MODULE

VEHICLE AIR CONDITIONING SERVICE

AIRCOND SERVICE

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MODUL SERVIS PENGHAWA DINGIN KENDERAAN ini merupakan satu modul pembelajaran yang diolah untuk tujuan bahan kursus pembelajaran sepanjnag hayat di bawah Automoitve Technology Center, Politeknik Sultan Mizan Zainal Abidin. Modul ini merangkumi teori berkenaan penghawa dingin kenderaan dan juga praktikal proses servis penghawa dingin kenderaan. Di dalam modul ini, terdapat penerangan berkaitan jenis-jenis gas penghawa dingin, komponen-komponen di dalam system penghawa dingin, dan juga prinsip kerja system penghawa dingin kenderaan. Dalam bahagian praktikal pula merangkumi arahan kerja bagi mengukur tekanan gas penghawa dingin. Dalam modul ini juga terdapat dua lagi praktikal berkenaan penghawa dingin iaitu kaedah pengosongan gas penghawa dingin dan juga vakum gas penghawa dingin.

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PREFACE

In the name of Allah, The most Gracious and Merciful. All praise to Allah S.W.T for His great loving kindness and blessing, this book is successfully published.

This book is designed to explain more detail on theory of vehicle air conditioners as well as the practical process of servicing vehicle air conditioners. In this module, there is a description of the types of air conditioning gases, the components in the air conditioning system, as well as the working principles of the vehicle air conditioning system. In the practical part, it includes working instructions for measuring the gas pressure of the air conditioner. In this module, there are also two other practical's regarding air conditioning, namely the air conditioning gas emptying method and also the air conditioning gas vacuum.

The authors would like to express deepest appreciation to all those who provided the possibility in publishing this book especially friends and colleagues. Many thanks also go to the Mechanical Engineering Department administration team for the support and guidance throughout the process of completing this book. Thank You.

CONTENT

THEORY

1.1. INTRODUCTION OF AUTOMOTIVE AIR CONDITIONING

Purpose

Air conditioning is the controlled environment of an enclosed space, such as inside an auto. Air conditioning involves dehumidifying, cleaning and cooling the air inside the car. This provides comfort to the driver and passengers alike. The main purpose of air conditioning systems is to transfer heat from inside the passenger's compartment, to the surrounding outside air.

Comfort affects driver responsiveness and reaction time to a given situation. Air conditioning provides greater safety by reducing driver fatigue. In addition, interior noise level is reduced when all windows are closed and the air conditioner is on. Air conditioning also eliminates windshield fogging. This allows the driver to maintain good visibility of the road and other cars.

Conditions Affecting Body Comfort

The three main factors that affect body comfort are temperature, relative humidity, and air movement.

- **Temperature**; Cool air increases the rate of convection; warm air slows it down. Cool air lowers the temperature of the surrounding surfaces. Therefore, the rate of radiation increases. Since warm air raises the surrounding surface temperature, the radiation rate decreases. In general, cool air increases the rate of evaporation and warm air slows it down. The evaporation rate also depends on the amount of moisture already in the air and the mount of air movement.

- **Humidity**; Moisture in the air is measured in terms of humidity. For example, 50% relative humidity means that the air contains half the amount of moisture that it is capable of holding at a given temperature. A low relative humidity allows heat to be taken away from the body by evaporation. Because low humidity means the air is relatively dry, it can readily absorb moisture. A high relative humidity has the opposite effect. The evaporation process slows down in humid conditions; thus, the speed at which heat can be removed by evaporation decreases. *An acceptable comfort range for the human body is from 22°C to 26.6°C at from 45% to 50% relative humidity*.

- **Air Movement**; another factor that affects the ability of the body to give off heat is the movement of air around the body. As air movement increases, the following processes occur:
  - The evaporation process of removing body heat speeds up because moisture in the air near the body is carried away at a faster rate.
  - The convection process increases because the layer of warm air surrounding the body is carried away more rapidly.
  - The radiation process increases because the heat on the surrounding surface is removed at a faster rate. As a result, heat radiates from the body at a faster rate

Automotive Air Conditioning Physical Laws

The automotive air conditioning works because of the application of six physical laws, or principles of physics. These are:

1. Heat always flows from hot to cold.
2. Cold objects have less heat than hot objects of same mass.
3. Everything in the universe is matter. All maters exist in one of three states: solid,liquid, or vapor.
4. When vapor is cooled below its dew point, it becomes a liquid. This is calledcondensation.

5. To increase the boiling point of a liquid, increase the pressure above the liquidsurface. To decrease the boiling point, decrease the pressure.
6. When a vapor is compressed, its temperature and pressure will increase even thoughheat has not been added. This is the result of compressing the vapor.

1.2. AUTOMOTIVE AIR CONDITIONING OPERATION

Operating Conditions

The basic components of automotive air conditioning are the same as other air conditioners. These include a compressor, condenser, refrigerant control and evaporator. The difference is in the operation and servicing the system. The basic operation of the automotive air conditioner is shown in Fig. 1-1.

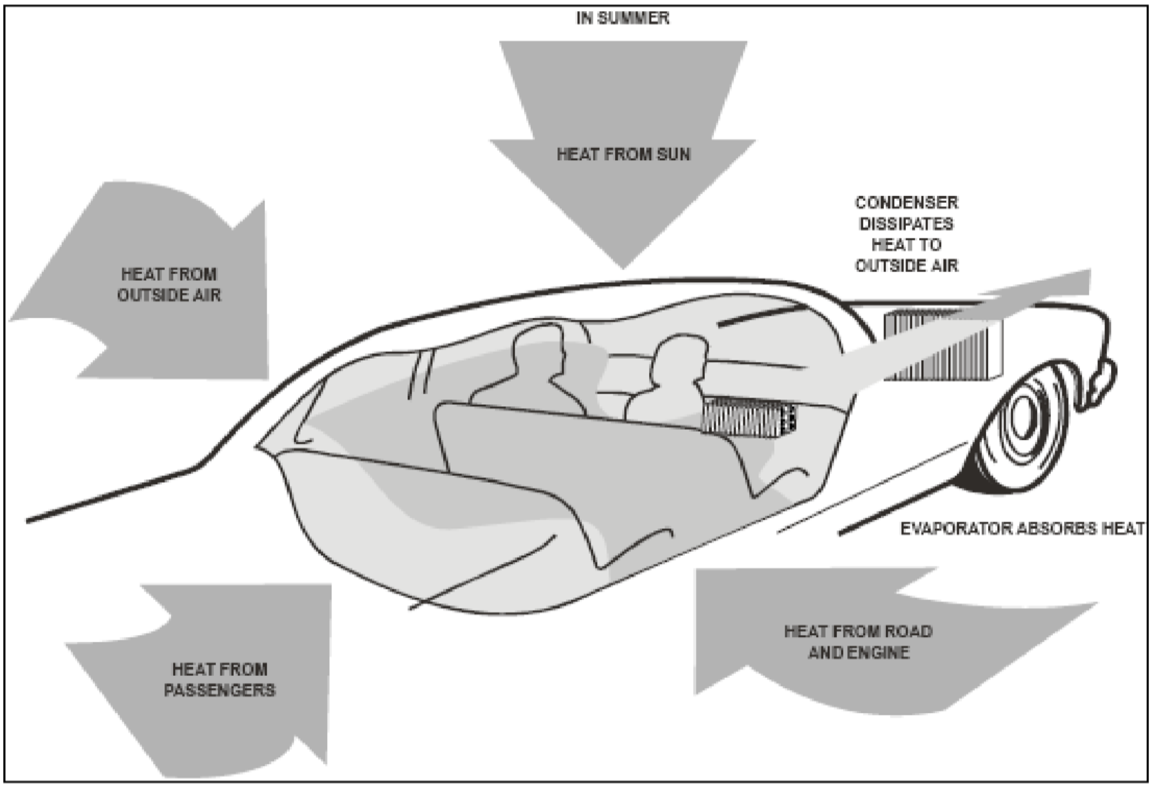

Figure 1: Absorb and Releasing the Heat in Automotive Air Conditioning Operation.

In summer, heat enters the passenger compartment from the sun, from the outside air, from the road, and from the engine. The passengers themselves produce heat. The evaporator absorbs this heat and carries it to the condenser. The condenser releases the heat to the outside air.

The automobile air conditioner must provide comfort in vehicle in all weather. This control must be adequate during cold, mild, damp and hot weather. It must provide heating, defogging and de-icing and must also remove dust, smoke and odor.

In typical automotive air conditioning system, the belt-driven compressor is mounted on the engine, ahead of the vehicle radiator. This allows cool air to flow over the condenser. The evaporator is mounted inside the plenum chamber in the passenger compartment. All of these devices are connected together by lines and hoses.

Liquid refrigerant flows from the condenser to the liquid receiver. The refrigerant is dried and filtered. Then it flows through a control device into the evaporator. In the evaporator, the refrigerant is vaporized and absorbs heat. The vaporized refrigerant finally flows back through the suction line to the compressor.

Low-pressure refrigerant vapor enters the compressor through the low side. The vapor is drawn into the cylinder and is compressed by the piston. It is then discharged through the high side back to the condenser. The heat of compression and the latent heat of vaporization absorbed by the refrigerant are given up to the air flowing over the condenser fins. At this point, the entire process repeats itself. Meanwhile, a blower (fan) forces air through the evaporator. The resulting cool air is circulated to the vehicle's interior through air distribution ducts and grilles.

The compressor speed will vary with engine speed. The system must have enough capacity to provide sufficient cooling. It must function at idling speed, in the sun, and in the wind. There must be considerable excess capacity for normal driving speeds.

Varying weather conditions can cause problems with the control of the temperature. Refrigerant flow problems may occur (both liquid and vapor) within the system. With the compressor operating and little may drop too low.

