interdynamics

How-To Guide

A/C System Basics

A/C SYSTEM OVERVIEW

(Please click on images below for a larger view.)

There are three primary components in a vehicle's air conditioning system including the compressor, condenser, and evaporator. These parts are connected by tubes and hoses to form a continuous path with two distinct sections: a high-pressure side and a low-pressure side. In order to transfer heat from the vehicle's interior to the outside air, a chemical refrigerant is circulated throughout the system. In theory, the A/C system accomplishes the same task as the engine's cooling system, in that both absorb the heat from one area and release it to another (heat transfer). While coolant remains a liquid during the heat transfer process however, refrigerant repeatedly alternates between a liquid and a gas as it circulates throughout the air conditioning system.

THE REFRIGERANT CYCLE

The refrigerant cycle involves a three-step process that includes pressurization, condensation, and vaporization. Starting at the compressor, let's identify these steps as we trace the flow of refrigerant through the system (See A/C System Diagrams: Orifice Tube A/C System and Expansion Valve A/C System). The refrigerant enters the compressor through the suction port as a low-pressure vapor. After squeezing this vapor into a confined area (pressurization), it is released through the compressor's discharge port. By pressurizing the refrigerant, the compressor causes the refrigerant vapor to become much hotter than the outside air. This ensures that it will change to a liquid as the cycle enters the next phase.

Once pressurized, the compressor pumps the high-pressure refrigerant vapor to the condenser, which is located directly behind the grille in front of the radiator. As outside air is drawn over the condenser by the engine fan, or forced past it by the ram-air effect, the incoming air absorbs the heat contained in the high-pressure vapor. This causes the vapor to condense into a high-pressure liquid, completing the second phase of the process (condensation).

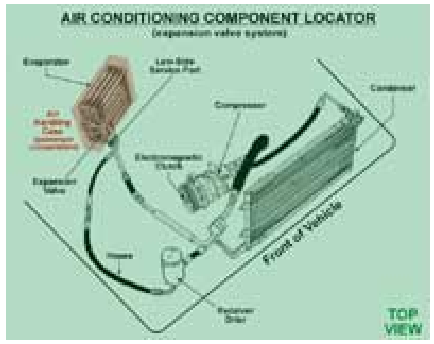
As the refrigerant leaves the condenser, it makes its way toward the evaporator, which is located within the air hadling case along with the blower. Before entering the evaporator, the refrigerant flows through a metering device. This results in a significant drop in pressure, allowing the refrigerant to vaporize at a lower temperature. This ensures that the refrigerant will absorb the maximum amount of heat as the blower forces warm air over the evaporator. At this point, the vaporization phase is complete, and the heat-laden vapor is drawn back into the compressor so the cycle can be repeated.

Since heat is removed from the air during the vaporization phase, the air exits the panel vents at a much lower temperature. This not only results in cool air, but dehumidified air as well. Remember, warm air has high moisture content. Consequently, when the warm air comes in contact with the cold evaporator, the moisture condenses on the evaporator surface and eventually drains onto the ground. This is why a puddle of water forms under the car after it has been shut off with the air conditioner on.

A/C SYSTEMS

[Click image for enlargement]

Orifice tube air conditioning systems regulate refrigerant flow to the evaporator using a fixed metering device (orifice tube).



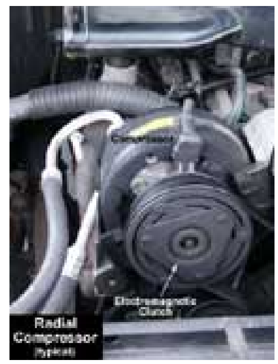
[Click image for enlargement]

In an expansion valve air conditioning system, refrigerant flow to the evaporator varies according to the pressure in the suction line (evaporator outlet). This is detected by a sensing bulb mounted on the line, and relayed to the expansion valve via a capillary tube.

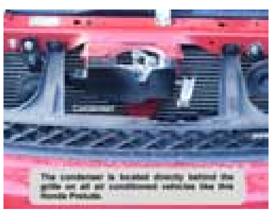
A/C COMPONENTS

Compressor

The compressor is a pump that pressurizes and circulates the refrigerant in the air conditioning system. It is mounted on the front of the engine and driven by the serpentine drive belt or its own individual belt. The compressor also serves as one of the two junctions separating the high and low sides of the system.



Condenser



Similar to the radiator, the condenser is a large heat exchanger located directly behind the grille. As part of the system’s high side, the condenser is used liquefy the high-pressure vapor discharged from the compressor. A condenser consists of a series of tubes surrounded by thin fins, which provide a large surface area for heat dissipation. While there are various tubing arrangements used, refrigerant flow is always from top to bottom.

