



Consulting, Resource, Education, and Support Services for Professional Home Inspectors
"A candle loses no light when it lights another candle."

Electric, Split System, Central Refrigerated Central Air-Conditioning

-System Components and Operation-

An electric, split system, central, refrigerated air conditioning system uses a refrigerant circulated within a closed system to remove heat from the air in the interior of the house (a sensible heat process, so-termed because it can be measured or "sensed" with a thermometer) and to dehumidify the air in the interior of the house (a latent heat process, so-termed because latent heat is "hidden" and cannot be measured with a thermometer).

It is referred to as a "split system" because it has both interior and exterior components.

EXTERIOR COMPONENTS

- **An exterior electrical service disconnection means within sight of the exterior unit. This is typically connected by electrical conduit appropriate for the use and location to an exterior unit case with protective grilles which houses:**
- **A compressor (typically 220 volt nominal)**
- **A finned-tube condenser (outdoor) coil (a radiator)**
- **An accumulator**
- **A fan (fan motor [110 or 220 volt nominal] and a fan / propeller)**
- **An insulated refrigerant suction line (typically $\frac{3}{4}$ inch diameter copper tubing)**
- **An uninsulated liquid refrigerant line (typically $\frac{3}{8}$ inch diameter copper tubing)**
- **Electrical / electronic components**
- **Valves**

In addition, outside of the exterior unit case there may also be the following:

- **A sight glass**
- **A filter / drier / receiver on the liquid line**
- **A filter / drier on the suction line (if a compressor has been replaced)**

INTERIOR COMPONENTS

- A thermostat / electronic controls
- An air circulation blower
- Air filtration and cleaning component(s)
- A conditioned air supply plenum and ducting system
- A liquid refrigerant line (typically $\frac{3}{8}$ inch diameter copper tubing) and metering / expansion device
- A metering device
- An finned-tube evaporator (indoor) coil installed inside of the supply plenum
- A condensate collection and discharge system
- An insulated refrigerant suction line (typically $\frac{3}{4}$ inch diameter copper tubing)
- A conditioned air return plenum and ducting system

THE SYSTEM IN OPERATION

When the thermostat demands cooling, the compressor, the condenser fan, and the conditioned air distribution system blower are all energized and the following process is initiated:

The compressor operates as both a compressor and as a pump to move and circulate the refrigerant through the system. When activated, it draws in and compresses the **warm, low pressure refrigerant GAS** through the suction line which is connected to the upstream side of the compressor. The process of compressing the refrigerant gas also raises its temperature so that when it is pushed/pumped out of the downstream side compressor, it exits the compressor at the compressor outlet as a **hot, high pressure GAS**. It travels from the compressor to the condenser coil through the discharge line, a short section of tubing which connects the compressor outlet to the condenser inlet. It enters the upstream side of the condenser coil at the condenser coil inlet as a **hot, high pressure GAS**.

As the refrigerant gas moves through the condenser (outdoor) coil, the condenser fan pulls ambient outside air across the finned surfaces of the condenser coil finned tubing lowering the temperature of the refrigerant gas within the condenser coil. This reduction in temperature causes the refrigerant to change state from a **hot, high pressure GAS** to a **hot, high pressure LIQUID**. Because the process of condensing, that is, of changing from a less dense (gaseous) state to a more dense (liquid) state, occurs in this coil, the outdoor coil is also referred to as the condenser coil.

This process of removing heat is the first law of thermodynamics at work – “HEAT” MOVES FROM A HOT, LESS STABLE STATE, TO A COOL, MORE STABLE STATE where “heat” is defined as the transfer of thermal energy between two bodies which are at different temperatures. In this case, the two bodies are the hot refrigerant gas inside the system and the cool air outside the system. Remember, “hot” and “cool” are relative terms. Even though the outside air temperature may be 100° F, it is still “cool” relative to the 150° F temperature of the refrigerant gas.

The **hot, high pressure LIQUID** refrigerant exits the downstream end of the condenser coil at the condenser coil outlet into a small diameter (usually $\frac{3}{8}$ inch), uninsulated, copper tube called the liquid line. In some installations, an inline sight glass and/or a filter/drier may be installed on the liquid line immediately downstream of the compressor/condenser unit.

NOTE: A sight glass permits observation of the refrigerant as it moves through the liquid line from the condenser toward the evaporator (indoor) coil. Bubbles visible in the refrigerant as it passes through the sight glass are an indication that the system refrigerant charge is low and the system needs to be serviced to determine the cause of the low refrigerant charge, to make any necessary repairs, and to recharge the system. A filter/drier device on the liquid line is designed to remove any particulate contamination and moisture in the liquid refrigerant.

The **hot, high pressure LIQUID** refrigerant continues to move through the liquid line to a component called the expansion device. The expansion device is located immediately upstream of the evaporator (indoor) coil in the supply plenum of the conditioned air supply distribution system on the interior of the house.

The expansion device may be capillary tubing, a metering orifice, a thermostatic expansion valve, or an electronic expansion valve depending on the manufacturer. All of these expansion devices perform the same function – that is, to direct the **hot, high pressure LIQUID** refrigerant into and through one or more very small orifices. The refrigerant exits the downstream end of expansion device and enters the upstream end of the evaporator coil as a **cold, low pressure atomized LIQUID mist** – an aerosol of fine droplets of liquid refrigerant.