Decreasing the low-side pressure lowers the evaporator temperature. The evaporator surface temperature should not be allowed to drop below 33°F (0.5°C). The evaporator surface may become covered with ice if it operates at 32°F (0°C) or lower for any length of time. This will stop air circulation through the evaporator. Cool air cannot enter the passenger compartment.

Also, operating the system with low-side pressure too low may cause oil pumping. This condition may damage the compressor valve and, if continued, may burn out the compressor.

A typical automotive air conditioning system will cool an automobile from 110°F (43°C) to 85°F (29°C) in about 10 minutes. The vehicle's interior may reach 150°F (66°C) when parked in the sun with the windows closed. The greatest heat load or heat gain is the sun load and heat conducted through car windows.

Automotive air conditioning systems use anywhere, from no fresh air (all recirculated) to 100% fresh air. When outside, or "fresh air" ducts are closed off, the vehicle's inside air is circulated back through the evaporator plenum. This is known as using recirculated air. The recirculated air has previously been cooled by the evaporator.

Therefore, it is possible to obtain colder interior temperatures than when using outside air. Remember, fresh air ducts must be closed for maximum cooling. The fan blower uses approximately 200 watts or 15 amps of power. It delivers from 250 cfm to 325 cfm of air. Operation of an air conditioning system may reduce fuel economy by as 10 %. This is primarily due to the power needed to turn the compressor shaft. A typical automotive air conditioning system is shown in Figure 2.

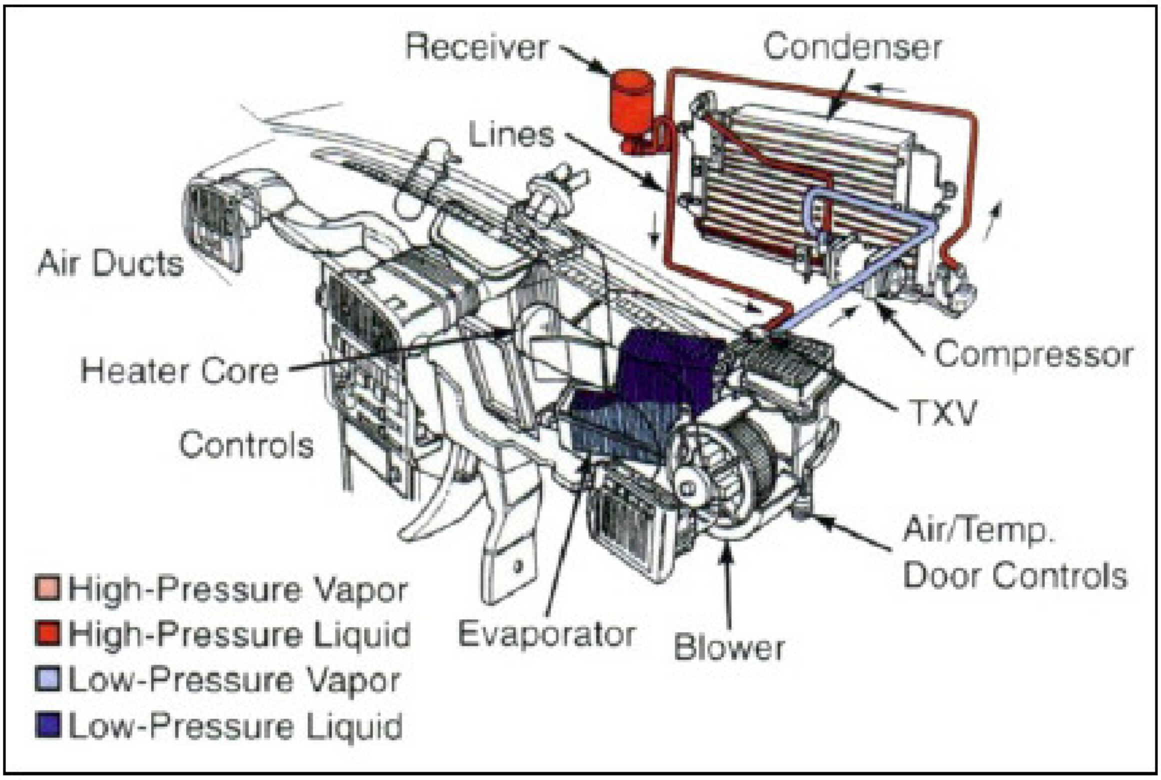

Figure 2: Typical Automotive Air Conditioning System that use a TXV and Receiver Drier.

Cooling Capacity

Automobile air conditioning systems range in size and cooking capacity. Their output range is similar to the one-to four-ton residential or commercial units. A cooling capacity of 12,000 Btu/hr. (12660 kJ/hr) (one ton) is minimum. Capacities up to 48,000 Btu/hr. (50.64 kJ/hr) are available for special applications – station wagons or vans, for example.

The capacity of the air conditioning system should match vehicle size. Under capacity will result in inadequate cooling in hot weather. Overcapacity is uneconomical and causes frequent cycling of the system. Systems are usually designed to keep inside temperature 8°C to 11°C below outside (ambient) temperature with the vehicle traveling about 30 mph (48 km/hr).

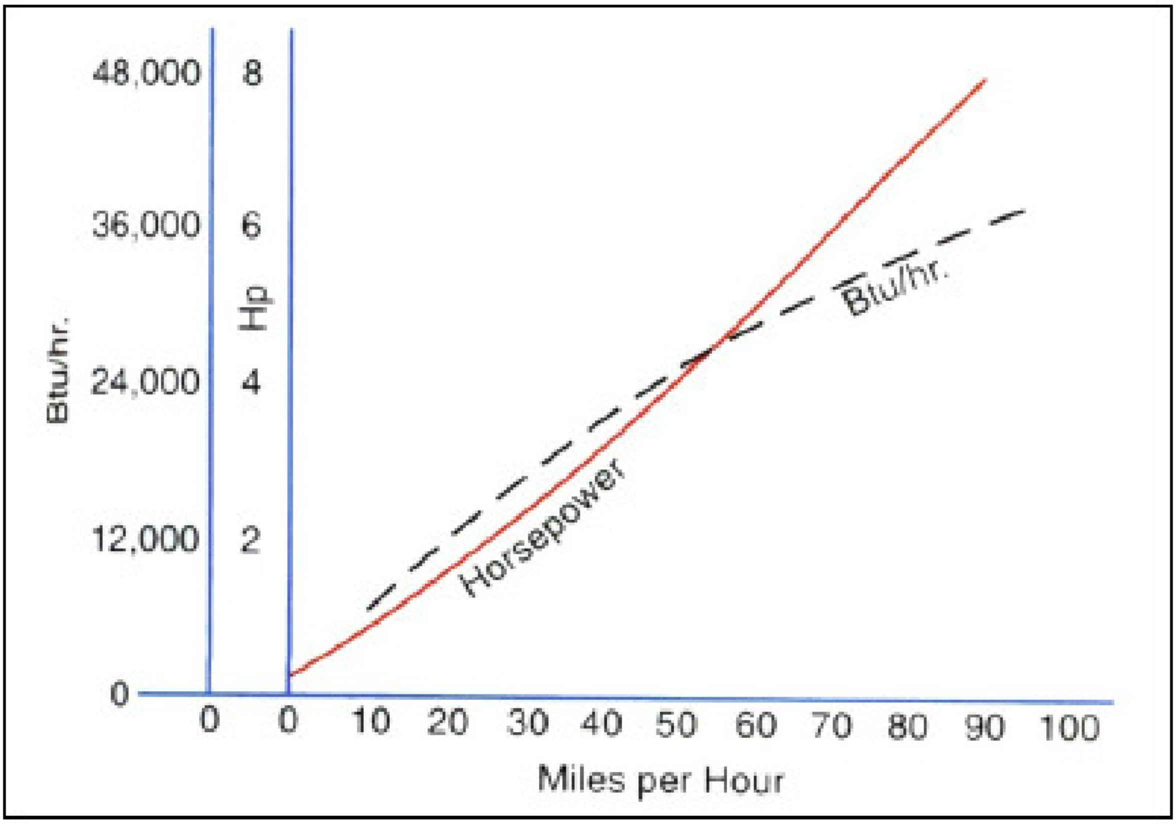

Fig. 3: Curves show relationship between car speed, heat load, and horsepower required to drive air conditioning system.

Figure 3 shows how horsepower required for air conditioning system operation varies as vehicle speed changes. As the vehicle speeds up, the capacity of the compressor will increase. As it slows down, the capacity will decrease. This variation in output is somewhat parallel to the changing heat load, except when the vehicle is parked or in slow moving traffic.

One solution is a variable displacement compressor. At these critical times, compressor capacity may be below normal. A partial solution may be to idle the engine at a higher speed or use a lower transmission gear to obtain higher engine speeds.

Larger air conditioning systems can consume as much as 8 hp (6kW) from the engine at high speeds. Capacity at this speed will be approximately 48,000 Btu/hr. This means that 2 hp (1.5 kW) for each ton of refrigeration in a motor-driven, constant-speed compressor comparably built, with the evaporator and condenser more ideally located.

Refrigeration Cycle in Automotive Air Conditioning System

A schematic vapor compression system is shown in Figure 1-4A. It consists of a compressor, a condenser, an expansion device for throttling and an evaporator. The compressor-delivery head, discharge line, condenser and liquid line form the high-pressure side of the system. The expansion line, evaporator, suction line and compressor-suction head form the low-pressure side of the system.

