

# Cooling/Heat Pump

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## INTRODUCTION

THERE ARE MANY TYPES OF AIR CONDITIONING AND HEAT PUMP SYSTEMS; HOWEVER, THEY ALL WORK ON THE SAME PRINCIPLE. THEY MOVE HEAT FROM A RELATIVELY COOL SPACE TO A RELATIVELY WARM SPACE. IN THE SUMMER, THEY TAKE HEAT FROM THE HOUSE AIR AND TRANSFER IT TO THE EXTERIOR. THIS HEAT MAY BE TRANSFERRED TO THE OUTSIDE AIR, A BODY OF WATER, OR INTO THE GROUND. IN THE HEATING SEASON, HEAT PUMPS REVERSE THE PROCESS, MOVING HEAT FROM THE OUTSIDE AIR, GROUND, OR WATER, INTO THE AIR INSIDE THE HOME.

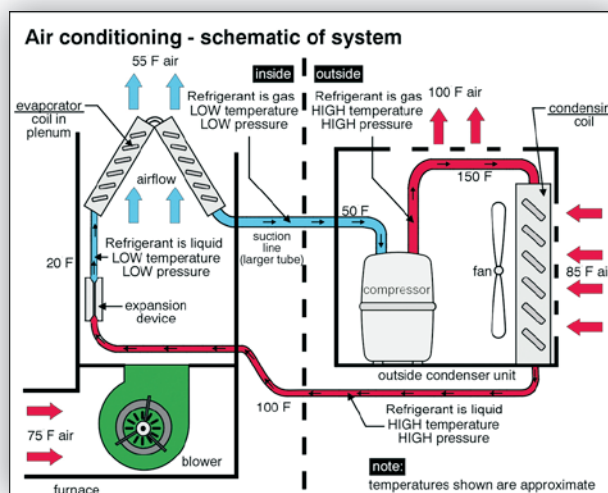
### 1.0 Air Conditioning

#### 1.1. Air Cooled

**REFRIGERANT TAKES HEAT FROM HOUSE AIR** **1.1.1 Description and Components:** Air-cooled air conditioning systems are the most common. They have two main components: the evaporator, which may be in the ductwork immediately above the furnace or in the attic, and the condenser, which is outdoors. The refrigerant (a liquid/gas that moves the heat) enters the evaporator as a cold liquid. It removes heat from the house air, which is blown across the cooling coil by a fan.

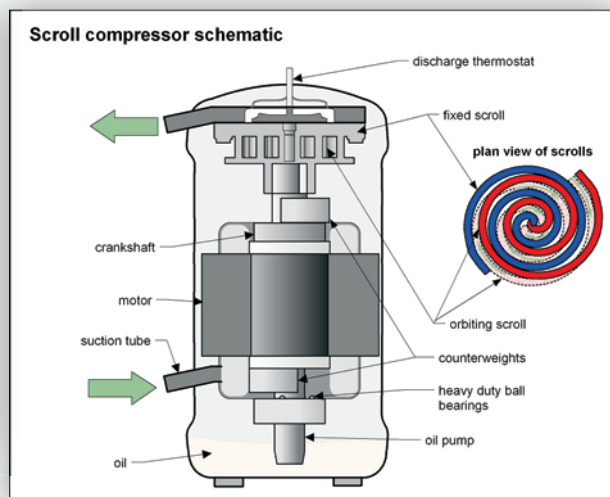
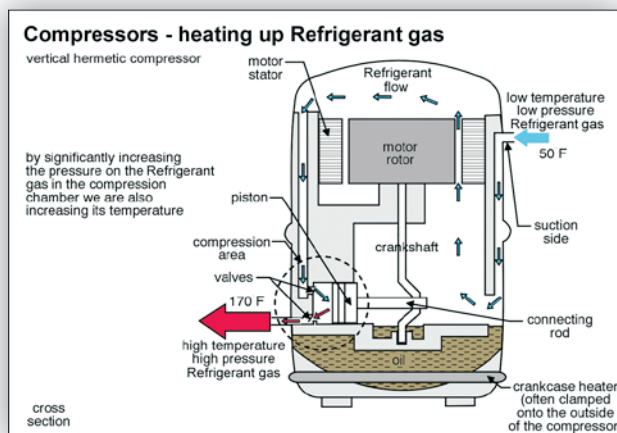
**HOUSE AIR IS COOLED AND DEHUMIDIFIED** As the house air cools, water in the house air condenses, reducing humidity levels. This dehumidifying helps make the house more comfortable. Air conditioning systems both cool and dehumidify the house air.

**GETTING BACK TO THE REFRIGERANT** The refrigerant, which is now a gas, moves outdoors to the condenser unit. The compressor squeezes the gas, raising the temperature above the outdoor air temperature (This is the magic! We can squeeze the gas coming from the house and make it hotter than the outdoor air). The hot gas enters the condenser coil and a fan blows outdoor air across the coil, removing heat from the gas. As it cools, the refrigerant condenses into a liquid. The liquid moves indoors and goes through a pressure-reducing device, which cools the liquid below the temperature of the house air. The liquid passing through the evaporator coil is evaporated into a gas again, removing more heat and humidity from the house. The cycle continues.



**1.1.2 Compressor:** The compressor is a pump that moves the refrigerant through the system and compresses the refrigerant when it is a gas, raising its temperature significantly. The compressor is the heart of the system. It is usually located outdoors in the condenser cabinet.

Older compressors are piston-type. Scroll-type compressors are used in many new systems.



**EASILY DAMAGED** Severe damage can occur to air conditioning compressors if they are turned on when the outside temperature is below 65° F (16° C). Some compressors contain a small heating element (crankcase heater) that must be on for 12 to 24 hours prior to the compressor starting up. The heater ensures there is no liquid refrigerant mixed in with the lubricating oil. If the heater has not been turned on, or if the outside temperature is low, the compressor cannot be tested.

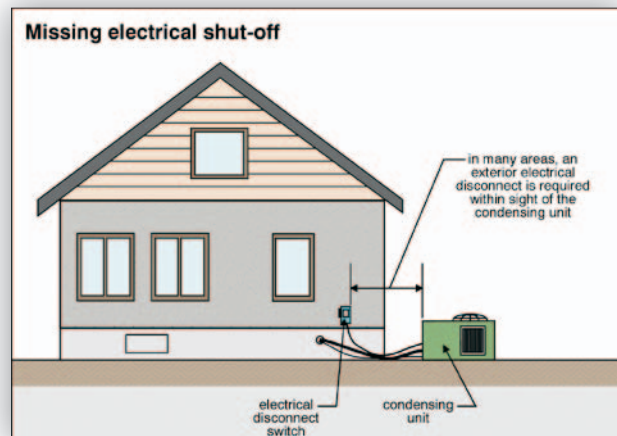
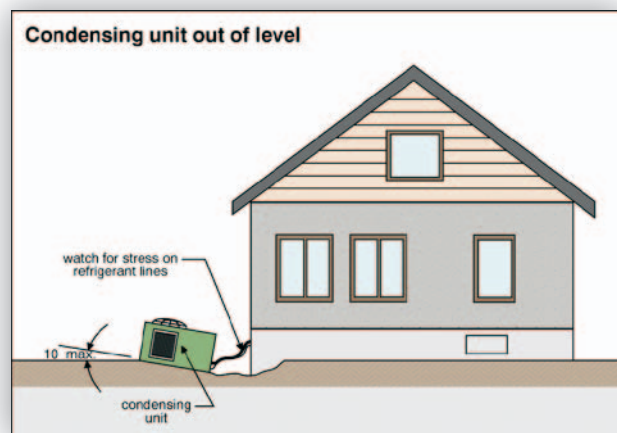
## Common Problems with Compressors

**OLD** The life expectancy of a compressor is typically 10 to 15 years in moderate climates and as little as 8 to 10 years in hot climates. It is not uncommon for a compressor to constitute 30% to 50% of the cost of an entire system. The compressor age typically cannot be determined during a home inspection.

