► TABLE OF CONTENTS

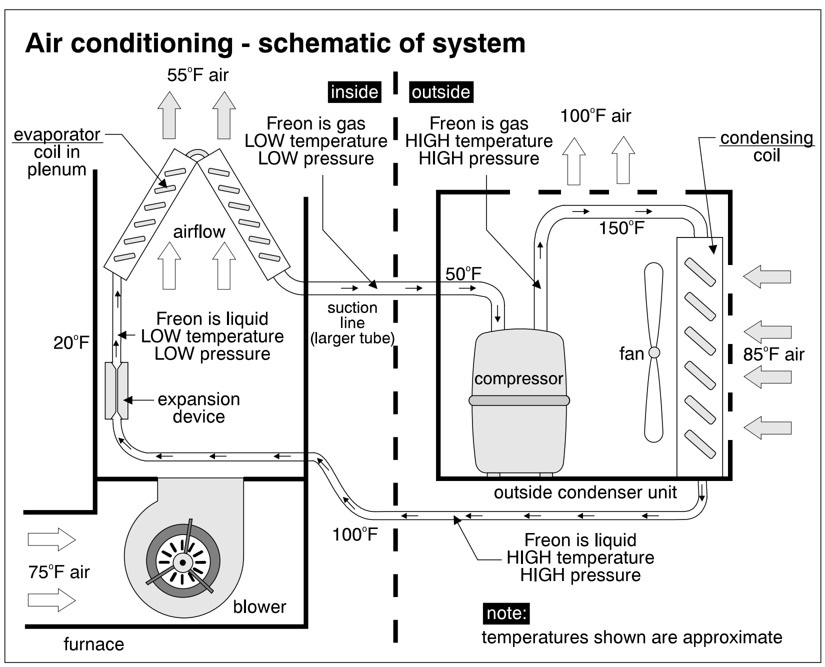
Page

INTRODUCTION

There are many types of air conditioning systems; however, they all work on the same principle. They move heat from a relatively cool space to a relatively warm space. The systems all take advantage of some basic scientific laws of liquids and gases. When liquids evaporate into gases, they absorb a considerable amount of heat. When gases are condensed back into a liquid state, they give off heat. In addition, if the pressure of a gas is increased, the temperature will also increase. Many systems use the refrigerant "Freon", a substance which changes state at temperatures and pressures which are well suited to this application, although new refrigerants have come onto the market as Freon is being phased out.

1.0 AIR CONDITIONING

1.1 Air Cooled Air Conditioning: Air cooled air conditioning systems usually work in conjunction with a forced-air furnace. The systems have two main components: the evaporator unit located in the ductwork immediately above the furnace, and the condenser unit located outdoors. The refrigerant enters the evaporator as a cold liquid and absorbs heat from the household air to boil the liquid and turn it into a gas. The resulting reduction in air temperature also causes water in the house air to condense, reducing humidity levels within the house. This dehumidifying helps make the house more comfortable.

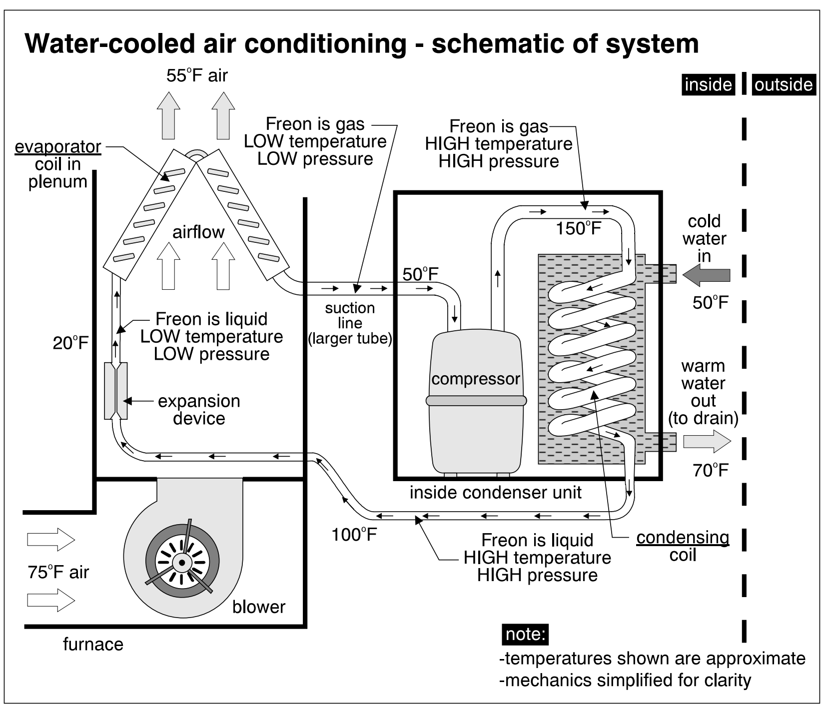


The refrigerant, which is now a gas, moves outdoors to the condenser unit. The compressor squeezes the gas into a smaller volume. All the heat which is contained in the gas is also squeezed into a smaller volume and consequently, the gas becomes hotter than the outside air. The hot gas then enters the condenser coil. A fan in the condenser unit blows outdoor air across the coil and cools the gas. As it cools, it condenses into a liquid. The liquid then passes through a pressure reducing device which causes the temperature of the liquid to drop below that of the household air. The liquid passing through the evaporator coil is evaporated into a gas again, stealing more heat and humidity from the house and the cycle continues.