NOTE: This is similar to what occurs when the spray release nozzle (a type of expansion device) on an aerosol spray can is depressed. The liquid in the can (just like the liquid refrigerant) is under pressure. When the spray release nozzle is depressed, the high pressure in the can forces the liquid in the can through a very small orifice in the spray nozzle causing the liquid to exit the nozzle as an atomized, cold, low pressure mist.

By passing the liquid refrigerant through the expansion device and turning it into an aerosol mist of fine droplets, the total surface area of the refrigerant is greatly increased. This increase in surface area allows for much more efficient heat transfer than if the refrigerant were to simply pass through the evaporator coil tubing in a non-aerosol liquid state.

As the **cold, low pressure LIQUID** refrigerant moves through the evaporator coil, the blower for the circulated conditioned air supply and return system passes air across the outer finned surfaces of the evaporator coil tubing and the cold, atomized liquid refrigerant within the evaporator coil absorbs heat from the air and its temperature increases.

As the refrigerant within the evaporator coil absorbs heat from the air being passed across the exterior surfaces of the coil, its temperature rises to its boiling point causing it to change state from a **cold, low pressure LIQUID mist** to a **warm, low pressure GAS** and exits the downstream end of the evaporator coil into the suction line - typically, a 3/4 inch diameter insulated copper tube.

As this process occurs in the evaporator coil, the air that is being blown across the coil is cooled, dehumidified, and circulated through the house via the conditioned air supply and returns ducting systems to cool the interior. The cooling of the air (the removal of heat from the air) as it passes across the coil is the 1st law of thermodynamics at work again, i.e., heat moving from a hot, less stable state, to a cool, more stable state.

NOTE: Dehumidification of the interior house air condenses occurs as moisture present in the interior house air condenses on the exterior surfaces of the evaporator coil. The condensate water runs off of the outer surfaces of the evaporator coil into a condensate collection pan below the coil. The water collected in the condensate pan drains via piping (and in some installations through a condensate collection and discharge pump system) to the exterior of the house where it is discharged.

The **warm, low pressure refrigerant GAS** is pulled through the suction line back toward the outside unit where it passes through an accumulator and back into the compressor to repeat the cycle. The accumulator is a component installed inline on the suction line to protect the compressor against liquid “slugging,” a condition which occurs when liquid refrigerant enters the compressor. Because liquid is practically non-compressible, the compressor seals may be compromised and the compressor may be damaged if the compressor attempts to compress the liquid refrigerant. It is not uncommon to have to replace the evaporator coil when the compressor is replaced as they are “matched” components and replacing the compressor without replacing the evaporator coil may result in a loss of system efficiency and/or damage to the new compressor.

NOTE: If the compressor has been replaced due to over-heating or burnout of the previous compressor, there may be an inline filter/drier on the suction line immediately upstream of the exterior unit to capture and remove particulates, varnish, and acids that can contaminate the system, especially the metering device, when compressor overheating or burnout occurs.

A filter/drier placed on the suction line when a new compressor is installed should be removed and replaced after a few days or weeks of operation. This is to reduce the potential for suction line restriction and back pressure in the system that can be caused if the filter becomes clogged with particulates and varnish (see illustration on next page).

NOTE: The illustration below shows both an accumulator and a filter/dryer installed on the system.

System Schematic

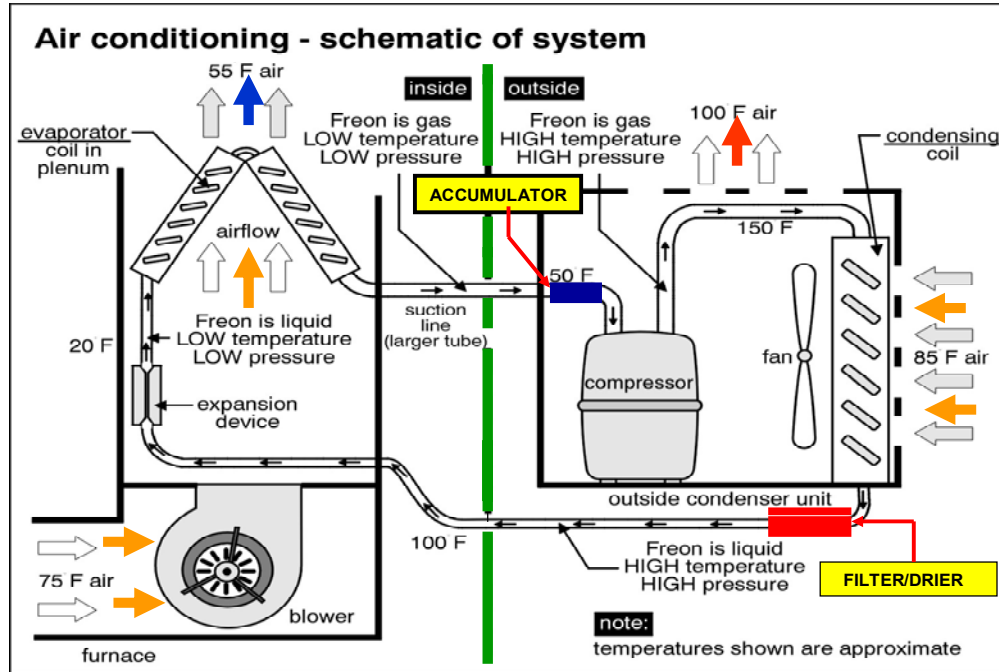


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