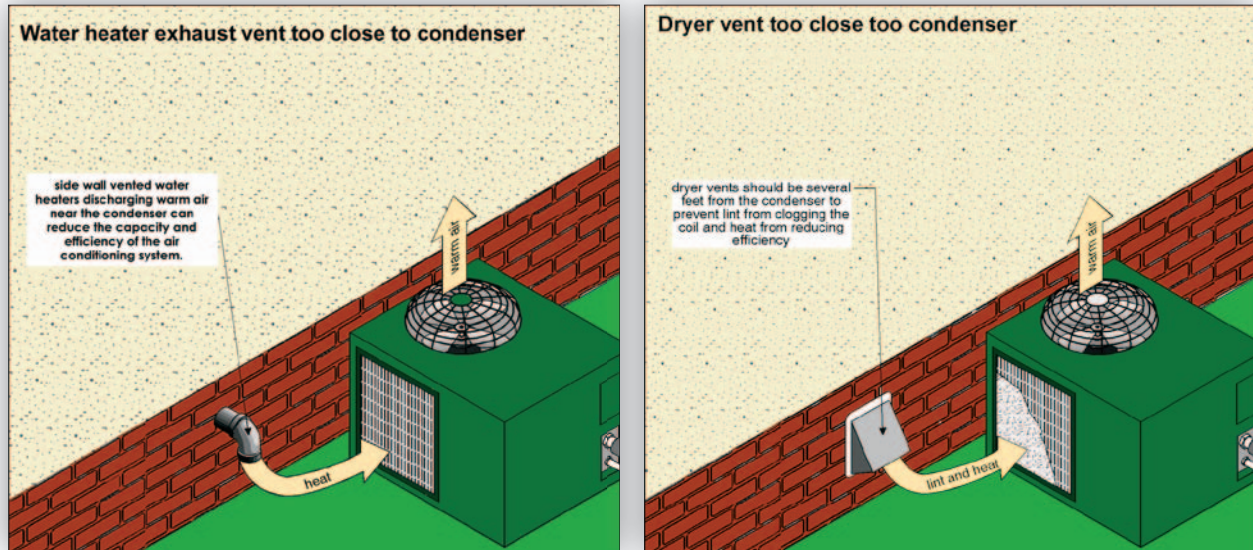
**INOPERATIVE** Depending on the unit age, replacement of a failed compressor may not be cost effective. If the unit is so old that replacement parts are not readily available or if the system uses an older refrigerant, it may be better to replace the entire condenser unit, rather than just the compressor.

**NOT LEVEL** The compressor (located outdoors in most systems) should be level (within roughly ten degrees). The compressor or the refrigerant lines may be damaged if the unit is out of level.

**ELECTRICAL DISCONNECT – MISSING** There should be an outdoor electrical disconnect that can be seen from the compressor unit so that the outdoor unit can be turned off for safe servicing.



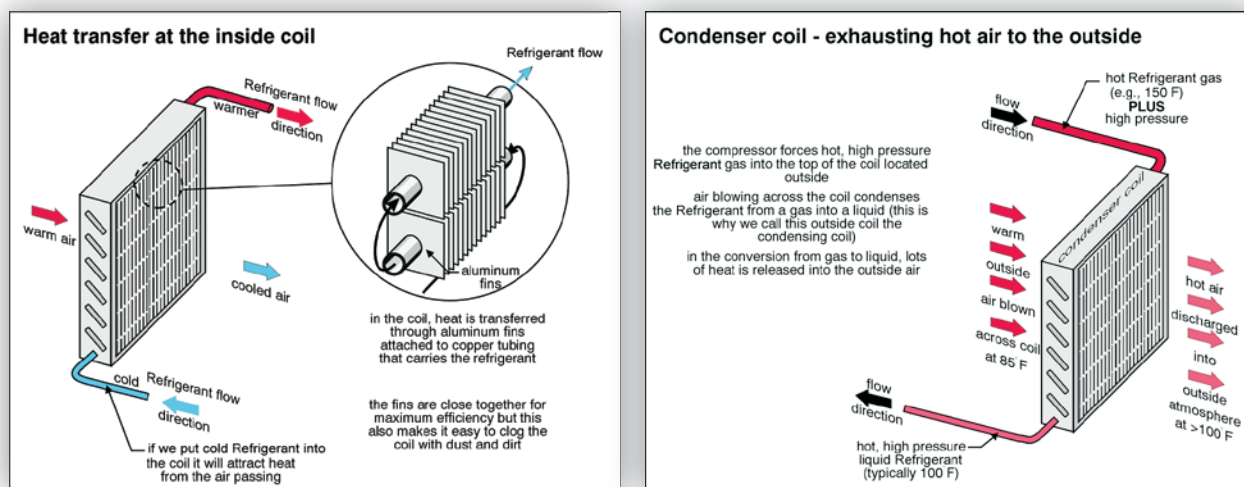
**APPLIANCE EXHAUST TOO CLOSE TO CONDENSER** Hot air discharging from a water heater exhaust vent or clothes dryer vent can affect the operation of air conditioning systems. These should be kept several feet from the condenser.



**NOISY** There are several causes of noisy compressors. A service specialist should be engaged to diagnose and correct the problem.

**1.1.3 Indoor and Outdoor Coils:** The indoor (evaporator) coil sits in the ductwork downstream of the heat exchanger in a gas or oil furnace or in the attic in a fan coil unit, typically. The evaporator coil moves heat from the house air to the refrigerant in the coil. The outdoor condenser coil moves heat from the refrigerant to the outside air.

Coils are normally made of copper or aluminum tubing with very thin fins to enhance the heat transfer. The fins are delicate and easily damaged by power washers for example.



## Common Problems with Coils

**CORROSION, BLOCKAGE OR DAMAGE** Coils are subject to corrosion, blockage and damage. Dirt or other foreign matter can inhibit airflow across the coil. Grass clippings from lawn mowers can clog condenser coils. Damaged fins reduce efficiency and increase operating costs.

**LEAKAGE** Leaking refrigerant reduces efficiency and comfort while increasing costs. In a worst-case scenario, the system will not work. Leaks are difficult to identify visually. They are most often picked up during regular servicing.

**HIGH/LOW TEMPERATURE DROP ACROSS COIL** The air temperature should drop 14° to 22° F as it moves across the indoor (evaporator) coil. If heat transfer is inhibited by dirty or damaged coils, the temperature drop will be less, indicating poor performance. Dirty coils may be the result of a missing house air filter or poor maintenance.

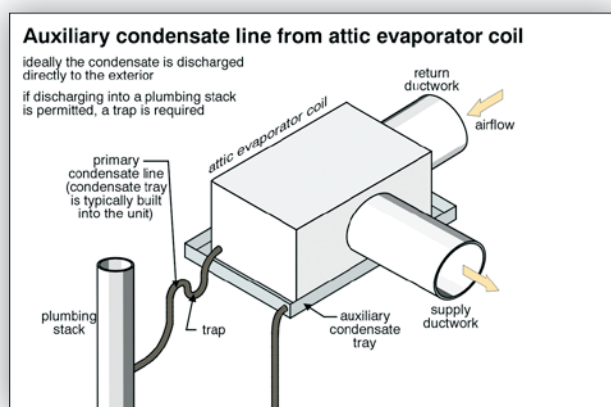
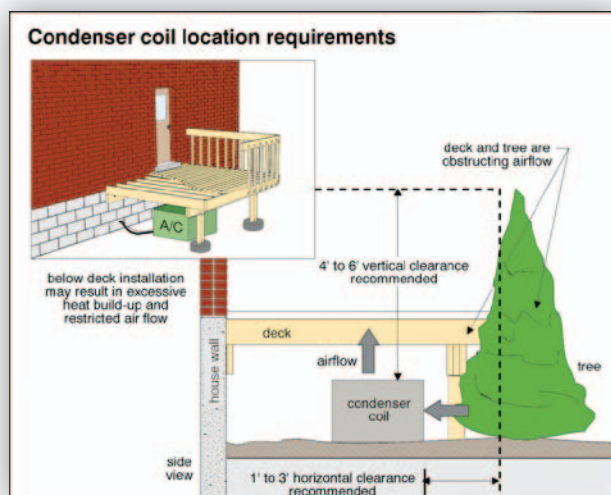
If airflow is restricted by a dirty air filter for example, the air may not move quickly enough across the coils and may get too cold. The temperature drop may be more than 22°, also indicating poor performance. In severe cases, the coil may ice up.

Improper temperature drops may also indicate refrigerant level problems.



**POOR LOCATION OF OUTDOOR (CONDENSER) COIL** Outdoor coils should be several feet from clothes dryer vents and furnace or water heater vents coming out through the wall. Coils should not be located under decks or surrounded by trees or shrubs, since this will restrict the airflow, adversely affecting performance.

