SERVICE MANUAL SECTION

AIR CONDITIONING BASIC THEORY, SYSTEM DIAGNOSIS AND SERVICE

Model: 1000
Start Date: 01/02/1993

Model: 2000
Start Date: 01/02/1993

Model: 4000
Start Date: 01/02/1993

Model: 5000
Start Date: 11/30/1992

Model: 5000i
Start Date: 03/01/1999

Model: 8000
Start Date: 01/02/1993

Model: 9100
Start Date: 10/01/1997

Model: 9100i
Start Date: 03/01/1999

Model: 9200
Start Date: 11/30/1992

Model: 9200i
Start Date: 03/01/1999

Model: 9300

Start Date: 11/30/1992

Model: 9400
Start Date: 11/30/1992

Model: 9400i
Start Date: 03/01/1999

Model: 9600
Start Date: 01/02/1993

Model: 9700
Start Date: 01/02/1993

Model: 9800
Start Date: 03/01/1996

Model: 9900
Start Date: 10/01/1998

Model: 9900i
Start Date: 03/01/1999

S16019

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1. BASIC PRINCIPLES

NOTE – For vehicles built before the dates specified in this section, refer to s16012, AIR CONDITIONING BASIC THEORY, SYSTEM DIAGNOSIS AND SERVICE (WITH R-12 REFRIGERANT SYSTEM)

1.1. HEAT

The word **heat** may be defined in many ways. The definition best suited for refrigerant service is that heat is a form of energy which can be transferred from one place to another. This transfer, however, cannot take place unless there is a difference in temperature between the two places.

Everything in nature contains heat. Some things contain more heat than others, but all contain heat. Heat cannot be created or destroyed, but it can be moved from one place to another or from one form of energy to another form of energy. Heat energy travels in one direction only: from a warmer object to a cooler object. This movement of heat takes place in one of three ways: convection, conduction or radiation.

Convection means that heat transfer is taking place as a result of the circulation of a fluid. The cooling system in a truck is a good example of convection cooling. The coolant (water and anti-freeze) in the cooling system removes the heat created by the engine by carrying it from the engine block to the radiator. The heat is then dissipated into the surrounding air.

Conduction means that heat is being transferred through a solid. For example, when food is frying in a pan, heat from the burner is conducted through the metal of the pan to the food.

Radiation means that heat is being transferred through a medium and the medium does not become hot. An example of this is the way people acquire sunburns at the beach. Part of the heat from the sun is transmitted to the skin through the air.

1.2. SENSIBLE HEAT

Sensible heat is any heat that can be felt and can be measured with a thermometer.

An example of sensible heat is the heat in the surrounding air. This air is called **ambient air**. The temperature of this air is called **ambient temperature**. When this temperature drops ten or fifteen degrees, the difference in temperature can be felt. An increase in the temperature causes one to feel warmer.

1.3. LATENT HEAT

Latent heat is the term applied to the heat required to cause a change of state of matter. This heat cannot be recorded on a thermometer, and it cannot be felt. A change of state occurs when a solid changes to a liquid or a liquid changes to a gas or vice versa. Water at 32 degrees F (0 degrees C) is called **subcooled liquid**. Water at 212 degrees F (100 degrees C) is called **saturated liquid**. That is, water at 212 degrees F (100 degrees C) contains all the heat it can hold and still remain a liquid. Additional heat will cause the water to vaporize (Figure 1).

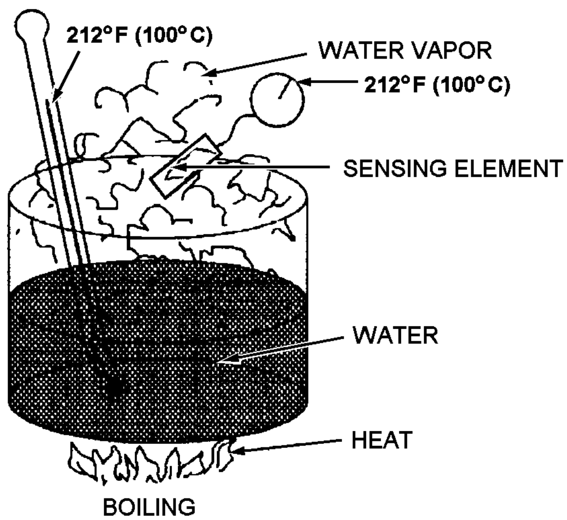


Figure 1 Water Vaporizing

To change water to steam requires heat. This heat is called the **latent heat of vaporization**. Remember this heat cannot be measured on a thermometer and does not cause a change in the temperature of the water.

To change steam back into water, the steam must give up heat as it condenses into a liquid. The heat released in this process is called the latent heat of condensation (Figure 2).

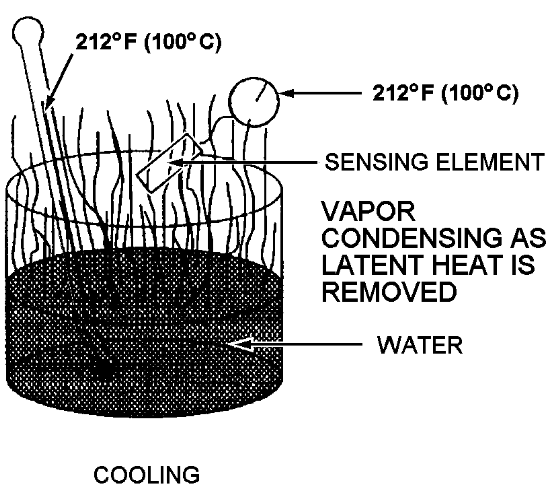


Figure 2 Latent Heat of Condensation

Additional removal of heat will continue to lower the temperature of the water. This temperature decrease can be measured on a thermometer until 32 degrees F (0 degrees C) is reached. At 32 degrees F (0 degrees C), all the heat that can be removed from the water without causing a change of state is removed. The heat that must be removed to change the water from a liquid to a solid (ice) is called **latent heat of fusion**.

This principle governing the addition and removal of heat energy is the basis for air conditioning. A refrigerant is selected for its ability to absorb and to give up large quantities of heat rapidly.

1.4. COLD

Cold is the absence of heat. To understand cold, we must first understand what heat is. Heat is energy and is present at all times. Heat cannot be contained. As explained under HEAT, the structure of all things is changed into one of three forms by heat.

All matter generates heat which is called **specific heat**. The body generates heat that must be overcome if one is to be cool. The food stored in a refrigerator generates heat that must be overcome if the food is to be kept at a safe temperature required for short or long term storage. Any matter that is to be cooled must first have its specific temperature lowered or overcome.

1.5. PRESSURE OF VAPORIZATION

The **latent heat of vaporization** and **latent heat of condensation** of a liquid or vapor increases or decreases according to the pressure exerted on it.

At sea level 14.7 psi atmospheric pressure, at 212 degrees F (100 degrees C) a boiled egg will become cooked in three minutes. In Colorado, at 8,900 ft., the atmospheric pressure is lower than at sea level. The same water now boils at 202 degrees F (94.6 degrees C). That means the three minute egg at sea level that cooked in 212 degrees F (100 degrees C) water will take longer to cook because it is being cooked in 202 degrees F (94.6 degrees C) water at 8900 ft. If we go to Death Valley, which is below sea level, we will find our eggs cook in less time because the increase in atmospheric pressure causes the boiling point temperature of water to increase (Figure 3).

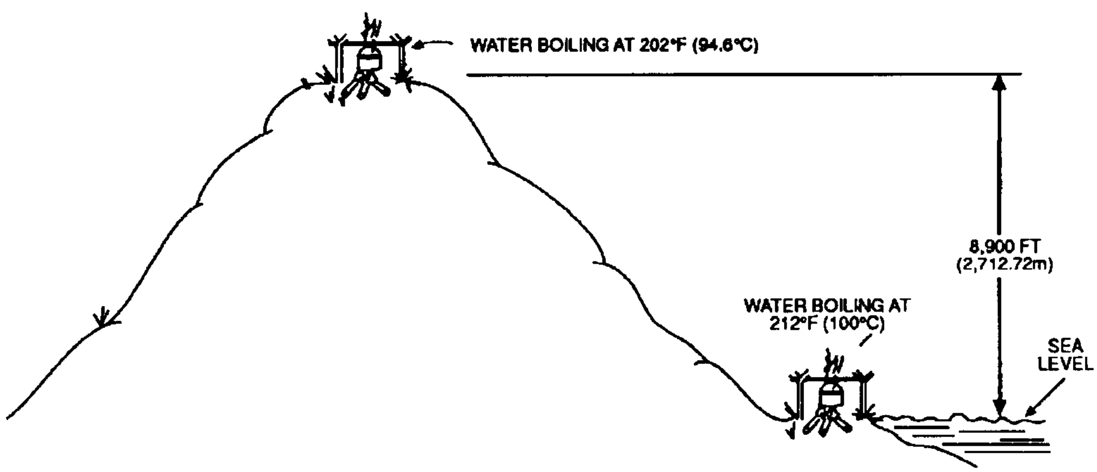


Figure 3 Boiling Points of Water

1.6. PRINCIPLES OF AIR CONDITIONING

When we hear the term air conditioning, usually the first thing that comes to mind is cold fresh air. In automotive applications, air conditioning is any system that cools and dehumidifies the air inside the passenger compartment of an automobile or truck.

The air conditioning system installed in International trucks uses a special refrigerant to absorb heat inside the evaporator. To do this the refrigerant changes from a liquid to a vapor (latent heat of vaporization). Since the evaporator is located inside the cab, air blown over the fins of the evaporator becomes cool and is directed to the occupants of the cab for their comfort.

It is necessary to remove the heat absorbed by the refrigerant inside of the evaporator. To do this, the refrigerant is recycled for reuse within the system. The heat is removed from the refrigerant (latent heat of condensation) and expelled into the outside air.

The process of recycling the refrigerant starts at the compressor. The compressor pressurizes the heat-laden vapor until its pressure and temperature are much greater than that of the outside air. The compressor also pumps the vapor to the condenser. The condenser is located at the front of the vehicle and since the air passing over the fins of the condenser is much cooler than the vapor inside the condenser, the vapor gives up much of its heat to the outside air and changes back into a liquid. The liquid refrigerant then passes from the condenser to the receiver-dryer where it is stored until it is needed again by the evaporator.

This example of heat removal demonstrates three basic laws of refrigeration which are the basics of all air conditioning systems.

LAW I

To refrigerate is to remove heat. The absence of heat is cold. Heat is ever present.

Law I is illustrated by the air conditioning system of a truck. Heat is removed from the cab. In so doing, the temperature is lowered. The absence of heat is cold.

LAW II

Heat is ready to flow or pass to anything that has less heat. Nothing can stop the flow of heat; it can only be slowed down.

Law II is demonstrated by the special refrigerant in the evaporator. In this instance, heat is ready to flow to anything that contains less heat.

LAW III

If a change of state is to take place, there must be a transfer of heat. If a liquid is to change to a gas, it must take on heat. The heat is carried off in a vapor. If a vapor is to change into a liquid, it must give up heat. The heat is given up to a less hot surface or medium.

Law III is shown by the liquid refrigerant in the evaporator. That is, as the refrigerant takes on heat, it changes to a vapor. The heat is carried off to the condenser to be expelled outside the vehicle which in turn changes the vapor back into a liquid.

1.7. HOW THE SYSTEM WORKS

Basic Review

When liquid refrigerant absorbs heat from the surrounding area, it changes to a vapor. This action is referred to as the latent heat of vaporization.

Liquid refrigerant, like most liquids, boils and changes to a vapor when pressure is reduced (Figure 4). When pressure is applied to the refrigerant vapor, it is condensed to a liquid (Figure 5). During the process of converting a vapor to a liquid, latent heat of condensation is dissipated to the outside air (Figure 6).

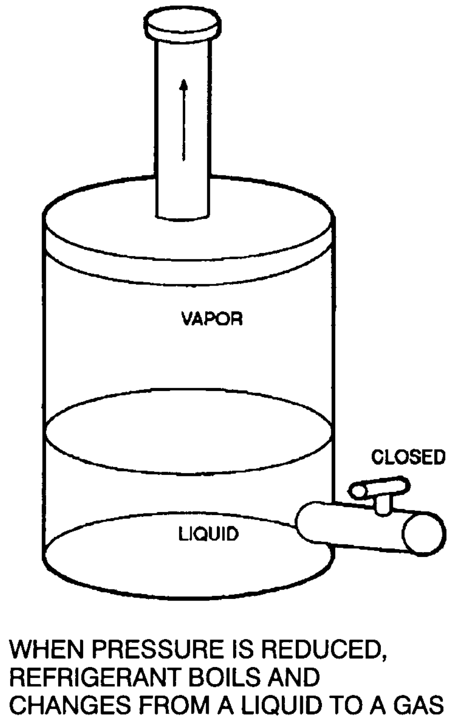


Figure 4 Refrigerant Boils and Changes to a Vapor

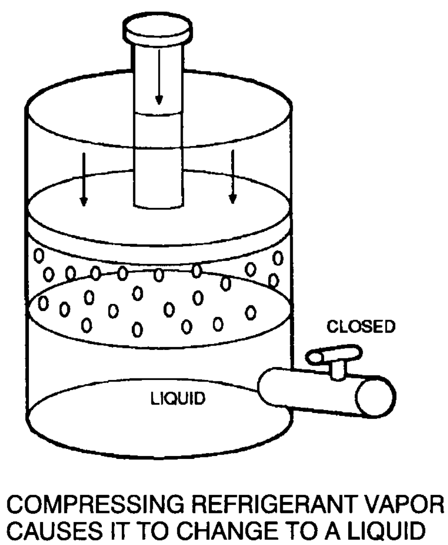


Figure 5 Refrigerant Vapor Condenses to a Liquid

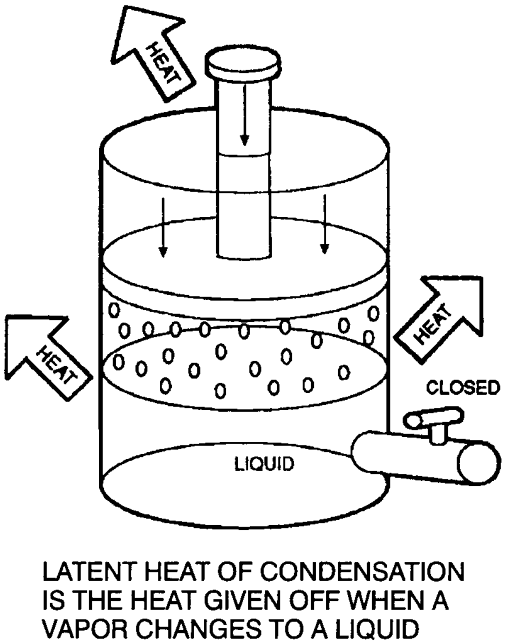
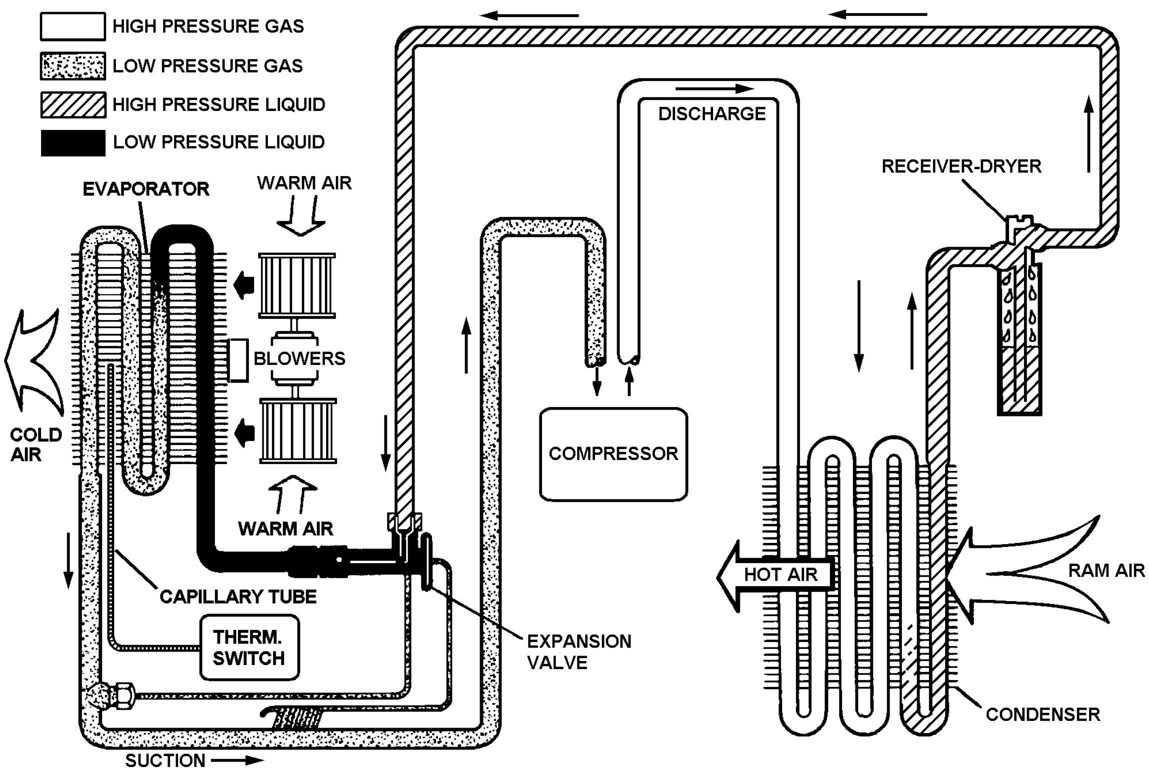


Figure 6 Latent Heat of Condensation Dissipates

Basic Refrigerant Cycle

The refrigerant cycle (Figure 7), consists of four phases: compression, condensation, expansion, and evaporation of refrigerant. Consider the starting point at the receiver-dryer. At this point, the refrigerant is a hot liquid under high pressure. The liquid refrigerant flows to the expansion valve under high pressure. The expansion valve meters the flow of refrigerant, thus reducing its pressure to a low-pressure liquid. The low-pressure liquid moves into the evaporator where it expands and changes to low pressure, low temperature vapor. During the change of state, large quantities of heat are absorbed from the cab by the refrigerant.