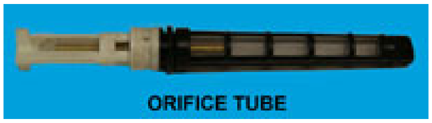
Evaporator

Like the condenser, the evaporator is also a heat exchanger consisting of tubes and fins. However, that’s where the similarity ends. Unlike a condenser, which is designed to release large quantities of heat, an evaporator is used to absorb large quantities of heat. An evaporator is also much smaller than a condenser and is part of the system’s low side. Evaporators are located in the air handling case along with the blower.

Metering Devices

Metering devices are used to regulate the flow of liquid refrigerant into the evaporator. They also serve as one of the two junctions between the high and low sides of the system. There are two basic types of metering devices used in A/C systems: fixed and variable.

Orifice Tube



This is a fixed metering device located inside the liquid line between the condenser and evaporator. The orifice tube is enclosed within a plastic housing and protected by a fine mesh filter. The filter prevents debris from clogging the tube.

Expansion Valve

On most older vehicles (pre-1990), the expansion valve is usually accessible from uner the hood. On most later models however, the expansion valve is located inside the air handling case along with the evaporator.

A variable metering device that varies refrigerant flow based on cooling demand. As demand increases, the valve opens wider to permit more refrigerant into the evaporator. Once the demand has been satisfied, the valve opening is reduced to decrease flow. Cooling demand is monitored by a sensing bulb mounted on or near the evaporator.

Although there are a variety of A/C systems used in cars and light trucks, they are all generally classified according to the type of metering device they use. Consequently, an A/C system is either referred to as an orifice tube system or an expansion valve system.

Receiver Dryer or Accumulator

Depending on the vehicle, the A/C system will either have a receiver dryer or an accumulator. Both of these components contain a desiccant, which is a chemical that attracts moisture. The desiccant serves a vital function, since the combination of water and refrigerant forms corrosive acids. Acids not only reduce A/C performance, they can ultimately destroy the system. The receiver dryer and accumulator also serve as temporary holding tanks for liquid refrigerant.

Although these two parts serve similar purposes, the receiver dryer is connected to the condenser outlet (high-pressure side) and is used exclusively in expansion valve systems. In contrast, the accumulator is attached to the evaporator outlet (low-pressure side), and is only found in orifice tube systems. The primary functional difference is that the accumulator is designed to prevent liquid refrigerant from being drawn into the compressor.

REFRIGERANT

Regardless of the type, all air conditioning systems function according to a basic law of physics that states 'a fluid absorbs heat as it changes from a liquid to a gas, and a vapor releases heat as it changes from a gas to a liquid.' In an A/C system, refrigerant is the transfer medium used to absorb the heat inside the passenger compartment and release it to the outside air. Refrigerant is a tasteless, odorless gas with an ability to change state rapidly within a specific temperature range. It is also oil soluble and non-corrosive. While there are scores of refrigerants on the market, there are only two types approved by vehicle manufacturers: R-12 and R-134a.

R-12, commonly referred to as Freon, has long been used as the refrigerant in all automotive A/C systems.

However, R-12 contains chlorine, which is the primary cause of ozone layer damage. Consequently, legislation was passed calling for a halt in R-12 production by 1996. Long before the phase-out of R-12 began however, the automotive industry conducted extensive research and development to find an environmentally friendly alternative. They ultimately selected R-134a as the new refrigerant, and began using it in vehicles as early as 1992.

R-134a is similar to R-12, in that it absorbs, transfers, and releases heat efficiently. It is also non-flammable, and mixes well with oil, just like R-12. However, R-134a does have some unique characteristics.

- R-134a requires a special synthetic lubricant since it does not mix with mineral oil (standard R-12 lubricant).
- R-134a operates at higher discharge pressures than R-12. Therefore, systems using R-134a may not cool as well as R-12 when the vehicle is idling for extended periods (e.g. heavy traffic).
- R-134a and R-12 cannot be mixed, which is why separate equipment is needed to service vehicles using either refrigerant.

Depending on the vehicle, refrigerant capacity can range anywhere from about 28 ounces (1.75 lbs.) to as much as 64 ounces (4.00 lbs.) or more. To avoid an improper charge, always consult the manufacturer's specifications for refrigerant capacity. An improper charge will cause reduced system performance, and may even result in system damage.

REFRIGERANT OIL

In order to function properly, an A/C system requires the appropriate type and amount of oil. In addition to lubricating the compressor, refrigerant oil also maintains the operation of the expansion valve on systems so equipped. Since the oil is transported through the system by the refrigerant, it has to be compatible with the type of refrigerant being used. Mineral oil is the lubricant used for all R-12 systems, while R-134a systems use synthetic oils such as PAG (polyalkylene glycol) and POE (polyolester).