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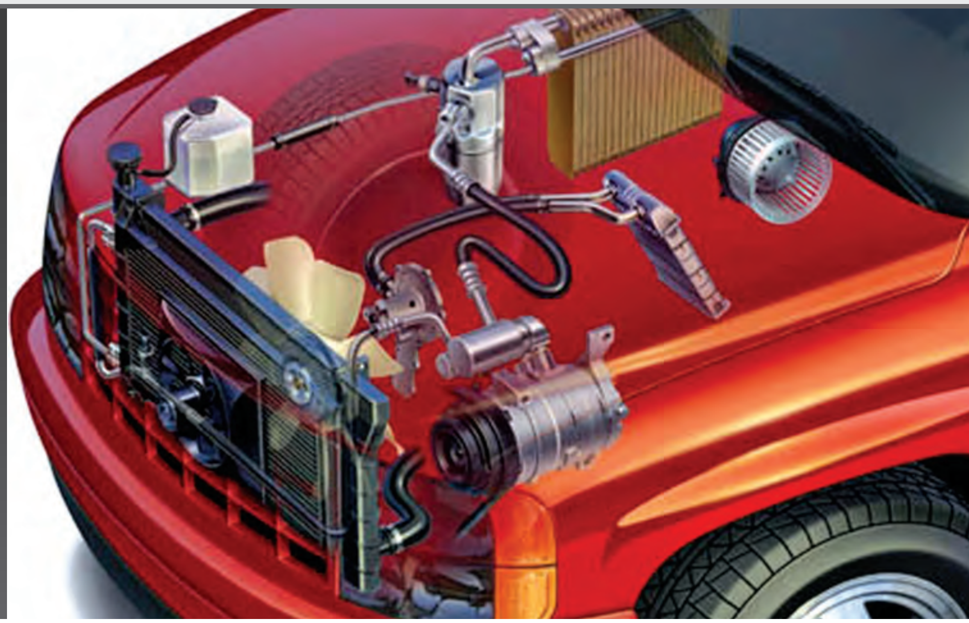
Air Conditioning

MAY 2016

There are several laws of physics involved with the automotive air conditioning (A/C) system. Although the technician is expected to understand these laws, the typical customer only expects cool air to be expelled from the vents when they turn the A/C system on.



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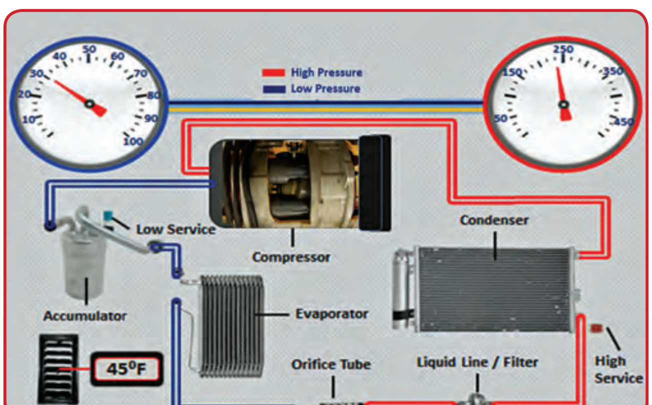
Air Conditioning System Operation

The heart of the A/C system is the compressor. It provides refrigerant flow and direction, and raises the boiling point and temperature of the refrigerant by raising its pressure. At the compressor, the refrigerant is forced through the system as a gas to the condenser.

Air flow through the condenser changes the gas to a hot liquid. In this system example, the refrigerant is sent to the orifice tube where it drops pressure and temperature. The low pressure-low temperature liquid refrigerant enters the evaporator where it absorbs the heat from the vehicle cabin and reverts back to a gas. The refrigerant exits the evaporator and flows to the accumulator where any water is removed. Finally, the low pressure gas is sent back to the compressor where the process is repeated.

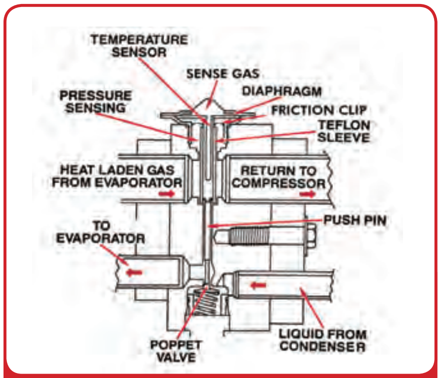


Typical orifice type A/C system.

Types Of A/C Systems

The A/C system requires the use of a restriction to provide rapid cooling. The type of A/C system is determined by the restriction used — the orifice tube or the expansion valve. The restriction causes a pressure drop, so when pressure is released past the restriction the refrigerant becomes cold instantly.