EARLY VERSION - EXPANSION VALVE

LATE VERSION - BLOCK STYLE EXPANSION VALVE

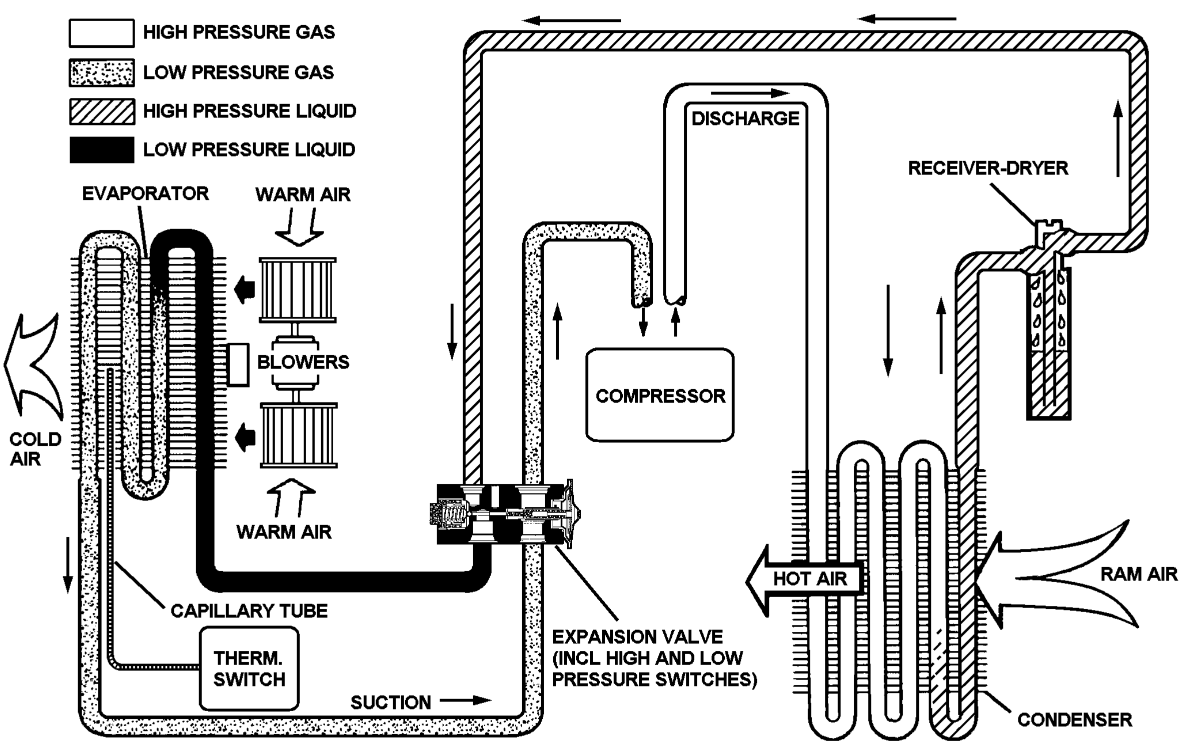


Figure 7 The Refrigerant Cycle

The heat-laden, low pressure vapor is drawn to the compressor. The compressor changes the low pressure, low temperature vapor to a high pressure, high temperature vapor. The high temperature, high pressure vapor is pumped to the condenser. The cooler outside air passing over the condenser fins removes heat from the refrigerant that was picked up in the cab of the vehicle and condenses the high temperature, high pressure vapor back to a high temperature, high pressure liquid. The high temperature, high pressure liquid is then pumped to the receiver-dryer. The cycle is then repeated.

As a means of better understanding the overall system, consider the following description of the components used in an International truck air conditioning system. The system has the following components:

- Compressor and Clutch
- Condenser
- Receiver-dryer
- Expansion Valve
- Evaporator
- Thermostatic Control Switch
- Refrigerant Low Pressure Switch
- High Pressure Safety Switch
- Fan Drive Override Switch (optional)
- Shutter Override Switch (optional)
- Air Blower
- Blower Speed Control Resistors.

2. DESCRIPTION OF SYSTEM COMPONENTS

For more information on the following components (including removal/installation procedures), refer to the AIR CONDITIONING – HEATER SYSTEM Service Manual Section in GROUP 16 of the Master Service Manual, for the vehicle being serviced.

2.1. COMPRESSOR AND CLUTCH

The compressor is mounted on the engine and is belt-driven through an electromagnetic clutch which acts to engage (turn ON) or disengage (turn OFF) the compressor in response to the air conditioning system controls.

When engaged, the clutch armature assembly is magnetically drawn to the pulley assembly on the compressor shaft, thereby engaging the clutch and driving the compressor.

The suction side of the compressor draws low pressure refrigerant vapor (5 to 50 psi) from the evaporator (low pressure side of system). The compressor then compresses the refrigerant vapor and discharges it at increased temperature and pressure (120 to 300 psi) through the high side line which connects the compressor to the condenser (Figure 8).

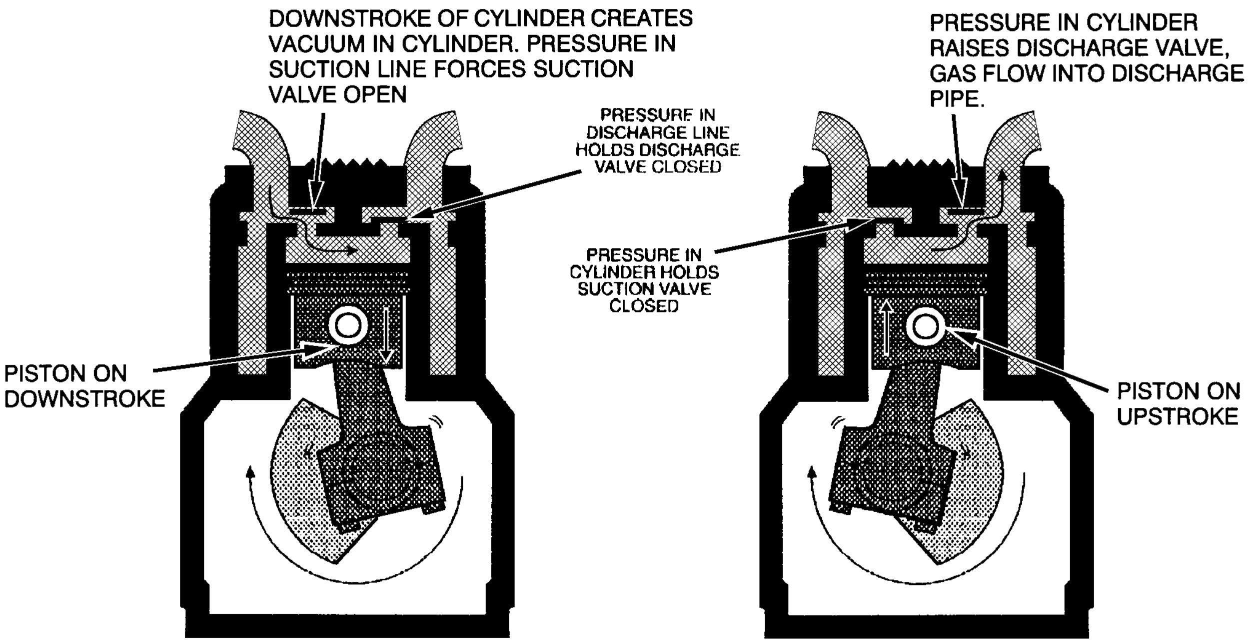


Figure 8 Refrigerant Vapor is Compressed and Discharged (CCI Type Compressor Shown)

TWO-CYLINDER CCI COMPRESSOR

Refer to Figure 9.

Before 11/1/02, a two-cylinder, CCI compressor was used. In this compressor, each piston is actuated via its connecting rod, in response to crankshaft rotation.

An internal lubricating system uses the suction side intake crankcase pressure differential to coat internal parts with a thin film of oil. This lubrication also travels along with the refrigerant throughout the air conditioning system to lubricate various system components.

Refer to the s16017, AIR CONDITIONING COMPRESSOR AND CLUTCH Service Manual Section in the Master Service Manual for greater detail on these units.

A pressure relief valve was located on the receiver-dryer on earlier systems. The pressure relief valve is located on the compressor on later systems. This offers better protection to the compressor in extreme high pressure.

The label on the clutch side of the compressor (Figure 9) lists the type of refrigerant and oil used in the system and the refrigerant charge quantity recommended by International.

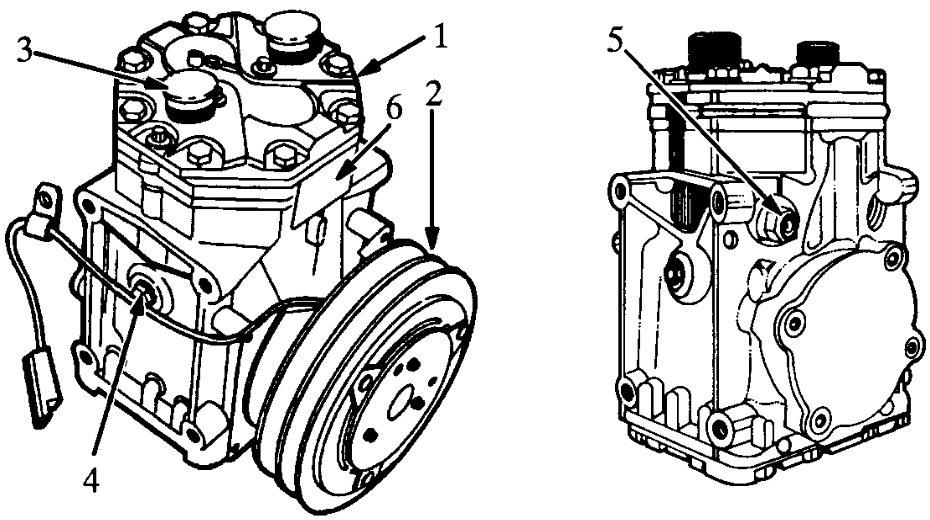


Figure 9 Two-Cylinder CCI Compressor and Clutch – (Used Before 11-1-02)

1. REFRIGERANT COMPRESSOR
2. COMPRESSOR DRIVE CLUTCH
3. PORT CAPS (KEEP IN PLACE WHEN LINES ARE DISCONNECTED)
4. OIL FILL PLUG
5. HIGH PRESSURE RELIEF VALVE
6. LABEL

SEVEN-CYLINDER SANDEN COMPRESSOR

Refer to Figure 10.

Since 11/1/02, a Sanden, seven-cylinder 'wobble plate' compressor has been used. These compressors use 'peanut' style fittings on the A/C lines. Prior to this date, the Sanden compressor was available only as an option. The earlier version of the Sanden compressor used standard threaded fittings on the A/C lines. In this compressor, each piston is actuated via its connecting rod, in response to the action of a wobble plate. A pressure relief valve is located on the compressor to provide protection to the compressor in the event of extreme high pressure.

The compressor, and the other system components, are lubricated by the lubrication that travels along with the refrigerant throughout the air conditioning system. The label on the compressor lists the type of refrigerant and oil used in the system, and the refrigerant charge quantity recommended by International.

The Sanden compressor and clutch are to be replaced as an assembly. Additional service information for this compressor is found in this manual.

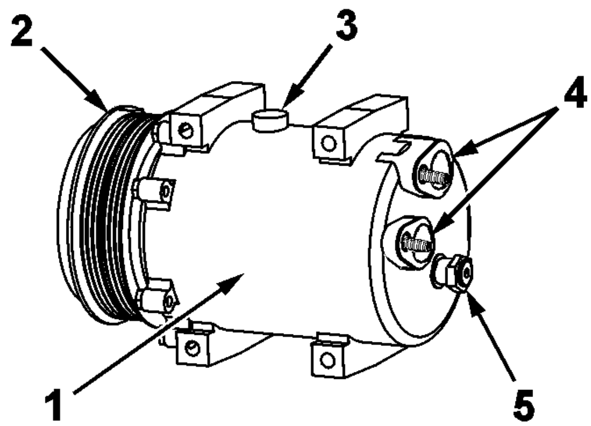


Figure 10 Typical Seven-Cylinder Sanden Compressor and Clutch (Version with 'Peanut' Style Fittings Shown)

1. REFRIGERANT COMPRESSOR
2. COMPRESSOR DRIVE CLUTCH
3. OIL FILL PLUG
4. PORT CAPS (KEEP IN PLACE WHEN LINES ARE DISCONNECTED)
5. HIGH PRESSURE RELIEF VALVE

2.2. CONDENSER

Refer to Figure 11.

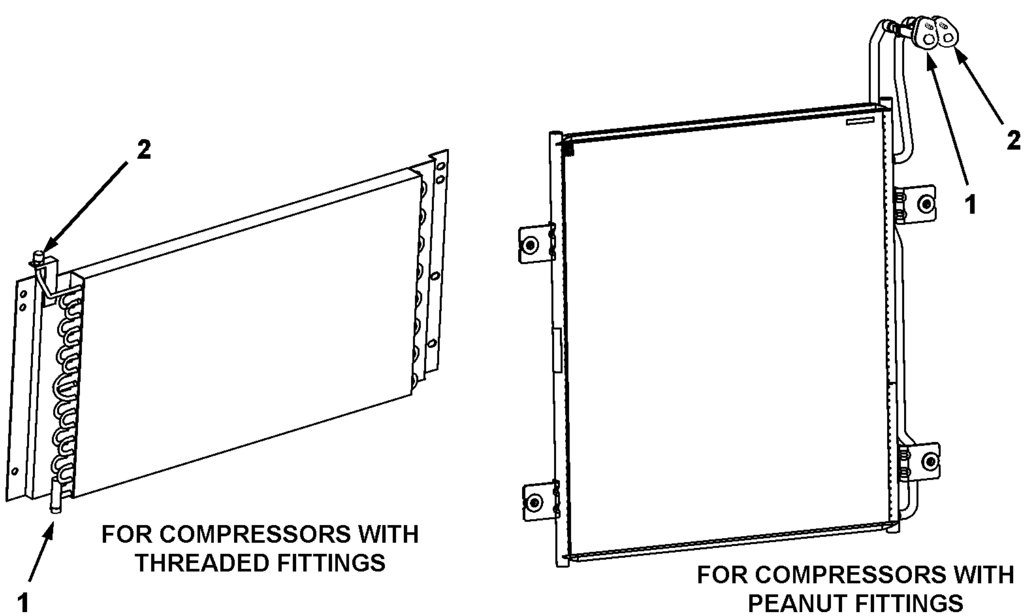


Figure 11 Typical Condensers

1. OUTLET FITTING
2. INLET FITTING

The air conditioning condenser is located at the front of the vehicle between the engine radiator and the grille. It consists of a series of coils, with inlet and outlet fittings, surrounded by thin cooling fins. High pressure/high temperature refrigerant vapor from the compressor enters at the top of the condenser, circulates down through the coils and exits at the bottom of the condenser as high pressure/high temperature refrigerant liquid. As the vapor condenses (changes state), heat is released to the outside air which passes over the fin external surfaces to carry the heat away.

The efficiency of the condenser operation is affected by ram air flowing across the condenser. For this reason, it is important that the condenser cooling fins remain free of airborne contamination (leaves, insects, dirt, etc.) which can block the fins and cause system temperatures to run higher than normal.

When operating properly, the condenser acts as an efficient heat exchanger, containing refrigerant vapor in approximately two-thirds of the upper portion of its coils and condensed refrigerant liquid in the lower one-third portion. The condenser passes high temperature/high pressure liquid refrigerant to the receiver-dryer.

2.3. RECEIVER-DRYER

Refer to Figure 12.

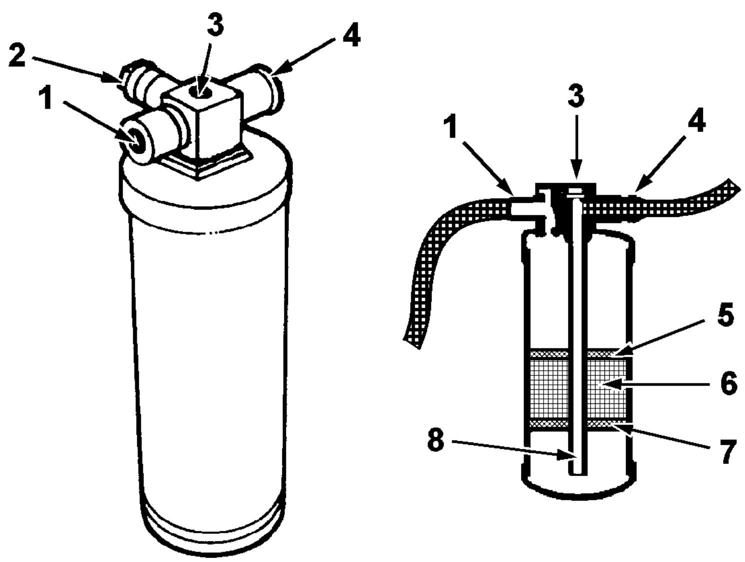


Figure 12 Receiver-Dryer

1. INLET PORT
2. HIGH PRESSURE SERVICE VALVE
3. SIGHT GLASS
4. OUTLET PORT
5. FILTER
6. DESICCANT
7. STRAINER
8. PICKUP TUBE

The receiver-dryer performs three important functions:

- Filters particles from the liquid refrigerant.
- Removes moisture from the liquid refrigerant.

- Stores a portion of the liquid refrigerant until needed in the system evaporator to meet high cooling demands.

High pressure liquid refrigerant flows from the condenser to the receiver-dryer. To protect the system from moisture, a drying agent (desiccant) absorbs and separates any moisture contained in the liquid refrigerant. The cylinder or tank portion of the receiver-dryer collects and stores liquid refrigerant until system demands require additional refrigerant. The primary function of the receiver-dryer, however, is the removal of any liquid or solid contamination before it can cycle through the system and cause internal damage. Moisture-free, contaminant-free, high temperature/high pressure liquid refrigerant leaves the receiver-dryer.