**1.1.4 Attic Drip Pan:** Where the air conditioning coil is in the attic, a drip pan should be provided as an extra safety precaution. When the condensate tray overflows, the drip pan provides a second line of defense.



### Common Problems with Attic Drip Pans

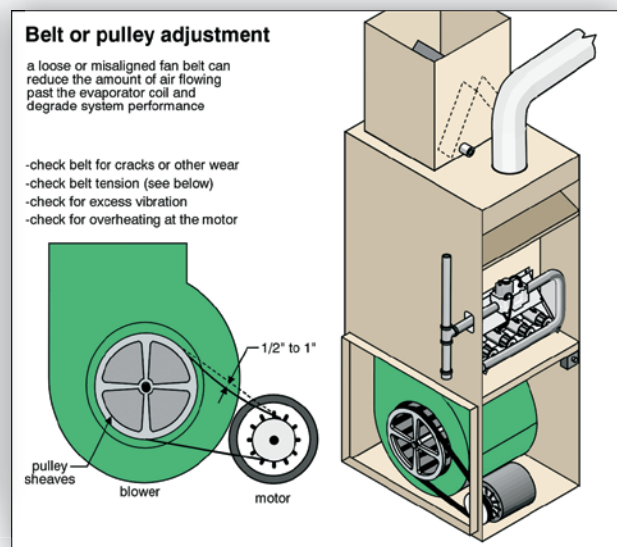
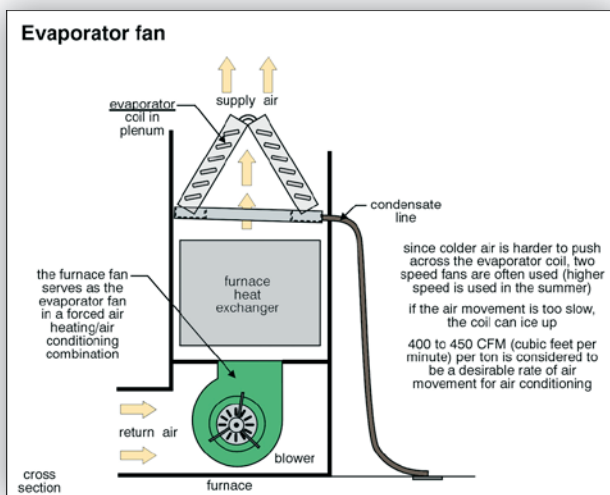
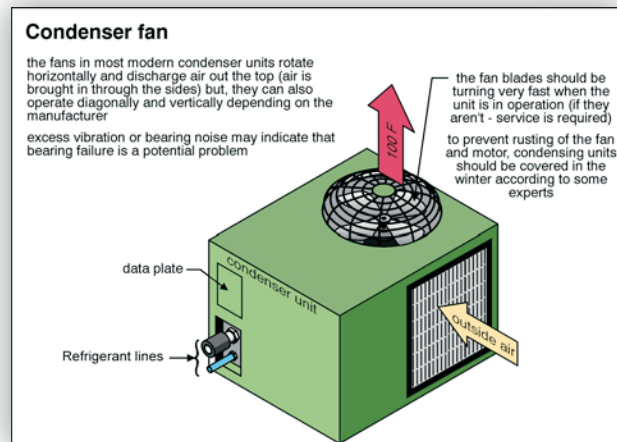
- MISSING/ LEAKING** While they are not always installed, drip pans can prevent a lot of damage. However, a leaking or clogged drip pan is as bad as a missing drip pan.
- NO SECONDARY DRAIN** The drip pan should have its own drain line. A common drain line between the condensate tray and drip pan may cause a flood if it plugs. In this case, there is no second line of defense.
- POOR DRAIN DISCHARGE LOCATION** Some drains discharge into the plumbing stack. This may allow sewer gases to back up into the house through the air conditioning system.

**1.1.5 Indoor and Outdoor Fans:** The fans move air across the coils, picking up or giving off heat. The cooled air is distributed throughout the house by the indoor fan. The indoor fan is often also the furnace fan (usually modified for increased airflow). On independent systems, a separate fan is provided.

The outdoor fan moves air over the outdoor coil. This cools and condenses the refrigerant, which has been heated to above the outdoor air temperature by the compressor. The outdoor fan is in the condenser cabinet.

## INDOOR FAN PROBLEMS

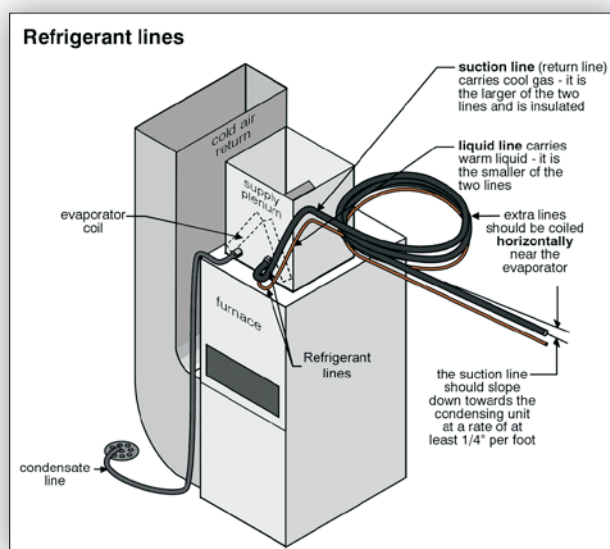
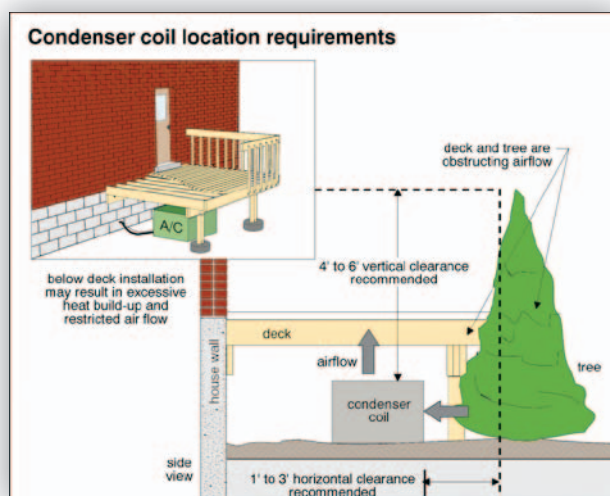
Fan bearings and motors can wear out. On belt driven fans, the belt tension can be incorrect or the pulleys may be improperly set up. Missing air filters allow the blower (fan) to get dirty. Fans that are unbalanced can be noisy, especially attic fans as the noise is transmitted through the rafters and ceilings. Bad bearings can also make the fan noisy. Fans may be inoperative due to belt or pulley problems, a failed electric motor, or interrupted electrical supply.





- FAN SIZE** If the indoor fan is too small, airflow 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 strong airflow, but the air will not be as cool as it should be. The system may also be noisy.
- DAMAGE AND WEAR** Outdoor fans are exposed to the elements, and blades can be damaged by foreign matter. Also, motors and bearings can wear out. Corrosion is also an issue.
- OBSTRUCTED** The outdoor fan can wear out prematurely if the intake air or the exhaust air is obstructed. This will also greatly reduce efficiency. It is important to keep the area around the outdoor unit free of obstructions.

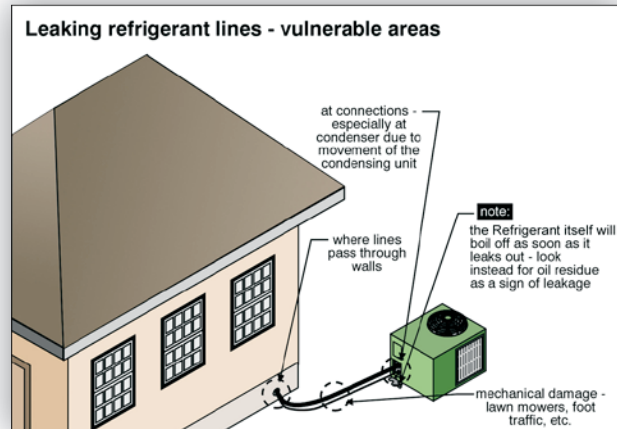
**1.1.6 Refrigerant Lines:** The copper refrigerant lines move the refrigerant between the condenser and the evaporator. Refrigerant lines are normally arranged in pairs, with the larger diameter line carrying gas and the smaller one carrying liquid. The larger refrigerant pipe containing cool gas is typically insulated to prevent condensation and increase efficiency.