Compressor

The compressor which moves the refrigerant through the lines and compresses the refrigerant is the heart of the system. It is usually located outdoors in the same cabinet as the condenser.

1.2 Water Cooled Air Conditioning: Water cooled air conditioning systems work essentially the same way as conventional systems which are air cooled. They have a section above the furnace which evaporates a liquid into a gas and steals heat from the house. The gas is then compressed to concentrate the heat (consequently raising the temperature). Then, instead of blowing outside air across the gas to cool it, water from the plumbing system in the house is used. Consequently, the condenser portion of the air conditioning system does not have to be outdoors. It is normally located in the basement near the furnace.



Once the water has cooled the gas back down to a liquid, the warmed water must be disposed of. It is no longer drinkable and, therefore, must go down the drain. As an alternative, some people use the warm waste water to fill a swimming pool or water the lawn.

Compressor

On these systems, the compressor is just as critical as it is on an air cooled system. It is the heart of the air conditioner. The compressor is located in the basement and, therefore, it is not subjected to the extremes of the outdoors.

NOTE: On water cooled air conditioning systems, water must flow through the system when it is operating or severe damage can occur to the unit. The supply water valve must be open.

On systems where the discharged water goes straight down a drain, there is usually no problem. However, on systems where the water can go down a drain or be used to water the lawn or fill a swimming pool, there are usually several valves which dictate where the water will go. It is imperative that at least one valve be open to allow water to flow. Automatic valves are available; however, like any mechanical device, they can fail and, therefore, should be checked regularly.

1.3 Independent Air Conditioning: In houses which are heated by some other means than a forced-air system, central air conditioning systems are inde- pendent of the heating. Since there is no distribution ductwork, special air condi- tioning ducts must be added. They are identical in operation to the air conditioning systems described above; however, the evaporator coil does not sit in the ductwork above the furnace. Instead, it sits in independent ductwork. On an air conditioning system which shares ductwork with a heating system, the blower for the heating system is used for air conditioning. With an independent system, a separate blower must be provided.

Ductwork

Independent systems are normally located in attics; however, they are sometimes in the basement. Most independent systems are installed on a retrofit basis and, consequently, there are limitations as to the size and location of the ductwork. Limited space dictates that many of the systems must have very small ductwork. Most of these systems employ round, flexible, insulated ductwork which has a very small diameter. To compensate for the small ducts, the velocity of the air travelling through the ducts is increased dramatically. With these systems, discharge nozzles (diffusers) mounted in ceilings are used instead of conven-tional heating registers. A large return air grille is typically ceiling mounted on the top floor. Other than the size and location of ductwork, and the location of the major components, these systems are very similar to conventional air conditioners.

Disadvantages

Because independent systems are normally installed on a retrofit basis, a few compromises have to be made. Attic mounted units are more difficult to service simply because of their location. Also, a system mounted in the attic tends to be noisier than a system mounted in the basement. Special care should be taken in attic installations to prevent leakage of condensate into the living space below. Please refer to 16.0, Attic Drip Pans, in this section.

Since independent systems are normally installed in houses which did not have ductwork, it is not uncommon to take advantage of the ductwork to perform other functions. Therefore, electronic air cleaners, humidifiers, and plenum heaters are sometimes found with independent systems. For more information on these components, please refer to the Heating Section.

NOTE: Systems employing humidifiers which are attic mounted are prone to winter freezing problems.

1.4 Gas Chillers: Gas chillers work on the same basic principle as conventional air conditioners in that they rely on changes of state of a refrigerant at different pressures. Rather than using a compressor to drive the system, heat is used. While this sounds contradictory, the systems do work. The process tends to be more complicated than for conventional air conditioning.

The system consists of a pressure vessel containing a strong solution of liquid ammonia (modem systems use lithium bromide). When heat is added, ammonia is boiled off, producing a high temperature, high pressure vapor. The refrigerant vapor is then cooled to a liquid state (at high pressure). The still relatively hot liquid ammonia is then pushed to the evaporator where it passes through a flow restrictor which drastically reduces its pressure and, consequently, its temperature. The evaporator is a tank in which water, warmed by the household air in a coil over the furnace, is cooled by the ammonia. (The chilled water, then returns to the coil over the furnace where it can cool the household air.) Heat from the water causes the ammonia to boil off again. This relatively cool ammonia (low pressure) gas is then mixed with a low pressure weak solution of hot liquid ammonia. This mixture is cooled until the vapor is absorbed into the solution making it a strong solution again. A high pressure pump sends this solution on its way back to the pressure vessel for the process to begin again. Very few gas chillers are still made for residential applications and replacement parts are not available for some systems. Consequently, when a gas chiller fails it is normally replaced by a conventional air conditioning system.

