A/C System Basics

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Many collector car owners wonder what to do about their air conditioning (A/C) systems as ever-changing government regulations dictate the type of refrigerants allowed. In 1994, Freon, or R-12, was outlawed and replaced by R-134a and that is now being replaced. Before addressing how best to cope with these changes, a review of air conditioning (A/C) system basics is in order.

Refrigeration System Theory

Automobile A/C systems operate on a single-stage vapor compression refrigeration cycle as shown in Figure 1. Refrigeration is the process of removing heat from a confined space and transferring it elsewhere.

Figure 1

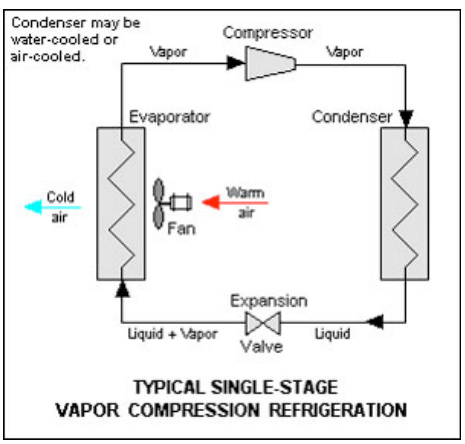

Figure 1 - Single Stage A/C

The system shown in Figure 1 uses the refrigerant to absorb the heat from the space to be cooled and transferring it elsewhere using four main components – an evaporator, a compressor, a condenser and an expansion valve. The circulating refrigerant enters the compressor as a saturated vapor and is compressed to a higher pressure, and resulting higher temperature, to a superheated vapor state at which it can be condensed by cooling air passing through the tubing in the condenser. In the condenser the captured heat is rejected and carried away by the cooling air and the refrigerant is changed to a saturated liquid. The liquid refrigerant is routed through an expansion valve where its pressure is abruptly reduced which results in the flash evaporation of part of the liquid and lowering the temperature of the liquid/vapor mixture to one that is lower than the space to be cooled. The cold mixture is routed through the tubing of the evaporator. A fan circulates the warm air in the space to be cooled over the evaporator tubes. The circulating refrigerant in the evaporator absorbs the heat from the enclosed space and the cycle repeats.

Automotive A/C System Components

Figure 2 presents a schematic configuration of the typical automotive A/C system. The **compressor** is the heart of the system. Although the configuration of this pump can vary, the typical capacity is about 27,000 BTU's (British Thermal Units) or 2 "tons" of cooling at 2000 rpm. This is the typical "average" summertime heat load from the sun and outdoor temperature on the exposed surfaces of a car's passenger compartment. The compressor is belt-driven and the pulley sized so that it operates at about 1000 rpm at idle and 6000 rpm at 100 mph for most collector cars. The pulley is integral with an electrically-actuated clutch so that it can be disconnected when cooling is not desired.

Figure 2

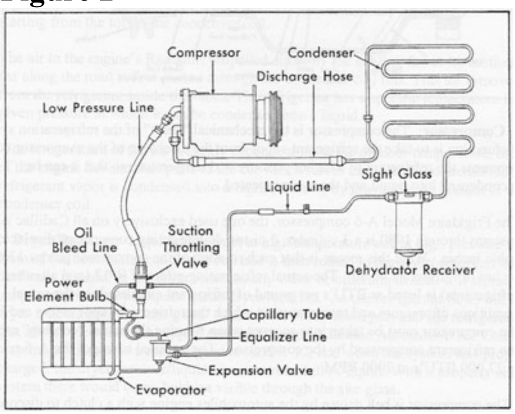

Figure 2 - A/C Components

The automotive **condenser** is located in front of the radiator and is quite similar in appearance. As the compressed refrigerant vapor passes through the condenser from top to bottom, air is passed through the fins and tubing by the action of the cooling fan or movement of the car. The temperature of the outdoor air, the speed of the fan, and the speed of the car determine the extent of cooling.

The cooled vapor becomes a liquid and flows to the bottom of the condenser and then is routed to the dryer/receiver. The **dryer/receiver** contains a desiccant material that removes water and impurities from the liquid refrigerant. The clean, liquid refrigerant is temporarily stored within the dryer/receiver. Some dryer/receivers contain a sight glass permitting the observation of the liquid refrigerant flow. If properly charged, there should be no air bubbles visible in the sight glass.

The **expansion valve,** or sometimes a fixed orifice, meters the flow of liquid refrigerant in response to the needs of the evaporator. It operates by sensing the pressure and temperature of the refrigerant vapor leaving the evaporator to assure that the entire liquid refrigerant has been vaporized. If liquid refrigerant enters the compressor, damage to the compressor could result.