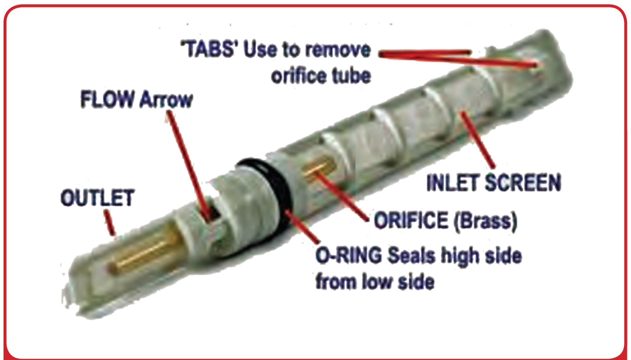
The thermostatic expansion valve meters the exact amount of refrigerant required to maintain proper heat transfer efficiency, and



The internal components of an "H" style expansion valve.

to ensure the entire liquid refrigerant is changed to a vapor before it reaches the evaporator outlet. Expansion valve systems will use a receiver/drier located before the valve.

The orifice tube system is a flooded system, meaning that some liquid refrigerant may exit the evaporator. The orifice tube is located in the line between the condenser and the evaporator. Some systems are equipped with a variable orifice valve (VOV) that changes orifice size based on system load. System pressure and refrigerant flow moves a metering piston relative to a fixed opening in the sleeve. When idling at high ambient temperatures, the piston shifts to a smaller metering area. This compensates for the reduced compressor output and increases cooling performance. At highway speeds, the VOV operates on a large orifice.



The orifice tube is installed in the line to create a pressure and temperature drop.

A/C System Updates

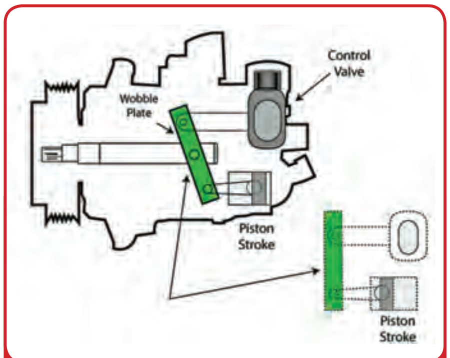
Recent years have seen numerous changes in the industry concerning A/C system construction, operation, and servicing. New laws, new regulations, and new systems are still being implemented. This means new service procedures and new equipment.

Internal heat exchanger technology is not new; however, it has only been introduced to the automotive market in recent years. The coaxial refrigerant pipe is two A/C lines in one. Liquid refrigerant flows in the outer line to the metering device. Refrigerant vapors flow back to the compressor in the inner line. This action transfers heat from the high pressure liquid to the low pressure vapors.

DENSO's ejector cycle system uses a specially shaped pipe that produces a pumping action from the pressures of the A/C system, allowing the use of low compression ratio compressors. The ejector has two inlet ports and one outlet port. A nozzle is located in the primary port where refrigerant leaving the condenser enters the ejector. Gas from the evaporator enters the ejector at the secondary port. The gas entering the primary port creates a high velocity, low pressure flow through the nozzle outlet. In the mixing section, the gases from the primary and secondary ports are mixed and exits the ejector through a diffuser where it goes through a pressure recovery.

The system uses a dual evaporator that has a gas-liquid separator function. After passing through the separator, gas from the ejector is returned to the compressor. Since the gas is at a high pressure when it enters the compressor, the compressor does not have to work as hard.

The liquid is sent to the second part of the evaporator where it vaporizes and returns to the ejector through the secondary port. Since only liquid refrigerant flows into the evaporator, pressure loss is reduced improving evaporator performance.



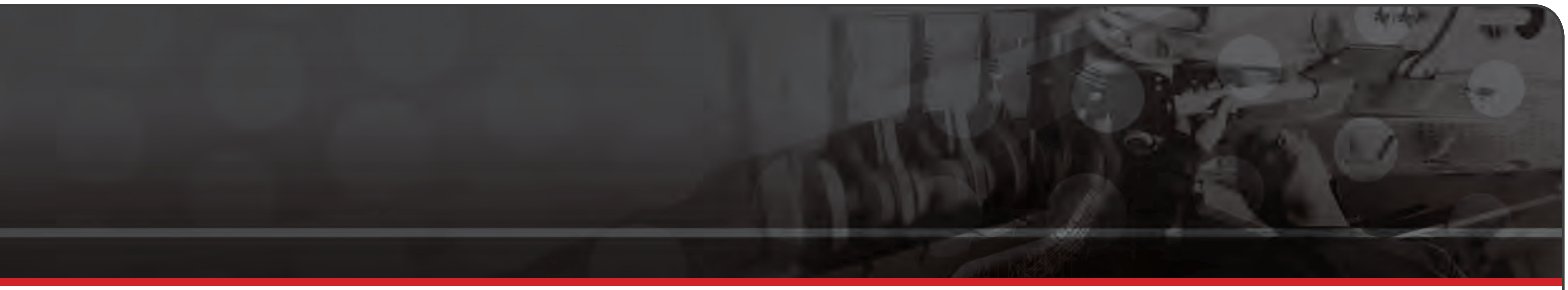
ECVD compressors alter the stroke of the pistons to control displacement.