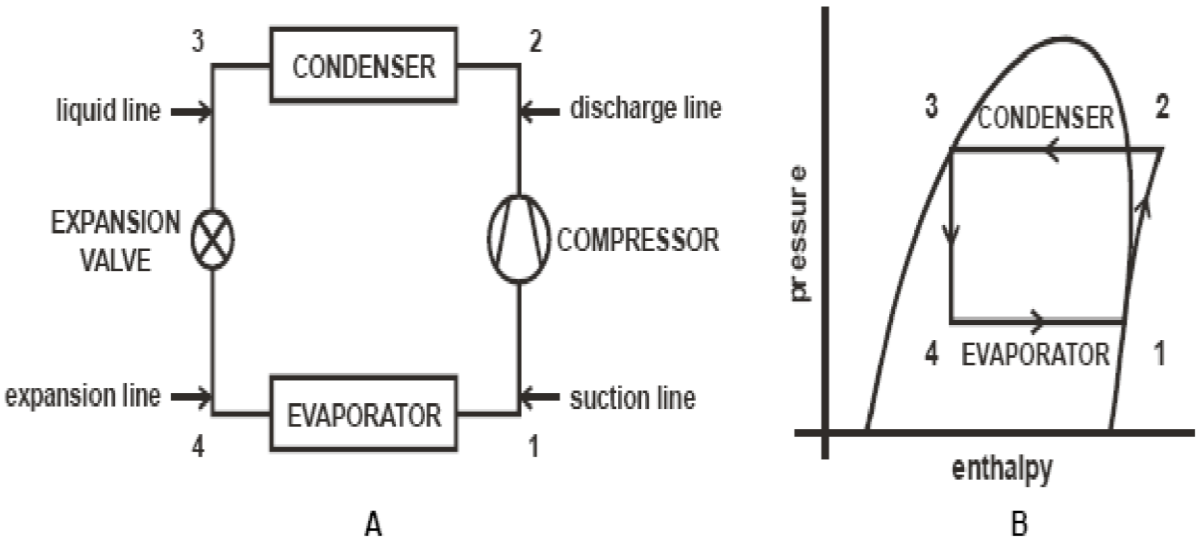

Figure 4: Vapor Compression System Schematic and refrigeration Cycle pressure-Enthalpy Diagram

Most refrigerants undergo a series of evaporation, compression, condensation, throttling, and expansion process, absorbing heat from a lower-temperature reservoir and releasing it to a higher-temperature reservoir in such a way that the final state is equal in all respects to the initial state. It is said to have undergone a closed refrigeration cycle.

When air or gas undergoes a series of compression, heat release, throttling, expansion, and heat absorption processes, and its final state is not equal to its initial state, it is said to have undergone an open refrigeration cycle. Figure 3.2-4B shows the refrigeration cycle on a pressure-enthalpy (p-h) diagram.

The pressure-enthalpy diagram *is the most common graphical tool for analysis and calculation of the heat and work transfer and performance of a refrigeration cycle*. A singlestage refrigeration cycle consists of two regions: the high-pressure region (high side) and the low-pressure (low side). The change in pressure can be clearly illustrated on the p-h diagram. Also, both heat and work transfer of various processes can be calculated as the change of enthalpy and state easily shown on the p-h diagram.

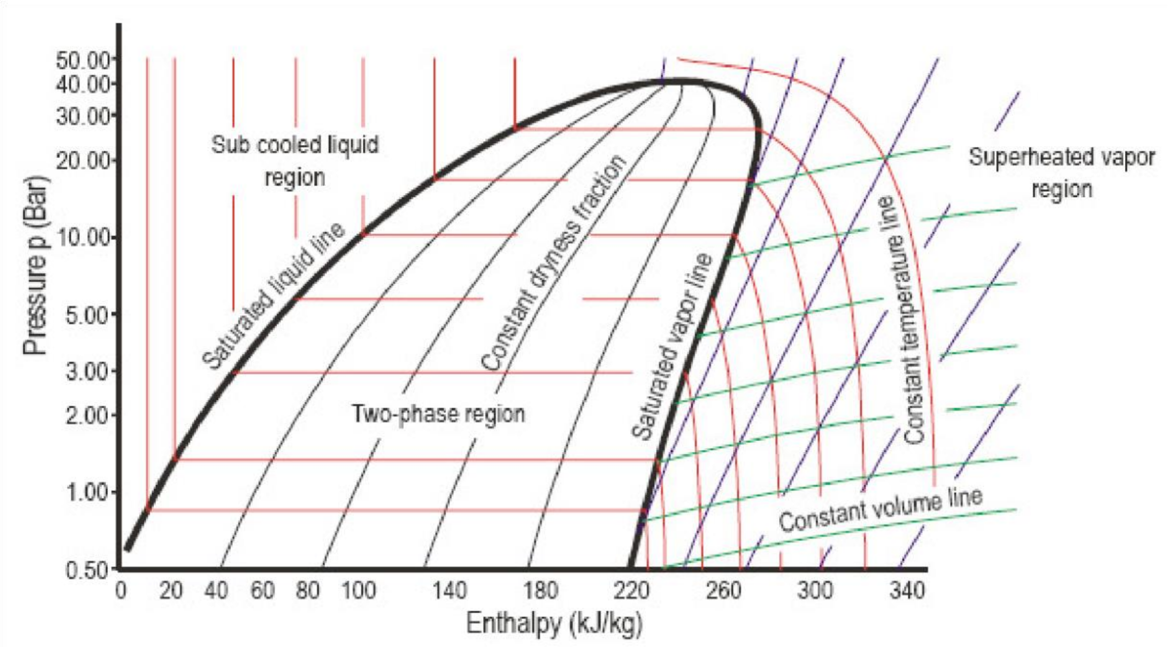

Figure 5: Skeleton of Pressure-Enthalpy Diagram.

Figure 5 is a skeleton p-h diagram for refrigerant R134a. Enthalpy h (in kJ/kg) is the abscissa, and absolute pressure (bar), both expressed in logarithmic scale, is the ordinate. The saturated liquid line separates the sub-cooled liquid from the two-phase region in which vapor and liquid refrigerants coexist. The saturated vapor line separates this two-phase region from the superheated vapor. In the two-phase region, the constant-dryness-fraction quality line subdivides the mixture of vapor and liquid.

The constant-temperature lines are nearly vertical in the sub-cooled liquid region. At higher temperatures, they are curves near the saturated liquid line. In two-phase region, the constant temperature lines are horizontal. In the superheated region, the constant-temperature lines curves down sharply. Because the constant-temperature lines and constant-pressure lines in the two-phase region are horizontal, they are closely related. The specific pressure of a refrigerant in the two-phase region determines its temperature, and vice versa. Also in the superheated region, the constant-entropy lines incline sharply upward, and constant volume lines are flatter. Both are slightly curved.

1.3. REFRIGERANTS

Refrigerant and the Ozone Layer

The word “ozone” has become a part of our everyday terminology. A very thin layer of the earth’s upper atmosphere contains ozone. The ozone layer acts as a filter for the sun’s ultraviolet rays. This protects human, plant, and sea life from the damaging effects of these rays.

Scientists have found that releasing chlorofluorocarbons (CFCs) from some refrigerants can harm the ozone layer. The CFCs destroy this protective layer of the earth’s atmosphere. This concern has developed into what we refer to as the EPA (Environmental Protection Agency) regulations. These regulations identify the types of refrigerants that can be produced. They also regulate how the refrigerants will be used. Most refrigerants commonly used today are classified into four areas:

- Chlorofluorocarbons (CFCs)
- Hydro chlorofluorocarbons (HCFCs)
- Hydro fluorocarbons (HFCs)
- Refrigerant blends (azeotropic and zeotropic)

R-12 Dichlorodifluoromethane (CCL_2, F_2)

R-12 was used in most domestic refrigeration and automotive air conditioner applications before 1997. Due to its suspected impact on the earth’s ozone, the production of R-12 in the United States was stopped in 1997. There still exists a limited supply of R-12 for service usage.

Most automotive air conditioning systems stopped using R-12 in 1995 and today use R-134a. R-12 is a colorless, almost odorless liquid. It has a boiling point of -21.7°F (-29°C) at atmospheric pressure. It is nontoxic, noncorrosive, nonirritating and nonflammable.
Chemically, it is inert at ordinary temperatures and thermally stable to above 800°F (427°C). This temperature is well above the safe operating temperatures of most refrigerating mechanism materials and lubricants.

R-12 has a relatively low latent heat value. In the smaller refrigerating machines, this is an advantage. The large amount of refrigerant circulated permits using less sensitive and more positive operating and regulating mechanisms. It has been widely used in reciprocating, rotary, and large centrifugal compressors. It operates at a low but positive head and backpressure, with a good volumetric efficiency. R-12 has a pressure 26.5 psia (183kPa) or 11.8 psig (81kPa) at 5°F (-15°C). It has a pressure of 108 psia (745 kPa) of 93.3 psig (644 kPa) at 86°F (30°C). The latent heat of R-12 at 5°F (-15°C) is 68.2 Btu/lb (159 kJ/kg).

An R-12 leak may be detected by means of a soap solution, a halide lamp, colored oil added to the system, or an electronic leak detector. Water is only slightly soluble in R-12. At 0°F (18°C), R-12 will hold only six parts per million of water by weight. The solution formed is only very slightly corrosive to metals commonly used in refrigerator construction. The addition of mineral oil to the refrigerant has no effect on the corrosive action. It does lessen the amount of discoloration caused by the free water.

R-12 is soluble in oil down to -90°F (-68°C). This helps the oil flow in very cold evaporators. The oil will begin to separate at this temperature. Because it is lighter than the refrigerant, it will collect on the surface of the liquid refrigerant. The pressure-enthalpy diagram for this refrigerant is shown in Figure 6.