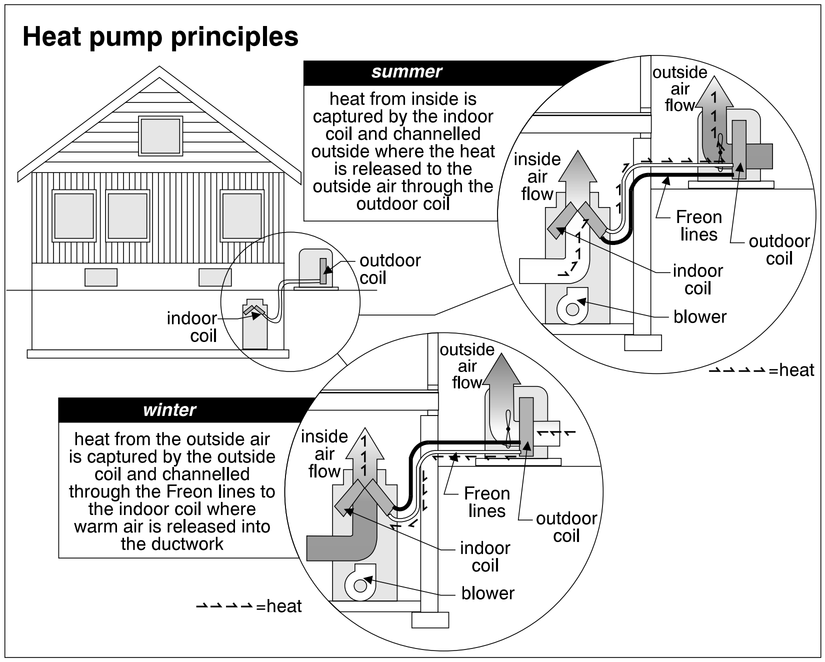
It is essential that a qualified serviceman work on gas chilling systems as the pressure within the system is extremely high.

► 2.0 HEAT PUMPS

A heat pump is simply an air conditioner which can work in reverse to help heat the house when cooling is not needed. During the cooling season, it collects heat from the interior of the house and discharges it to the exterior, like any other air conditioner. During the heating season, the opposite is true. This is accomplished by simply reversing the flow of the refrigerant. The condenser becomes the evaporator and the evaporator becomes the condenser.

Refrigerator Analogy

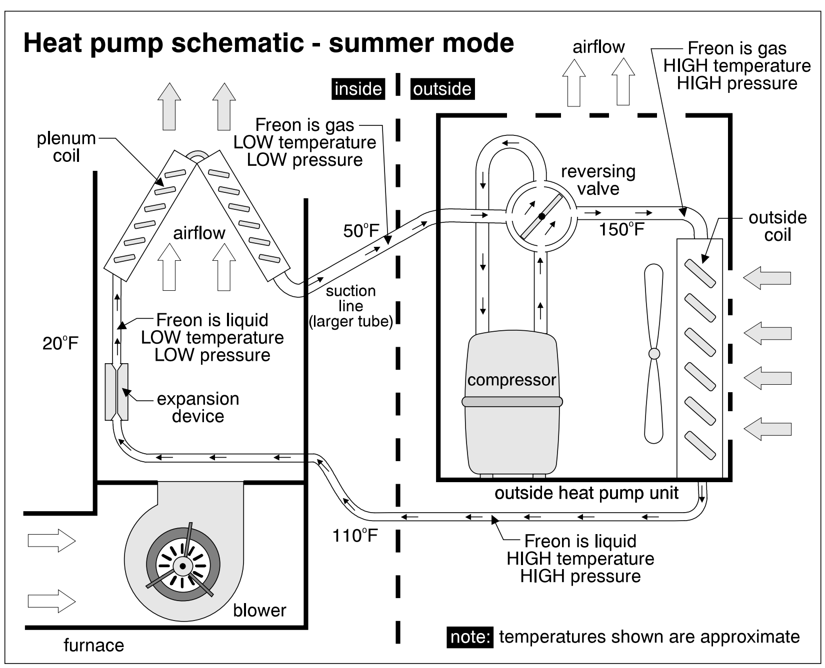
To further illustrate the idea, one might consider a refrigerator as a heat pump working in the heating mode to heat a kitchen. The temperature within the refrigerator is obviously cooler than the temperature within the kitchen, yet the refrigerator's cooling system is able to steal heat from the inside of the refrigerator and release the heat into the kitchen, via the coils on the back of the refrigerator.



As with conventional air conditioning, the compressor is the most critical component.

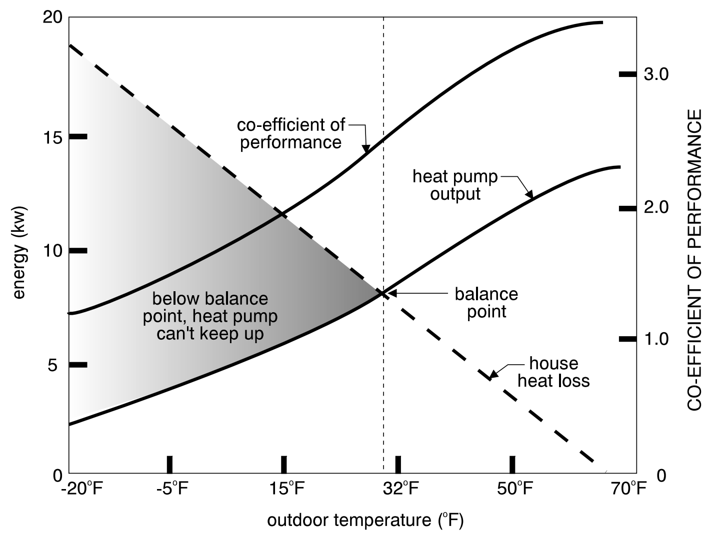
Economical Operation

In northern climates, heat pumps are not capable of carrying the entire heating load of a house. They are only practical to operate when the outside air has enough heat that it can be collected economically. In other words, when it costs more than a dollar's worth of electricity to get the heat pump to generate a dollar's worth of heat, the system is no longer efficient and is shut down. At this stage, the central heating system takes over.



Depending upon the design of the heat pump and the insulation of the house, the heat pump may be forced to shut off earlier. Even if the heat pump is operating economically, it may not be able to generate enough heat to keep the house warm (the system has slipped below the balance point). If this should occur, the heat pump will shut off and the main heating source will take over. This assumes that the furnace is gas or oil. Electric furnaces and heat pumps can run simultaneously.