If the compressor or any other component fails or requires replacement, the receiver-dryer must also be replaced to prevent subsequent corrosion and damage to the system.

Always replace the receiver-dryer whenever the system has been opened to the atmosphere for more than 30 minutes. This will help prevent moisture contamination of the system.

System protection is provided by a direct-acting high pressure relief valve (on Service Parts Receiver-Dryers only) that will discharge refrigerant if the pressure exceeds the system limit. This is not a fusible plug and does not expel the entire charge. Relief pressure ranges from 450 psi to 600 psi. On some vehicles, the pressure relief valve has been moved from the receiver-dryer to the refrigerant compressor. Replacement receiver-dryers furnished by International will have the pressure relief valve on the receiver-dryer. The receiver-dryer used in production will be equipped with a service port.

The receiver-dryer is not serviceable, and must be replaced if found to be defective.

2.4. EXPANSION VALVE

The expansion valve is located between the receiver-dryer and the evaporator, and is the dividing line between the high pressure side and low pressure side of the A/C system (see Figure 7). High pressure/high temperature liquid refrigerant enters the expansion valve. Leaving the expansion valve, the refrigerant starts to expand, entering the evaporator as a low pressure, low temperature liquid.

The A/C systems covered in this manual have used two different expansion valves (refer to Table 1). The valve used on early production units had a capillary tube and an equalizer line attached. The block style expansion valve used on later production units, had no capillary tube or equalizer line.

Table 1 Expansion Valve Usage by Model

Models	Early Production Expansion Valve Capillary Tube/Equalizer Line Style	Later Production Expansion Valve Block Style
1000	All	N/A
2000, 4000, 8000	Before 12/5/94	After 12/5/94
5000, 9000 Daycabs & Box Sleepers	Before 7/18/99	N/A
9000 Pro Sleepers	Before 5/1/97	5/1/97 to 7/18/99
All 5000i, 9000i	N/A	After 3/1/99

Table 1 Expansion Valve Usage by Model (cont.)

Models	Early Production Expansion Valve Capillary Tube/Equalizer Line Style	Later Production Expansion Valve Block Style
9600, 9700	Before 7/1/97	N/A
9800	Before 7/1/97	After 7/1/97

Early Production Expansion Valve (With Capillary Tube and Equalizer Line)

Attached to the top of the early production expansion valve is a capillary tube with a feeler bulb which is clamped to the outlet (suction) pipe of the evaporator (refer to Figure 7 and Figure 13). The sealed bulb and tube are filled with R-134a that expands and contracts according to the temperature surrounding the bulb. The feeler bulb senses the temperature of refrigerant leaving the evaporator.

A second capillary tube (the equalizer line) is attached under the valve diaphragm and is connected to the evaporator outlet (suction) pipe. This line which senses suction pressure. Together, the capillary tube and equalizer line regulate the amount of refrigerant entering the evaporator.

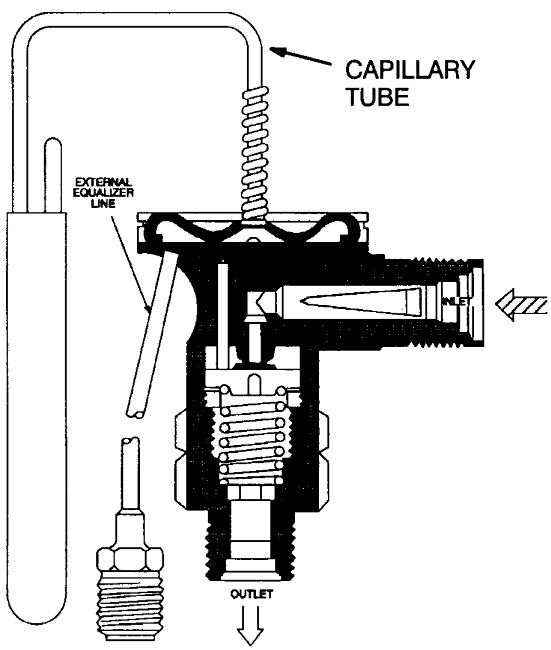


Figure 13 Expansion Valve with Capillary Tube

Later Production Expansion Valve (Block Style)

The block valve does not have a capillary tube with a feeler bulb or an equalizer line (refer to Figure 7 and Figure 14). Temperature sensing and suction pressure sensing are built into the valve (Figure 15).

This type of expansion valve is designed with a metering orifice that serves the following two (2) functions:

- It provides a pressure drop which changes the high pressure/high temperature refrigerant liquid into a low pressure/low temperature liquid.
- It regulates the amount of refrigerant entering the evaporator to match cooling demands.

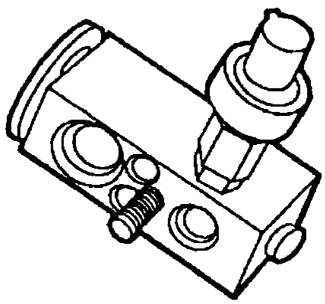


Figure 14 Block Style Expansion Valve (Valve with One Pressure Switch Shown, Others May Have Two Pressure Switches)

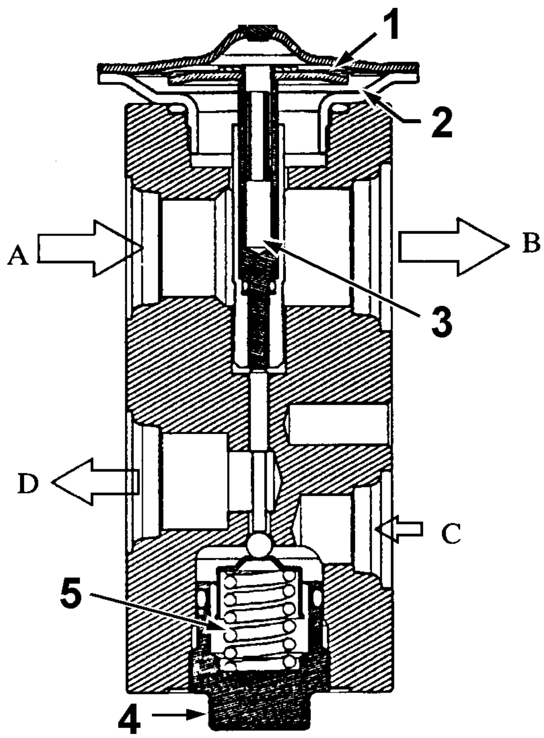


Figure 15 Expansion Valve Flow and Pressure

A. SUPERHEATED R-134A RETURN FLOW FROM EVAPORATOR
B. SUPERHEATED R-134A FLOW TO COMPRESSOR
C. SUBCOOLED LIQUID R-134A FLOW FROM RECEIVER-DRYER
D. EXPANDING R-134A FLOW OUT TO EVAPORATOR
1. THERMAL-SIDE PRESSURE R-134A AT SATURATION (AT EVAPORATOR OUTLET TEMPERATURE)
2. SYSTEM SIDE PRESSURE AT EVAPORATOR OUTLET
3. THERMAL-SIDE CHARGE EVAPORATION/CONDENSATION DUE TO SENSED TEMPERATURE
4. CALIBRATION SCREW
5. SUPERHEAT ADJUSTMENT (BIAS) SPRING

2.5. EVAPORATOR

Refer to Figure 16.

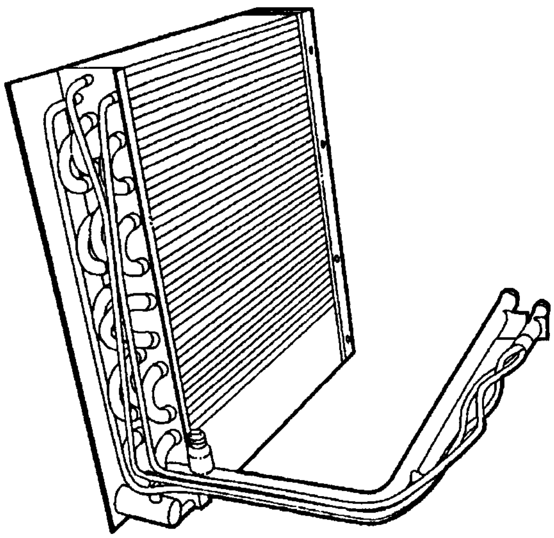


Figure 16 Typical Evaporator

The evaporator is a cooling assembly made of fin and tube construction. Low pressure/low temperature liquid refrigerant from the expansion valve enters the evaporator. Upon entering the evaporator, the pressure is immediately reduced. This permits the liquid refrigerant to boil or evaporate, thereby changing its state from a liquid to a low pressure/low temperature vapor.

Cooling and dehumidifying of the cab's interior takes place as the refrigerant vapor passes through the evaporator's finned tubes and absorbs heat from the cab air forced across the evaporator by the blower. Humidity condenses on the external surface of the cooled fins and is channeled out of the cab. The refrigerant exits the evaporator outlet as a low pressure/low temperature vapor and is drawn into the suction side of the compressor.

2.6. THERMOSTATIC CONTROL SWITCH

Refer to Figure 17.

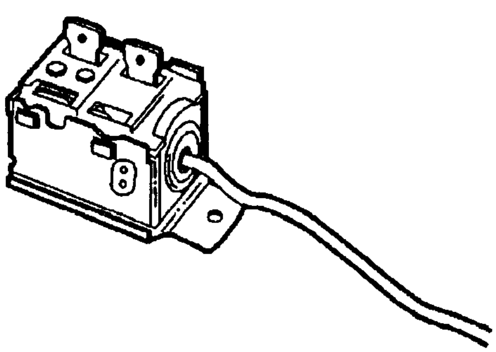


Figure 17 Thermostatic Control Switch

The thermostatic control switch is a thermal device that controls an electrical switch. At predetermined evaporator temperatures, the switch energizes or de-energizes the clutch that drives the A/C compressor.

A refrigerant-filled capillary tube is inserted into the fins and tubes of the evaporator core. The other end of the capillary tube is attached to a bellows inside the thermostat portion of the thermostatic switch. When the capillary tube senses 40 to 44 degrees F (temperature may vary by model), the thermostat closes a set of contacts, which sends current to the magnetic clutch on the A/C compressor. The energized compressor provides low pressure/low temperature liquid refrigerant to the evaporator. When the capillary tube senses 30 to 34 degrees F (temperature may vary by model), the thermostat switch opens, disengaging the magnetic clutch so the evaporator does not freeze up and stop air flowing through it.

2.7. REFRIGERANT LOW PRESSURE SWITCH

Refer to Figure 18.

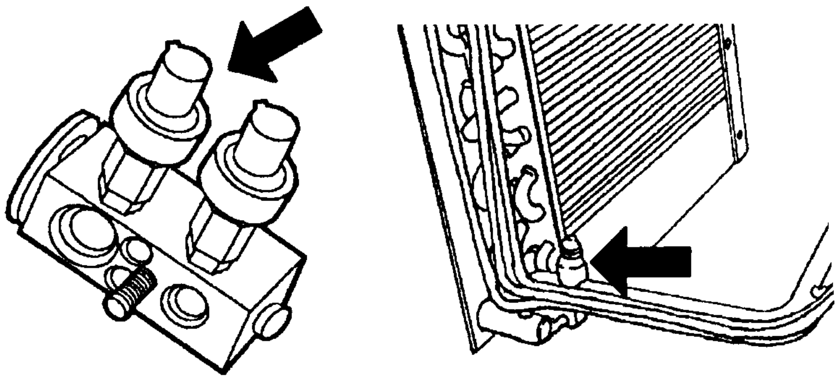


Figure 18 Refrigerant Low Pressure Switch (Typical Locations)

A low pressure switch is used to protect the compressor. It is located in the refrigerant return line and prevents compressor operation if the refrigerant level is too low. Low refrigerant also means low lubricant and can result in compressor damage. The low pressure switch may be located on the expansion valve or at the outlet of the evaporator.

When the system operates, normal system pressure holds the switch open. If system low pressure (compressor suction) gets too low, the switch closes, energizing a relay that opens the circuit to the compressor magnetic clutch and stops operation of the compressor. Refer to SPECIFICATIONS (See Table 7, page 83) for the opening and closing pressures of this switch.

2.8. HIGH PRESSURE SWITCH

Refer to Figure 19.

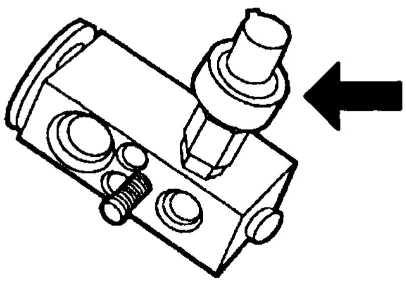


Figure 19 High Pressure Switch (Mounted on Expansion Valve)

A high pressure switch has been added to air conditioning systems to prevent exhausting refrigerant into the atmosphere under high pressure conditions. When abnormally high pressures are reached, the high pressure switch will disengage the A/C clutch before the pressure relief valve opens. The high pressure switch is typically located on the expansion valve. If necessary, refer to the air conditioning service section for the vehicle being serviced for the location of the switch. Refer to SPECIFICATIONS (See Table 7, page 83) for the opening pressures of this switch.

2.9. FAN DRIVE SWITCH

Refer to Figure 20.

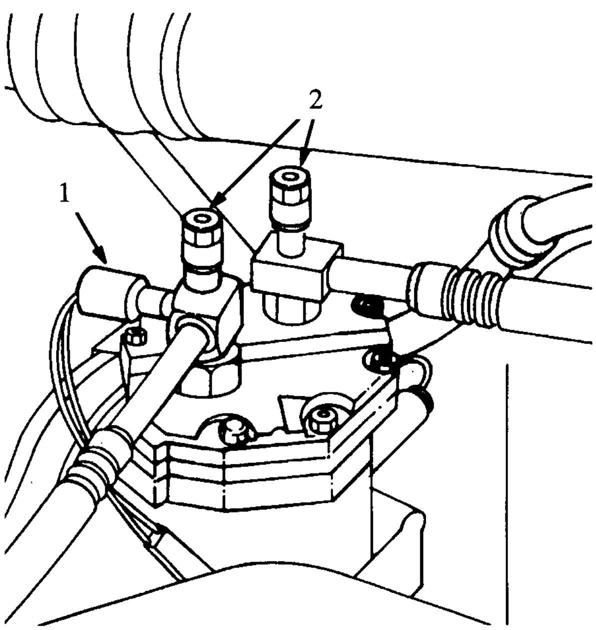


Figure 20 Fan Drive or Shutter Override Switch (Shown on a CCI Compressor)

1. FAN DRIVE OR SHUTTER OVERRIDE SWITCH
2. COMPRESSOR SERVICE PORTS

Vehicles equipped with an electric or air operated engine cooling fan clutch have a fan drive switch. On vehicles equipped with CCI compressors, this switch is typically located on the refrigerant compressor discharge port fitting. The fan drive switch is located on the high pressure line on vehicles equipped with Sanden compressors.

When the compressor discharge pressure exceeds 300 psi ± 10 psi (pressure may vary by model), this switch is activated and the engine fan drive clutch engages to provide maximum air flow through the condenser. The fan remains engaged until the compressor discharge pressure falls below 210 psi ± 10 psi (pressure may vary by model). There are several types of fan drives and each has a specific switch and solenoid valve combination. For more detailed information, refer to GROUP 12-ENGINES and GROUP 8 ELECTRICAL CIRCUIT DIAGRAMS in the Master Service Manual.

2.10. RADIATOR SHUTTER OVERRIDE SWITCH

Vehicles equipped with radiator shutters also have a pressure switch. This switch is also typically located in the refrigerant compressor discharge line (Figure 20).

The shutter override switch is identical in appearance to the fan drive switch, but is set to operate at different pressure levels.

The radiator shutters are held open by spring pressure and are closed by an air cylinder working against the spring(s). The switch operates a solenoid valve that shuts off the compressed air to the cylinder and allows the spring(s) to open the shutters. Refer to SPECIFICATIONS (See Table 7, page 83) for the opening and closing pressures. For more detailed information, refer to GROUP 12-ENGINES and GROUP 8 ELECTRICAL CIRCUIT DIAGRAMS in the Master Service Manual.

2.11. FAN DRIVE AND RADIATOR SHUTTER SOLENOID VALVES

Refer to Figure 21.

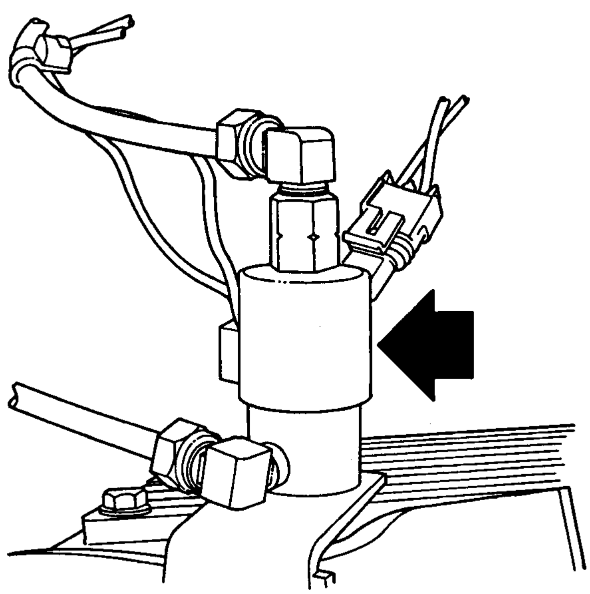


Figure 21 Typical Solenoid Valve (Fan Drive or Radiator Shutter)

The radiator shutters and many fan clutches are operated by compressed air. The air is controlled by solenoid valves that are operated by the pressure switches. The valves are all of the same construction, but have different operating characteristics depending on the system that they are installed in.

2.12. AIR BLOWER

Refer to Figure 22.

