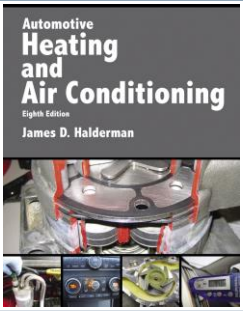
# Automotive Heating And Air Conditioning

Eighth Edition




## Chapter 2

The Refrigeration Cycle



## Learning Objectives (1 of 2)

**2.1** Prepare for the ASE Heating and Air Conditioning (A7) certification test content area "A" (A/C System Service, Diagnosis and Repair).

**2.2** Explain how the A/C system works.

**2.3** Identify the low and high side of an A/C system.



## Learning Objectives (2 of 2)

**2.4** Explain the purpose and function of evaporators in an A/C system.

**2.5** Explain the purpose and function of thermal expansion valves and orifice tube systems.

**2.6** Explain the purpose and function of condensers.

## Basic Principles (1 of 9)

- High-pressure liquid refrigerant flows through an expansion device, which controls the amount of refrigerant that is allowed to pass through.




## Basic Principles (2 of 9)

- When the high-pressure liquid passes through the expansion device, the pressure drops. This causes the liquid refrigerant to evaporate in a small radiator-type unit called the evaporator.
  - When the refrigerant evaporates, it absorbs heat when changing from a liquid to a gas. As the heat is absorbed by the refrigerant, the evaporator becomes cold.




## Basic Principles (3 of 9)

- The refrigerant flows into the engine-driven compressor
  - The compressor compresses the low-pressure refrigerant gas into a high-temperature, high-pressure gas and forces it through the system.

## Basic Principles (4 of 9)

- This high-pressure gas flows into the condenser located in front of the cooling system radiator.




## Basic Principles (5 of 9)

- The high-pressure liquid then flows to the expansion device, which controls the amount of refrigerant that is allowed to pass through and meters the flow into the evaporator.
  - When the high pressure of the liquid passes through the expansion device, the pressure drops and causes the refrigerant to vaporize, starting the cycle all over again.




## Basic Principles (6 of 9)

- Air is blown through the evaporator by the blower motor. The air is cooled as heat is removed from the air and transferred to the refrigerant in the evaporator, then directed inside the passenger compartment through vents.

**FIGURE 2–2 The evaporator removes heat from the air that enters a vehicle by transferring it to the vaporizing refrigerant.**

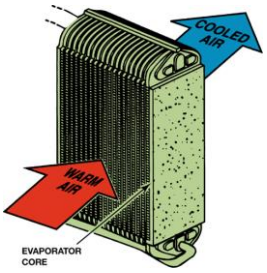




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**FIGURE 2–3 The compressor provides the mechanical force needed to pressurize the refrigerant.**

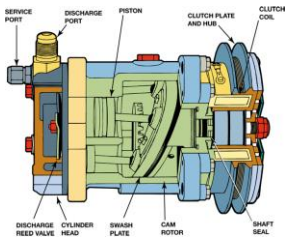



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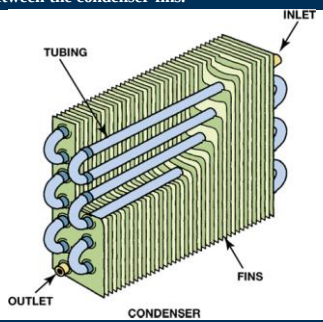
**FIGURE 2–4 The condenser changes the refrigerant vapor into a liquid by transferring heat from the refrigerant to the air stream that flows between the condenser fins.**





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## Basic Principles (7 of 9)

- Low side—it has low pressure and temperature.
  - The low side begins at the expansion device and ends at the compressor. The refrigerant boils or evaporates in the low side.


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## Basic Principles (8 of 9)

- High side—it has higher pressures and temperatures.
  - The high side begins at the compressor and ends at the expansion device. The refrigerant condenses in the high side. The high side line is often called the liquid line.


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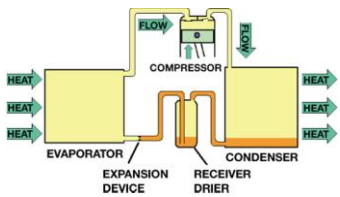
**FIGURE 2–5 Refrigerant changes state to a vapor as it absorbs heat in the low side and into a liquid as it loses heat in the high side.**





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## Basic Principles (9 of 9)

- In an operating system, the low and high sides can be identified by:
  - Pressure
  - Sight
  - Temperature
  - Tubing size

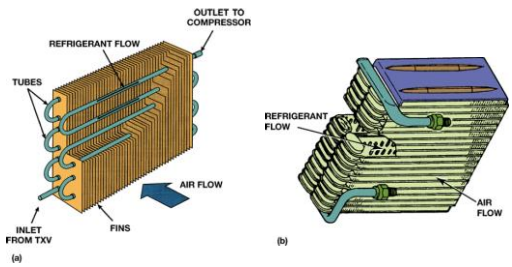



## Evaporators (1 of 2)

- The evaporator is the heat exchanger and absorbs heat from the passenger compartment.
- Like most heat exchangers, a well-designed evaporator has a large amount of surface area in contact with the refrigerant and the air from the passenger compartment.