Co-efficient of performance (COP) and balance point



modern heat pumps have COP's greater than 1.0 down to -25°F

Limited Testing

A heat pump cannot be tested during exceptionally cold periods of the year, when the heat pump is not working. During other portions of the year, if the heat pump is operating in the heating mode, it should not be tested in the cooling mode, to prevent added stress on the system. Conversely, if the system is operating in the cooling mode, it should not be tested in the heating mode.

Drafty

When the heat pump is operating in the heating mode, the air coming out of the registers feels drafty to some people. It is not as warm as the air from the registers when the furnace is operating (roughly 90°F. as opposed to 120°F.).

2.1 Air Source: Most residential heat pumps are very similar in appearance to air cooled air conditioners. There is an outside box which is used to dissipate heat during the air conditioning season and collect heat during the heating season. These systems are called air source heat pumps.

Furnace

2.2 Auxiliary Heat: As mentioned earlier, heat pumps are not capable of carrying the entire heating load during the coldest parts of a northern winter. With most systems, the heat pump has to eventually shut down and let the furnace take over because there is not enough heat in the outside air to be collected economically.

Kool-Fire

Some systems are designed to fool the heat pump. They have a burner (usually natural gas) outdoors below the evaporator coil (the coil which is collecting the heat). Just when the system is about to shut down and pass over its responsibilities to the furnace, the outdoor burner comes on and the evaporator coil thinks that there has suddenly been a heat wave. All of a sudden there is enough heat in the outside air to keep going. These systems do not require a furnace to supplement the heat pump because the heat pump never experiences the coldest part of the winter – or at least it thinks it doesn't. It's being fooled by an outdoor auxiliary heater.

Advantages

These systems require no furnace and no chimney.

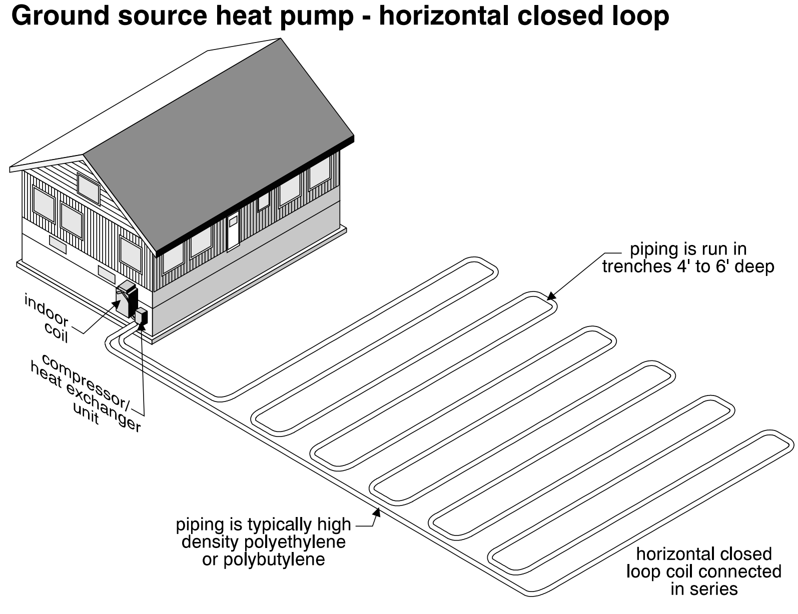
Disadvantages

These systems have a high initial cost. Long term durability and life expectancy are unknown, however oxidation has been noted on the burner and the coil as a result of condensation.

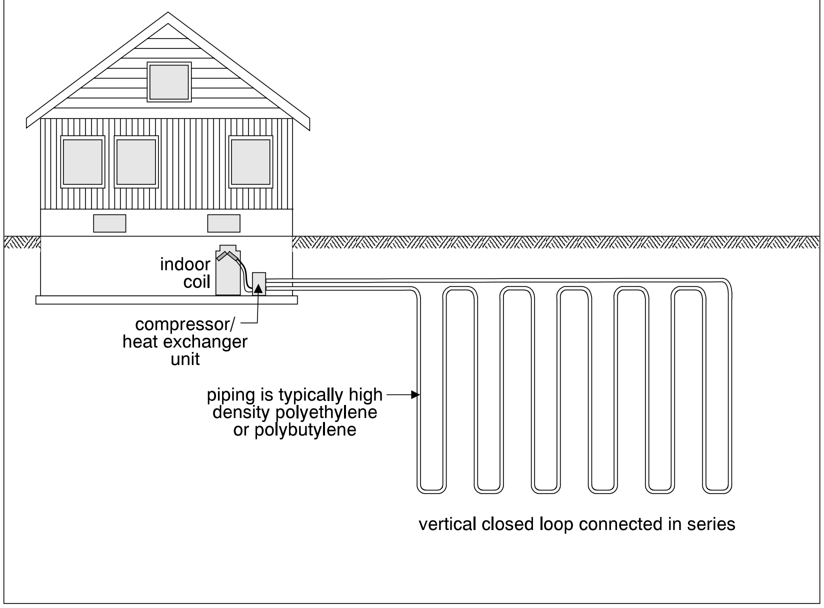
2.3 Ground Source And Water Source: Rather than using outside air to collect or dissipate heat, some systems use the ground or water. A ground source heat pump has piping running through the ground which is used to collect or dissipate the heat. The piping can be installed horizontally (shallow) or vertically (deep) below the ground surface.