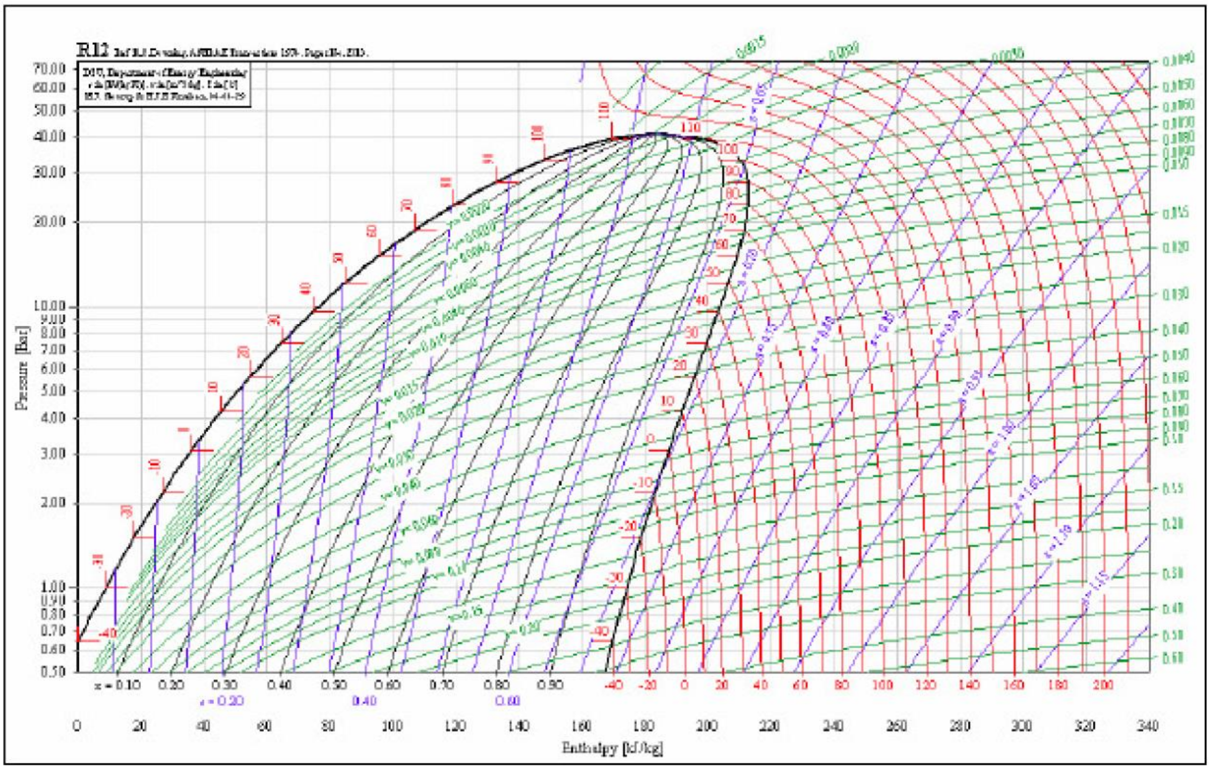

Figure 6: Pressure – Enthalpy Diagram for R-12.

R-134a Tetrafluoroethane (CF_3CH_2F)

R-134a is an HFC refrigerant. It is used as a replacement for R-12 (a CFC refrigerant) though operates at slightly higher pressures. It is used in centrifugal, reciprocating, rotary, screw, and scroll compressors. R-134a is nontoxic, noncorrosive, and nonflammable. However, exposure to concentrations over 75,000 ppm may cause cardiac irregularities.

R-134a has a boiling point of –14.9°F (-26.1°C). It is auto-ignition temperature is 1418°F (770°C). It is ozone depletion level is 0. The coefficient of performance for R-134a is slightly lower than that of R-12. The solubility of R-134a in water is 0.11% by weight at 77°F (25°C). The critical temperature of R-134a is 252°F (122°C). The cylinder color code is light blue.

Refrigerant 134a is not compatible with the mineral based refrigerant oils and lubricants presently used for R-12. It is compatible with polyol ester (POE) oil for most domestic refrigeration applications and polyalkyleneglycol (PAG) oil for automotive usage. Check with manufacturer for exact specifications.

Numerous design changes have been developed and are being implemented for use with R134a. These include a 30% increase in condenser and evaporator sizing, a change in desiccant type (from silicone gel to molecular sieve), the use of smaller hoses, and 30% increase in control pressure regulations.

Leaks of R-134a can be detected by use of: soap solution or fluorescent dyes, ultrasonic leak detectors, halogen-selective detectors and electronic leak detectors.

R-134a is presently being used as a standard refrigerant in vehicular air conditioning. It has been named as a substitute for a wide range of applications. These include air conditioning and refrigeration systems in residential, commercial, and industrial applications. A pressure enthalpy diagram for R-134a is shown in Figure 1-7.

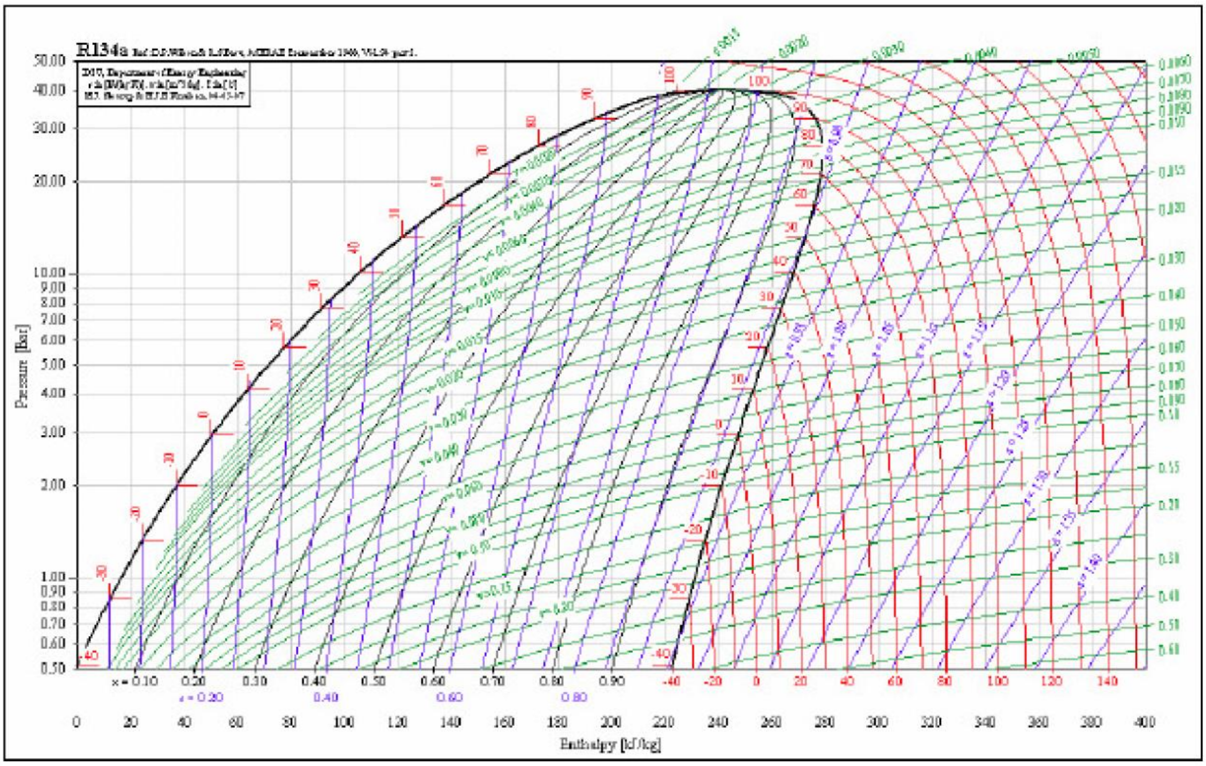

Figure 8: Pressure – Enthalpy Diagram for R-134a.

1.4. AIR CONDITIONING COMPONENTS Compressor

To create high-pressure concentration, the compressor pistons draw in refrigerant through the discharge valve. With the on the down side, the suction valve is opened to allow low-pressure gas to enter. With the piston in the upstroke, refrigerant is forced through. The discharge valve divides the high side of the system from the low side of the system.

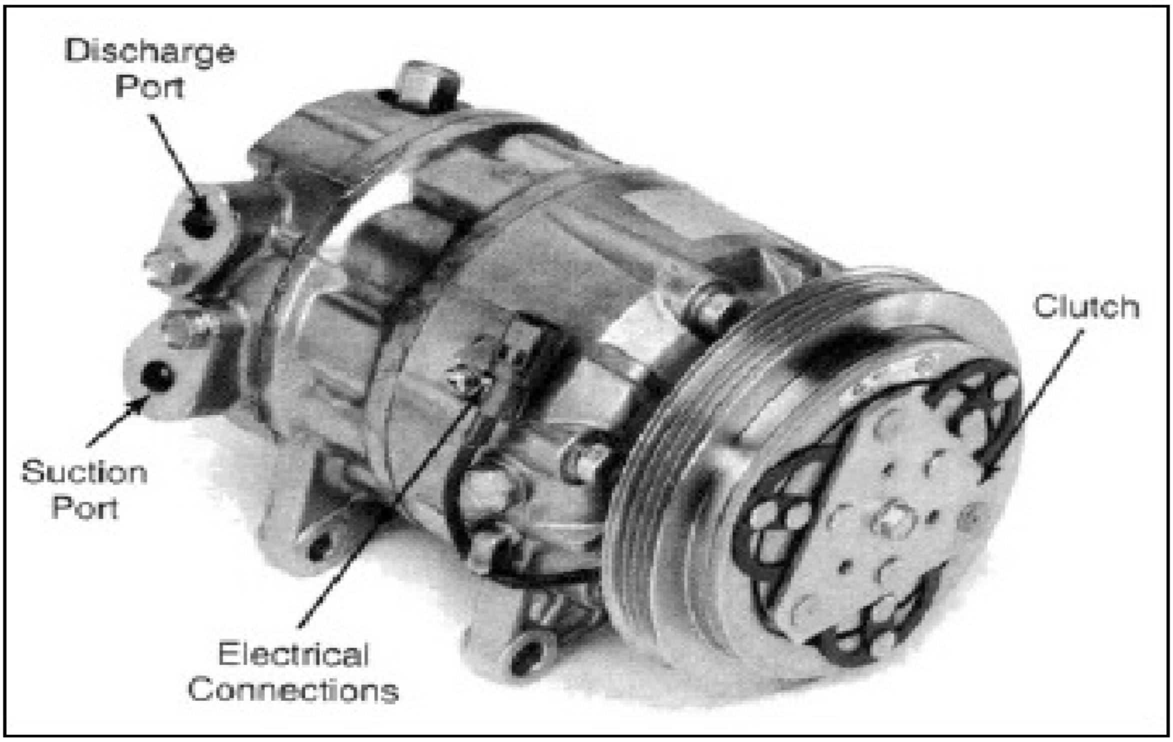

Figure 9: Compressor.