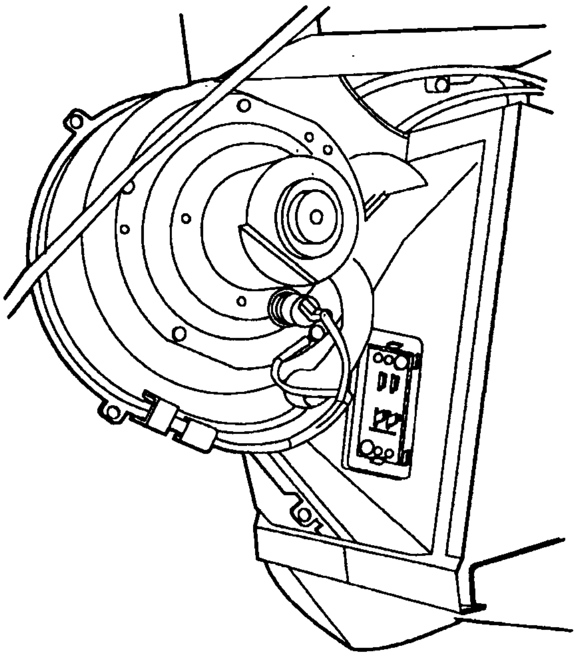


Figure 22 Air Blower (Typical Blower Assembly for 2000/4000/8000 Models)

The air blowers used in the heater or heater-air conditioning systems are permanent magnet motors that are operated by a knob on the control unit on the instrument panel. The blowers provide air circulation through the heater core and evaporator, and delivery of the treated air throughout the cab interior. Some models contain two blowers in the heater A/C box. Vehicles equipped with a sleeper have a separate blower for the sleeper compartment. For more detailed electrical information, refer to GROUP 8 ELECTRICAL CIRCUIT DIAGRAMS in the Master Service Manual.

2.13. BLOWER SPEED CONTROL RESISTORS

Refer to Figure 23.

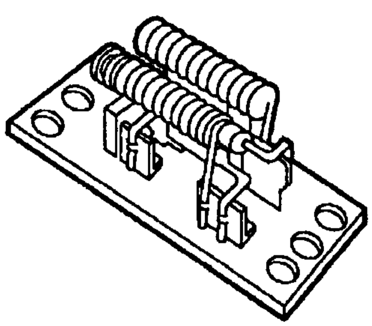


Figure 23 Blower Speed Control Resistors

The blower speed control resistors consist of a resistor network located in the blower motor circuit. By connecting to different points in the network, the blower speed control can change the resistance in the blower motor circuit, providing multiple blower speeds. The resistor assembly is usually located in the blower air stream to prevent overheating.

The blower resistors influence blower speed as follows:

- Blower speed is decreased by increasing resistance in the blower motor circuit.
- Blower speed is increased by reducing resistance in the blower motor circuit.

During high speed operation, a relay routes current from a 30 amp fuse directly to the blower motor, bypassing the speed control resistors. For more detailed information, refer to GROUP 8 ELECTRICAL CIRCUIT DIAGRAMS in the Master Service Manual.

2.14. REFRIGERANT OIL

CAUTION – Keep spare refrigerant oil in a sealed container. The oil draws moisture and will become moisture contaminated if exposed to the atmosphere for any period of time.

NOTE – The label on the refrigerant compressor specifies the type of oil it is filled with.

The refrigerant oil used in the A/C compressor depends on the type of compressor and the production date of the vehicle.

OIL IN CCI COMPRESSORS

Effective approximately February 1, 1995, all CCI refrigerant compressors used in truck production were filled with Ester Oil. Prior to this date, all CCI refrigerant compressors were filled with PAG oil. If it is necessary to add refrigerant oil to an early production A/C system with a CCI compressor, check the label on the compressor to verify the type of oil currently in the system. If the compressor is currently filled with PAG oil, we recommend that the PAG oil be drained from the compressor and refilled with Ester Oil.

NOTE – If the compressor is refilled with Ester oil, it is recommended that the oil identification on the label on the compressor be changed to reflect the change in oil.

Refer to SPECIFICATIONS (See Table 7, page 83) for the amount of Ester oil for the system.

Ester oil is compatible with mineral and PAG oil. When changing from mineral or PAG oil to Ester oil, it is not necessary to flush the system unless it is contaminated.

Be sure to observe the following:

- PAG oil can never be mixed with mineral oil and can only be used in R-134a systems.
- Mineral oil can never be mixed with PAG oil and can only be used in R-12 systems.
- Ester oil can be mixed with either mineral or PAG oil. It is permissible to add Ester oil in small amounts to systems filled with either PAG or mineral oil.

OIL IN SANDEN COMPRESSORS

Effective approximately November 1, 2002, all 5000i and 9000i series models were built with Sanden compressors using Sanden SP-15 refrigerant oil (International P/N ZGGR6822). Prior to this date, the Sanden compressor was available only as an option.

Refer to SPECIFICATIONS (See Table 7, page 83) for the refrigerant oil capacity for the system.

2.15. SYSTEM HOSES

Hoses used with air conditioning systems are nylon barrier type hoses This type of hose prevents the refrigerant from escaping through the walls of the hose into the atmosphere. When servicing air conditioning systems, use only replacement hoses approved for air conditioning systems.

3. DIAGNOSIS AND TESTING

3.1. DIAGNOSIS

IMPORTANT – Before connecting any service equipment to the refrigerant system, the refrigerant in the system must be identified. Refer to REFRIGERANT IDENTIFICATION. Failure to identify system refrigerant before connecting equipment could result in contamination of your service equipment and any refrigerant stored in the equipment.

Effective diagnosis of the HVAC system consists of the following steps:

1. Inspection of Components – Before starting the engine inspect the following items:
   - compressor and clutch mounting
   - compressor clutch coil wiring and connection
   - compressor drive belt and tension
   - all A/C and heater hoses and connections
   - condenser mounting
   - condenser fins (and blockage by debris)
   - receiver-dryer mounting
   - expansion valve mounting
   - filter element
   - HVAC box drain
   - low and high pressure switch connections
2. Refrigerant Identification – Identify the refrigerant currently in the HVAC system to protect shop equipment and to identify a possible cause of poor system operation. Refer to REFRIGERANT IDENTIFICATION (See REFRIGERANT IDENTIFICATION, page 44).
3. Check for Non-Condensable Gases – Verify that the system does not contain air or some other non-condensable gas. A common cause of poor system operation. This check is covered in the first several steps of the SYSTEM OPERATING TEST (see next step).

4. Symptom Identification – Perform the SYSTEM OPERATING TEST to determine which of the following conditions exists (See SYSTEM OPERATING TEST, page 24).

   — No Air Flow
   — Low Air Flow
   — Air Not Cold Enough
   — Compressor Has Excessive Vibration or Noise
   — Clutch Does Not Engage.

Refer to TROUBLESHOOTING (See TROUBLESHOOTING, page 34) for each of these conditions. The charts are designed to identify the condition first, then provide corrective steps. These charts begin with the most common and easiest to repair causes, followed by the less common and more difficult causes.

Prior to referring to the AIR NOT COLD ENOUGH or CLUTCH DOES NOT ENGAGE troubleshooting chart, perform the PHYSICAL CHECKS (See PHYSICAL CHECKS, page 30) to help identify any conditions that indicate a malfunctioning A/C system.

After isolating the cause of the condition, service the system as indicated in the respective troubleshooting chart. Once the system is repaired, the SYSTEM OPERATING TEST(See SYSTEM OPERATING TEST, page 24) should be performed to verify that the system is operating correctly.

NOTE – For diagnosis and troubleshooting of electrical problems, refer to Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.

3.2. SYSTEM OPERATING TEST

This test is used to determine if the air conditioning system is properly charged with refrigerant and the refrigerant cycle is functioning correctly. The test is performed using a recovery station (or manifold gauge set), two thermometers and an electronic leak detector. When a fault is detected perform the repairs indicated. Repeat this test after repairs involving the refrigerant system to verify correct operation.

WARNING – During system pressure tests the recovery station (or manifold gauge set) is only being used to read high and low pressures. DO NOT open either hand valve on recovery station for any reason. Equipment can be damaged, and personal injury can result.

CAUTION – To prevent damage to the test equipment, make sure test equipment and all connections are clear of all moving parts in the engine compartment.

NOTE – In some instances it may be necessary to set a fan in front of the condenser large enough to develop air flow comparable to normal ram air flow.

1. If the system has not yet been diagnosed, perform step 2 to determine if the system contains air or some other non-condensable gas. Step 2 must be performed with the engine and A/C system **at ambient temperature**. The engine and A/C system must NOT have been run within the last 30 minutes.

If the system being tested has been repaired and this test is being performed to verify correct operation, skip step 2 and proceed to step 3.

2. With the engine off, connect a recovery station to the A/C system. Refer to RECOVERY STATION, Install (See RECOVERY/RECYCLING/CHARGING STATION, page 48). If a manifold gauge set is used, refer to MANIFOLD GAUGE SET, Install (See MANIFOLD GAUGE SET, page 45).
   a. Determine (and record) the ambient temperature (within a degree or two).
   b. Record the system pressures indicated on the high and low gauges connected to the A/C system. Both gauges should read close to the same value when the truck is not running.
   c. Compare the pressure readings recorded in the last step to the pressures shown in TABLE 4. (The table is also part of the Performance AC Chart TMT-3416.)
   d. If the pressure on the gauges is more than 10 psig higher than the pressure listed in the chart, the A/C system contains air or some non-condensable gas in the refrigerant system. The system needs to be discharged, evacuated, and recharged using a recovery system. Refer to SECTION 5 (See AIR CONDITIONING SYSTEM SERVICE, page 40).

      EXAMPLE: If the ambient is 75°F, the A/C system pressure should be in the 78–79 psig range. If the pressure is 90 psig or higher it indicates that there is air or some non-condensable gas in the system.

      NOTE – A refrigerant identifier can also be used to verify the contents of the A/C system. Refer to SECTION 5.3 (See REFRIGERANT IDENTIFICATION, page 44).
   e. If the pressure on the gauges is more than 10 psig lower than the pressure listed in the chart, the system is undercharged. The system needs to be discharged, evacuated, and recharged using a recovery system. Undercharged systems should be inspected for a possible leak before being discharged. Refer to SECTION 5 (See AIR CONDITIONING SYSTEM SERVICE, page 40).
   f. If no faults have been noted, proceed to step 3.

3. Run the remainder of the test under the following conditions:
   a. Park the vehicle so there is no solar loading and no wind.
   b. Position a thermometer approximately 30 to 60 cm (12 to 24 inches) in front of the vehicle grille to measure ambient temperature of air entering the condenser.
   c. Position a humidistat with the thermometer to measure the approximate relative humidity of the air entering the condenser.
   d. If not connected previously, connect a recovery station to the A/C system. Refer to RECOVERY STATION, Install (See RECOVERY/RECYCLING/CHARGING STATION, page 48) . If a manifold gauge set is used, refer to MANIFOLD GAUGE SET, Install (See MANIFOLD GAUGE SET, page 45) .
   e. If the vehicle has a solenoid-controlled fan drive, engage it. The fan can be operated with a jumper wire or by disconnecting the solenoid valve, depending on the system.
   f. If the vehicle has radiator shutters, open them. The shutters can be operated with a jumper wire or by disconnecting the solenoid valve, depending on the system.
   g. Slowly close the hood, being careful not to damage test equipment connections.
   h. Insert a thermometer into the center air conditioning duct. Do not allow thermometer to touch the side of the duct.
   i. Run the engine at 1800 RPM.

j. Open both cab doors.

k. Set the A/C control for maximum cooling, blower switch on high and heater off.

4. Operate the system for at least five minutes, or until the gauge readings settle. Check the gauge readings on the recovery station. If the A/C refrigerant system is operating properly, the high and low pressure readings will be within the listed pressure ranges in the appropriate System Pressure Test Chart. If the gauges are not reading within the System Pressure Chart ranges, refer to ABNORMAL GAUGE READINGS (See ABNORMAL GAUGE READINGS, page 28).

5. If the recovery station gauge readings are within specifications, but one of the following symptoms is still occurring, refer to TROUBLESHOOTING (See TROUBLESHOOTING, page 34). The charts are designed to identify the condition first, then provide corrective steps. These charts begin with the most common and easiest to repair causes, followed by the less common and more difficult causes.

   — No Air Flow

   — Low Air Flow

   — Air Not Cold Enough

   — Compressor Has Excessive Vibration or Noise

6. If no adverse symptoms are present and the high and low pressure readings are within specifications, the A/C system is operating correctly. Turn the engine off and carefully remove the service equipment from the vehicle.

System Pressure Test Charts

Table 2 System Pressure Test Chart (for Models 1000, 2000, 4000, 5000, 8000, and All 9000 Models WITHOUT the Lowered Heater Box and Side Filter Access Cover)

Relative Humidity	Ambient Temperature		Refrigerant Pressure (PSI)		Register Temperature	
(Percent)	(°F)	(°C)	High	Low	(°F)	(°C)
Below 30%	70*	21.1*	125 - 155	7 - 11	36 - 42	2.2 - 5.6
	80	26.7	150 - 180	9 - 13	39 - 45	3.9 - 7.2
	90	32.2	165 - 200	10 - 16	40 - 48	4.4 - 8.9
	100	37.8	190 - 230	12 - 18	42 - 55	5.6 - 12.8
	110	43.3	230 - 275	13 - 21	43 - 58	6.1 - 14.4
*System may cycle at these ambient temperatures. Above readings will occur prior to compressor cycling.						

Table 2 System Pressure Test Chart (for Models 1000, 2000, 4000, 5000, 8000, and All 9000 Models WITHOUT the Lowered Heater Box and Side Filter Access Cover) (cont.)

Relative Humidity	Ambient Temperature		Refrigerant Pressure (PSI)		Register Temperature	
(Percent)	(°F)	(°C)	High	Low	(°F)	(°C)
Above 30%	70*	21.1*	135 - 165	8 - 14	36 - 44	2.2 - 6.7
	80	26.7	155 - 185	10 - 15	41 - 47	5.0 - 8.3
	90	32.2	170 - 205	11 - 17	42 - 52	5.6 - 11.1
	100	37.8	215 - 255	15 - 22	45 - 60	7.2 - 15.6
	110	43.3	250 - 295	18 - 27	50 - 65	10.0 - 18.3
*System may cycle at these ambient temperatures. Above readings will occur prior to compressor cycling.						

Table 3 System Pressure Test Chart (for 5000i/9000i Models and All 9000 Models WITH the Lowered Heater Box and Side Filter Access Cover)

Relative Humidity	Ambient Temperature		Refrigerant Pressure (PSI)		Center Air Duct Temperature	
(Percent)	(°F)	(°C)	High	Low	(°F)	(°C)
Below 30%	70	21.1	125 - 155	6 - 12	46 - 50	7.8 - 10.0
	80	26.7	150 - 180	10 - 14	52 - 56	11.1 - 13.3
	90	32.2	165 - 200	12 - 18	56 - 61	13.3 - 16.1
	100	37.8	190 - 230	16 - 20	60 - 64	15.6 - 17.8
	110	43.3	230 - 275	20 - 28	68 - 73	20.0 - 22.8
Above 30%	70	21.1	135 - 175	10 - 15	51 - 56	10.6 - 13.3
	80	26.7	155 - 185	12 - 18	53 - 57	11.7 - 13.9
	90	32.2	170 - 205	14 - 20	60 - 64	15.6 - 17.8
	100	37.8	215 - 255	20 - 25	68 - 73	20.0 - 22.8
	110	43.3	250 - 295	25 - 35	77 - 81	25.0 - 27.2

Table 4 System Pressure Versus Ambient Temperature

Temperature °F	R134A PSIG	Temperature °F	R134A PSIG
40	35.07	80	86.99
45	40.07	85	95.23
50	45.46	90	104.3
55	51.23	95	113.93
60	57.42	100	124.12
65	64.04	105	134.92
70	71.11	110	146.33
75	78.66		

3.3. ABNORMAL GAUGE READINGS

WARNING – During system pressure tests the recovery station (or manifold gauge set) is only being used to read high and low pressures. DO NOT open either hand valve on recovery station for any reason. Equipment can be damaged, and personal injury can result.

CAUTION – To prevent damage to the test equipment, make sure test equipment is clear of all moving parts in the engine compartment.

If a specified pressure cannot be achieved during the system pressure test, check the following paragraphs to isolate the malfunctioning component in the A/C refrigerant system. In addition to the following paragraphs it may be necessary to perform the PHYSICAL CHECKS (See PHYSICAL CHECKS, page 30) to further isolate the component.

Diagnosis of Abnormal Gauge Readings

1. **Low suction pressure-High discharge pressure** (Figure 24).

   • Indicates restriction in the system at a location between the compressor discharge port and the inlet to receiver-dryer.

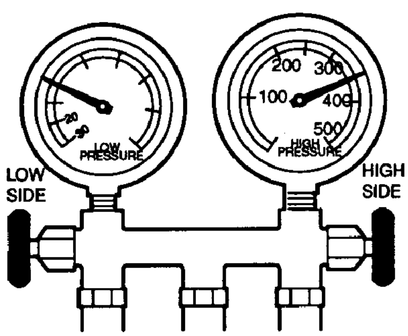


Figure 24 Low Suction Pressure-High Discharge Pressure

2. **Extremely low suction pressure-Normal to low discharge pressure** (Figure 25).

   • Restriction in the system between outlet of the receiver-dryer and the compressor, usually at the expansion valve.

   • Low refrigerant charge.

   • Moisture freezing in the expansion valve.

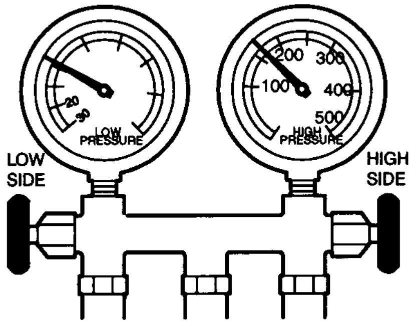


Figure 25 Extremely Low Suction Pressure-Normal to Low Discharge Pressure

3. **High suction pressure-Normal to slightly low discharge pressure** (Figure 26).