Some systems use two wells instead of piping. Ground water is pumped from one well. Heat is extracted from the water and the water is pumped back into the other well.

Ground source heat pump - horizontal closed loop

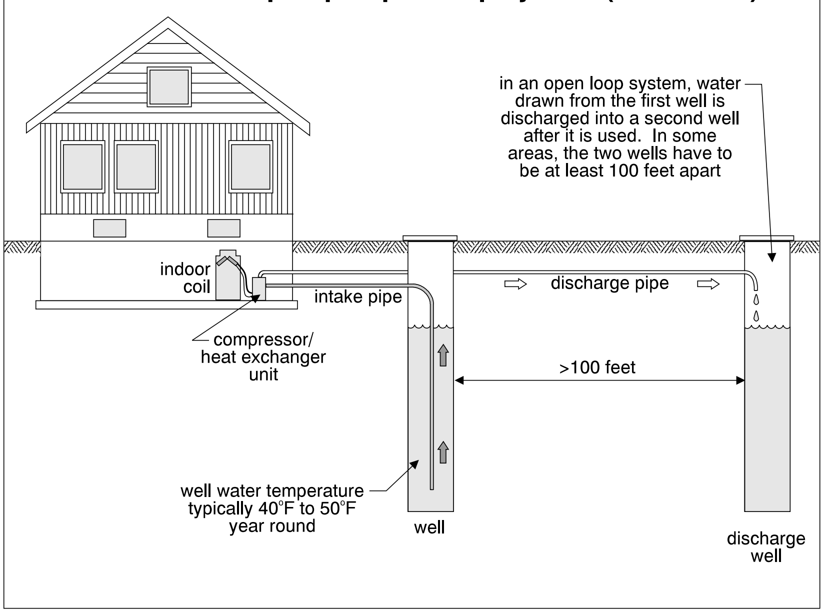


Ground source heat pump - vertical closed loop



In houses located near a reasonably large body of water, the water can be used as a source for collecting and dissipating heat. These systems are called water source heat pumps.

Water source heat pump - open loop system (well based)



The advantages of ground source and water source heat pumps are that the medium, namely the ground below the frost line or the water below the ice in a pond or river, never freezes. Consequently, there is more heat available to be collected during winter months. In addition to high installation costs, the disadvantage of these systems is that the buried piping in the ground or the water can develop a leak which is difficult to locate and repair. On two well systems the discharge well can become blocked causing water to bubble to the surface

In some instances, environmental laws prohibit the use of ground or water source heat pumps.

2.4 Independent Heat Pumps: In houses which are heated by some other means than a forced-air system, heat pump systems are independent of the heating. Since there is no distribution ductwork, special ducts must be added. They are similar in operation to other heat pump systems described above; however, the indoor coil does not sit in the ductwork above the furnace. Instead, it sits in independent ductwork.

Blower

On a heat pump system which shares ductwork with a heating system, the blower for the heating system is used for the heat pump. With an independent system, a separate blower must be provided.

Ductwork

Independent systems are normally located in attics; however, they are sometimes in the basement. Most independent systems are installed on a retrofit basis and, consequently, there are limitations to the size and location of the ductwork. Limited space dictates that many of the systems must have very small ductwork. Most of these systems employ round, flexible, insulated ductwork which has a very small diameter. To compensate for the small ducts, the velocity of the air travelling through the ducts is increased dramatically. With these systems, discharge nozzles (diffusers) mounted in ceilings are used instead of conventional heating registers. A large return air grille is typically ceiling mounted on the top floor. Other than the size and location of ductwork, and the location of the major components, these systems are identical to conventional heat pumps.

Disadvantages

Because independent systems are normally installed on a retrofit basis, a few compromises have to be made. Attic mounted units are more difficult to service simply because of their location. Also, a system mounted in the attic tends to be noisier than a system mounted in the basement. Special care should be taken to avoid leakage of condensate into the living space below. Please refer to 16.0 Attic Drip Pans, in this section.

Independent systems are often limited in size (capacity). Therefore, they are not practical in some instances.

Since independent systems are normally installed in houses which did not have ductwork, it is not uncommon to take advantage of the ductwork to perform other functions. Therefore, electronic air cleaners, humidifiers, and plenum heaters are sometimes found with independent systems. For more information on these components, please refer to the Heating Section.

NOTE: Systems employing humidifiers which are attic mounted are prone to winter freezing problems.

► 3.0 COOLING CAPACITY

Both air conditioners and heat pumps have a rated cooling capacity. Heat pumps also have a rated heating capacity which varies, depending on outside temperature.

Ratings

The ratings are given in tons. A ton represents 12,000 BTU's per hour. A BTU is a British Thermal Unit and it represents the amount of heat required to raise the temperature of a pound of water by one Fahrenheit degree (or in the case of cooling, the amount of heat which must be absorbed to lower the temperature of a pound of water one Fahrenheit degree).

Heat Gain

Cooling systems are sized by calculating the heat gain for the house. The heat gain is dependent upon the size and configuration of the house, the construction, the amount of insulation, the type, size and orientation of windows, as well as several other variables. Cooling systems are sized to keep the house roughly fifteen to twenty degrees cooler than outdoors during the hottest day of the year.

In northern climates, heat pumps are not designed to carry the entire heating load for a house. They are sized to meet the cooling demands of the house. The heat they provide varies with the outdoor temperature. The colder it gets, the less heat they can provide.