The Magnetic Clutch

An Electro-magnetic clutch is used in conjunction with the thermostat to disengage the compressor when it is not needed, such as when a defrost cycle is indicated in the evaporator, or at other times when the Air conditioner is not being used.

The stationary field clutch is the most desirable type since it has fewer parts to wear out. The field is mounted to the compressor by mechanical means depending on the type of field and compressor.

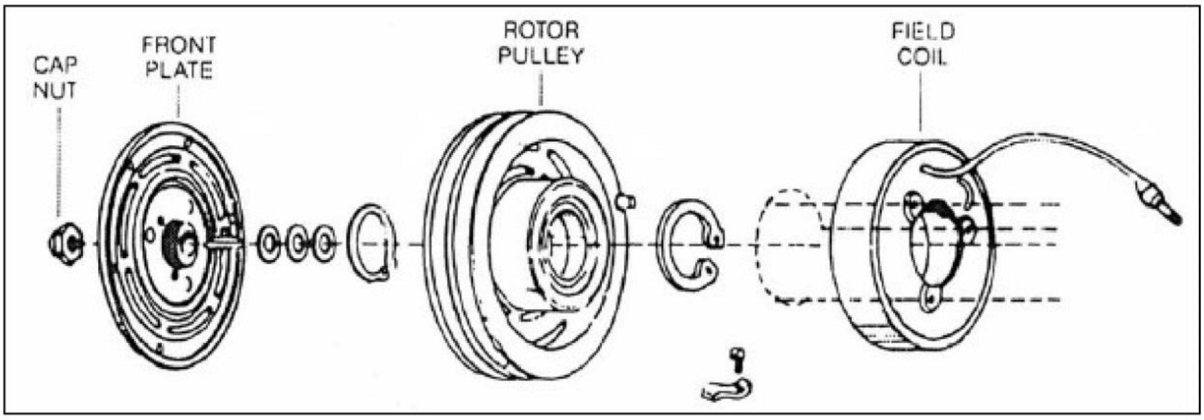

Figure 10: Internal View of The Compressor Magnetic Clutch.

The rotor is held on the armature by means of bearing and snap rings. The armature is mounted to the compressor crankshaft.

When no current is fed to the field there is no magnetic force applied to the clutch and the rotor is free to turn on the armature, which remains stationary on the crankshaft. When the thermostat is on and closed, current is fed to the field. This set up a magnetic force between the field and armature, pulling it into the rotor. When the armature becomes engaged with the rotor, it becomes as one piece and the complete unit turns while the field remains stationary. This causes the compressors crankshaft to turn, starting the refrigeration cycle.

When the thermostat is on but cuts off or opens, current is cut off. The armature snaps out and stops while rotor continues to turn. Pumping action of the compressor is stopped until current is again applied to the field.

Condenser

The condenser receives the high pressure, high temperature refrigerant vapor from the compressor and condenses it to a high temperature liquid. It is designed to allow heat movement from the hot refrigerant vapor to the cooler outside air. The cooling of the refrigerant changes the vapor to the liquid.

Heat exchange is accomplished using cooler air flowing through the condenser. Ram Air Condensers depend on the vehicle movement to force a large volume of air pass the fins and tubes of the condenser. The condenser is usually located in front of the car's radiator. Refrigerant temperature in the condenser varies from 120ºF (49ºC) to 170ºF (76.7ºC), with pressure ranging from 150 (10.5) to 300 PSI. (21 kg/cm^2).

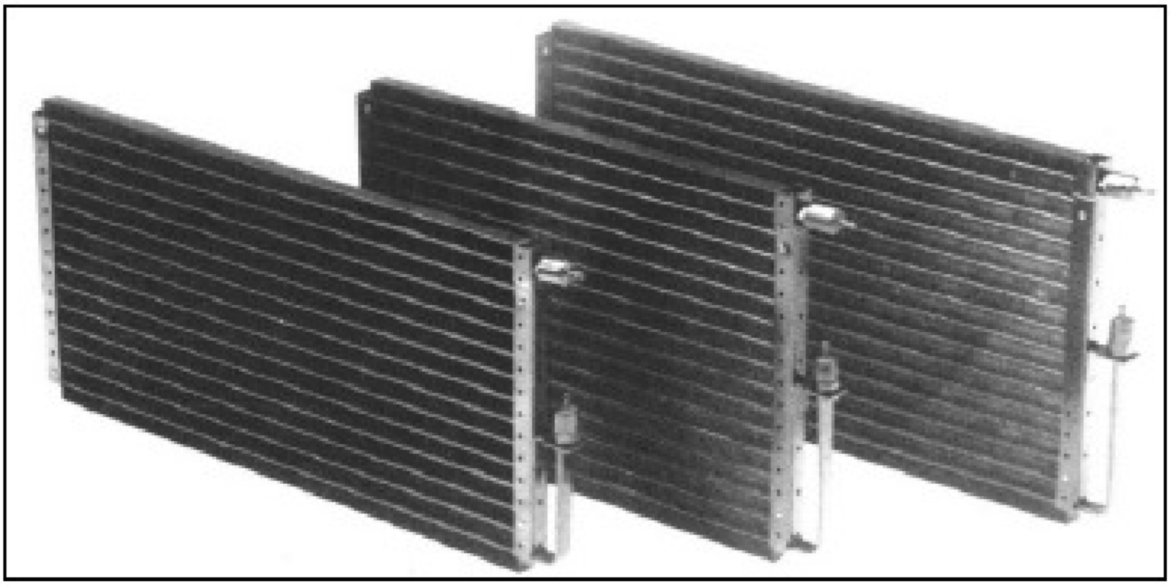

Figure 11: Condenser.

Condensing of the refrigerant is the change of the refrigerant from vapor to liquid. The action is affected by the pressure of the refrigerant in the coil and airflow through the condenser. Condensing pressure in an Air-conditioner system is the controlled pressure of the refrigerant that affects the temperature at which condenses to liquid, giving off large quantities of heat in the process. The condensing point is sufficiently high to create a wide temperature differential between the hot refrigerant vapor and the air passing over the condenser fins and tubes. This difference permits rapid heat transfer from refrigerant to air.

Receiver Drier-Filter

The receiver drier is an important part of the air-conditioning system. The drier receives the liquid refrigerant from the condenser and removes any moisture and foreign matter present that may have entered the system also for storing liquid refrigerant and desiccant.. The receiver section of the tank is designed to store extra refrigerant until the evaporator needs it.

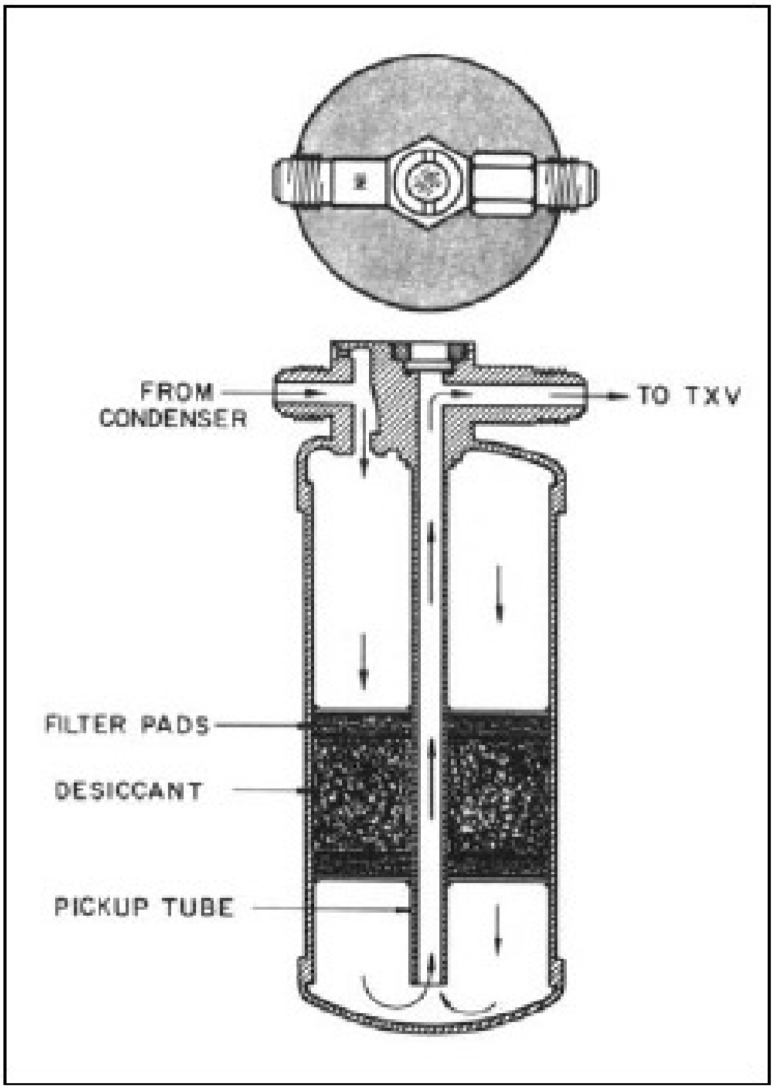

Figure 12: Receiver Drier

The Desiccant

A desiccant is a solid substance capable of removing moisture from gas, liquid or solid. It is held in place within the receiver between two screen, which also act as strainers. Sometimes it is simply placed in a metal mesh or wool felt bag.