- Expansion valve stuck open.
- Suction side of compressor not functioning.

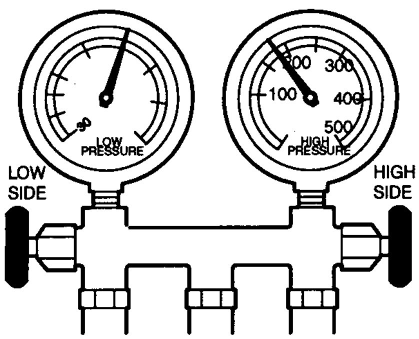


Figure 26 High Suction Pressure-Normal to Slightly Low Discharge Pressure

4. **High suction pressure-High discharge pressure** (Figure 27).

- Excessive air or oil in system.
- Overcharged system.
- Condenser plugged with debris.
- Engine fan not operating properly.

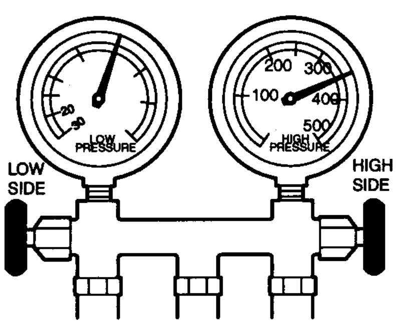


Figure 27 High Suction Pressure-High Discharge Pressure

5. **High suction pressure-Normal to slightly high discharge pressure** (Figure 28).

- Heater core water valve not shut off completely (except 2000, 4000 and 8000).
- Blend Air door not completely closed.
- Vents or window open.

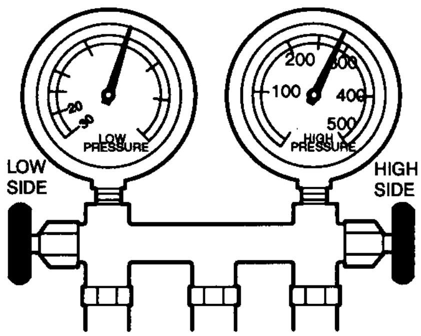


Figure 28 High Suction Pressure-Normal to Slightly High Discharge Pressure

6. **Low suction pressure-Low discharge pressure** (Figure 29).

- Low refrigerant charge.
- Compressor not functioning properly.

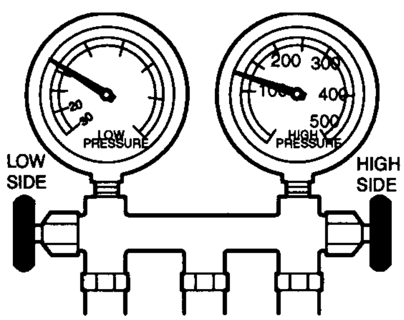


Figure 29 Low Suction Pressure-Low Discharge Pressure

3.4. PHYSICAL CHECKS

To help isolate a malfunctioning component in the refrigerant system, perform the following physical checks, if necessary.

Start the engine and turn on the A/C system.

1. With air conditioning controls set for maximum cooling (A/C selected, blower switch on HIGH and temperature control to COLD), operate engine at 1800 RPM and air conditioning system for about five minutes or until initial heat has been removed from the cab and an average flow of cold air is achieved.
2. With the system operating, feel all air conditioning system components and refrigerant lines for proper operating temperatures, as described in the following paragraphs.

3. If the system does not cool, refer to AIR NOT COLD ENOUGH (See AIR NOT COLD ENOUGH, page 37) diagnosis chart.

WARNING – Avoid contact with moving belts, pulleys and fan when making this check. Beware of extremely high temperatures at compressor outlet (discharge) hoses and tubing as personal injury may result.

NOTE – For vehicles equipped with a CCI compressor, additional A/C compressor and/or magnetic clutch diagnosis can be found in s16017, COMPRESSOR-CLUTCH in the Master Service Manual.

The following is a brief description of symptoms or conditions that could exist if the vehicle air conditioning system is malfunctioning.

From the discharge side of the compressor along the high pressure line, through the condenser, receiver-dryer and up to the expansion valve, everything should be hot or warm to the touch. The expansion valve, evaporator and all the lines on the low pressure side leading back to the compressor should be cool to the touch. Any deviation from the above conditions indicates a malfunction in the system.

Malfunctions or stoppages may be indicated by extreme cold or frosted areas (example: a cold receiver-dryer frosted part way up indicates a stoppage or serious restriction in the receiver-dryer). A stoppage or severe restriction in the refrigerant system can be located by looking for these indications.

Receiver-Dryer

The receiver-dryer is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cold spots exist, replace the receiver-dryer.

A blockage at the receiver-dryer will cause high head pressure and little or no cooling.

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and expansion valve will be at outside temperature; when stuck open, both the evaporator coil and the valve will be extremely cold with frost or ice build-up.

Because the expansion valve channels are very small, blockage in the system is usually found here (the valve is very sensitive to contamination). Usually the contamination is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming an ice blockage. After the system shuts down and the valve warms up, and the valve operates again, only to freeze up when the moisture returns and the temperature drops.

On-and-off operation of the expansion valve means that the receiver-dryer is not removing moisture from the system.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or high suction and low discharge pressure. Resonant noises are not a cause for alarm; irregular noise or rattles are likely caused by broken parts.

WARNING – The engine must be switched off before checking the compressor for seizure.

CAUTION – In the following step, the compressor should be turned only in its normal direction of travel.

To check for seizure, de-energize the magnetic clutch and attempt to turn the clutch drive plate using a clutch wrench. If it won't turn, the compressor has seized.

If a compressor is suspected of malfunctioning, but testing has been inconclusive, a simple test may confirm the condition of the compressor. NOTE: This test can confirm that the compressor is operating correctly, but will not identify the faulty component if the test fails. Refer to COMPRESSOR TEST (See COMPRESSOR TEST, page 34).

NOTE – For vehicles equipped with a CCI compressor, additional A/C compressor and/or magnetic clutch information can be found in s16017, COMPRESSOR-CLUTCH in the Master Service Manual.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockage will cause low suction pressure as well as little or no cooling. If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

Evaporator Freeze-ups are the result of the moisture in the air condensing and then freezing on the evaporator core. The ice on the fins blocks the airflow through the evaporator and stops the cooling until the ice melts. If the components that control temperature and pressure in the evaporator malfunction and allow the evaporator's temperature to drop to 32 degrees F (0 degrees C), freeze-up of the evaporator core will occur.

A flooded evaporator occurs when there is too much refrigerant flowing into the evaporator. On older systems, flooding can be the result of the sensing bulb of the expansion valve being misplaced, improperly insulated, in poor contact with the evaporator suction side tube, or a defective expansion valve. A starved evaporator occurs when there is not enough refrigerant flowing into the evaporator. Starvation can be caused by a defective expansion valve.

The evaporator is the most difficult of all the components to inspect visually because of its enclosed location. Airflow blockage due to debris, bent fins, and/or refrigerant leaks (oil smudges) requires removal of the evaporator for visual inspection.

Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris (such as leaves or dirt build-up) cakes up, airflow over the condenser fins is reduced; air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High discharge pressure will result. In these cases, carefully clean off the outer surface of the condenser with soap and water and compressed air; be careful not to bend the fins.

High discharge pressure will also occur if the condenser's tubing is abnormally bent, restricting or blocking the flow of refrigerant. Frost will appear at the point where the flow of refrigerant is restricted. Less common internal blockage (foreign material or metallic grit build-up) will restrict or stop the flow of refrigerant.

Thermostatic Switch

Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the test below, the switch seems to be out of adjustment, replace it.

1. Be sure the compressor clutch is operating correctly.

   NOTE – For vehicles equipped with a CCI compressor, additional clutch information can be found in s16017, COMPRESSOR-CLUTCH in the Master Service Manual.

2. Expose the evaporator coils.

3. Start the engine. Place the air conditioning temperature control at its coldest setting; turn on the air conditioner and the fan.

4. Place an accurate thermometer into contact with a tube in the evaporator coil. Be sure it makes good contact with the tube, or you will get an incorrect reading.

   When the temperature drops below the ’A/C Off’ set point, compressor clutch should disengage and remain disengaged until evaporator temperature rises to the ’A/C On’ set point. Refer to THERMOSTATIC CONTROL SWITCH CYCLE POINTS (See Table 10, page 86).

5. If the compressor clutch did not engage when the temperature was at or above the high temperature ’A/C On’ point, do the following:

   a. Connect a voltmeter or a test light from one terminal on the thermostatic switch to ground. Repeat on the other terminal of the switch. With the engine running and the air conditioning and blower on, both terminals will show voltage when the compressor should be engaged (temperature above ’A/C On’ level). One terminal will show voltage when the compressor should be disengaged (temperature below ’A/C Off’ level).

   b. If there is no voltage at either terminal, there is a problem in the electrical system to the thermostatic switch. Check all circuits for the cause, and repair.

   c. If there is voltage at only one terminal, even when the temperature is above the ’A/C On’ level, the thermostatic switch is not functioning correctly. Check placement and condition of capillary tube. If a problem with the capillary tube is not apparent, replace the thermostatic switch.

   d. If voltages are correct, either the compressor clutch is malfunctioning; or, there is a problem in the electrical circuit between the thermostatic switch and the compressor clutch. Check all circuits for the cause, and repair.

NOTE – For diagnosis and troubleshooting of electrical problems, refer to Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and poor cooling. Generally, if the line is not entirely blocked, the area immediately after the restriction will be cold. A completely blocked line will result in high head pressures, but no physical symptoms at the blockage.

3.5. COMPRESSOR TEST

If a compressor is suspected of malfunctioning, but testing has been inconclusive, perform this test. NOTE: This test can confirm that the compressor is operating correctly, but will not identify the faulty component if the test fails.

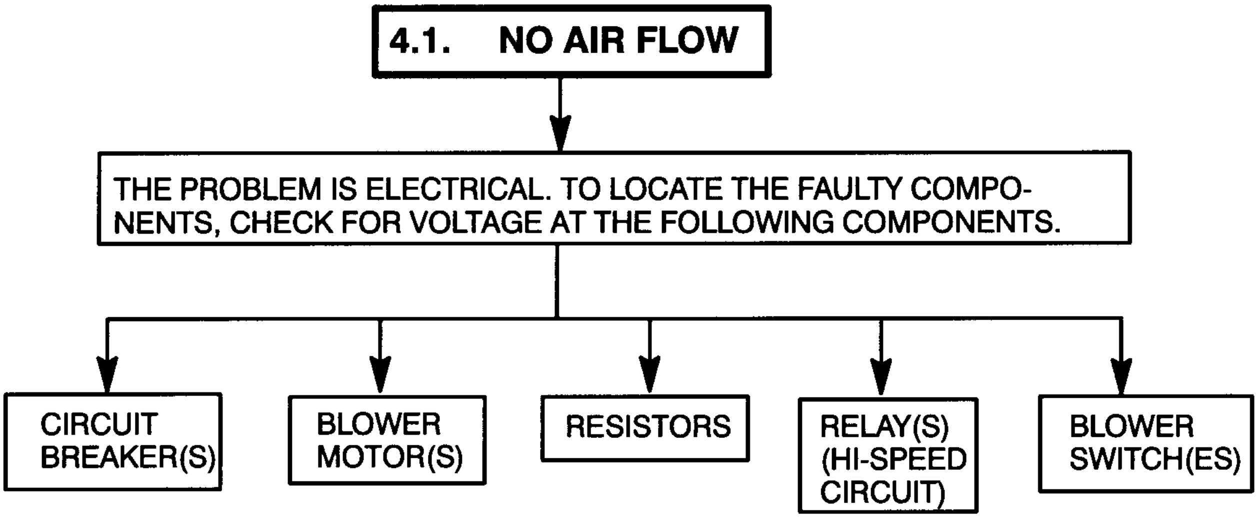
1. Remove covers, as necessary, to have access to the expansion valve.
2. Connect recovery station to the A/C system. Refer to RECOVERY STATION, Install (See RECOVERY/RECYCLING/CHARGING STATION, page 48). If a manifold gauge set is used, refer to MANIFOLD GAUGE SET, Install (See MANIFOLD GAUGE SET, page 45).
3. Block the airflow through the condenser by inserting a piece of cardboard in front of the condenser.
4. Run the engine at 1800 RPM.
5. Set the A/C control for maximum cooling, blower switch on high and heater off.
6. Observe the high side gauge reading. The high side pressure should climb very quickly to 275 – 300 psi.
7. If the specification is not met, the system is not functioning correctly. Review the DIAGNOSIS AND TESTING, and TROUBLESHOOTING sections to determine the cause of the malfunction.
8. If the specification is met, remove the cardboard.
9. With the system still running, spray the expansion valve with an aerosol ’cooling spray’. NOTE: On early production, capillary tube type expansion valves, the feeler bulb must be sprayed.
10. The low side pressure should drop to 10 – 15 psi.
11. If the specification is met, it indicates that the compressor is functioning correctly and is not the cause of the system malfunction.
12. If the specification is not met, the system is not functioning correctly. Review the DIAGNOSIS AND TESTING, and TROUBLESHOOTING sections to determine the cause of the malfunction.

4. TROUBLESHOOTING

4.1. NO AIR FLOW

A ’NO AIR FLOW’ problem is caused by an electrical malfunction. Refer to Figure 30 for a general procedure to troubleshoot the problem.

For detailed information and troubleshooting on electrical circuits, refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.



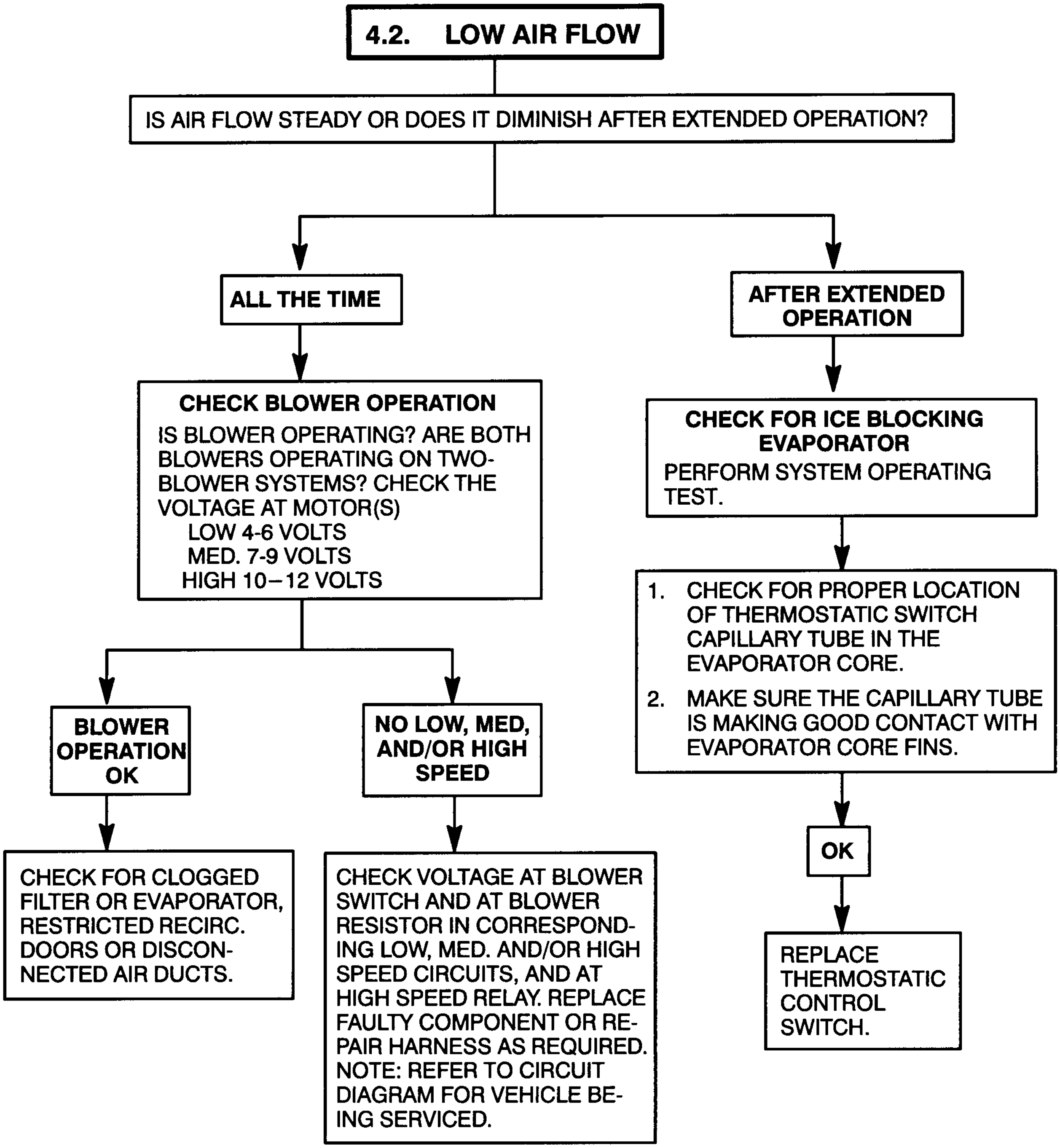
For Electrical Problems Refer to the GROUP 8
ELECTRICAL CIRCUIT DIAGRAMS;
ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE;
and/or
HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE
in the MASTER SERVICE MANUAL

Figure 30 No Air Flow Troubleshooting Chart

4.2. LOW AIR FLOW

Refer to Figure 31 for a general procedure to troubleshoot the ’LOW AIR FLOW’ problem.

For detailed information and troubleshooting on electrical circuits, refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.



For Electrical Problems Refer to the GROUP 8
ELECTRICAL CIRCUIT DIAGRAMS;
ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE;
and/or
HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE
in the MASTER SERVICE MANUAL

Figure 31 Low Air Flow Troubleshooting Chart

4.3. AIR NOT COLD ENOUGH

Refer to Figure 32 for a general procedure to troubleshoot the 'AIR NOT COLD ENOUGH' problem.