Without performing detailed heat gain calculations, it is not possible to determine the size of system which will be adequate for a house. In addition, some systems (both heat pumps and air conditioners) are installed without matching condenser and evaporator coils. One coil might be rated for two tons while the other is rated for two-and-one-half tons. It is not usually possible to determine this at the time of an inspection. Incidentally, the size of systems such as these is approximated by taking the outdoor coil rating and going 1,000 BTU in the direction of the plenum coil rating. For example, if the outdoor coil is 36,000 BTU and the indoor coil is 30,000 BTU, the system capacity is roughly 35,000 BTU.

Most often, inadequate air conditioning or heat pump performance is due to an inadequate ductwork system as opposed to undersized equipment. As a general rule, however, most houses have systems sized at one ton of cooling for every seven hundred to one thousand square feet of house in moderate climates, and four hundred and fifty to six hundred square feet of house in warmer climates. Modern, well insulated and designed homes may need considerably less. Older, energy inefficient homes may need more. From a durability standpoint, most installers say it is better to slightly undersize a cooling system. The equipment will probably last longer if this is done.

► 4.0 FAILURE PROBABILITY

Any piece of mechanical or electrical equipment can fail at anytime. It is impossible to determine which component of your car, for example, will fail next. It could be a door handle which would be inconvenient, or it could be the engine block which would be catastrophic. A ten dollar fan belt or a three dollar gasoline filter can render your car immobile.

The same is true of an air conditioning system or a heat pump. Since it is impossible to determine when a minor component will fail, we have concentrated on the major components and estimated failure probability by considering the age and condition of the equipment. The type of failure we have contemplated would involve replacement of one or more major components, or replacement of the entire system. The compressor is the major component of these systems.

5.0 COMPRESSOR

The compressor is the heart of every heat pump and air conditioning system (with the exception of gas chillers). It is responsible for moving the refrigerant through the system, and compressing the refrigerant to the point where it becomes a high pressure, high temperature gas. Once the gas is in this state, it is capable of giving off heat. A compressor can be thought of as simply a pump for gases.

Life Expectancy

The life expectancy of a compressor is typically ten to fifteen years, in moderate climates and eight to ten years in hot climates. It is not uncommon for a compressor to constitute thirty to fifty percent of the cost of an entire system. Unfortunately, from a visual inspection it is usually not possible to tell whether the compressor in the system is the original or a replacement. Residential compressors are hermetically sealed, and cannot be closely examined. Therefore, when looking at a twelve year old air conditioner, it is not possible without dismantling the system, to determine whether the compressor will need replacement in the near future or whether the compressor has recently been replaced.

Depending on the unit age, replacement of a failed compressor may not be cost effective. If the unit is so old that replacement parts are not readily available or if the system uses an older refrigerant which is now banned (a suspected ozone threat), it may be better to replace the entire condenser unit, rather than just the compressor.

Easily Damaged

Severe damage can occur to air conditioning compressors if they are turned on when the outside temperature is below 60° F. (15° C.). Some compressors contain a small heating element which must be on for twelve to twenty-four hours prior to the compressor starting up. If the heater has not been turned on, or if the outside temperature is low, the compressor should not be tested.

Cannot Test

The compressor for a heat pump must operate over a much larger temperature range than an air conditioner compressor; however, below a given temperature the heat pump is locked out and the only source of heat is the furnace, or back up plenum heaters. Under these conditions, the compressor cannot be tested.

The compressor (located outdoors in most systems) must be kept level (within roughly ten degrees). Failure to do so will damage the compressor.

6.0 PLENUM COIL

The plenum coil sits in the ductwork immediately downstream of oil or gas furnaces and upstream (usually) of electric furnaces. On an air conditioning system, the plenum coil (known as the evaporator coil) is used to transfer heat from the house air to the refrigerant within the coil. On a heat pump, the coil works the same way in the summer, and in reverse during the heating season when it transfers heat from the coil to the air being passed across it. In the winter, it is acting as a condenser.

Coils are normally made of copper or aluminum tubing to which very thin fins are attached to enhance the heat transfer. With age, coils can corrode. This can result in a blockage of the refrigerant line or leakage.

Temperature Drop

The temperature drop across the coil should be 14° to 22° F. If fins are not cleaned regularly, air flow across the coil can be blocked by dust and other foreign matter. Dirty fins are also a common problem where the furnace filter is dirty or missing. The fins are extremely delicate and can easily be damaged. Low air flow can lead to excess temperature drop across the coil, resulting in ice build-up problems. Too low a temperature drop also indicates the need for service. The problems may include fan size or coolant pressures.

The plenum coil is not visible or readily accessible.

► 7.0 OUTDOOR COIL

The function of the outdoor coil is to transfer heat from the refrigerant to the outside air when the system is in the cooling mode. On a heat pump, the system works in reverse during the heating mode, transferring heat from the outside air to the refrigerant.

The coils are constructed of copper or aluminum and have very fine fins attached to improve heat transfer. As with plenum coils, outdoor coils are subject to corrosion, blockage and leakage. Air flow across the coil can be inhibited by dirt or other foreign matter. Damaged fins will reduce efficiency.

Ice Up

Air flow can also be inhibited on a heat pump during the heating mode if the coils ice up. This happens because the outdoor air is being cooled to a point where it can no longer hold its water vapor. The moisture falls out of the air as liquid and quickly freezes on the coil. Heat pumps have a defrost cycle to prevent ice up problems. Some are timed defrost cycles while others operate on a demand defrost system.

► 8.0 WATER COOLED COIL

A water cooled coil performs the same function as the outdoor coil on an air cooled central air conditioning system. It is a condenser which cools the refrigerant to the extent that it returns to a liquid state.