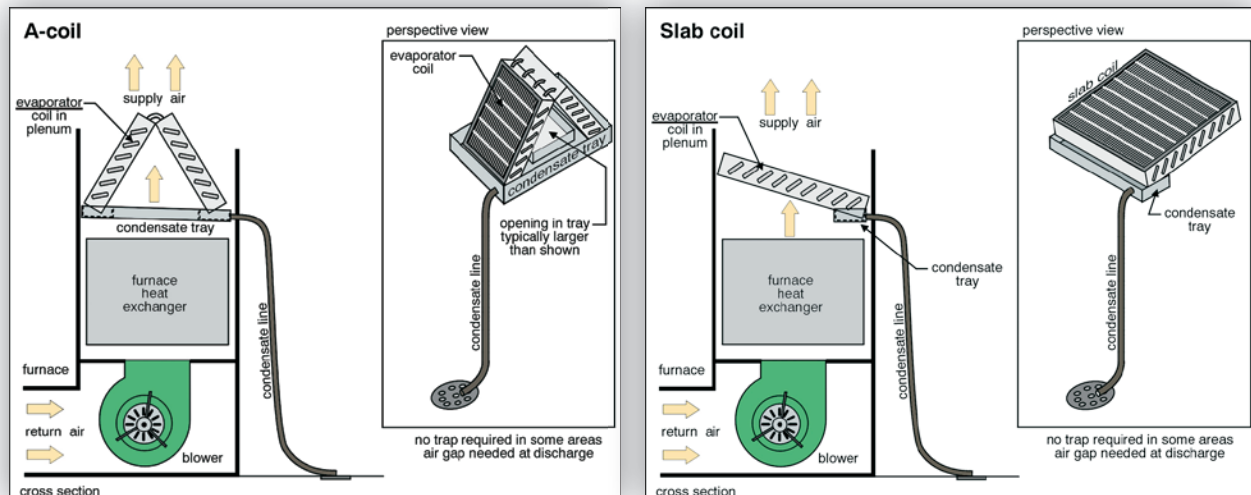
## Common Problems with Refrigerant Lines

**DAMAGE/ LEAK/CORROSION** 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. Leaking refrigerant lines are usually identified by oil deposits on the line.

**INSULATION MISSING/ DAMAGED** Insulation on the outdoor larger (suction) line may be missing or damaged, significantly reducing the efficiency of the air conditioning system. If insulation is missing on the larger line indoors, condensation may be a problem.



**1.1.7 Condensate System:** When an air conditioning system or a heat pump is cooling, house air passing across the cold evaporator coil condenses as it cools. The condensation is collected in a tray below the coil. A condensate line carries the water from the tray to a floor drain or sink in the house, or to the outdoors. The piping should be arranged so that siphoning cannot occur.



If the water cannot flow by gravity, a condensate pump moves the water to a suitable location. The condensate should not discharge directly into a plumbing vent or stack, or onto a roof.

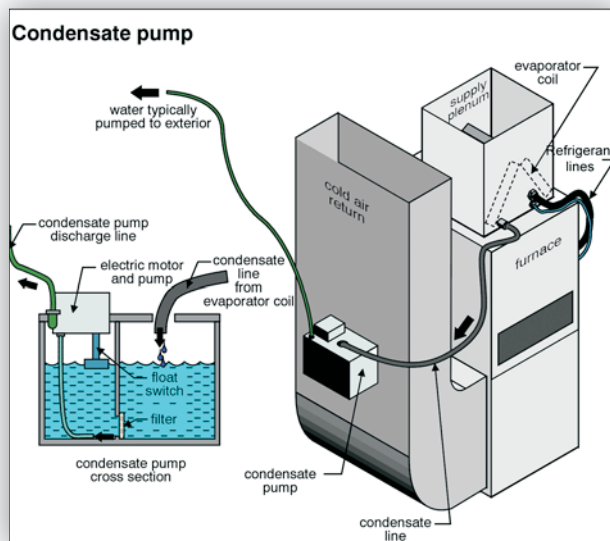
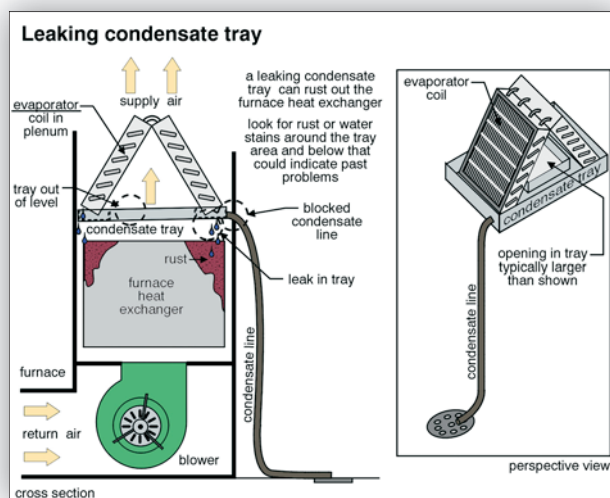
## Common Problems with Condensate Systems

**TRAY LEAKING/ OVERFLOWING** While the condensate tray is not visible, there is sometimes evidence of a problem. Water stains may be seen below the evaporator coil indicating a cracked or broken condensate tray, a condensate tray that is not level, or a plugged condensate tray that is overflowing.

Where the air conditioner is installed above a furnace, it is important that the condensate tray function properly. Water dripping on a furnace heat exchanger can rust it prematurely, necessitating furnace replacement.

**PIPE – MISSING/ LEAKING/ CLOGGED** The condensate line that takes the condensation from the tray may be leaking, missing or plugged.

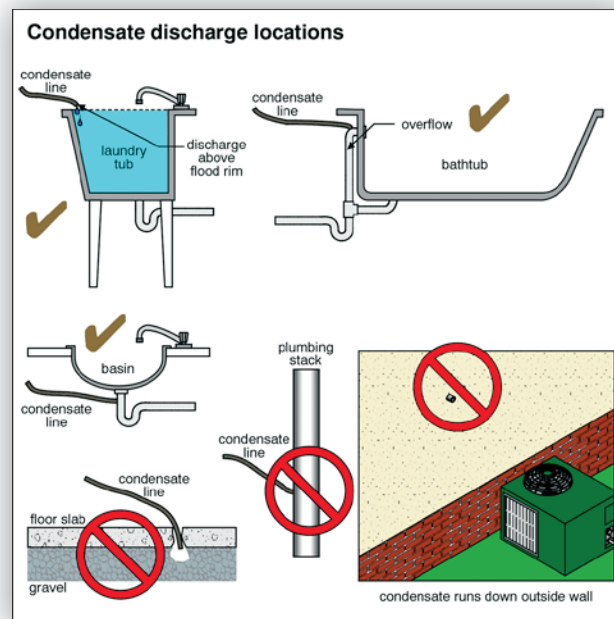
**PUMP PROBLEMS** Inoperative condensate pumps are a common problem. These are typically low-cost pumps that are easily replaced.



**POOR DISCHARGE LOCATION FOR CONDENSATE** Condensate should not discharge into plumbing fixtures where siphoning problems may develop. Condensate should not discharge into the space below a floor slab or into a plumbing stack, in most cases. Condensate should not run down the outside of the building wall because the wall may be damaged.

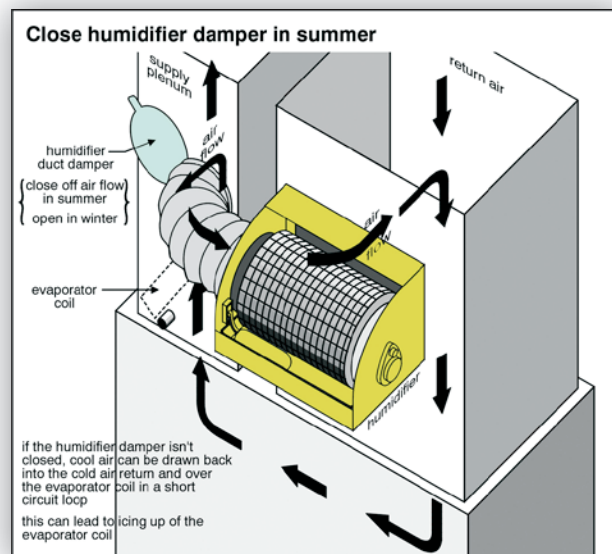
**PUMP INOPERATIVE** In some cases the condensate is pumped up to a drain. Water damage may occur if the pump fails.

