electrically operated or activated by the heat of the flue gas.

Vent dampers should only be installed on furnaces specifically designed to accommodate them.

Humidifiers add moisture to indoor air to improve comfort and maintain a healthy environment. Most use a medium to hold water that is exposed to the airstream in the ductwork.

The simplest humidifier is the plate-type. Porous plates absorb water from a reservoir. Warm air passing over the plates causes the water to evaporate.

The rotating drum humidifier rotates a pad in a reservoir to pick up water.

The rotating disk humidifier is similar to the rotating drum except it uses disks instead of a pad to absorb water.

The fan-powered humidifier is mounted on the supply air plenum and uses a small fan to move warm air across a moistened pad.

A bypass humidifier can be mounted on the supply or return plenum and uses the pressure differential between the two ducts to move air across a moistened pad.

An atomizing humidifier operates by injecting a fine mist of water into the supply plenum where it evaporates instantly.

The vaporizing humidifier uses an electric heater immersed in water to evaporate moisture into the supply air plenum.

The ultrasonic humidifier uses a piezoelectric crystal vibrating at a high frequency to atomize water droplets that are then injected into the air stream.

The steam humidifier converts water to steam for injection into the air stream.

Furnaces must be installed in compliance with all national and local codes.

Furnaces should be centrally located, have adequate room for servicing, and must not be exposed to household bleaches and detergents that might cause corrosion.

Furnaces are equipped with safety features such as a flame rollout switch, a limit switch, and features that prevent fuel flow or shut the furnace down if ignition does not occur.

Local and national codes specify the required clearances between the furnace and any combustible materials.

The flue gases leaving the furnace normally contain carbon dioxide and water and may, under certain conditions, contain highly toxic carbon monoxide. For safety reasons, these combustion products must be vented to the outdoors.

Gas furnaces must be vented through a correctly sized special metal vent or a correctly sized and lined masonry chimney.

It is very common for a gas-fired water heater to be common-vented with a gas furnace.

High-efficiency condensing gas furnaces are usually direct-vented through an outside wall or roof through PVC pipe.

Combustion air for non-condensing furnaces is normally supplied from air entering the structure by infiltration.

Combustion air for condensing furnaces is often piped directly to the furnace from the outdoors.

All gas furnaces, regardless of the brand name, contain similar components.

The gas burner assembly in a modern gas furnace consists of a gas valve, an ignition device, burner manifold with orifices, and burners.

There are several ways that the fuel gas can be ignited in a gas furnace.

Standing pilots that produce a small, continuous flame are used on older gas furnaces to light the burners.

The safety pilot igniter contains a thermocouple that generates a small electric current used as part of a safety circuit. If the pilot flame goes out, no current is generated and the safety circuit prevents gas flow to the burners.

A re-ignition or electric spark ignition system uses a high-voltage spark to light a pilot only when there is a call for heat. Many modern furnaces eliminate the pilot and ignite the burner directly by using a hot surface igniter. The device glows red-hot to ignite the main burners.

Older gas furnaces used a separate gas valve and pressure regulator.

Newer furnaces use a redundant gas valve that contains a safety feature of two internal valves in series. If one valve sticks open, the other valve will prevent gas flow.

Gas valves use a variety of mechanisms to control gas flow. The solenoid-operated valve uses electromagnetic force to open the valve.

Diaphragm-operated valves control pressure above and below a diaphragm with an electrically operated coil to open and close the valve.

A heat motor valve uses an electric heating coil to heat an expanding metal rod that opens and closes the valve.

Modern modulating and two-stage gas valves enable the burner heat output to better match the actual heating load of the building being heated.

The burner manifold delivers gas equally to all burners through orifices drilled in a brass plugs called spuds.

Burners require primary and secondary air for complete combustion. Too much primary air causes the flames to lift off the burner, while too little primary air causes a yellow flame.

Gas burners can be either the single-port type that generates a single, large flame or a multi-port type that generates smaller flames along the length of a burner.

Gas furnaces contain several safety switches. The limit switch shuts off the burners if the furnace overheats.

If flames roll out of the combustion chamber because of a blockage or other problem, the flame rollout switch will shut off the burners.

Pressure switches are used to sense the presence of combustion airflow through the heat exchangers of induced-draft furnaces. If there is no combustion air, the ignition system is disabled by the switches.