Rather than using a finned coil with air passing across it, this coil is surrounded by a water jacket to take the heat away.

As with all coils, there is potential for a refrigerant leak. There is also the possibility of a water leak from the jacket. Corrosion from recycled pool water (which contains chlorine) is also a possibility and, consequently, reusing pool water as opposed to fresh water is not recommended.

► 9.0 OUTDOOR FAN

The function of the outdoor fan is to move air over the outdoor coil. This cools the refrigerant during the cooling mode or adds heat to the refrigerant in the heating mode.

Outdoor fans are subjected to the elements and blades can be damaged by foreign matter. Also, motors and bearings can wear out. The outdoor fan section can wear out prematurely if the intake air or the exhaust air is obstructed. This will also greatly reduce efficiency. Consequently, it is important to keep the area around the outdoor unit free of obstructions.

► 10.0 CONDENSATE TRAY/LINE/PUMP

When an air conditioning system or a heat pump is cooling, household air passing across the cold plenum coil causes condensation to form. This condensation is collected in a condensate tray. A condensate line carries the water from the tray to a floor drain or sink, arranged so that siphoning cannot occur. Condensate can also be discharged into the ground outside the house.

If the water cannot flow by gravity, a condensate pump is installed to pump the water to a suitable location. The condensate should not discharge directly into a plumbing vent or stack, nor onto a roof.

While the condensate tray is not visible, there is sometimes evidence of a malfunction.

Water stains can sometimes be detected on the top of the furnace indicating a cracked or broken condensate tray, a condensate tray which is not level, or a condensate tray which has a plugged outlet and is overflowing. It is essential that the condensate tray function properly or the excess water will drip onto the heat exchanger (the most critical component of the furnace). Water dripping on a heat exchanger can rust it prematurely, requiring furnace replacement.

The condensate line which takes the condensation from the tray to a drain can be leaking, missing, broken, or plugged. On systems requiring condensate pumps, it is important that the pump be inspected monthly. While the pumps are relatively inexpensive and are easily replaced, they are prone to failure.

► 11.0 REFRIGERANT LINES

Refrigerant lines which are normally copper, transfer refrigerant back and forth between the condenser and the evaporator. Refrigerant lines which contain cold vapor should be insulated to prevent condensation from forming. With conventional air conditioners and heat pumps, this is the larger tube between the plenum coil and the outdoor unit.

The most common problems with refrigerant lines are mechanical damage, leakage and corrosion. Refrigerant lines are frequently damaged where they pass through the house wall. It is preferable, although not critical, to keep the length of refrigerant lines to a minimum.

► 12.0 INDOOR FAN

The purpose of the indoor fan is to move air across the indoor coil picking up or giving off heat. The warmed or cooled air is distributed throughout the house. On conventional air conditioning systems and heat pumps, the indoor fan is actually the blower for the furnace (usually modified for increased air flow). On independent systems, a separate fan is provided.

Problems Fan bearings and motors can wear out. On belt driven fans, the belt tension can be incorrect or the pulleys improperly set up. Missing filters allow the blower to get dirty. Fans which are out of balance can be extremely noisy, especially attic fans since the noise is transmitted through the rafters and ceilings.

Fan Size If the fan is too small, air flow through the house will be weak. The air at the registers may be cool, but the velocity will be too low. An oversized fan will give very strong air flow, but the air will not be as cool as it should be. The system may also be noisy.

► 13.0 DUCTWORK

The ductwork distributes the heated or cooled air throughout the house. Ductwork can be disconnected, obstructed or dirty. Supply and return registers can be missing, damaged, inoperative or covered with furniture or carpets. Ductwork originally designed for heating only, may be undersized for cooling. When air conditioning or a heat pump is being added to an existing system, the size of the ductwork may limit the size of the air conditioning or heat pump. On poorly matched systems, the air flow at the registers will be weak. In most cases, major ductwork modifications are not cost-effective.

Humidifiers Poor humidifier installations can cause air conditioning problems. The most common by-pass humidifiers are mounted on furnace ductwork near the air conditioner. A section of ductwork runs between the supply and return ductwork, with the humidifier in the duct. A damper should be provided to shut off the air flow through this duct during the cooling season. If there is no damper, or it is left open in summer, the air conditioner will suffer. At best, efficiency will be reduced. At worst, the evaporator coil will ice up.

Balancing Where heating and cooling systems share the same ductwork, rebalancing of the distribution system is usually necessary when switching from heating to cooling and vice versa. The rooms requiring the most cooling are usually not the rooms which require the most heating. Rebalancing is best accomplished by moving dampers located in the ductwork. To a lesser extent, rebalancing can be accomplished by opening or closing the grilles on the registers.

Damaged Ductwork may be crushed, separated or obstructed, either during original construction or subsequently.

Ducts in Concrete Slab-on-grade houses often have 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.

► 14.0 ATTIC DUCTWORK INSULATION

On any system that has ductwork passing through the attic, it is important to provide proper insulation on the ductwork. Without insulation, extreme temperatures in the attic can reduce the effectiveness of the system significantly. Some ductwork is manufactured with integral insulation for this purpose. In some attic installations, insulation is missing, improperly installed, or of insufficient quantity (minimum of R-7).

► 15.0 SUPPLEMENTAL COOLING

In many houses, there are rooms which are not heated by the central heating system. In most cases, heating is supplemented by electric baseboard heaters. While these will do an adequate job of heating, they are of no value when cooling is required. In areas such as these, or areas supplied by insufficient ductwork, supplemental cooling may be required. It is often easier to install a window mounted air conditioner to provide or supplement the cooling in a given area, than it is to make major modifications to the ductwork.