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



## Common Problems with Duct Systems

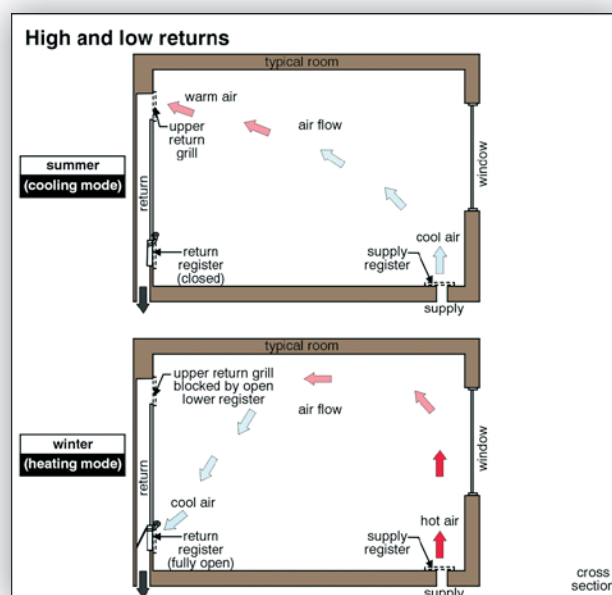
**HUMIDIFIER DAMPER MISSING/OPEN** Humidifiers on furnaces can cause air conditioning problems. The most common bypass humidifiers are mounted on furnace ductwork near the air conditioner. A section of ductwork runs between the supply and return ductwork, with the humidifier in the duct. A damper should be provided to shut off the airflow through this duct during the cooling season to prevent short circuiting of the airflow. 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 between heating and cooling. The rooms requiring the most cooling don't always need the most heating. Rebalancing is usually done by moving dampers in the ductwork and by adjusting the supply registers and return grilles.

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

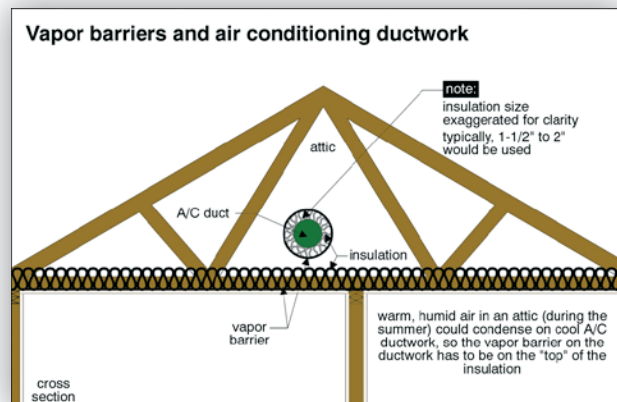
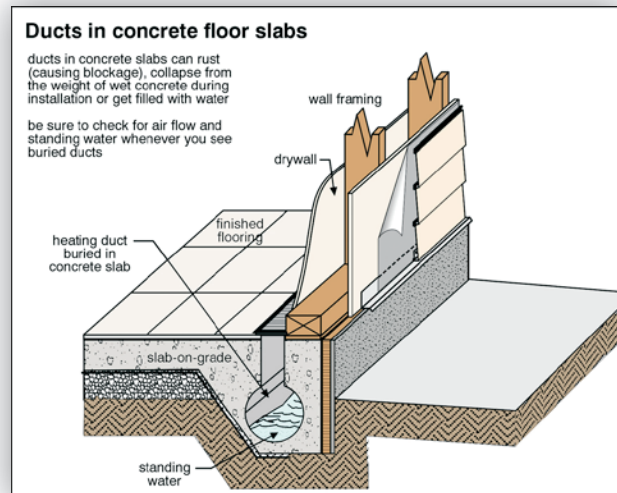
**MISSING** Some rooms may have no air conditioning. This is typical in additions and garages that have been converted to rooms. They may have no heating ductwork and be heated by electric baseboards. Since there is no ductwork, there is no air conditioning to this part of the home.



**DUCTS IN CONCRETE FLOOR SLABS** 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, restricting airflow through the system. Ductwork in poured slabs and foundations is difficult to inspect and to repair.

**INSULATION OR VAPOR BARRIER MISSING ON ATTIC DUCTS** Attic ductwork should be insulated to prevent heat transfer in the attic. The vapor barrier should be on the outside of the insulation to prevent condensation.





**1.1.9 Thermostat:** The thermostat allows the homeowner to adjust the house temperature. It should not be exposed to drafts, direct sunlight, heating sources or cooling sources. Homes with heating and cooling systems often have a single thermostat to control both.

**SWITCHING MODES** Most thermostats that are designed for heating and cooling require the operator to choose whether they want heating or cooling. We don't want a system that allows the house to try to heat and cool at the same time. Once the mode is chosen, the thermostat attempts to maintain the desired temperature. Switching back and forth repeatedly between heating and cooling modes can damage the compressor. Allow at least fifteen minutes between operation of the heating system and the cooling system.

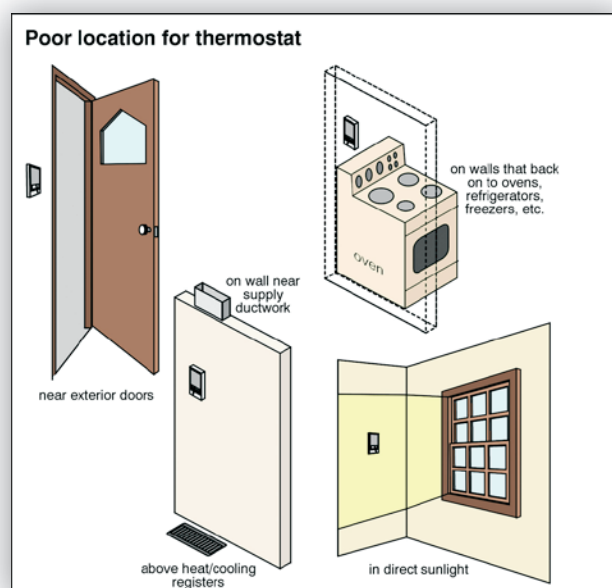
Many thermostats also have a fan switch that allows for continuous or intermittent operation of the blower. The fan always operates when the air conditioner or furnace is working. Some people like to run the fan all the time to circulate and filter house air. Some fans can operate at a lower speed when the heating or cooling are not working.

**MULTIPLE THERMOSTATS** Houses with multiple heating and cooling systems or zoned heating and cooling have more than one thermostat. 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 are often interlocked to prevent simultaneous heating and cooling. If they are not, care should be exercised.

### Common Problems with Thermostats

**MALFUNCTIONS DAMAGE/LOOSE** Thermostats can function improperly if they are dirty, not level, or improperly calibrated. They can also suffer mechanical damage. The thermostat may be poorly secured to the wall.

**POOR LOCATION** The thermostat should not be placed where it may get a false reading of the room temperature. It should not be close to exterior doors, in direct sunlight, or close to heat sources like ovens and heating/cooling supply registers. This will make the house uncomfortable and may increase cooling costs.



## 1.2 Water Cooled Air Conditioners

**1.2.1 Description and Components:** Water-cooled air conditioning systems work almost the same way as air-cooled systems. They have a coil in the house ductwork that evaporates a liquid refrigerant into a gas and draws heat out of the house. The gas is then compressed to raise its temperature. Then, instead of blowing outside air across the gas to cool it, water is moved across the coil. The condenser does not have to be outdoors. It can be in the home.

Once the water has cooled the gas back to a liquid, the warmed water is disposed of. It is no longer drinkable and, therefore, must go down the drain, into a swimming pool or be used to water the lawn. Water cooled air conditioners consume a lot of city water and are not permitted in all municipalities.

**COMPRESSOR** On these systems, the compressor is just as critical as on an air-cooled system. It is the heart of the air conditioner. The indoor compressor is not exposed to outdoor weather conditions and often enjoys a longer life expectancy than outdoor units.

The system is simple where the discharged water goes straight down a drain. 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 that determine where the water will go. At least one valve is always open to allow water to flow. Automatic valves are available.

**1.2.2 Water 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 that cools and condenses the refrigerant. Rather than using a finned coil with air passing across it, this coil is surrounded by a water jacket to take the heat away.