Thermostatic Expansion Valve

The thermostatic expansion valve controls the amount of refrigerant entering the evaporator coil. Both internally and externally expansion valves are used. The expansion valve is located near the inlet of the evaporator and provides the function of throttling, modulating, and controlling the liquid refrigerant to the evaporator coil. The refrigerant flow is restricted creating a pressure drop across the valve.

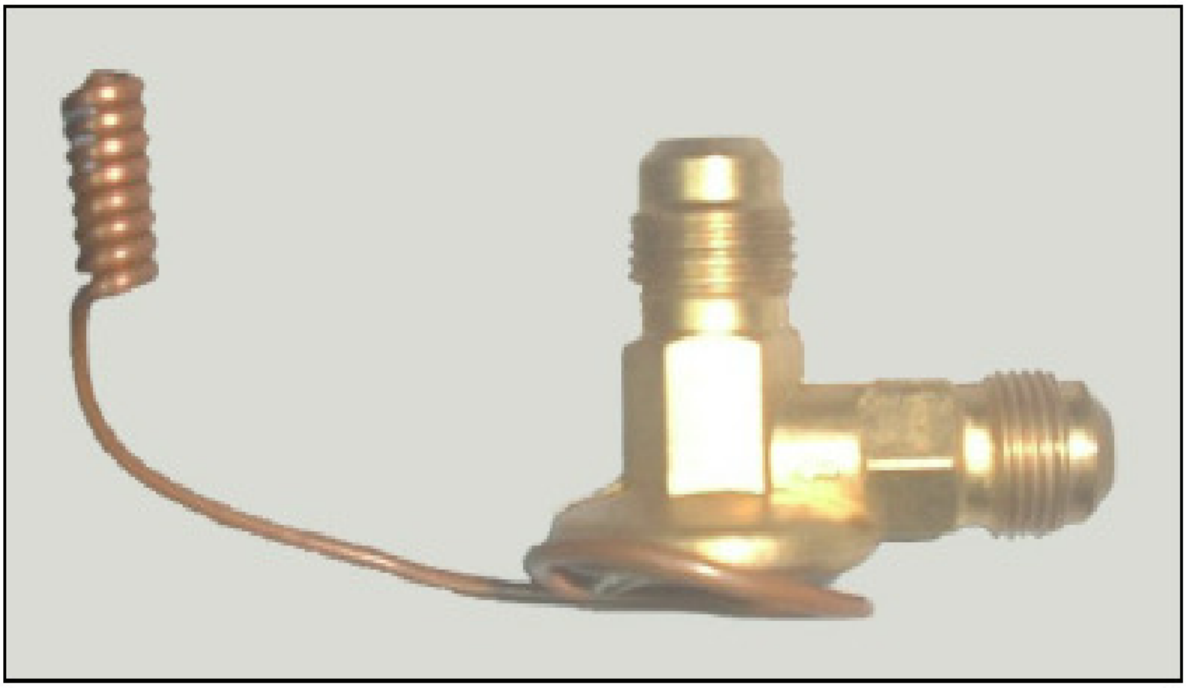

Figure 13: Thermostatic Expansion Valves.

Since the expansion valve also separates the high side of the system from the low side, the state of the refrigerant entering the valve is high pressure liquid; exiting it as low-pressure liquid.

The amount of refrigerant entering the evaporator varies with different heat loads. The valve modulates from wide open to fully closed position, seeking a point between for proper metering of refrigerant.

Both the temperatures of the power element bulb (or pigtail) and the pressure of the liquid control The expansion valve in the evaporator. As the load increases, the valve responds by opening wider to allow more refrigerants into the evaporator. It is this controlling action that provides the proper pressure and temperature control in the evaporator.

Evaporator

The evaporator cools and dehumidifies the air before it enters the car's interior. Cooling a large area requires that large volumes of air be passed through the evaporator coil for heat exchange. Therefore a blower becomes a vital part of the evaporator assembly. It not only draws heat-laden air into the evaporator, but also forces this air over the evaporator fins and coils where the heat is surrounded to the refrigerant.

The blower forces the cooled air out of the evaporator into car's interior. Heat exchange, as explained under condenser operation, depends upon a temperature differential; the greater will be the amount of heat exchange between the air and the refrigerant.

A high heat load condition, as is generally encountered when the Air-conditioning system is turned on, will allow rapid heat transfer between the air and the coolant refrigerant. The change of state of the refrigerant in the evaporator coil is as important as that of the airflow over the coil.

When low-pressure liquid refrigerant enters the evaporator, it boils (expand) and vaporizes immediately. The latent heat of evaporation is the heat absorbed by expanding refrigerant in the evaporation process.

Some liquid refrigerant must be supplied throughout the total length of the evaporator. As the process of heat loss from the air to the evaporator coil surface is taking place, any moisture (humidity) in the air condenses on the outside surface of the evaporator coil and is drained off as water.

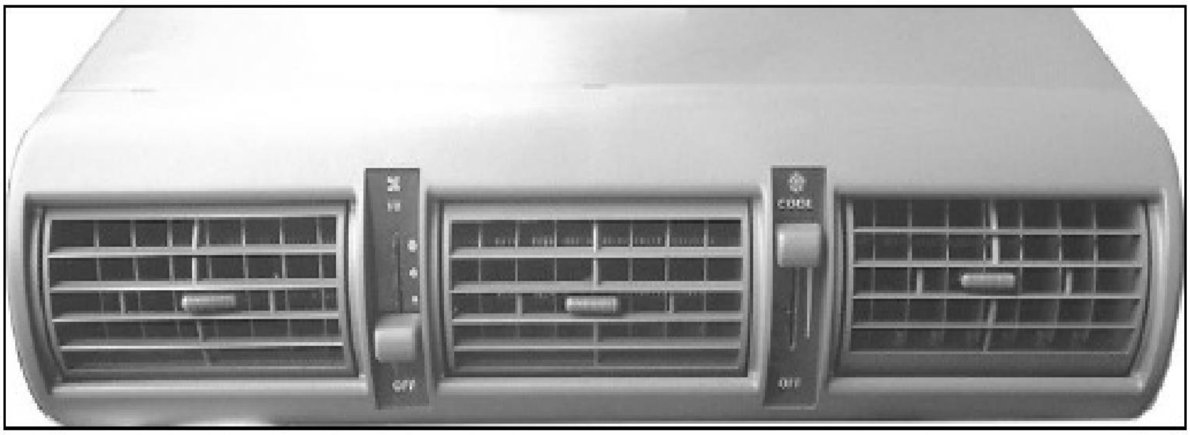

Figure 14: Evaporator.

At atmospheric pressure, refrigerant boils at -21.6ºF (-30ºC) and water freezes at 32ºF (0ºC). Therefore, the temperature in the evaporator must be controlled so that the water collecting on the coil surface does not freeze on and between the fins and restrict the airflow. The evaporator temperature is controlled through pressure inside the evaporator, and temperature and pressure at the outlet of the evaporator.

Thermostat

An Electro magnetic clutch is used on the compressor to provide constant temperature control of the car's interior. The clutch is controlled by a thermostat in the evaporator, which is set initially by the driver to a predetermined point. Coil temperature is then maintained by cycling action of the clutch.

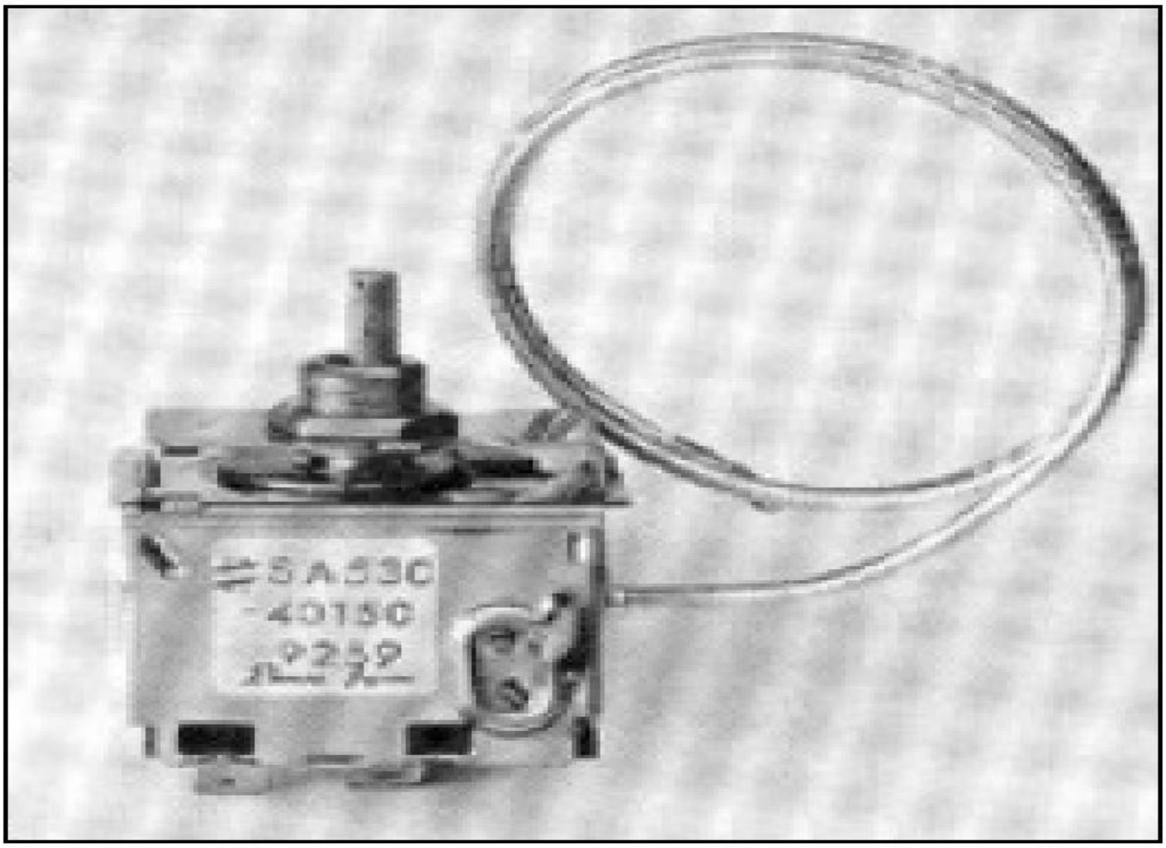

Figure 15: Thermostat.