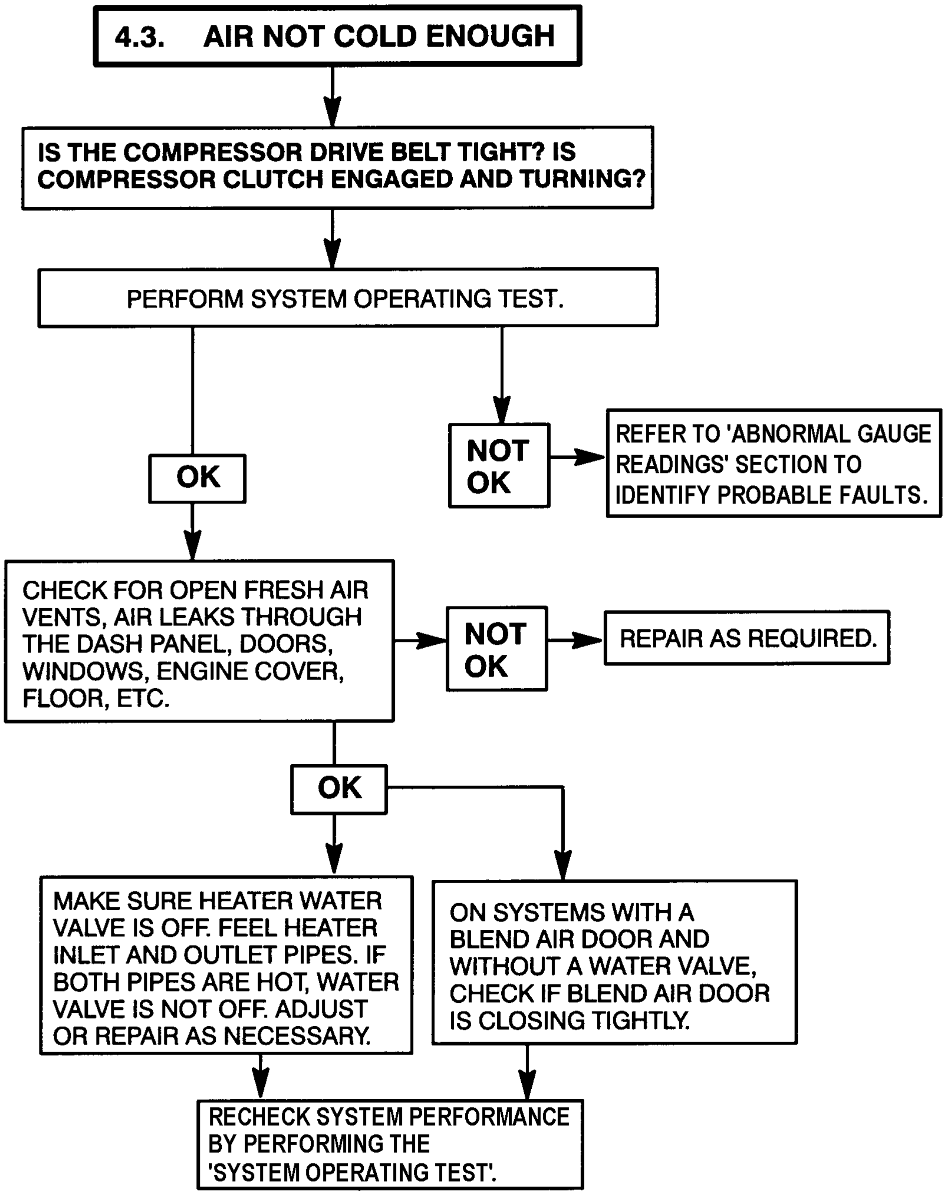


Figure 32 Air Not Cold Enough Troubleshooting Chart

4.4. CLUTCH DOES NOT ENGAGE

Refer to Figure 33 for a general procedure to troubleshoot the 'CLUTCH DOES NOT ENGAGE' problem.

For detailed information and troubleshooting on electrical circuits, refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND

AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.

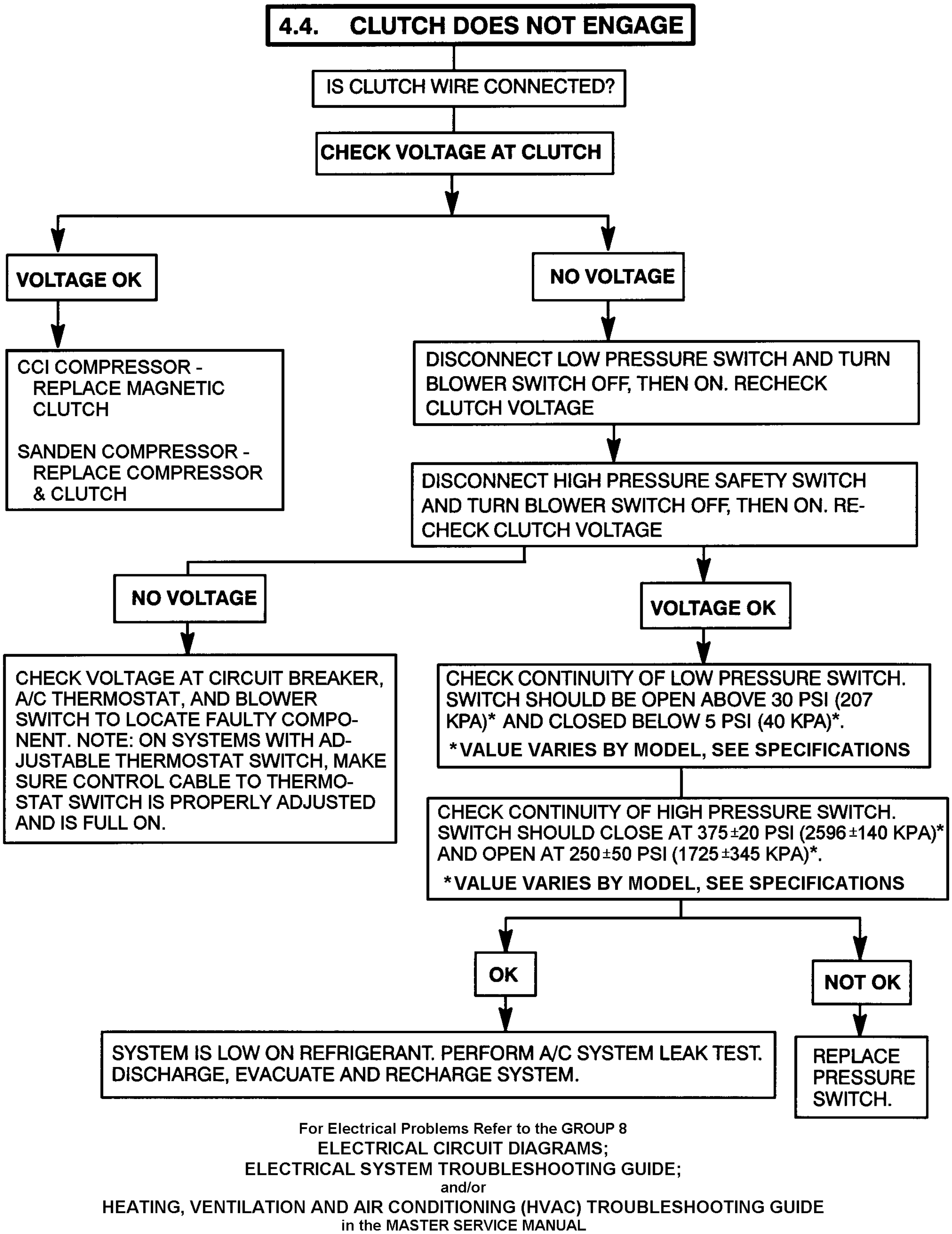


Figure 33 Clutch Does Not Engage Troubleshooting Chart

4.5. COMPRESSOR HAS EXCESSIVE VIBRATION OR NOISE

Refer to Figure 34 for a general procedure to troubleshoot the 'COMPRESSOR HAS EXCESSIVE VIBRATION OR NOISE' problem.

For detailed information and troubleshooting on electrical circuits, refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS; ELECTRICAL SYSTEM TROUBLESHOOTING GUIDE; and/or HEATING, VENTILATION AND AIR CONDITIONING (HVAC) TROUBLESHOOTING GUIDE, in the MASTER SERVICE MANUAL, for the vehicle being serviced.

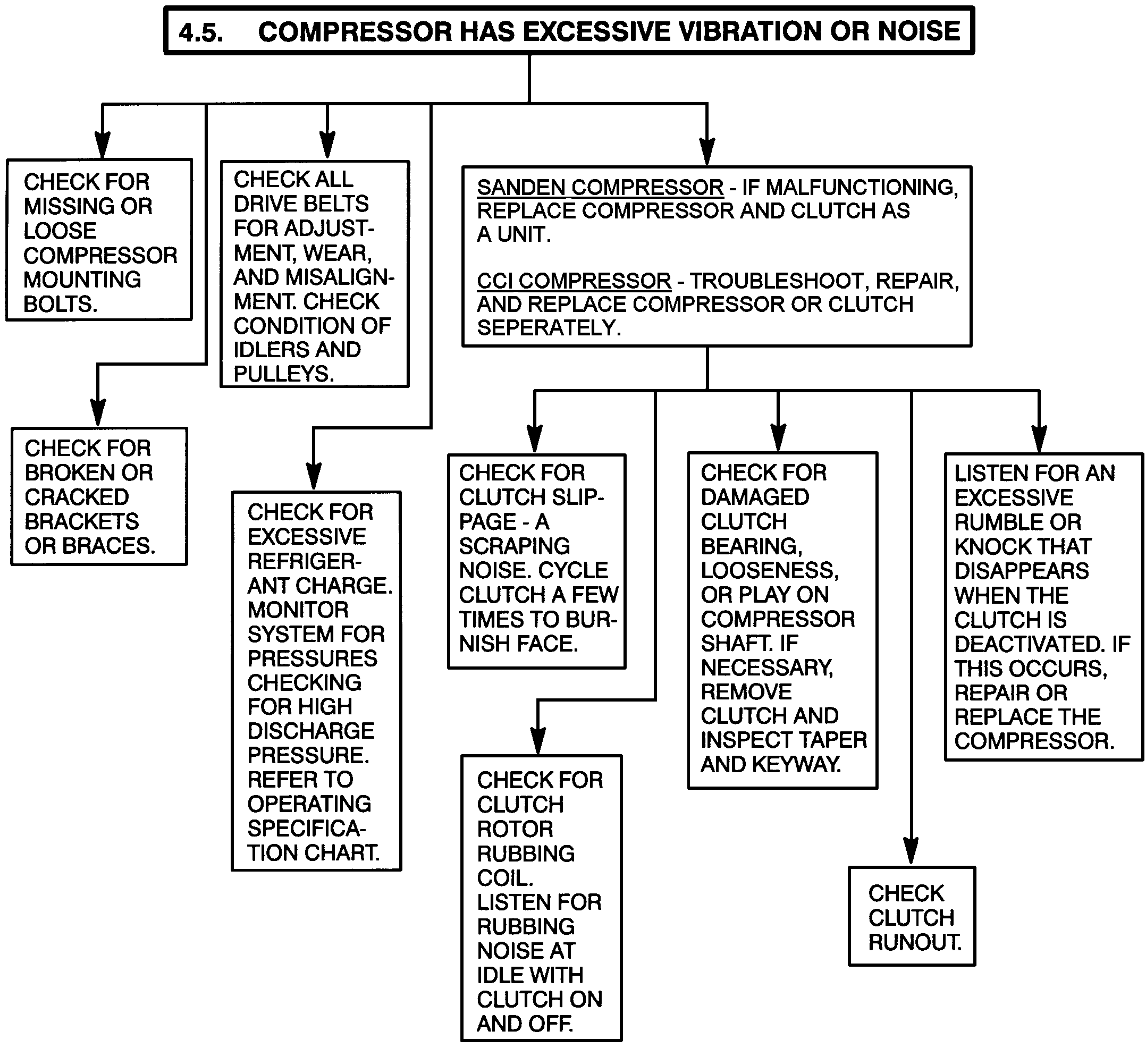


Figure 34 Compressor Has Excessive Vibration or Noise

5. AIR CONDITIONING SYSTEM SERVICE

5.1. SERVICE WARNINGS

Refrigerant R-134a is a nonflammable, nonexplosive, and noncorrosive hydrofluorocarbon refrigerant. R-134a is heavier than air and has a slight ether-type odor. Although R-134a is classified as a safe refrigerant, the following precautions must be observed to protect the A/C system components and the person working on the system.

WARNING – Carbon monoxide is a colorless, odorless, and dangerous gas that is present in vehicle exhaust. When it is necessary to operate the engine during vehicle service in a confined area, always use the proper equipment to vent the exhaust gasses outside of the work area.

WARNING – Safety goggles or other adequate eye protection must be worn when working with refrigerant. The temperature of liquid refrigerant is -20 degrees F (-29 degrees C). Serious injury or blindness will result from refrigerant contacting the eyes.

WARNING – If the refrigerant should contact the eyes, DO NOT rub them. Splash the eyes with cold water for at least 15 minutes to gradually get the temperature above the freezing point. See a doctor immediately.

WARNING – Wear nonporous gloves. Should liquid refrigerant come into contact with the skin, remove any contaminated clothing, including shoes; then treat the injury as though the skin had been frostbitten or frozen. See a doctor immediately.

WARNING – Be certain that pressurized refrigerant containers are not exposed to open flame or temperatures above 125 degrees F (51 degrees C). Do not discard empty refrigerant containers where they are likely to be subjected to the heat of trash burners, etc.; they may explode, resulting in personal injury or possible death. Containers must be stored, installed, and disposed of in accordance with all state and local ordinances.

WARNING – Never weld, solder, steam clean or use excessive heat on any of the air conditioning lines or equipment while the system is charged. Heat applied to any part will cause the pressure within the system to become excessive, which may result in an explosion and possible personal injury.

WARNING – Do not smoke or allow any type of fire or flame in the immediate area while servicing the air conditioning system. Refrigerant is not combustible; however, in the presence of heat it changes to a poisonous gas. Inhalation can cause death or serious injury.

WARNING – R-134a must not be mixed with air and then pressurized. When mixed with large quantities of air and pressurized, R-134a becomes combustible.

WARNING – Refrigerant must be recovered from the air conditioning system before any components of the system are removed or replaced. Removing components while pressure is in the system will cause personal injury or death.

WARNING – Do not remove the compressor oil fill plug to check the oil level in the refrigerant compressor while the A/C system is charged with refrigerant. The crankcase side of the compressor is under pressure and personal injury may result. It is not possible to check the oil level in the compressor on an A/C system that is under system pressure.

WARNING – Do not install or remove A/C testing or charging equipment while the engine is running. Serious injury may result from doing so.

WARNING – Always use approved refrigerant recycling equipment when working with R-134a to prevent accidental discharge. If released into the atmosphere, the refrigerant evaporates very quickly and may displace the oxygen surrounding the work area, especially in small or enclosed areas. This situation creates the hazard of suffocation or brain damage for anyone in the work area. If a leak should occur, avoid breathing the refrigerant and lubricant vapor. Thoroughly ventilate the area before continuing with service. Federal and state laws require that refrigerant be recovered and recycled to help protect the environment.

WARNING – When using a manual manifold gauge set connected to both the air conditioning system and refrigerant supply cylinder, never open the high side hand valve of the manifold gauge set while the A/C system is operating. If hot, high pressure refrigerant is forced through the gauge to the refrigerant supply cylinder; it could cause the cylinder to rupture and cause personal injury.

WARNING – When using a recovery station to service the air conditioning system, carefully follow the equipment manufacturer's operating instructions (including all cautions and warnings).

WARNING – Always use correct replacement refrigerant hoses. Do not use hoses other than those specified for the system being serviced. The use of improper hoses may cause a hose rupture, which may result in personal injury.

5.2. SERVICE PROCEDURES

Special attention to the following during component remove and install will aid in avoiding unnecessary and time-consuming problems.

1. Note and label electrical connections during removal.

2. Note cable routings during removal. Where necessary, cables should make sweeping curves. Sharp bends tend to increase resistance to bowden wire movement and sometimes cause kinks, which render the cable inoperative.

3. It is important that all refrigerant hose O-rings and tubing fittings be lubricated with **MINERAL-BASED** refrigerant oil (Figure 35).

   IMPORTANT – Never use grease, penetrating oil, motor oil, Ester or PAG oil, etc. to lubricate fittings.

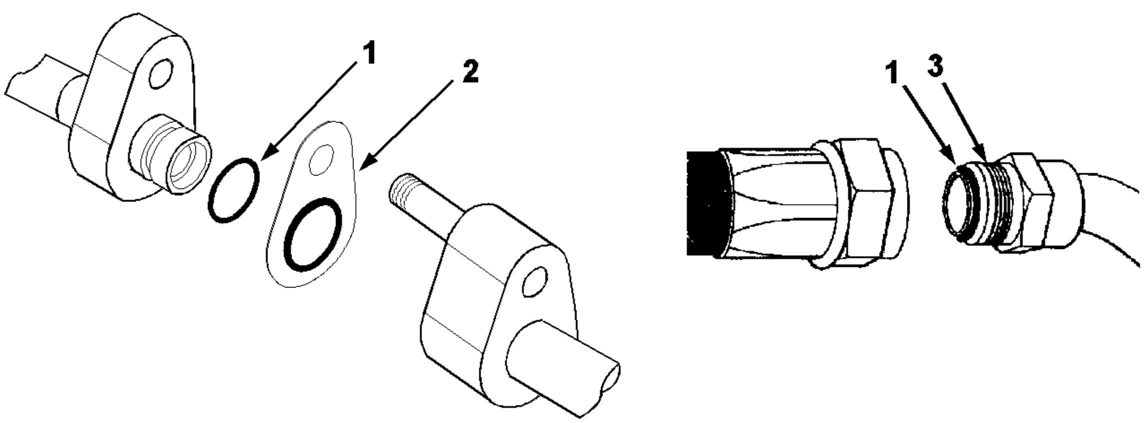


Figure 35 Lubricating O-Rings and Fittings

1. O-RING
2. C-PLATE
3. THREADS

4. Tighten fittings as specified in the torque chart of the Air Conditioning - Heating Service Section for the particular vehicle. Use only a torque wrench known to be accurate. Always use a back-up wrench when loosening or tightening fittings (Figure 36).