The **suction throttling valve** [POA (pilot operated absolute) valve] maintains the evaporator at a temperature above freezing by not allowing the suction pressure to fall below 28 psig. It does this by spring pressure. If pressure rises above 28 psig, the valve opens allowing more refrigerant vapor through to the compressor.

On the air side of the system, an enclosure houses the evaporator coil and a heating coil supplied by hot water from the engine through which a centrifugal squirrel cage fan pushes air. Air is routed from the outside or from the car's interior over the evaporator or heater coil by a system of manually or vacuum-operated dampers and through dash and floor outlets.

Sizing of these components to function in varying climates from winter to summer throughout the world and to be manufactured at an affordable cost required a series of compromises. The design process took into account both known conditions – surface area of metal and glass of the passenger compartment, air flow quantities, compressor displacement, heat transfer area of the evaporator – and anticipated conditions – engine speed, outdoor temperatures, humidity and heat transfer though glass. Through the design process and testing of the system, the engineers determined the actual performance of the system under varying temperature and humidity conditions. Most shop manuals provide this data for diagnosis of system performance and problems. The warmer the outside air and higher humidity the greater the load applied to the A/C system. As the temperature climbs, particularly over the condenser, the compressor has to work harder and is able to circulate less refrigerant. With less refrigerant circulating, the system has less capacity to cool the air being forced over the evaporator. And, if humidity is high, it takes even more refrigerant circulation to cool and dehumidify the air.

Refrigerants

The ideal refrigerant will have favorable thermodynamic properties, be non corrosive to system components, and be safe. While many chemicals can be refrigerants, not all possible chemicals are ideal. The automotive industry settled on Freon (R-12), a chlorofluorocarbon, because it was non-flammable and non toxic as well as having thermodynamic properties best suited for the practical considerations of automobile A/C systems. It was used from the earliest days until 1995. Then, its use was outlawed because of its potential to deplete atmospheric ozone. The replacement refrigerant chosen because of its minimal impact on ozone was R-134a, a hydrochloroflourocarbon. Most recently, global warming concerns have dictated abandoning R-134a. The latest standards require automotive A/C systems to use a refrigerant with a global warming potential (GWP) of 150 or less. The GWP of R-134a is 1410.

Impacts on Collector Cars

Most of today's collector cars with A/C systems were designed to use Freon, which was outlawed in 1995, with all components sized based on its thermodynamic properties. Also, since 1995, those working on automotive A/C systems must be certified by the US Environmental Protection Agency. Additionally, it is illegal to vent a refrigerant to the atmosphere. So, it is best to leave A/C work to those certified. However, if a certified technician evacuates the refrigerant, anyone can remove and replace A/C components. Charging the repaired system must also be performed by a certified technician.

While the primary concerns are the refrigerant type and maintaining a proper charge, even a 1993 car is 20 years old. So, I recommended that if some work on the A/C system is needed, the entire system should be restored to as-new for optimum performance. Specialists exist that can rebuild existing units and functional replacements exist if one is not concerned about authenticity.

The replacement refrigerant can be Freon. It is still available to EPA-certified technicians, although somewhat expensive compared to R-134a ($13 to $20 per pound vs. $3.50 to $4 per pound). Additionally, given that 20 years has elapsed, not all shops have retained the equipment needed to handle Freon as it can't be mixed with R-134a. However, using Freon with a fully-restored system ensures that it will function as it did when new.

Today's common refrigerant, R-134a, can be used in a system originally designed for Freon. However, it is necessary to change the oil in the system. Automotive A/C systems carry the oil needed for essential compressor lubrication within the refrigerant. R-134a requires a synthetic oil containing esters instead of mineral oil used with Freon. It is also necessary to change the fittings to accept R-134a charging equipment. Early advice on conversion to R-134a suggested it was necessary to change the system seals and hoses. Experience has proven this not to be true. Additionally, it has also been established that a system designed for Freon should be charged to 90 percent of its full capacity with R-134a to obtain optimum performance. Shop manuals provide system refrigerant capacities and oil quantities. The downside of using R-134a in a system designed for Freon is a 10 to 20 percent reduction in cooling capacity; some say it is as much as 30 percent. This may or may not be a significant issue depending on how the collector car is used and the operating ambient temperature conditions.

Summary

Collector car air conditioning systems will benefit from a comprehensive restoration to restore optimum performance and eliminate nagging refrigerant leaks. Freon, the design refrigerant for most of these systems, remains available and will maximize an original system's cooling potential. R-134a refrigerant can also be used if appropriate procedures are followed. There are no other simple replacement refrigerants. While there are other available refrigerants, their installation requires precise servicing techniques.