**FIGURE 2–8 (a) A tube-and-fin and (b) a plate evaporator. Each type has a large contact area for heat to leave the air and enter the refrigerant.**



## Evaporators (2 of 2)

- The cold temperature in the evaporator is produced by boiling the refrigerant.
- Abnormal temperatures and pressures indicate that something is wrong, such as the evaporator might have too much or too little refrigerant.
  - Starved evaporator; flooded evaporator




## Thermal Expansion Valves (1 of 2)

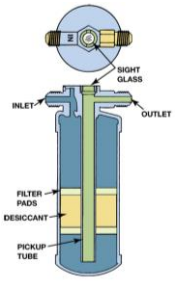
- A thermal expansion valve (TXV) is a variable valve that changes the size of the valve opening in response to the cooling load of the evaporator.




## Thermal Expansion Valves (2 of 2)

- A TXV is controlled by evaporator temperature and pressure so that it opens to flow as much refrigerant as possible when a lot of cooling is needed and all of the refrigerant must boil in the evaporator.

**FIGURE 2–11 Expansion-valve systems store excess refrigerant in a receiver–drier, which is located in the high-side liquid section of the system.**





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## Orifice Tube Systems

- An orifice tube is a restriction in the liquid line that forces the refrigerant to expand as it passes through the small opening (orifice).
- When the refrigerant expands, the temperature of the refrigerant drops and starts to evaporate in the evaporator.


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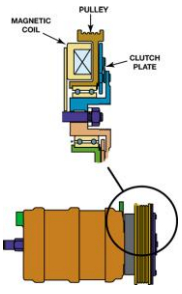
**FIGURE 2–12 The compressor clutch allows the compressor to cycle off and on to control evaporator temperature and to shut the system off.**





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## Condensers

- The condenser, like the evaporator, is a heat exchanger. Low-pressure refrigerant vapor is compressed by the compressor into a high-temperature, high-pressure vapor.
  - This vapor then passes into the condenser where air passing over the condenser cools the refrigerant and causes it to condense into a high-temperature liquid.


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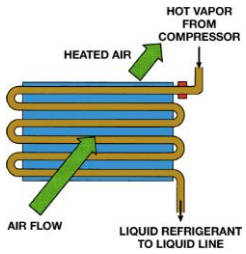
**FIGURE 2–14 A condenser is a heat exchanger that transfers heat from the refrigerant to the air flowing through it.**





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## Refrigerant Charge Level

- While operating, the following occurs:
  - The evaporator contains a refrigerant mist in the first two-thirds to three-fourths of its volume, with vapor in the remaining portion.
  - The condenser contains a condensing vapor in the upper portion, with liquid in the bottom passages.
  - The line connecting the condenser to the expansion device is filled with liquid.
  - The accumulator is about half full of liquid so that liquid refrigerant does not enter the compressor.


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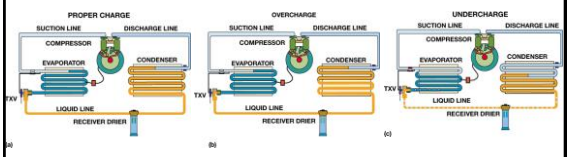
**FIGURE 2–15** (a) A properly charged system has the condenser filled with condensing vapor and some liquid, a liquid line filled with liquid, a receiver–drier about half full of liquid, and an evaporator with vaporizing liquid. (b) An overcharge with too much liquid causes liquid to partially fill the condenser. (c) An undercharge has vapor in the liquid line and a starved evaporator.





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## Evaporator Icing Controls

- What is the purpose and function?
- What is “Superheat”?
- Thermistor
- Pressure Switches


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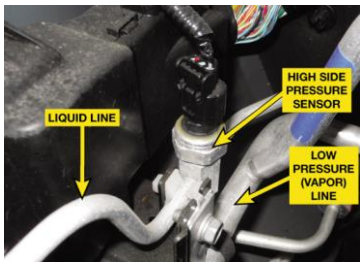
**FIGURE 2–17** A typical three-wire pressure sensor used on the high side (vapor) line. The three wires are the voltage supply (usually 5 volts), ground, and signal wire.





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## Summary (1 of 4)

- Automotive A/C systems operate on the principle of moving heat from inside to outside of the vehicle.
- All automotive air-conditioning systems are closed and sealed. A refrigerant is circulated through the system by a compressor that is usually powered by the engine through an accessory drive belt.




## Summary (2 of 4)

- The liquid refrigerant evaporates in a small radiator-type unit called the evaporator.
- After the refrigerant has evaporated into a low-pressure gas in the evaporator, the refrigerant flows into the engine-driven compressor.




## Summary (3 of 4)

- From the compressor, high-pressure gas flows into the condenser located in front of the cooling system radiator.
- Automotive A/C systems are either orifice tube (OT) systems or thermal expansion valve (TXV) systems.
- A receiver–drier is used with a TXV system and is located in the high pressure (liquid) side of the system.

## Summary (4 of 4)

- An accumulator is used in orifice tube system and is located in the low side of the system between the evaporator and the compressor.



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