



# Air Conditioning System Theory

To grasp air conditioning theory, it's necessary to understand that there is really no such thing as *cold*, only the *absence of heat*.

Heat is defined as a type of energy that acts on matter to raise temperature. The primary sources of automotive heat come from direct sunlight and engine heat. But there are many factors which contribute to the work load of an air conditioning system.

In order to solve the problems heat presents, it must be moved by applying the basic principle of heat transfer: Heat always moves from a warmer object to an object of lesser heat.

Automotive air conditioning systems absorb heat from inside the passenger compartment, then transfer that heat to the outside air.

Chemical compounds known as refrigerants serve as the carrier for heat transfer. The two most common refrigerants are *dichlorodifluoromethane* (R-12) and *tetrafluoroethane* (R-134a).

For a refrigerant to be suitable for an automotive air conditioning system, it:

- should be stable,
- non-toxic,
- non-corrosive and,
- soluble in oil.

But most important, it must have a very low boiling point and be able to evaporate and condense at normal ambient temperatures. Both R-12 and R-134a have these characteristics. However, R-12 and R-134a are made up of totally different chemical compounds and consequently they should never be mixed. Nor should their lubricants or system components ever be used interchangeably.

To develop a good understanding of air conditioning theory, we must understand the *Basic Principles of Heat Transfer* listed below:

- Heat always moves from a warmer object to an object of lesser heat.
- As liquid changes state to a vapor, or evaporates, it absorbs heat.
- As a vapor changes state to a liquid, or condenses, it releases heat.
- Pressure and temperature have a direct relationship. An increase in pressure results in increased temperature. A decrease in pressure results in a decrease in temperature.

## System Components

There are five basic components in an automotive air conditioning system. They are: the evaporator, the compressor, the condenser, the receiver/drier and the expansion valve. These devices carry and control the refrigerant throughout the system.

The primary components responsible for heat transfer are the evaporator and the condenser.

### Evaporator

The evaporator soaks up heat from the passenger compartment. A blower fan forces warm air across the tubes and fins of the evaporator. The refrigerant inside evaporates, absorbing a tremendous amount of heat. At this point the main principle of heat transfer comes into play. *Remember, heat always moves from a warmer object to an object of lesser heat.*

### Compressor

This heat-laden refrigerant must first travel to the compressor. The compressor utilizes the engine's power for operation. One important purpose of the compressor is to circulate refrigerant and oil throughout the system. But the most important job the compressor has is to boost the pressure of the refrigerant. The boosting of pressure primes the refrigerant and is essential to system performance. When the refrigerant is primed due to compression, another principle of heat transfer takes place. Pressure and temperature have a direct relationship. *An increase in pressure results in an increase in temperature.*



### Condenser

Next in line is the condenser, located in front of the engine radiator. When the refrigerant reaches the condenser from the compressor, it's in the form of a hot vapor under very high pressure. The reason for increasing the refrigerant's pressure and temperature back at the compressor is to create as much difference as possible between the temperature of the refrigerant and the temperature of the outside air passing over the condenser.

The heat that is trapped in the hot refrigerant vapor literally moves from inside the condenser to the cooler outside air. As the vapor starts to dissipate or give up its heat, it begins to change state again. It starts to condense. As this process takes place, another principle of heat transfer occurs: As the refrigerant vapor changes state or condenses to a liquid, it releases a tremendous amount of heat.



### Receiver/Drier

The next component, the receiver/drier, is a storage tank for the liquid refrigerant that is forced from the condenser. Inside the receiver/drier are a series of filters and a special drying agent, called a desiccant. The filters within the receiver/drier are designed to trap any matter that might be present. Foreign matter can disrupt or damage the system. The desiccants used in the receiver/drier absorb moisture inside the system. A tiny droplet of moisture can freeze and restrict the expansion valve.



## Expansion Valve

The fifth and final component in the system is the expansion valve. It is a metering device that divides the system's high and low pressure sides. The expansion valve is located at the inlet side of the evaporator.

The expansion valve meters the release of hot, high pressure liquid refrigerant into the low pressure environment of the evaporator. This creates a sudden, rapid decrease in temperature and pressure of the refrigerant. Remember, a decrease in pressure also results in a decrease in temperature.

The expansion valve utilizes a sensing bulb to monitor the temperature of the refrigerant as it leaves the evaporator. If the temperature is too high, the expansion valve allows more refrigerant into the evaporator. If the temperature is too low, it throttles back and restricts the flow of refrigerant. After the system has stabilized, the metering action of the expansion valve becomes very subtle.

The reason for releasing the high pressure liquid into the evaporator is to decrease pressure, and in the process, to decrease the temperature of the refrigerant. In this colder condition, the refrigerant's ability to absorb heat is increased. Warm air from the passenger compartment passes over the evaporator, heat is absorbed, and the whole process begins again.

## Air Conditioning Service Safety

Because of the dangers involved when handling refrigerants, it is important to understand the safety precautions you must follow:

- When working around automotive A/C system, always wear eye protection.
- Always wear gloves for skin protection.
- Always work in a well ventilated area.
- Never expose refrigerant to an open flame or extreme heat.
- Never use compressed air to flush an A/C system.

You must have a thorough working knowledge in the proper use of the following items:

- R-12 and R-134a compound manifold gauges,
- R-12 and R-134a vacuum pumps,
- R-12 and R-134a leak detectors,
- R-12 and R-134a refrigerant recovery and recycling system,
- Volt/ohm meter,
- An accurate service thermometer for measuring ambient air and air outlet air temperatures.

All equipment for the two main refrigerant types must be marked and used separately to prevent cross-contamination.

Always use quick-connect or anti-blowback fittings when installing and removing charge hoses from the vehicle charging valves.

R-134a systems are labeled as such, and use different types of service connections than R-12 systems to prevent any accidental intermixing of refrigerants.

The EPA requires that R-12 recovery equipment always be used when discharging any refrigerant from a system. Use the same procedures when handling R-134a.

There are similarities between R-12 and R-134a systems. But never take anything for granted when troubleshooting or diagnosing these systems. Get in the habit of referring to the specific reference manuals in order to determine the exact system specifications.

## Rules Are Rules

The components used in Subaru air conditioning systems will vary slightly with each vehicle and model. The manufacturers of these components and systems may also vary, but the underlying principles and theories that make automotive air conditioning possible never change. The understanding that you have gained about heat transfer and your dedication to applying those principles in your everyday diagnostic and service work will simply add to your expertise and help to create those satisfied customers that will make us all successful.