Gas furnaces require periodic cleaning and maintenance for reliable operation.

Filters should be cleaned or replaced, blower assembly cleaned, blower motor oiled, and the heat exchanger checked for blockages and cracks.

The burner flame should be checked and adjusted to prevent soot buildup or carbon monoxide formation.

Correct manifold pressure ensures that the burners are fired at the correct input rate. A manometer connected to the burner manifold measures manifold pressure.

In an oil furnace, a mist of oil is sprayed into the combustion chamber where a high-voltage spark ignites the oil.

The oil is pressurized for injection and mixed with air in a pressure-type burner.

The commonly used high-pressure burner pressurizes the oil to 100 PSI and forces it through a nozzle where it becomes a fine mist.

Combustion air, supplied by a vane fan, creates turbulence and mixing of the air and oil so it can be ignited by a high-voltage spark.

The power assembly of a high-pressure burner consists of the motor, fan, and oil pump.

Single-stage pumps are used if the oil supply is above the burner. Two-stage pumps are used if the oil supply is below the burner.

Oil supply piping can consist of a single fuel line or two fuel lines. Compression fittings should not be used in oil supply lines because they can cause air leaks.

The nozzle assembly consists of the oil feed line, nozzle, electrodes and transformer contacts.

The nozzle is selected by the oil burner manufacturer to deliver optimum performance.

Nozzles come in several spray patterns. A replacement nozzle should always have the same spray pattern as the original nozzle.

The spray angle of the nozzle should match the shape of the combustion chamber of the furnace it will be used in. A 70° to 90° nozzle is best for round or square combustion chambers.

The 10,000-volt ignition spark is provided by a transformer and is fed to the nozzle assembly where it arcs across a gap.

The position of the electrodes in relation to the nozzle is very important for proper ignition and flame shape.

The ceramic insulators for the electrodes are easily cracked if mishandled, so take care when handling them.

Oil furnace combustion chambers protect the heat exchanger and promote complete combustion of the oil. They can be made of stainless steel, firebrick, or molded refractory material.

A draft regulator installed in the vent connector helps control heat and combustion.

The primary control controls oil burner operation and shuts off the oil supply to the furnace if flame ignition does not occur within a specified time.

Modern primary controls use a cad cell flame detector that detects the light of a burner flame. If a flame is not detected, burner operation ceases.

An older primary control called a stack switch detected the presence of a flame by detecting the heat given off by the flames.

The installation of fuel oil storage tanks is covered by national and local codes.

Oil furnaces require periodic cleaning and maintenance for reliable operation. The fuel oil filter should be replaced annually.

The burner flame should be checked for the proper yellow color. Flames of other colors may indicate a need for adjustment or component replacement.

Electric heaters convert electricity directly to heat. Because no fuel is burned, there is no need for a chimney or vent.

The major components of an electric furnace include controls, heating elements and a blower assembly enclosed in a cabinet.

The heating elements in an electric furnace are similar to heating elements found in electric clothes driers.

The blower motor assemblies found in electric furnaces are very similar to those found in gas and oil furnaces.

The cabinet or enclosure of an electric furnace is also similar to gas or oil furnace cabinets.

Most of the accessories such as humidifiers that are used on other furnaces can be used on electric furnaces.

Most electric furnaces operate on 240 volts. Wiring and installation of electric furnaces is covered in the National Electric Code®.

Hydronic heating systems use a boiler to heat water or produce steam. That heated water or steam is then circulated around the building through pipes.

Hydronic heating systems offer several advantages over forced-air heating systems. Their major disadvantages are higher installed costs and the difficulty in adding air conditioning and other air treatment options.

The major components of a boiler consist of the burner and burner controls, the boiler sections where water is heated, and a circulator pump.

A unique temperature control found on boilers is the aquastat. This device keeps water in the boiler from becoming too hot or too cold and it also controls the circulator pump.

Radiators in a hydronic heating system use convection to transfer the heat from the water to the air in the room.

Manual or automatic vents installed at high points in the piping system allow trapped air to be bled from the piping.

Hydronic systems often contain valves that allow heated water to flow to different areas or zones in the structure. Each zone valve is controlled by its own room thermostat, allowing different zones to have different temperatures.

Other specialized components automatically replenish water in the system, and prevent excessive pressure from exploding the boiler.