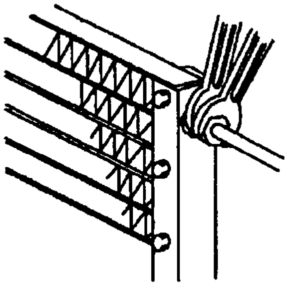


Figure 36 Use a Back-Up Wrench When Loosening or Tightening Fittings

5. Replace the receiver-dryer unit on any system which is opened for more than a very short period, when the system is flushed, and/or when the compressor is replaced because of an internal failure that contaminates the system.

6. Be certain that the evaporator core temperature sensing capillary tube is properly inserted into the evaporator core.

   When re-installing the capillary tube, **ALWAYS** insert it into a new location in the evaporator. This will insure that the capillary tube makes contact with the evaporator for correct temperature control sensing (Figure 37).

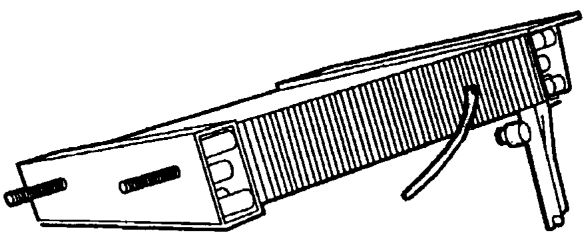


Figure 37 Insert Capillary Tube in New Location

7. On early production expansion valves, the expansion valve refrigerant temperature sensing tube must be securely attached to the evaporator refrigerant outlet tube. Also, the temperature sensing bulb and expansion valve must be tightly wrapped with insulating tape to prevent the ambient temperature from affecting correct sensing of the temperature of the refrigerant leaving the evaporator.

   The later production (block style) expansion valve does not have a refrigerant temperature sensing tube or equalizer line.

8. All refrigerant hose and tubing support clamps and strap locks must be re-installed in their original positions.

   Never bend to a radius less than ten (10) times the diameter of the hose.

   Never route any closer than two (2) inches from the exhaust manifold or related piping.

   Periodically inspect for leaks or brittleness. Replace lines immediately if damaged.

9. The air conditioning system must be flushed or purged as described in this section any time the compressor is replaced due to internal failure. Refer to PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM (See PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM, page 56).

10. The compressor oil level must be checked and replaced as specified in OIL FILL GUIDELINES (See OIL FILL GUIDELINES, page 62).

11. Use extreme care to prevent moisture from entering the system. Moisture can freeze at the expansion valve metering orifice and block refrigerant flow during system operation.

12. All A/C component and refrigerant line openings should be immediately covered or plugged during removal and remain so until re-installation to prevent the entry of dirt, moisture and other foreign material. Even the slightest particle can cause problems if carried to a vulnerable place within the system.

13. Never remove protective caps from components until the moment of assembly into the system.

14. Never install non-sealed components.

15. Spare components should be stored in a warm, dry facility.

16. Perform service inside a warm, well ventilated dry shop.

17. Never use hot steam to clean the inside of the system. Dry nitrogen cleaning is recommended for this purpose. Refer to PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM (See PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM, page 56).

5.3. REFRIGERANT IDENTIFICATION

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

Before any work is done on an HVAC system the refrigerant must be identified.

Refer to Figure 38.

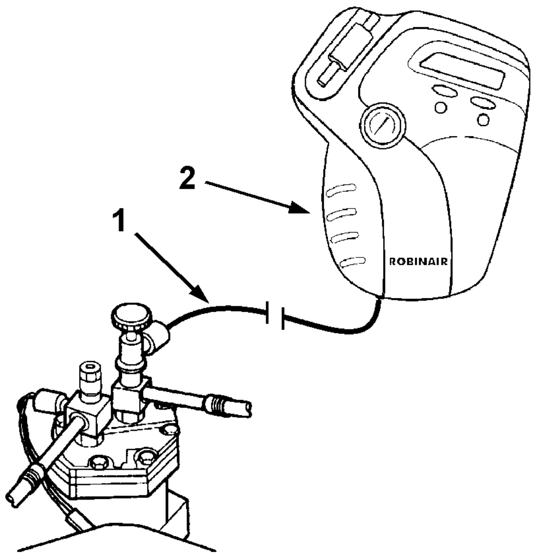


Figure 38 Typical Refrigerant Identification Setup Diagram (Location of Low Pressure Service Port Varies with Vehicle)

1. SAMPLING HOSE
2. REFRIGERANT IDENTIFIER

1. Calibrate the Refrigerant Identifier per the manufacturer's instructions.
2. Connect the sampling hose to the low pressure service port.
3. Connect the other end of the sampling hose to the Refrigerant Identifier.
4. Open the service valve.
5. Start the sampling procedure (refer to the manufacturer's instructions).
6. When the sampling is complete the Refrigerant Identifier will indicate a pass/fail condition, the type of refrigerant, and the percentage of concentration. International recognizes only R12 or R134a in a 98% concentration (these systems must be R134a). Anything else is considered contaminated.
7. Close the service valve and disconnect the sampling hose.

5.4. MANIFOLD GAUGE SET

This information covering the manifold gauge set hookup is provided in case service equipment with an internal gauge set is not available. A recovery station with internal gauges is the preferred equipment.

Install

Refer to Figure 39.

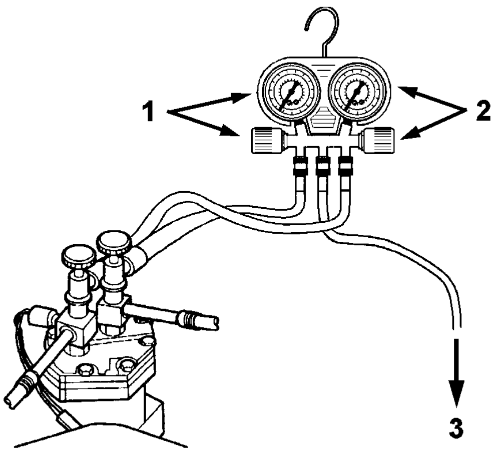


Figure 39 Manifold Gauge Set (Shown Connected to a CCI Compressor)

1. LOW SIDE VALVE AND GAUGE (BLUE)
2. HIGH SIDE VALVE AND GAUGE (RED)
3. CONNECT TO SERVICE EQUIPMENT

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

CAUTION – To prevent damage to the test equipment, make sure test equipment is clear of all moving parts in the engine compartment.

IMPORTANT – The fittings on the service hoses for R-134a air conditioning systems are standard Metric SAE quick connect fittings (Figure 40) that will work only on R-134a air conditioning system service ports.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer’s instructions supplied with that equipment.

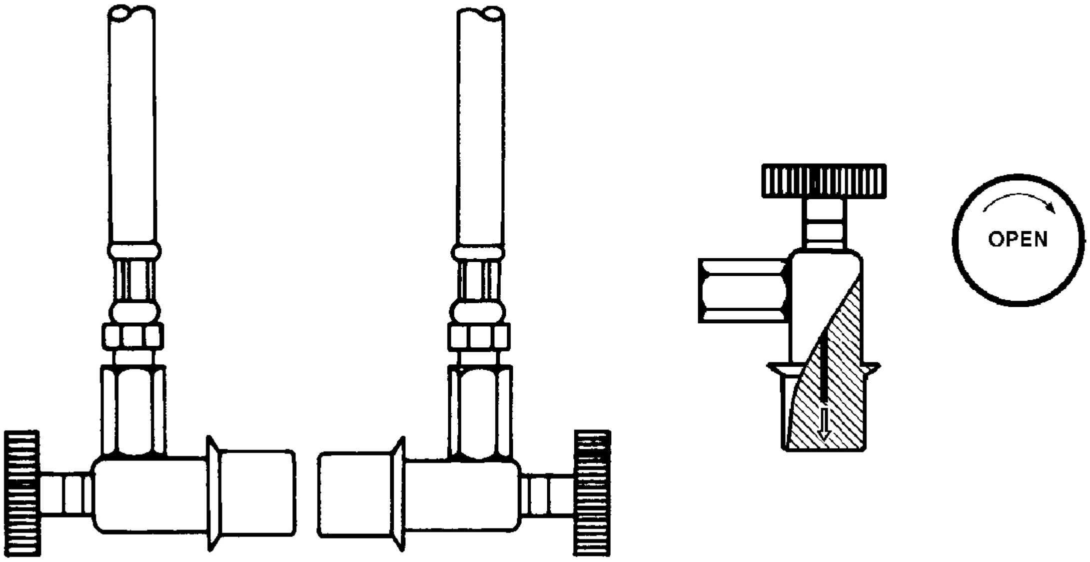


Figure 40 Quick Connect Fittings

1. Remove the protection caps from both service ports on the vehicle.

NOTE – The locations of the A/C system high pressure and low pressure service ports vary by vehicle model and year. The high pressure service port is located on the compressor's high pressure discharge line between the compressor and the expansion valve. Typical locations are on the receiver-dryer or on the compressor. The low pressure port is located on the compressor suction line, between the expansion valve and the compressor.

Discharge and suction ports are usually marked on the compressor head. If the marking is not visible, you can identify the suction (low pressure) side by the larger diameter hose connected to the compressor.

2. On the Manifold Gauge Set, verify that all valves are closed. The valves at the manifold must be set fully clockwise (CW). The valves at the quick connect fittings must be set fully counter-clockwise (CCW).

3. Start with the **blue** manifold suction hose and connect it to the low pressure service port. Connect the **red** hose to the high pressure discharge service port.

4. Connect the **yellow** hose, from the center fitting of the Manifold Gauge Set, following the instructions provided with the service equipment being used with each procedure being performed.

WARNING – During system diagnostic tests, DO NOT OPEN either hand valve on the manifold gauge set for any reason. Equipment can be damaged, and personal injury can result. During service procedures, DO NOT OPEN the valves on the manifold gauge set, or the valves on the Metric SAE quick connect fittings, until instructed to do so in the procedures.

IMPORTANT – Before opening the valves on the Metric SAE quick connect fittings, the fittings must be connected to the service ports on the vehicle, and the yellow service hose must be connected to the equipment required for each specific procedure being performed.

Once the quick connect fittings are attached to the service ports, turning the knob **clockwise** (CW) pushes an internal pin down **to open** the service port valve (refer to Figure 40). Turning the knob CCW raises the pin, closing the service port valve. Once closed the quick-disconnect fitting can be removed without venting refrigerant from the system.

Remove

1. Be sure the valves on the Metric SAE quick connect fittings at the service ports on the **red** and **blue** hoses are closed (fully CCW).
2. Verify that the manifold gauge set valves, at the manifold, are closed (turn the valve handles clockwise).
3. Close the valve on the equipment that is connected to the yellow hose (turn clockwise).
4. Remove the **blue** (low pressure) and **red** (high pressure) hoses from the vehicle service ports. Disconnect the **yellow** hose from the service equipment that it is connected to.

5.5. RECOVERY/RECYCLING/CHARGING STATION

Install

Refer to Figure 41.

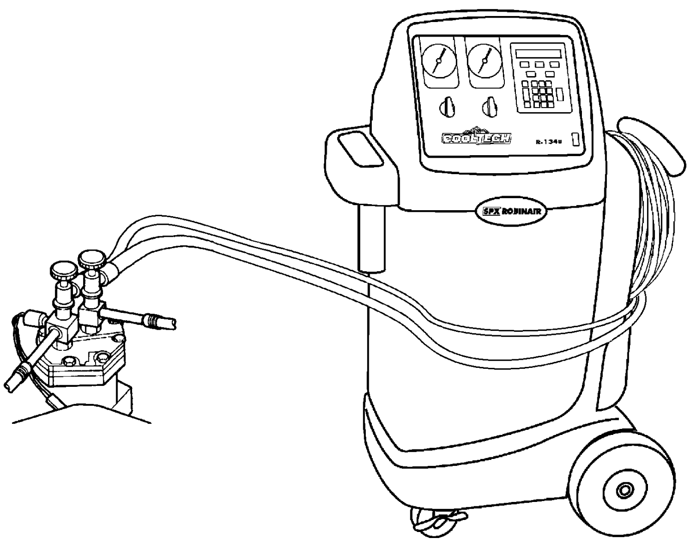


Figure 41 Recovery Station (Shown Connected to a CCI Compressor)

> **WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.**

CAUTION – To prevent damage to the test equipment, make sure test equipment is clear of all moving parts in the engine compartment.

IMPORTANT – The fittings on the service hoses for R-134a air conditioning systems are standard Metric SAE quick connect fittings (Figure 40) that will work only on R-134a air conditioning system service ports.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

NOTE – The locations of the A/C system high pressure and low pressure service ports vary by vehicle model and year. The high pressure service port is located on the compressor's high pressure discharge line between the compressor and the expansion valve. Typical locations are on the receiver-dryer or on the compressor. The low pressure port is located on the compressor suction line, between the expansion valve and the compressor.

Discharge and suction ports are usually marked on the compressor head. If the marking is not visible, you can identify the suction (low pressure) side by the larger diameter hose connected to the compressor.

1. Remove the protection caps from both service ports on the vehicle.

2. On the recovery station and hose fittings, verify that all valves are closed. The valves at the recovery station must be set to the CLOSED position. The valves at the quick connect fittings must be set fully counter-clockwise (CCW).

3. Connect the recovery station to the system as follows:
   a. Connect the **blue** hose to the low pressure service port.
   b. Connect the **red** hose to the high pressure service port.

WARNING – During system diagnostic tests, DO NOT OPEN either hand valve on the recovery station for any reason. Equipment can be damaged, and personal injury can result. During service procedures, DO NOT OPEN the valves on the recovery station, or the valves on the Metric SAE quick connect fittings, until instructed to do so in the procedures.

IMPORTANT – Before opening the valves on the Metric SAE quick connect fittings, the fittings must be connected to the service ports on the vehicle.

Once the quick connect fittings are attached to the service ports, turning the knob **clockwise** (CW) pushes an internal pin down **to open** the service port valve (refer to Figure 40). Turning the knob CCW raises the pin, closing the service port valve. Once closed the quick-disconnect fitting can be removed without venting refrigerant from the system.

Remove

1. Be sure the valves on the Metric SAE quick connect fittings at the service ports on the **red** and **blue** hoses are closed (fully CCW).
2. Verify that both valves on the recovery station are set to the CLOSED position.
3. Remove the **blue** and **red** hoses from the vehicle service ports.

5.6. DISCHARGING THE SYSTEM (REFRIGERANT RECOVERY)

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

IMPORTANT – If the system is being discharged because a leak is suspected, the leak must be located before discharging the system. Refer to LEAK DETECTION (See LEAK DETECTION, page 69).

NOTE – The locations of the A/C system high pressure and low pressure service ports vary by vehicle model and year. The high pressure service port is located on the compressor's high pressure discharge line between the compressor and the expansion valve. Typical locations are on the receiver-dryer or on the compressor. The low pressure port is located on the compressor suction line, between the expansion valve and the compressor.

Discharge and suction ports are usually marked on the compressor head. If the marking is not visible, you can identify the suction (low pressure) side by the larger diameter hose connected to the compressor.

Refer to Figure 41.

1. Empty the 'recovered oil' catch bottle on the recovery station. This will make it easier to determine the amount of oil recovered during the refrigerant recovery procedure.
2. Remove the protection caps from both service ports.
3. On the recovery station and hose fittings, verify that all valves are closed. The valves at the recovery station must be set to the CLOSED position. The valves at the quick connect fittings must be set fully counter-clockwise (CCW).
4. Connect the recovery station to the system as follows:
   a. Connect the **blue** hose to the low pressure service port.
   b. Connect the **red** hose to the high pressure service port.

5. Open (turn clockwise) the valves on the Metric SAE quick connect fittings connected to the service ports on the vehicle.

6. Set both hand valves on the recovery station to the RECOVERY/VACUUM position.

7. Turn the recovery station main power switch on and press the RECOVER button. The recovery station will automatically shut off when the refrigerant in the system has been exhausted to the storage tank.

8. Close the quick connect valves, and set both valves on the recovery station to the CLOSED position.

9. When recovering refrigerant by use of a recovery station, system oil is separated from the refrigerant during the recovery cycle. When the refrigerant recovery operation is complete, the recovery station will drain the oil into the station's calibrated catch bottle. The amount of oil recovered may be used to determine the amount of NEW oil that must be added back to the A/C system. Refer to OIL FILL GUIDELINES (See OIL FILL GUIDELINES, page 62).

10. Remove the **blue** and **red** hoses from the service ports on the refrigerant compressor.

11. Work may now begin on the air conditioning system.

5.7. EVACUATING THE SYSTEM

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

CAUTION – The amount of oil lost during the recovery process, component replacement, or purging/flushing must be replaced with new oil. The method for determining how much refrigerant oil must be added to the A/C system is located in the OIL FILL GUIDELINES.

CAUTION – Use only the refrigerant oil specified for the A/C system being serviced (refer to SPECIFICATIONS).

CAUTION – PAG oils absorb atmospheric moisture very quickly. Never leave PAG oil exposed to air for a prolonged time. Tightly reseal the oil container immediately after each use.

CAUTION – Do not re-use recovered oil. Be sure to dispose of recovered oil properly to avoid an environmental hazard.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

NOTE – The locations of the A/C system high pressure and low pressure service ports vary by vehicle model and year. The high pressure service port is located on the compressor's high pressure discharge line between the compressor and the expansion valve. Typical locations are on the receiver-dryer or on the compressor. The low pressure port is located on the compressor suction line, between the expansion valve and the compressor.

Discharge and suction ports are usually marked on the compressor head. If the marking is not visible, you can identify the suction (low pressure) side by the larger diameter hose connected to the compressor.

Whenever the air conditioning system has been discharged, the system must be completely evacuated of air and moisture before being recharged. After evacuation the system vacuum should measure between 750 and 1000 microns.