The thermostat is simply a thermal device, which controls an electrical switch. When warm the switch is closed; when cold, it is open. Most thermostats have a positive off position to turn the clutch off regardless of temperature.

The bellows type thermostat has a capillary tube connected to it which is filed with refrigerant and extends into the evaporate core to sense temperature. The capillary tube is attached to the bellows inside of the thermostat. Expansion of the gases inside the capillary tube exerts pressure on the bellows, which in turn close the points at a predetermined temperature.

EXPERIMENT

2.1. INSTALLING MANIFOLD GAUGE SET

OBJECTIVES

After completing this experiment, you will be able to install the manifold gauge set to the air conditioning system.

EQUIPMENT

1. Automotive Air Conditioning Trainer
2. Experiment Manual HC-AC1-T.
3. Protective covers and eye goggles.
4. Manifold gauge.
5. Service hoses with Schrader adapter pins.
6. High side and low side quick couplers.
7. Vacuum pump.

PROCEDURES

1. Prepare all equipment for this experiment.
2. Ensure that the system is not activated.
3. Connect the service hoses to the manifold gauges. Make sure that valves (V1 and V2) of the manifold gauge are at ***closed*** position.

   Note: *High side hose (red color) is connected to high-pressure gauge of manifold. Low side hose (blue color) is connected to low-pressure gauge of manifold. Centre hose (yellow or black color) is connected to centre connection of manifold.*

4. Connect the high side quick coupler (red color) and it adapter with high side manifoldgauge. Connect low side quick coupler (blue color) and adapter with low side manifold gauge. Ensure that quick couplers are at ***closed*** position.

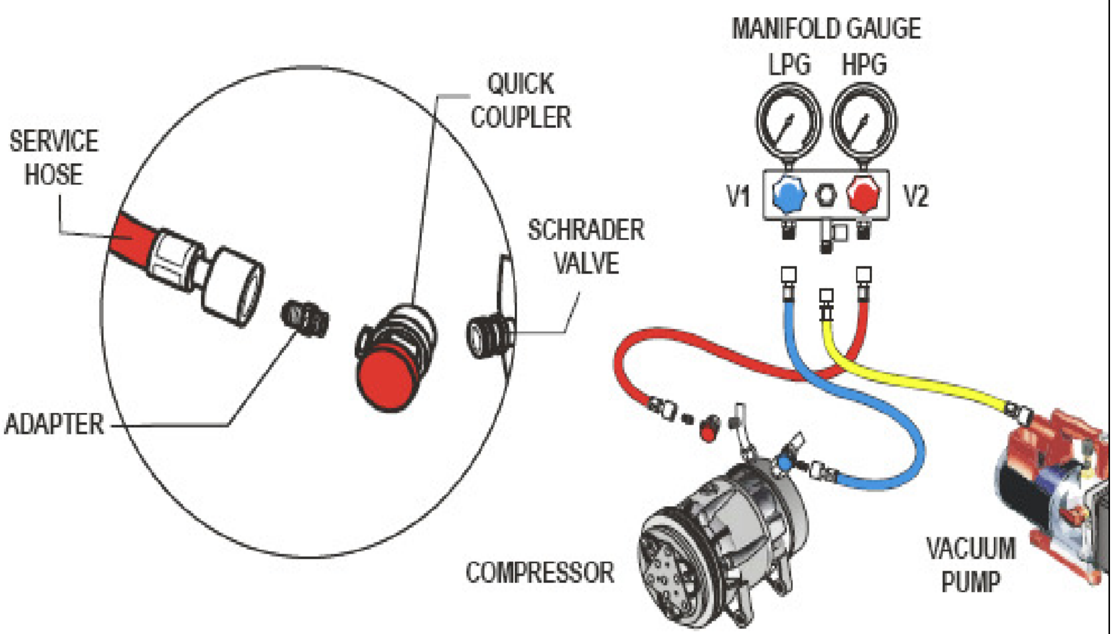

Figure 16: Connections parts for installing manifold gauge into the system and purging the air in the service hoses.

5. Connect the high side quick coupler to high side of the system. Ensure it connectedcorrectly. Connect the low side quick coupler to low side of the system. Ensure it connected correctly.
6. Connect the centre hose to the vacuum pump. Connect the vacuum pump power cable intoAC power source.
7. Open the vacuum pump valve (isovalve) and switch ON the vacuum pump.
8. While observe the high pressure gauge, purge the air from the high side hose by *opening* high side valve (V2) for few seconds or until the pressure gauge shows vacuum pressure, and then ***close*** the valve (V2). Ensure the high side quick coupler at ***open*** position.
9. While observe the low pressure gauge, purge the air from the low side hose by *opening* low side valve (V1) for few seconds or until the pressure gauge shows vacuum

pressure, and then ***close*** the valve (V1). Ensure the low side quick coupler at ***open*** position.

10. After the purging process is finish, close the vacuum pump valve (isovalve) and switch OFF the vacuum pump. Disconnect the centre hose from the vacuum pump.
11. Manifold gauge is ready to use. Observe the refrigerant pressures of the system.Complete data in student sheet 1. *Note: In the balance condition when the system is not active, the normal pressures of the system should be:*
    a. *Discharge pressure = ± 200 PSIG*
    b. *Suction pressure = ± 30 PSIG*
12. *If the pressure is less than 30 PSIG, add refrigerant into the system. If the pressure is too far below than 30 PSIG, the system must be checked from the leak and it is need to recharge.*
13. Return all equipment to the respective place and clean your work area.

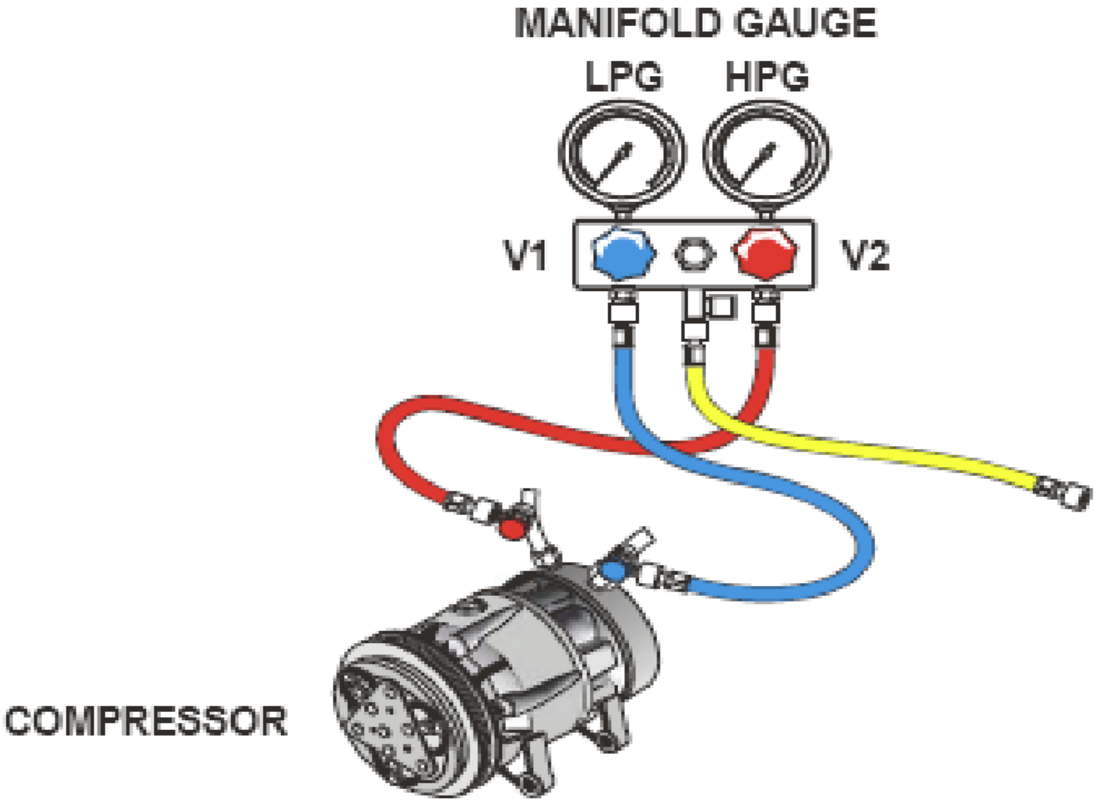

Figure 17: Installing Manifold Gauge into the System.

2.2. DISCHARGING THE REFRIGERANT

OBJECTIVES

After completing this experiment, you will be able to understand the discharging process for removing the entire refrigerant from the system into a refrigerant recovery system.

EQUIPMENT

1. Automotive Air Conditioning Trainer
2. Experiment Manual HC-AC1-T.
3. Manifold gauge set.
4. Recovery unit.
5. Protective covers and eye goggles.