► 16.0 ATTIC DRIP PAN

On independent heat pump or air conditioning systems which have indoor components located in attics, a drip pan should be provided as an extra safety precaution. Should the condensate tray overflow, the drip pan acts as a second line of defense. The drip pan should have its own drain line. A common drain line between the condensate tray and drip pan may cause a flood if it plugs. In this case, there is no second line of defense. Some drains discharge into the plumbing stack. This is not permitted in some areas and it is a better practice to discharge straight outside. While they are not always installed, drip pans are considered to be a wise investment as their omission can result in damaged ceilings.

► 17.0 WATER LINES

On water cooled air conditioning systems, water is provided from the plumbing system. The waste water must go down a drain or may be used for watering a lawn or filling a swimming pool. The water is non-potable (non-drinkable) and cannot be re-introduced to the drinking water.

On systems where water can be directed to one of several locations, it is imperative that the supply valve and at least one discharge valve (on some systems they are automatic) be open during operation so that there is water flow through the air conditioning system. A lack of water flow can seriously damage the unit.

On some installations, the waste water is not only used to fill the swimming pool but it is also recycled to cool the air conditioning system and heat the pool. A loop is created, flowing pool water through the air conditioner. This is not considered to be advisable as the chemicals in the pool water can cause corrosion to the air conditioning system. The warm pool water also reduces the efficiency of the system.

► 18.0 THERMOSTAT

The purpose of a thermostat is to ensure that the temperature within the house is maintained at the temperature setting which is called for by the homeowner. For this reason, the location of the thermostat is critical. It should not be exposed to drafts, direct sunlight, heating sources or cooling sources.

Most houses which have central air conditioning or a beat pump have a single thermostat which controls the furnace and the air conditioner or heat pump.

Switching Modes

Most thermostats that are designed for heating and cooling require the operator to choose the mode of operation. Once the mode of operation is chosen, the thermostat attempts to maintain the desired temperature. One should never switch back and forth between heating and cooling modes on the thermostat. As a rule, at least fifteen minutes should elapse between operation of the heating system and operation of the cooling system, and vice versa. Most thermostats for air conditioning also have a fan switch. This switch allows for continuous or intermittent operation of the blower.

Multiple Thermostats

Houses which have multiple heating and cooling systems or zoned heating and cooling have more than one thermostat. This is as it should be. However, some houses with a single furnace and an air conditioner or heat pump have more than one thermostat. This is often the case with independent air conditioners or heat pumps, or systems installed on a retrofit basis. In this case, the thermostats should be interlocked to prevent simultaneous heating and cooling. If they are not, care should be exercised.

Heat Pumps

Thermostats for heat pumps are somewhat different. They are normally arranged in such a way as to allow the heat pump to attempt to maintain the desired temperature first. Should the heat pump fail to keep up, it is shut off and the furnace is activated. Most heat pump systems have a switch on the thermostat marked "emergency heat". This switch enables the operator to bypass the heat pump and rely solely on heat from the furnace.

Heat pumps should not be run in the cooling mode when outside temperatures are below 65°F. Above 65°F, heat pumps should not be run in the heating mode.

► 19.0 HOUSE FAN

Some houses have exhaust fans (usually located in the hallway on the top floor) which are used to cool the house during summer months. Most of these fans have no ductwork associated with them; they simply discharge into the attic. The attic must be well vented to take full advantage of these fans. They can be extremely powerful and draw a significant amount of air out of the house.

Avoid Winter Use

Problems arise when they are used during winter months (to clear the house of cigarette smoke during a party, for example). Since they draw so much air out of the house, the house is under negative pressure and outside air tries to get back into the house any way it can. One way air gets back into the house is by coming down the chimney. This can cause fireplaces to smoke and heating systems to backdraft. In addition, it causes a significant amount of warm moist air to be discharged into the attic where it can cause condensation problems.

Therefore, house fans should ideally be scaled off during the winter to prevent their use and prevent warm moist house air from sneaking by the fan into the attic.

► 20.0 EVAPORATIVE COOLER

Principles of Operation

Evaporative cooling systems are used in warm, dry climates such as those found in southwestern United States. Evaporative coolers use a high volume, low speed blower to draw outside air into the house, typically through a moist cooling pad. As the air passes over the moisture, the water absorbs heat from the air. This evaporates some of the water and lowers the temperature of the air delivered into the house. A pump draws water out of a tray to keep the pads wet. Variations include a drip type cooler which allows water to drip down through the air flow. No pads are used with this system. The rotary type cooler has a drum made up of fine metal screening which rotates through a tank of water. The air passes over the upper part of the rotor, again evaporating some of the moisture.

Water Supply and Blower

The water level in the tank or tray is maintained by a connection to the supply plumbing in the house. A float valve allows water to be added as needed. An electric motor drives the blower.

Problems

Evaporative coolers do not work well when the air outside is humid. Also, since the indoor air ends up being relatively humid, a drop in temperature can lead to condensation in the house and ultimately, mildew and bacteria problems. Also, water sitting in the tray or tank may become stagnant during idle periods. The unit should be drained seasonally. Difficulties with electric motors and blower bearings for example, are common failure points. Spray type units may have the spray nozzles clogged and water pads may become dirty, restricting air flow. Rust and leakage of the enclosures are other common problems.

Independent of Heating Ductwork

Evaporative coolers should not be interconnected with heating ductwork. Moist air passing over a furnace heat exchanger can rust it out, destroying the furnace.

► NOTES