Electronic control variable displacement (ECVD) compressors are becoming more popular. As an A/C technician, you need to be able to differentiate between a basic refrigeration system issue, a control issue, and sensor input issue.

The control module duty cycles the control valve that is connected to the compressor's suction and discharge ports. The pistons are attached to a wobble plate that changes angle, thus the stroke of the pistons. When air conditioning demand is high, the control valve is duty cycled to move the wobble plate to its greatest angle. This increases the stroke of the piston and the compressor will displace the maximum amount of refrigerant. As demand decreases, the wobble plate is moved to a lesser angle, thus reducing the stroke of the pistons and displacing less refrigerant.

Diagnostic Techniques

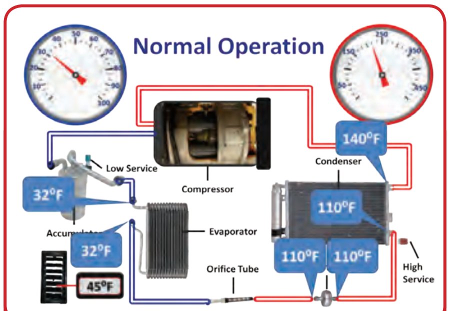
When checking system pressures and discharge temperatures, always refer to the service information. Humidity and ambient air temperature affect low side and high side pressures as well as discharge temperatures. High humidity results in lower evaporation rates while low humidity results in higher evaporation rates.



Because of its specific pressure to temperature correlation, HFC-134a is the most commonly used refrigerant in today's air conditioning systems. Gauge readings with the engine and A/C system at ambient temperature will correlate with temperature. If the pressure readings do not correlate, the system is not properly charged or has air in it.

Diagnostics should include measuring duct outlet and ambient air temperatures. The duct outlet reading is recorded as close to the evaporator as possible. Take the ambient air temperature reading 18 inches (45.7 cm) from the front of the condenser. Be sure to follow the manufacturer procedures for setting the A/C and for the expected temperature readings. If duct temperature is not within specifications, you will need to develop a diagnostic strategy that includes system pressure and temperature drop tests of all components.

Testing temperature drop locates restrictions in lines and components, as well as under or over charge conditions. Temperature drop testing is an effective way of confirming the performance of each component. When performing this test, a proper heat load is very important to obtaining good test results.



An example of temperature drops within a properly charged orifice tube system at ambient temperatures between 86°F and 95°F (30°C and 35°C).

Normally, there should be a 20°F to 50°F (11.1°C to 27.7°C) drop in temperature across the condenser. A temperature difference greater than 50°F (27.7°C) indicates an undercharged condition, internal restriction, or the presence of non-condensable gases. A temperature drop less than 20°F (11.1°C) indicates an overcharge condition, restricted condenser air flow, or system contamination.

There should be a large temperature drop across the orifice tube as high pressure liquid is changed into a low pressure liquid.

The temperature drop across the evaporator should be minimal; however, the amount of latent heat will be proportional to the heat load. Latent heat is energy released (or absorbed) by the refrigerant at the temperature where it changes states without changing the actual temperature of the refrigerant.

An undercharged system can be identified by measuring the low side temperature at the evaporator and comparing it to the duct discharge temperature. The temperatures should be within 10°F (6°C) of one another. In an undercharged system, there is an insufficient amount of refrigerant to match the heat load and the refrigerant becomes superheated. This results in an increase of sensible heat at the outlet of the evaporator.

An increase of sensible heat at the condenser inlet is the result of more latent heat being absorbed in the smaller quantity of refrigerant. Low refrigerant volume causes an increase in sub-cooling within the condenser. An undercharged system moves less oil through the system and the oil will fall out of the vapor and collect in the evaporator.

An overcharged system prevents all of the latent heat from being transferred into the air at the condenser. Overcharge can be identified by an insufficient temperature drop across the condenser and the temperature drop across the evaporator can be greater than 6°F (2.3°C). Low pressure liquid floods the evaporator, preventing most of the liquid from absorbing enough heat to change state. The accumulator may not handle the overflow of liquid refrigerant and will allow liquid to be sent back to the compressor.