**1.2.3 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, the supply valve and at least one discharge valve have to be open so that there is water flow through the air conditioning system. A lack of water flow can seriously damage the unit.

### Common Problems with Water Cooled Air Conditioners

- LEAKS/ CORROSION** 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 may contain chlorine) is also a possibility and that's why re-circulating swimming pool water is not recommended.
- LACK OF WATER** The water supply may be interrupted by closed valves, malfunctioning controls, a pipe leak or restricted flow. This can cause serious damage to the compressor.

### 1.3 System Types

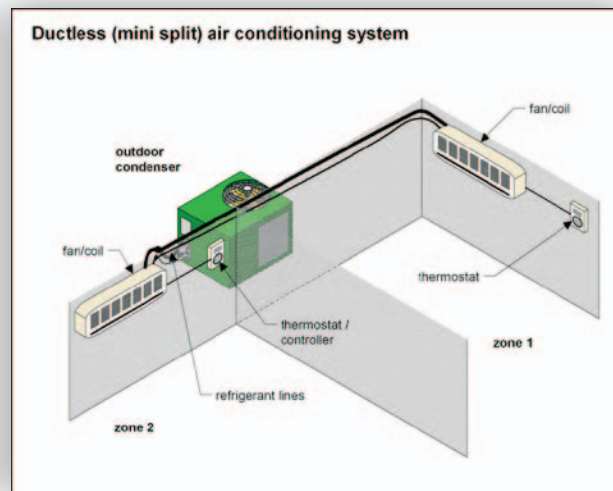
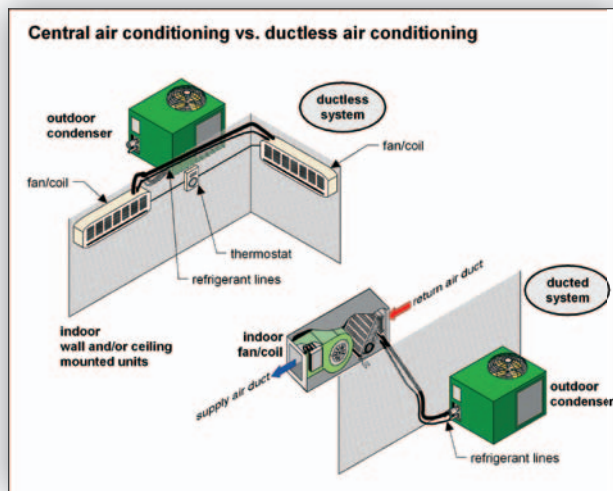
- SHARED DUCTWORK** **1.3.1 Central:** In air-conditioned homes that also have a furnace, the indoor coil is mounted in the duct-work near the furnace and the heating ductwork is used for cooling as well. Only one set of ductwork is needed, and the house air is moved across the indoor air conditioning coil by the furnace blower.
- 1.3.2 Independent – Ducted:** In houses with no ductwork, the air conditioner and ductwork must both be added and are independent of any heating system. The indoor coil is often in the attic. In some cases large ductwork is used, similar to that used with furnaces. Small diameter ducts are often used when adding air conditioning to an existing home because they take up less space, and are less disruptive to install. The small insulated ducts typically have high velocity air movement, and there may be several supply registers/diffusers/ nozzles in each room.
- BLOWER** On a cooling system that shares ductwork with a heating system, the blower for the heating system is used for the air conditioner or heat pump. With an independent system, a separate blower is provided.
- DISADVANTAGES** When independent systems are installed on a retrofit basis, a few compromises have to be made. Attic-mounted units are more difficult to service because of their location. Also, a system mounted in the attic may be noisier than a system mounted in the basement. Care should be taken to avoid damage due to condensate leaking into the living space below. Please refer to 1.1.4 – Attic Drip Pan on page 247.

**SPLIT SYSTEMS** **1.3.3 Independent – Ductless:** There are two common types of ductless systems – split systems and single component systems. Split systems have a condenser cabinet with a compressor, condenser coil and fan on the ground or on the roof, the same as any central split system. The evaporator coil and house air fan are inside the home, in the area to be cooled. There is a condensate collection and discharge system for the interior component. There are two refrigerant lines, often in a conduit, joining the outdoor condenser unit to the evaporator inside the home. These units have no ductwork to move cooled air to different rooms.

**COMPACT** Split systems, also called mini-splits, are easy to install and only require a 3-inch diameter hole through the house wall. The indoor components can be wall or ceiling mounted and don't take up much space. Some have remote controls so they can be mounted out of the way, high on walls or on ceilings.

**QUIET** These have a remote compressor (the noisiest part of an air conditioner) so the home is quieter. Some interior fans are multi-speed to minimize noise. There are also quieter fans in some systems that operate at very low rpm (less than 900 rpm).

**MULTI-ZONE SYSTEMS** Split systems can be multi-zone, with one condenser unit serving up to four evaporators in four different parts of the home.



**SINGLE COMPONENT SYSTEMS** Single component systems are also called through-wall or package systems. These are self-contained systems with the condenser, compressor and evaporator all in the same cabinet, installed in the wall of the room or area to be cooled. These units are common in hotels and apartments. These single component systems are noisier than split systems because the compressor is in the wall-mounted unit. Some include electric elements for supplementary heating. Again, there is no ductwork to move cooled air through the home. Some people think of these as permanently installed window air conditioners.

### Common Problems Specific to Ductless Units

**AIRFLOW ISSUES** Ductless air conditioners can blow air up to 40 feet in an open area, but since there is no distribution system, it is difficult to achieve balanced cooling in multiple rooms. In small rooms, air can bounce off walls or furnishings and create short cycling and comfort problems. These systems are often located near the top of the stairwell in a two-story home to cool as much of the home as possible.

**CONDENSATE DAMAGE** Condensate discharge systems are often on the building exterior, below the wall-mounted evaporator. Discoloration or wall damage may occur if the condensate runs down the wall surface.

## 1.4 Capacity of Air Conditioning and Heat Pump Systems

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.

**COOLING RATINGS** Cooling ratings are expressed in tons. A ton represents 12,000 BTUs per hour. One BTU (British Thermal Unit) is 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 by one Fahrenheit degree). Typical central air-conditioning systems in homes are two to five tons.

**HEAT GAIN: AIR-CONDITIONING** Cooling systems are sized by calculating the heat gain for the house. The heat gain depends on several variables including climate, the size and configuration of the house, the construction, the amount of insulation, and the type, size and orientation of windows. Cooling systems are sized to keep the house roughly 15 to 20 degrees cooler than outdoors during the hottest day of the year, not necessarily at 72° F.

**HEAT LOSS: HEAT PUMPS** 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. As the outdoor temperature drops, the house needs more heat and the heat pump may not be able to keep up with the heat loss. Depending on the system, when the heat pump can't keep up, it may be helped with supplementary heat (electric heating elements, for example), or the heat pump may be shut off and a gas or oil furnace may take over.

**CAN'T TELL WHETHER SIZE IS RIGHT** Without performing heat gain calculations, it is not possible to determine the size of system needed for a house. 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. This is not determined during a home inspection. The capacity of mismatched systems 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 rather than undersized equipment. As a general rule, however, air-conditioning systems provide one ton of cooling for every 700 to 1000 square feet of house in moderate climates, and 450 to 600 square feet of house in warmer climates.

**DON'T OVERSIZE AIR-CONDITIONING** Modern, well-insulated homes may need less cooling and heating. Older, energy-inefficient homes need more. Air conditioning systems perform better and last longer if they are slightly undersized rather than oversized. Oversized units tend to short cycle and fail sooner. They also do not do as good a job dehumidifying the home. High humidity in the home makes it uncomfortable, even if the temperature is fine.

### 1.5 Life Expectancy of Air Conditioners and Heat Pumps

Any piece of equipment can fail at any time. We can't predict which component of our car, for example, will fail next. It could be the radio, which would be inconvenient, or it could be the engine, which would be catastrophic. A \$10 fan belt or a \$3 gasoline filter can make your car un-drivable. The same is true of an air conditioning system or a heat pump. When minor components fail, they can be replaced. When the compressor fails, replacement of the whole system may make sense.

**10 TO 15 YEARS** Air conditioning systems are often considered to have a life expectancy of 10 to 15 years. Life expectancies tend to be shorter in hotter climates where the air conditioners work harder and for more of the year.