PROCEDURES

1. Prepare all equipment for this experiment.
2. Ensure that the system is not activated.
3. Connect the manifold gauge as described in experiment 1. Make sure that valves (V1and V2) of the manifold gauge are at ***closed*** position.
4. Connect center hose of manifold gauge to the recovery unit.
5. Make sure that high side and low side valves of manifold gauge are at ***fully open*** position.
6. Open valves on the recovery tank.
7. Switch ON the recovery unit.

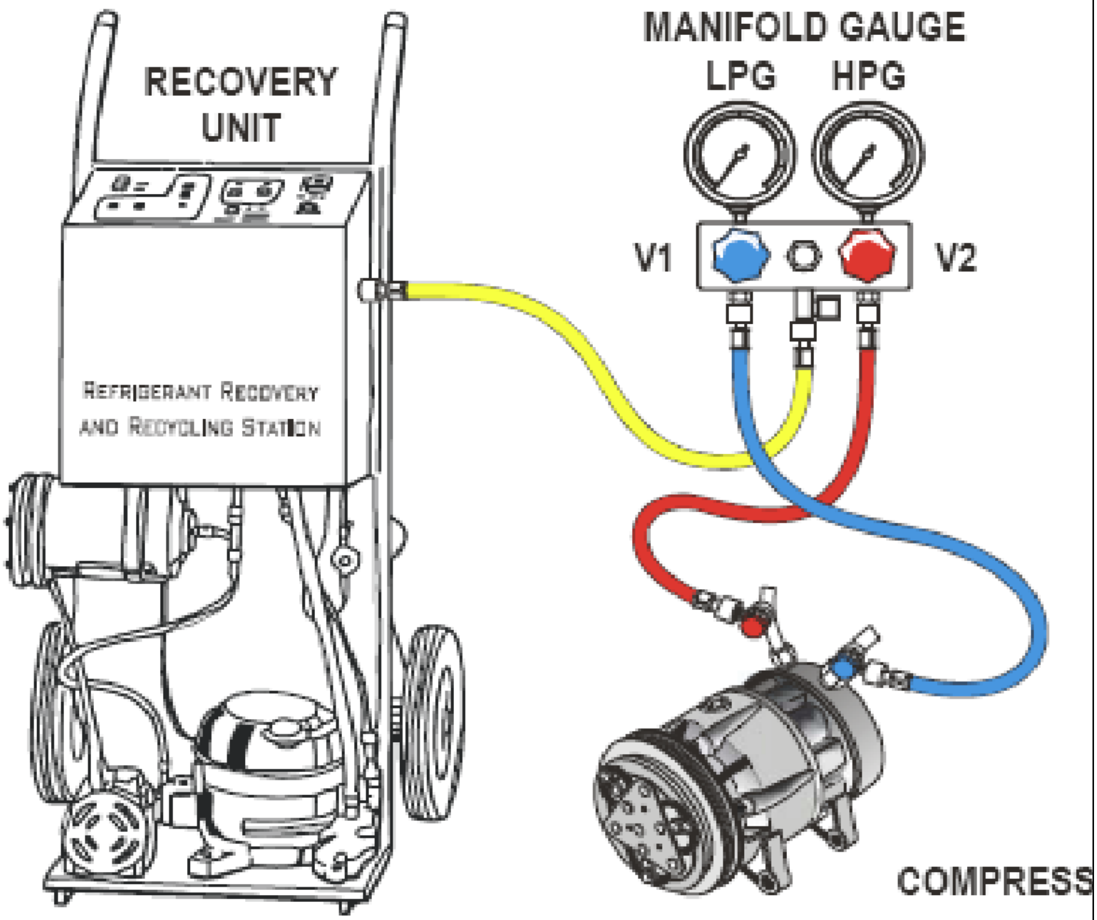

Figure 18: Connecting recovery unit to manifold gauge.

8. Allow all refrigerant to drain from the system (the manifold low pressure gauge moves to avacuum of approximately –25 kPa or 10 in.Hg).
9. Switch OFF the recovery unit and wait for about 5 minutes to allow the refrigerant to boilout of the oil.
10. Switch ON again the recovery unit.
11. Allow all refrigerant to drain from the system (the manifold low pressure gauge moves toa vacuum of approximately –25 kPa or 10 in.Hg).
12. Switch OFF the recovery unit.
13. After completing all procedures, ***close*** all manifold and recovery tank valves.

Note: *Follow specific instructions on the recovery unit available in your workshop.*

14. Return all equipment to the respective place and clean your work area.

2.3. EVACUATING THE SYSTEM

OBJECTIVES

After completing this experiment you will be able to understand how to evacuate the automotive air conditioning system.

EQUIPMENT

1. Automotive Air Conditioning Trainer
2. Experiment Manual HC-AC1-T
3. Manifold gauge set
4. Vacuum pump
5. Protective covers and eye goggles

PROCEDURES

1. Prepare all equipment for this experiment
2. Ensure that the system is not activated
3. Connect the manifold gauge as described in experiment 1. Make sure that valves (V1 andV2) of the manifold gauge are at ***closed*** position. Make sure the system has been discharged
4. Connect the centre manifold hose to the inlet of the vacuum pump and open the iso valve.
5. Run the vacuum pump. Open the low-side manifold valve (V1) and observe the low pressure gauge (LPG). Needle of pressure gauge should be pulled down to indicate a slight vacuum.

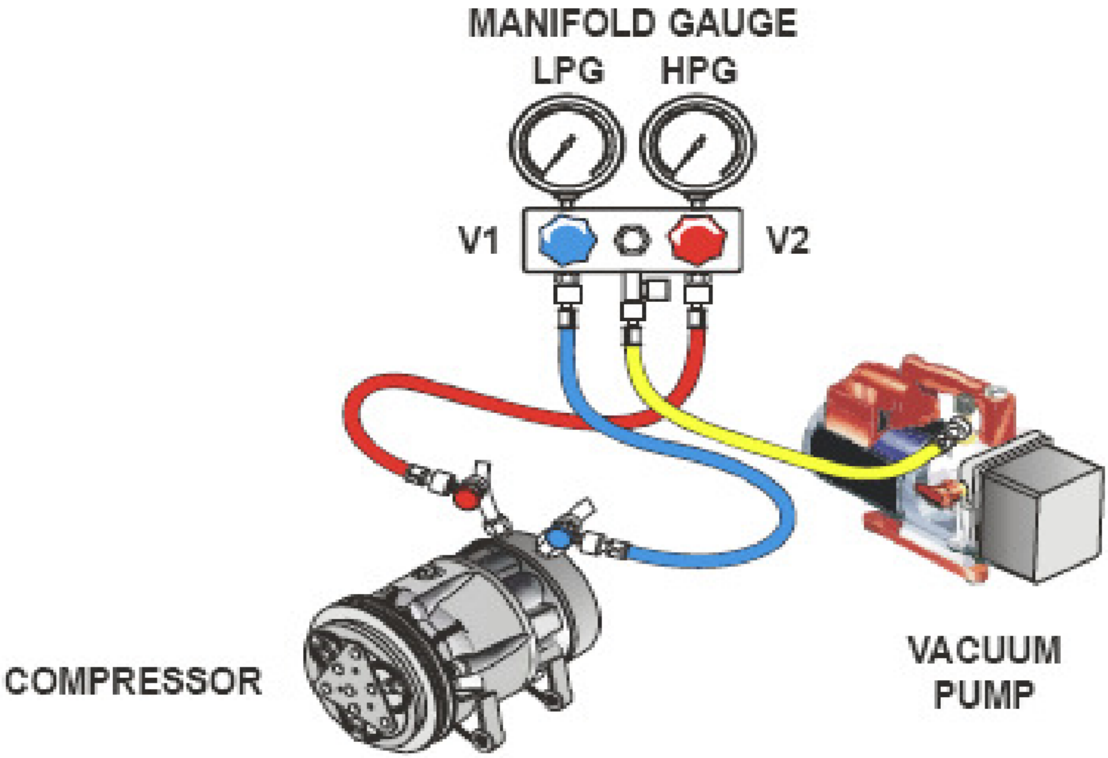

Figure 19: Evacuating the system

6. After about 5 minutes, the pressure gauge should indicate below –70kPa (20in.Hg) and thehigh pressure gauge should be slightly below the zero index of the gauge.
7. If the high pressure gauge needle does not drop below zero (unless restricted by a stop) blockage is indicated. (The high side manifold valve can be opened after the system is checked for blockage.)
8. If there is system blockage in the system, discontinue the evacuation. Repair or remove the obstruction. If the system is clear, continue the evacuation.
9. Operate the pump for 15 minutes and observe the gauges. The system should be at vacuum of from –91 to –99.5 kPa (27 to 29.5 in Hg).
10. Close the vacuum access valve and both manifold gauge valves.
11. Allow the unit to stand for 15 minutes to check for leaks.
12. If the manifold gauge needle rises, indicating a loss of vacuum, there is a leak. The leak must be repaired before the evacuation is continued. If there is leak in the

system, make the report (leak's description and problem solving) in student sheet 3 and follow procedures below:

a. Record the manifold gauge reading; it should be about –98 kPa (29 inHg). The Pressure gauge needle should not raise more than 3.4 kPa (1 in.Hg) within 10 minutes.
b. If the system fails to meet this requirement, although not indicated previously, a partial charge must be installed and the system must be leak-checked.
c. After the leak is detected and repaired, the system must be discharged of refrigerant and completely evacuated.

13. Ensure there is no leak in the system and continue with the evacuation the system at least30 minutes or more.
14. After evacuation, close the high and low side manifold valves and the vacuum pump iso valve.
15. Shut off the vacuum pump, disconnect the manifold hose, and prepare to recharge the system. Return all equipment to the respective place and clean your work area

NOTE:

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