The presence of non-compressible air results in elevated high side pressures. This can be improperly diagnosed as an overcharge condition. The clue lies in the temperature changes in the evaporator and the condenser, and the lack of accumulator flooding. Air cannot absorb heat in the evaporator, creating a slight drop in temperature; however, the inlet and outlet temperatures are higher than normal.

Any restriction will interfere with efficient cooling. Pressure and temperature measured before the restriction will be high and pressure and temperature after the restriction will be lower. Frost may form at the point of the restriction.

On expansion valve systems, the evaporator outlet temperature should be 4°F to 16°F (2.2°C to 8.9°C) warmer than the inlet temperature. The valve has a heat rating that determines the amount of superheat inside the evaporator and determines inlet and outlet temperatures.

Leak Testing

CO2 is an effective means of locating an A/C system leak.

The CO2 leak detection system introduces CO2 into the system and a sniffer identifies the higher concentrations of CO2 in the air to locate the leak source. Since the CO2 molecule is very small, it will move through small leak sites with low resistance. The exact location of the leak site is identified by spraying specifically-formulated foam onto the suspect area. At the leak, the foam will change color from pinkish red to yellow.

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Fluorescent dye can be introduced into the A/C system to isolate leak locations. The location of leaks can be pinpointed by the bright yellow-green glow of the fluorescent dye under a UV lamp.

Sealer Identifier and Protection Equipment

Sealers react with moisture in the system to set-up. If the sealer is exposed to air, such as opening a line, the sealer will set-up. Once set, the only course of action is to replace all components!

The sealer detection kit identifies the presence of sealers in the system by using a wet test orifice and flow meter. After the A/C system is operated for 10 minutes, and then shut off, the position of the ball in the flow meter is marked. After 3 minutes, the position of the ball is checked. If the ball has fallen below the check point, the system has sealer.

If sealer is present, do not attempt to service the system unless your equipment has some form of protection device installed. A filter connected between the vehicle and the inlet of the service equipment separates any sealers as the system is recovered.

Refrigerant Identifier

There are counterfeit and alternate refrigerants being sold that are potentially very dangerous. In addition, if these refrigerants enter your equipment, repairs to the equipment are very costly. Refrigerant identifiers should be used on every vehicle. The identifier tests the percentage of air in the system, determines refrigerant type, and warns you if hydrocarbons are present.

Always identify the refrigerant in the system before connecting your equipment.

Tech Tips

- Failing desiccant bags can plug the accumulator.
- After flushing the A/C system, install an in-line filter after the condenser to trap any debris that might work its way free.
- Poor airflow through the condenser can be caused by plugged or bent fins, improper cooling fan operation, missing air dams, or dirty air fins on the radiator.
- A visual sign of overcharge is frosting of the accumulator.
- Inserting too much leak detection dye into the system will limit the amount of refrigerant that can be installed.
- To locate a compressor seal leak, insert a 3x5 card behind the clutch plate, pull it out, and look for dye.
- Overfilling the system with oil displaces room for the proper amount of refrigerant. Oil is not effective at transferring and absorbing latent heat.
- Oil flooding is indicated by poor condenser action, causing increased high side and low side pressures.
- If the system has a leak, locate and fix the leak, replace the accumulator or receiver/drier, drain the oil from the compressor, and flush the system to remove the remaining oil.
- Use identifying equipment to determine refrigerant type and the presence of sealer BEFORE connecting the charging station.
- If contaminated refrigerant enters your recovery/charging equipment the machine will require service before it can be used again.

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Review Questions

1. Technician A says the refrigerant exits the condenser as a high pressure liquid. Technician B says the evaporator is where the refrigerant absorbs the heat from the vehicle cabin. Who is correct?

a. Technician A

b. Technician B

c. Both Technician A and Technician B

d. Neither Technician A nor Technician B

2. Technician A says a restriction can be identified by an increase in refrigerant temperature after the restriction. Technician B says a temperature difference between the condenser inlet and outlet that is greater than 50°F (27.7°C) indicates an undercharged condition. Who is correct?

a. Technician A

b. Technician B

c. Both Technician A and Technician B

d. Neither Technician A nor Technician B

3. Which of the following is NOT a true statement?

a. Injecting sealers in the A/C system is an effective means of preventing leaks.

b. Always identify the refrigerant in the system before connecting your A/C recovery/recharge equipment.

c. Hybrid vehicles require special A/C system oil.

d. If the system has a leak, you need to locate and fix the leak, replace the accumulator or receiver/drier, drain the oil from the compressor, and flush the system.

Answers: 1. c, 2. b, 3. a.