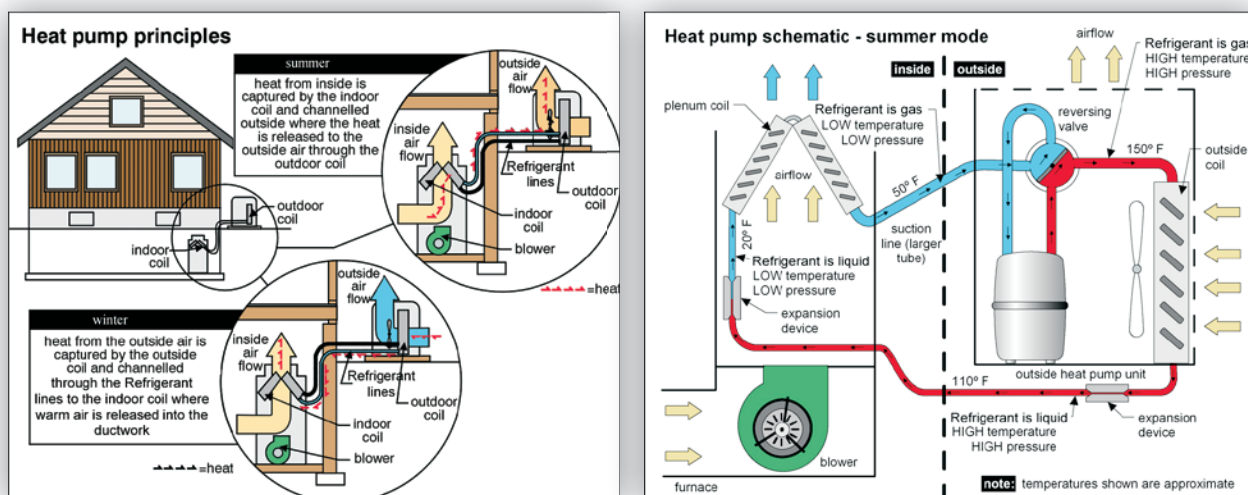
**HEAT PUMPS MAY BE LESS** Heat pumps work both summer and winter, and again may have life expectancies on the shorter end of the typical scale. Heat pumps are also more complicated than air conditioners because of things like reversing valves and defrost systems. They may require more maintenance than air conditioning systems.



## 2.0 Heat Pumps

### 2.1 Description and Components – Air Source Heat Pumps

A heat pump is simply an air conditioner that can work in reverse to help heat the house. In the cooling season, the heat pump removes heat from the house interior and discharges it to the exterior, like an air conditioner. In the heating season, the refrigerant flow is reversed, and we remove heat from outdoors and put it into the home. The outdoor coil acts as a condenser in the summer and an evaporator in the winter. The indoor coil acts as an evaporator in the summer and a condenser in the winter. As with air conditioning, the compressor is the critical component.

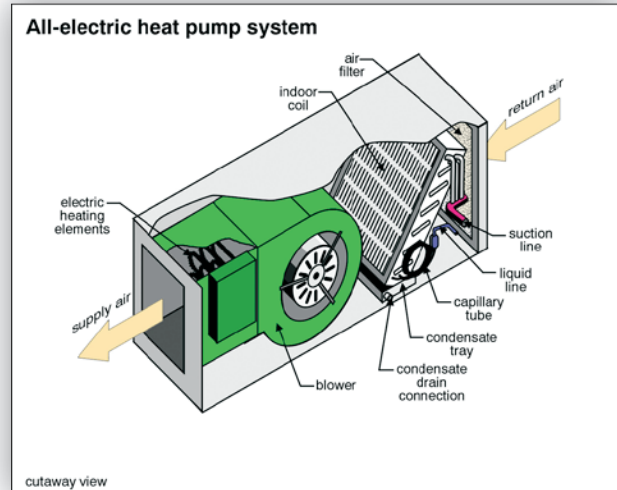


**AIR SOURCE,** Air source heat pumps work the same as air conditioners in the summer. They use the outdoor air to get rid of heat in the summer and they collect heat from the outdoor air in the winter. We can also collect heat from water in wells, rivers, lakes, etc. with water source heat pumps. Ground source heat pumps collect and discharge heat into the ground through a series of buried pipes.

We will look at air source heat pumps first, since they are the most common.

**ECONOMICAL OPERATION** In northern climates, heat pumps don't carry the entire heating load of a house. They only operate when they can add heat economically. When it costs more than a dollar's worth of electricity to add a dollar's worth of heat, the system shuts down. At this stage, the central heating system takes over. If the heating system is electric, the heat pump and electric heat can work together. If the heating system is gas or oil, the heat pump must be shut off when the furnace comes on.

**LIMITED TESTING** A heat pump cannot be tested during cold weather, when the heat pump is not working, and the heating system is gas or oil. Below a given temperature the heat pump is locked out and the only source of heat is 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.

**DRAFTY** When the heat pump is operating in the heating mode, the air coming out of the registers feels drafty to some people. The air at the registers from a heat pump is not as warm as the air from a gas or oil furnace (roughly 90°F rather than 120°F). The heat provided is helpful, but the comfort may not be the same.

**HEAT PUMP THERMOSTATS** Thermostats for heat pumps used with gas or oil furnaces are different than air conditioning thermostats. The heat pump tries 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 thermostats have a switch marked "Emergency Heat". This switch bypasses the heat pump and operates the furnace. This is useful because if the heat pump fails, we have a perfectly good furnace available. However if the thermostat is telling the heat pump to run, we can't get the furnace to turn on. The Emergency Heat switch allows the furnace to run.

## Common Problems with Air Source Heat Pumps

Heat pumps have all the same issues as air conditioners, and some additional issues. Because heat pumps are more complicated, and because they have to operate in cold weather as well as hot weather, they are more prone to problems than air conditioners.

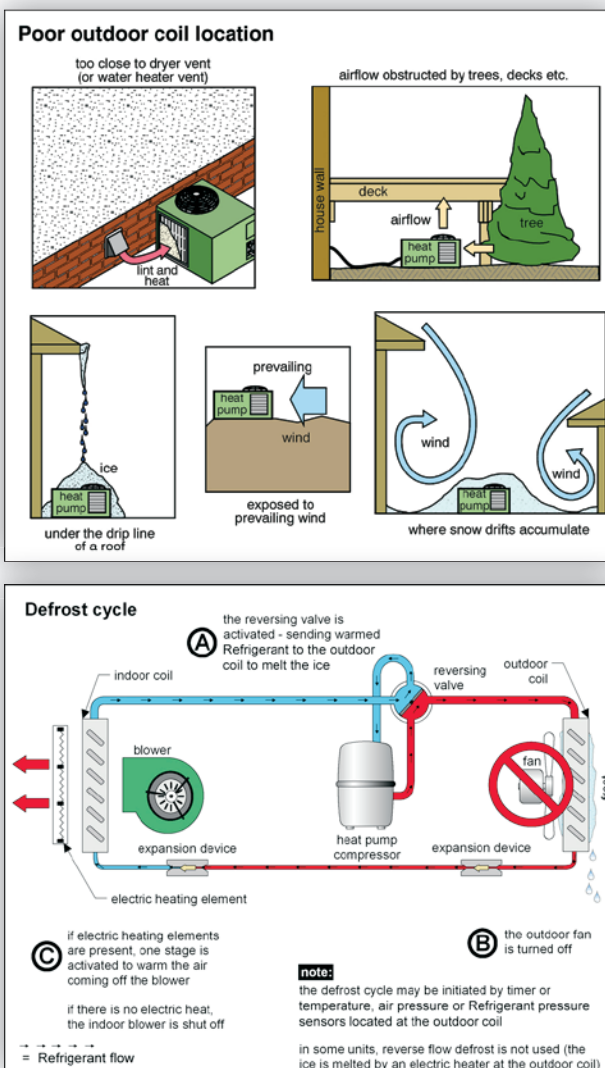
**POOR LOCATION FOR OUTDOOR COIL (AIR SOURCE)** Outdoor coils should not be exposed to ice buildup from water coming off the roof, strong winds or snowdrifts.

**ICED UP OUTDOOR COIL (AIR SOURCE)** The heat pump will not work if the outdoor coil ices up. This happens because the outdoor air condenses water when it cools as it passes over the coil. The moisture falls out of the air as liquid (condensate) and quickly freezes on the coil. Heat pumps have a defrost cycle to prevent icing problems. Defrosting problems can lead to icing up.

