BASIC PRINCIPLES

Vehicle air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three laws of nature. These laws of nature and their practical application are outlined.

Heat Transfer

If two substances of different temperature are placed near each other, the heat in the warmer substance will always travel to the colder substance until both are of equal temperature. For example, a cake of ice in an ice box does not communicate its coldness to the bottle of milk standing nearby. Rather, in obedience to nature's law, the heat in the warm milk automatically flows into the ice which has a lesser degree of heat. In order to determine the amount of heat that transfers from one substance to another, science has established a definite standard of measurement called the British Thermal Unit or BTU. One BTU is the amount of heat required to raise the temperature of one pound of water 0.55°C (1°F). For example, to raise the temperature of one pound of water from 0°C (32°F) to 100°C (212°F), one BTU of heat must be added for each 0.55°C (1°F) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of one pound of water from 100°C (212°F) to 0°C (32°F), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils (changes to a gas), it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, place one pound of water at 0°C (32°F) in a container over a flame. With each BTU of heat that the water absorbs from the flame, its temperature rises 0.55°C (1°F). Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 100°C (212°F). Here the law of nature is encountered. Even though the flame continues to give its heat to the water, the temperature of the water remains at 100°C (212°F). The water, however, starts to boil or change from the liquid to the gaseous state, and it continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were collected in a container and checked with a thermometer, it also would show a temperature of 100°C (212°F). In other words, there was a rise of only 82°C (180°F), from 0 to 100°C (32-212°F) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would reappear and flow into the cooler air as the vapor condensed back to water. Scientists refer to this natural law as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 100°C (212°F). This means that one pound of water at 100°C (212°F) will absorb 970 BTUs of heat in changing to vapor at 100°C (212°F). Conversely, the vapor will give off 970 BTUs of heat in condensing back to water.

This tremendous heat transfer that occurs when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigeration systems.

For a liquid to be a good refrigerant, the amount of heat that it absorbs when vaporizing is not the only factor. It must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled. To illustrate with water, place a bottle of milk at room temperature 21.6°C (70°F) next to boiling water 100°C (212°F). The heat would flow from the (higher temperature) water to the (lower temperature) milk. The milk would be heated rather than cooled, because the boiling point of water is too high.

In order to make practical use of the heat transfer that takes place when a liquid boils, we must choose a liquid with a low boiling point. Refrigerant-12 is the liquid most commonly used in automotive air conditioning systems because it boils at -29.85°C (21.7°F) below zero in an open container. Here is a liquid that boils or vaporizes well below passenger compartment temperatures and, in vaporizing, will absorb tremendous amounts of heat without getting any warmer itself.

Effect of Pressure on Boiling or Condensation

The saturation temperature (the temperature where boiling or condensation occurs) of a liquid or vapor increases or decreases, according to the pressure exerted on it.

In the fixed orifice tube refrigerant system, liquid refrigerant (Refrigerant-12) is stored in the condenser under high-pressure. When the liquid Refrigerant-12 is released into the evaporator through the fixed orifice tube, the resulting decrease in pressure and partial boiling lowers its temperature to its new boiling point. As the Refrigerant-12 flows through the evaporator, passenger compartment air or outside air passes over the outside surface of the evaporator coils. As it boils, the Refrigerant-12 absorbs heat from the air and thus cools the passenger compartment. The heat from the passenger compartment is absorbed by the boiling refrigerant. The refrigeration cycle is now under way. To complete the cycle, the following remains to be done:

1. Dispose of the heat in the vapor.
2. Convert the vapor back to liquid for reuse.