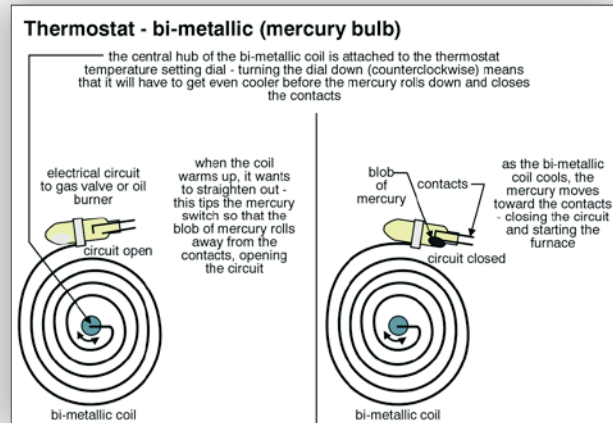
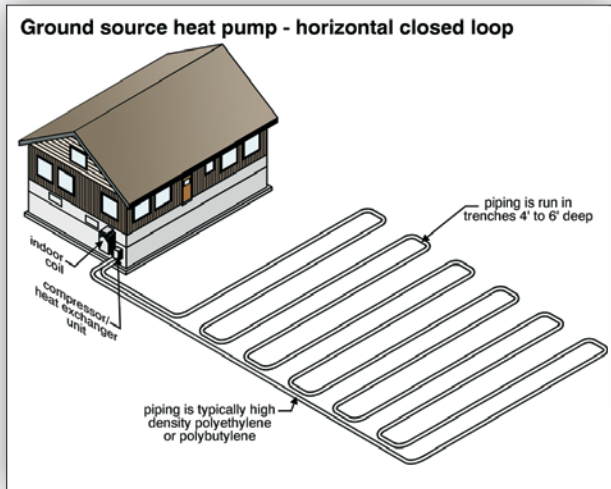
### 2.2 Other Types of Heat Pumps

Heat pumps can be central ducted systems, or ductless systems. They can be integrated with gas, oil or electric furnaces. They can be stand-alone systems that may have supplementary electric heating elements.

**AIR SOURCE HEAT PUMP** Most air source heat pumps look the same as air conditioners. There is an outside cabinet that is used to dissipate heat during the air conditioning season and collect heat during the heating season. The indoor section may be a coil near a furnace or a coil in an attic fan-coil cabinet where there is no furnace.



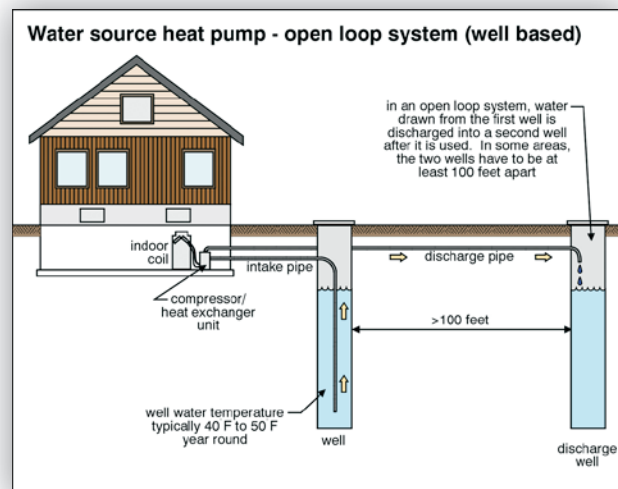
**GROUND SOURCE HEAT PUMP** Rather than using outside air to collect or dissipate heat, some systems use the ground or water. A ground source heat pump has piping running through the ground, with liquid that collects or dissipates the heat, depending on the season. The piping can be installed horizontally (shallow) or vertically (deep) below the ground surface.



**WATER SOURCE HEAT PUMP** 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. Rivers and lakes can also be used as a source for collecting and dissipating heat. These systems are called water source heat pumps.

The advantages of ground source and water source heat pumps are that the ground and the water are warmer than the outdoor winter air. There is more heat available to collect.

These systems are expensive to install, and early units had several problems. As energy costs increase and technology improves, the systems become more cost effective. They also work well for air conditioning.



## 2.3 Bivalent Systems

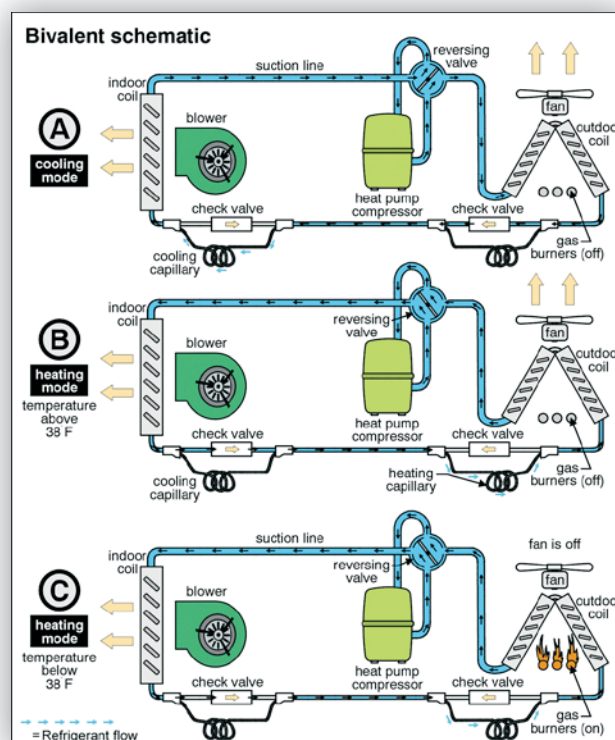
**FURNACE** As mentioned earlier, heat pumps are not capable of carrying the entire heating load during the coldest parts of a northern winter. With most systems, the heat pump has to eventually shut down and let the furnace take over because the heat pump cannot collect heat economically.

**BIVALENT HEAT PUMPS** These systems fool the heat pump. They have a burner (usually natural gas or propane) outdoors below the coil. Just when the system is about to shut down, the outdoor burner comes on and the coil thinks that there is a heat wave. Suddenly there is enough heat in the outside air to keep going.

These systems do not require a furnace in the house 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 getting heat from an outdoor auxiliary heater.

**ADVANTAGES** These systems require no furnace and no chimney.

**DISADVANTAGES** These systems have a high initial cost and there have been some reliability issues. The burner and the rest of the outdoor components are in a harsh environment. Corrosion on the burner and the coil can be a problem as a result of condensation.



### Common Problems with Bivalent Heat Pumps

These systems have all of the issues related to heat pumps, plus the complicating issue of an outdoor gas burner. Corrosion on the outdoor components can be a problem due to condensation from the products of combustion.

### 3.0 Evaporative Coolers

<b>FUNCTION</b>	Evaporative coolers are simple air conditioners that push outdoor air into the home after adding water to the air to cool it. The unit may be mounted on an exterior wall or on the roof. There is usually a simple, supply-only duct system to distribute the cooled moist air through the home.
<b>PRINCIPLE OF OPERATION</b>	Evaporative cooling systems are used in warm, dry climates such as those in the Southwest. 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 wet media, the water absorbs heat from the air. This evaporates some of the water and lowers the temperature of the air delivered into the house.
<b>MOVING AIR THROUGH WATER</b>	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.
<b>WATER SUPPLY AND BLOWER</b>	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.

#### Common Problems with Evaporative Coolers

<b>INOPERATIVE</b>	An evaporative cooler may not respond to its controls because power has been shut off, the water has been shut off or the blower or motor has failed. No air-conditioning will be available if the system does not respond.
<b>CONDENSATION/ MILDEW/ BACTERIA</b>	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. Water sitting in the tray or tank may become stagnant during idle periods. This can be a health concern. The unit should be drained seasonally. Leaking trays or tanks may cause water damage.
<b>SEIZED MOTORS/ FAILED BLOWER BEARINGS</b>	Difficulties with electric motors and blower bearings are common failure points.
<b>CLOGGED NOZZLES/DIRTY PADS</b>	Spray type units may have the spray nozzles clogged and water pads may be dirty, restricting air flow. Very little cooling will result.
<b>RUST/LEAK</b>	Rusting cabinets and leakage through the enclosures are other common problems. This can damage building components.
<b>INDEPENDENT OF HEATING DUCTWORK</b>	Evaporative coolers should not be interconnected with heating ductwork. Moist air passing over a furnace heat exchanger can rust it out, destroying the furnace.