NOTE – During the following procedure, oil should not be added until the system has been leak tested, and all leaks have been repaired.

1. Determine the amount of **NEW** refrigerant oil to be added to the system. Refer to OIL FILL GUIDELINES (See OIL FILL GUIDELINES, page 62). If oil is being added directly to the compressor, it must be added before starting the evacuation procedure. If oil is to be added during the evacuation/charging procedure, you must follow the instructions furnished with the recovery station, or refrigerant oil injector tool, to add the oil before the charging procedure.

2. On the recovery station and hose fittings, verify that all valves are closed. The valves at the recovery station must be set to the CLOSED position. The valves (knobs) at the quick-connect fittings must be set fully counter-clockwise (CCW).

3. Connect the electronic vacuum gauge to the recovery station, at the vacuum manifold, using a valve and 'T' fittings (refer to Figure 42). Close the valve that isolates the electronic vacuum gauge from the low pressure line.

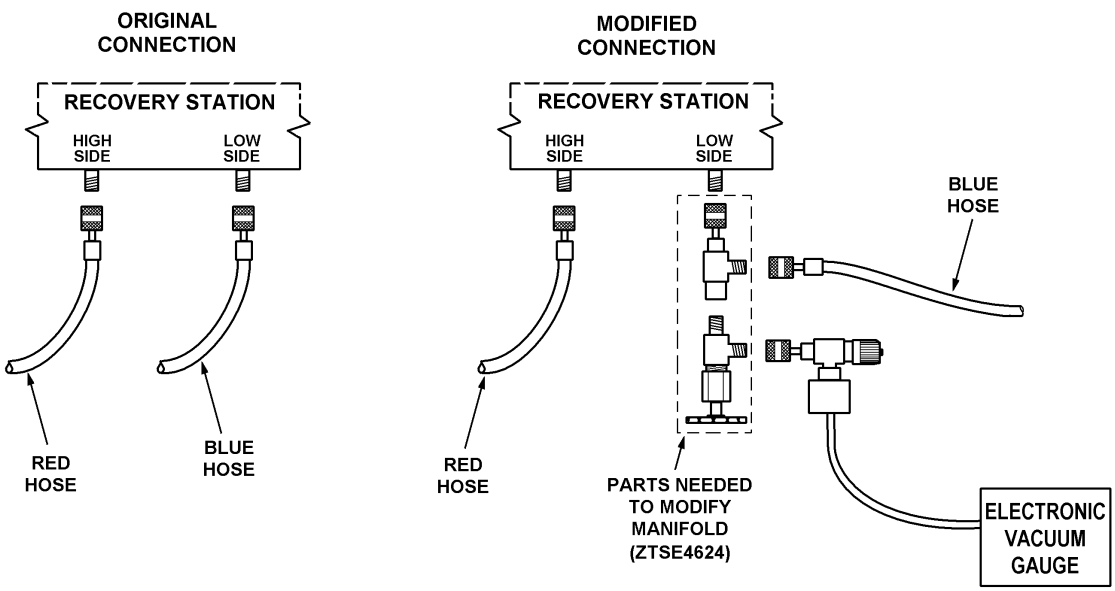


Figure 42 Connection of Electronic Vacuum Gauge

> **CAUTION – The valve for the electronic vacuum gauge must be in the closed position until instructed to open it. If the valve is open during system charging, excess pressure may damage the electronic vacuum gauge.**

4. Connect the recovery station to the system as follows (refer to Figure 41):
   a. Start with the **blue** low pressure hose, and connect it to the low pressure service port.
   b. Connect the **red** hose to the high pressure service port.
5. On the red and blue hoses, open the valves on the Metric SAE quick-connect fittings (turn the knobs fully CW).
6. On the recovery station, set both hand valves to the RECOVERY/VACUUM position.
7. On the recovery station, turn on main power switch and press the VACUUM button.
8. After the low pressure gauge on the station shows that vacuum is being established in the system, continue to operate the vacuum pump for ten minutes.
9. After ten minutes, set both valves on the recovery station to the CLOSED position, and observe low side gauge for one minute. The gauge should **not** indicate a rise of more than 2 inches-Hg. If the gauge rises more than 2 inches-Hg in one minute, the system has a leak which must be repaired. Refer to LEAK DETECTION (See LEAK DETECTION, page 69).
10. If there are no leaks:
    a. Set both hand valves on the recovery station to the RECOVERY/VACUUM position and press the VACUUM button.
    b. Open the valve connecting the electronic vacuum gauge to the recovery station low side line.

c. Continue to operate the recovery station vacuum pump until the system has pulled a vacuum of 750 – 1000 microns as measured by the electronic vacuum gauge. NOTE: Operate the vacuum pump for a minimum of 10 minutes even if the vacuum reaches its target value sooner.

d. Close both hand valves on the recovery station, and the valve connecting the electronic vacuum gauge to the recovery station low side line.

11. The A/C system is ready to be charged. **REMEMBER,** if the full amount of refrigerant oil has not yet been added to the system, it must be added before charging the system with refrigerant, as explained in the following procedure.

IMPORTANT – DO NOT disconnect the recovery/recycling/charging station from the A/C system before charging the system.

5.8. CHARGING THE AIR CONDITIONING SYSTEM (FULL CHARGE)

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

WARNING – Do not remove the compressor oil fill plug to check the oil level in the refrigerant compressor while the A/C system is charged with refrigerant. The crankcase side of the compressor is under pressure and personal injury may result. It is not possible to check the oil level in the compressor on an A/C system that is under system pressure.

CAUTION – Use only new or recycled R-134a refrigerant; not any of the so called “direct replacement” refrigerants. Use of equipment dedicated for R-134a is necessary to reduce the possibility of oil and refrigerant incompatibility concerns.

CAUTION – When charging the A/C system the refrigerant tank must be kept upright. If the tank is not in the upright position, liquid refrigerant may enter the system and cause compressor damage.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer’s instructions supplied with that equipment.

IMPORTANT – If recycled refrigerant is to be used, follow the instructions supplied with the recycling equipment to purge the air from the refrigerant before charging the system.

Perform the Charging procedures, using new or recycled refrigerant, only after the following actions have been completed:

- System components repaired and/or replaced.
- System flushed or purged **(if required)**.
- Refrigerant oil added (**only** if oil was added directly to the compressor, see OIL FILL GUIDELINES).
- System completely evacuated.

CAUTION – The electronic vacuum gauge used during the EVACUATION procedure (Figure 42) must be isolated from the refrigerant system (valve closed) before the system is charged. If the gauge is connected to the system during charging, excess pressure may damage it.

CAUTION – If the equipment being used adds system refrigerant oil during the evacuation/charging procedure, you must first determine the amount of oil to be added (refer to OIL FILL GUIDELINES). Then follow the instructions furnished with the recovery station, or refrigerant oil injector tool, to add the correct amount of NEW oil to the system during this procedure.

1. The recovery station **blue** (suction) and **red** (discharge) hoses should still be connected as they were during the evacuation operation (Figure 41).

2. If necessary, add oil to return the system oil capacity to its correct level (refer to OIL FILL GUIDELINES). To add oil during the evacuation/charging process, follow the instructions furnished with the recovery station, or refrigerant oil injector tool.

CAUTION – Due to the density of R-134a, the amount of refrigerant required to charge a typical air conditioning system has been reduced. Overcharging the system will result in excessively high head pressures during operation and may damage the compressor. Be sure to check specifications on the vehicle being serviced. This information is often located on a label on the refrigerant compressor.

3. Determine the amount of refrigerant needed to charge the A/C system. This information can be found in the SPECIFICATIONS section of this manual (See SPECIFICATIONS, page 83). This information is also, often located on a label on the refrigerant compressor.

4. Following the instructions provided with the recovery station; set the recovery station to charge the system with the specified amount of refrigerant.

5. On the recovery station, set the low side valve to CLOSED, and the high side valve to CHARGE.

6. Press the CHARGE button to start the charge procedure. When the system is fully charged, the recovery station will turn off.

7. Complete the charging procedure by setting both hand valves on the recovery station to the CLOSED position.

8. Before disconnecting the recovery station from the A/C system, perform the SYSTEM OPERATING TEST PROCEDURES (See SYSTEM OPERATING TEST, page 24).

9. After the pressure test is completed, stop the engine, close the valves on the Metric SAE quick-connect fittings (turn fully ccw) at the vehicle A/C service ports.

10. Disconnect the **blue** and **red** hose Metric SAE quick-connect fittings from the vehicle service ports.

11. Install the protective caps on both of the vehicle service port fittings.

5.9. ADDING REFRIGERANT TO THE SYSTEM

Since the introduction of R-134a, relying on a sight glass clearing up when the system has a full charge is no longer reliable. DO NOT add refrigerant to the system in hopes of improving cooling. It's very possible that the system will be overcharged and cause component failure.

If it is found, during A/C system tests, that the system needs refrigerant; it will be necessary to perform the following procedures:

- discharge the system, refer to DISCHARGING THE SYSTEM, (See DISCHARGING THE SYSTEM (REFRIGERANT RECOVERY), page 50);
- evacuate the system, refer to EVACUATING THE SYSTEM, (See EVACUATING THE SYSTEM, page 51);
- and recharge the system, refer to CHARGING THE AIR CONDITIONING SYSTEM (FULL CHARGE), (See CHARGING THE AIR CONDITIONING SYSTEM (FULL CHARGE), page 54).

5.10. PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

WARNING – Dry nitrogen gas is recommended for flushing and/or purging. Do not use nitrogen at pressures over 1378 kPa (200 psi). Personal injury or death may result from doing so. Commercial cylinders of dry nitrogen contain pressures in excess of 13780 kPa (2000 psi). This pressure must be reduced, using a pressure regulator, to 1378 kPa (200 psi) for purging.

WARNING – The A/C system can be flushed or purged only after the refrigerant has been discharged (recovered).

CAUTION – When flushing and/or purging components of the system use only dry nitrogen. The introduction of compressed air into the A/C system may cause contamination of the system.

CAUTION – When flushing components, use only flushing agents approved for R-134a charged air conditioning systems (refer to the Fleetrite HVAC catalog for an approved flush solvent). R-11 and any other flushing agents that were used to flush R-12 charged air conditioning systems CANNOT be used to flush R-134a systems. The residue left by these flushing products will destroy the lubrication properties of the oil used in R-134a systems.

NOTE – A flush gun is required to inject the flushing agent into the component being flushed. Refer to FLUSH GUN for complete information on this service equipment (See FLUSH GUN, page 82).

NOTE – Special adapters are required to connect the service equipment to some A/C system components. Refer to SPECIAL TOOLS for complete information on these service adapters (See SPECIAL TOOLS, page 74). Standard fittings and adapters can be purchased or fabricated locally. Quick disconnect fittings can reduce the time required to swap hoses, adapters and components.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

Systems that have had an internal compressor failure, that have been overcharged with refrigeration oil, or that have been left open for an extended period of time, will need to be flushed, purged or both. Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. Flushing is generally necessary only after an internal compressor failure has contaminated the refrigerant system. Flushing and purging are performed on a system after the refrigerant has been discharged (recovered) and before the system is reassembled and evacuated.

Flushing removes heavy contamination, such as gritty oil and large dirt buildup, which occur after an internal compressor failure. When a part is flushed, a flushing solvent is forced through it; the liquid solvent cleans the part, picks up contaminants and flushes them out.

Purging must always be performed: after flushing the system; any time there is excessive refrigerant oil found in the system; or, when the system has been left open for an extended period of time. Purging removes flushing solvent, excessive refrigerant oil, damp air, and loose particles from A/C system components by passing a stream of inert, dry nitrogen gas through parts of the system or individual components. This assures that A/C system components are dry and free of any contaminants. If left in the system, these contaminants would have a negative effect on the life and operation of the air conditioning system.

The following procedures must be observed whenever a component or system is flushed or purged.

- Never flush or purge the entire system. Flush or purge the system in segments (never larger than one component and one hose) to lessen the chance of blowing contaminants throughout the system.
- Never flush or purge the compressor, receiver-dryer, or expansion valve.
- Flush or purge each system section or component in the opposite direction of normal refrigerant flow.
- After flushing or purging the system, change oil in the compressor (refer to OIL FILL GUIDELINES) and replace the receiver-dryer prior to evacuating and charging the system.

Refer to Figure 43 and Figure 44.

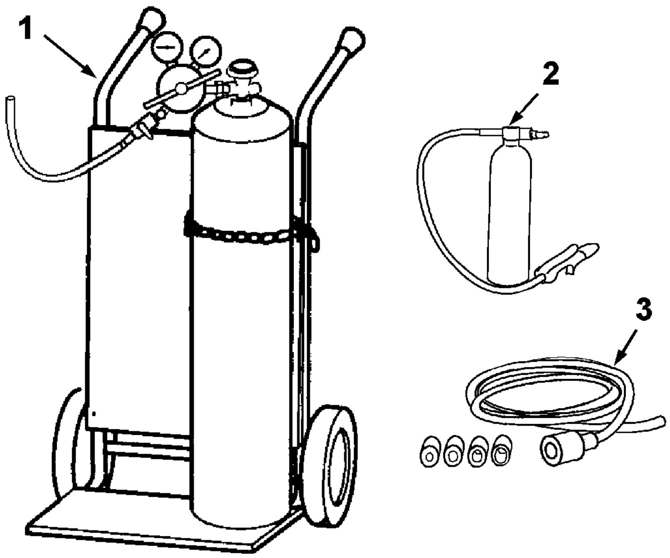


Figure 43 Typical Equipment Used for Flushing and Purging the A/C System

1. PRESSURIZED NITROGEN CYLINDER/CART/CONTROLS
2. FLUSH GUN
3. DRAIN HOSE WITH COMPRESSION FITTING AND ADAPTERS

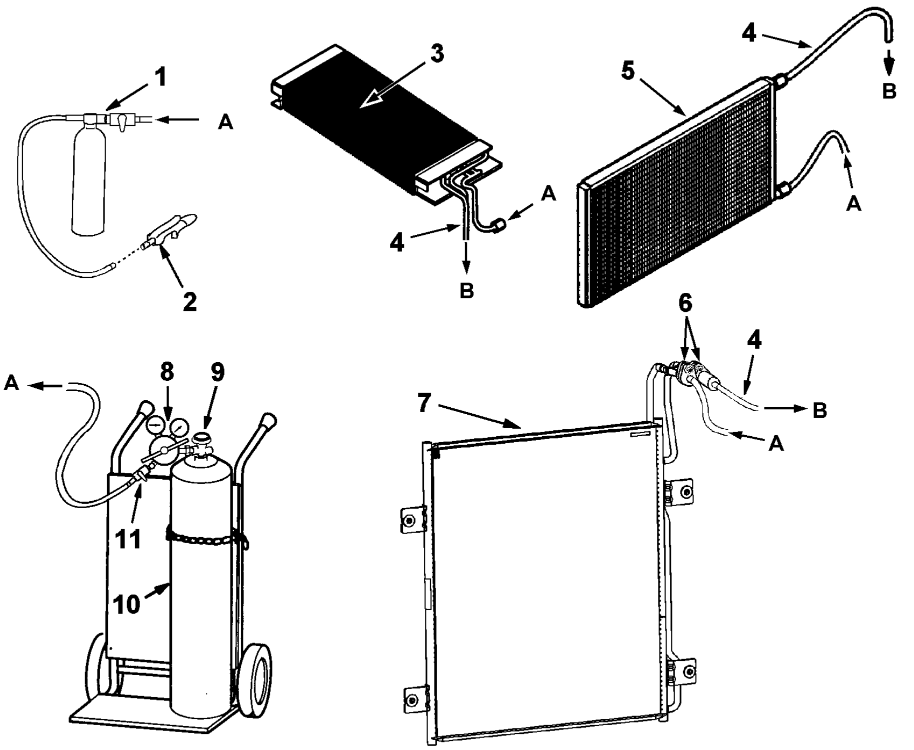


Figure 44 Typical Flushing and Purging Setup

A. NITROGEN IN
B. TO WASTE CONTAINER
1. FLUSH GUN
2. TRIGGER TYPE AIR GUN
3. EVAPORATOR CORE
4. DRAIN LINE
5. CONDENSER (CCI COMPRESSOR SYSTEMS)
6. BLOCK FITTING ADAPTERS (SANDEN COMPRESSOR SYSTEMS)
7. CONDENSER (SANDEN COMPRESSOR SYSTEMS)
8. NITROGEN BOTTLE REGULATOR/GAUGES
9. NITROGEN BOTTLE CONTROL VALVE
10. NITROGEN BOTTLE
11. SUPPLY LINE VALVE

NOTE – The following procedures for flushing and purging are general. The actual fittings and adapters required for each procedure will vary according to the component or components being connected.

Flushing Procedure

Refer to Figure 44 for all Items in parentheses.

> **CAUTION – Assemblies to be flushed must be no larger than one component and one attached hose.**

1. Verify that the system is discharged.

2. Disconnect both ends of the component or components to be flushed, and tightly cap the rest of the system.

3. With the tank regulator (8) turned off (closed), open the main nitrogen tank valve (9), and using the input gauge on the regulator, verify that enough pressure is available to perform the flushing procedure.

4. Connect the input of the flush gun (1) to the output of the supply line from the nitrogen tank. Some form of shutoff valve should be installed at the input of the flush gun.

5. Using the correct fittings or block fitting adapters (6), connect the drain line (4) to the component to be flushed. Components are flushed in the opposite direction of normal refrigerant flow.

6. Using the correct fittings or block fitting adapters (6), connect the flush gun output to the component to be flushed. NOTE: A trigger type air gun (2) may also be used as the flush gun output.

7. Place the outlet of the drain line into a suitable waste container.

8. Fill the flush gun tank with an appropriate amount of flushing agent.

9. Set the supply line air regulator (8) to 75 psi.

10. Open the supply line valve (11) at the output of the tank regulator.

11. Slowly open the flush gun valve and allow the flushing solvent to flow through the system until the drain line is clear; then, close the flush gun valve. If a trigger type air gun (2) is being used on the flush gun output, release all pressure from the flush gun tank by pointing the air gun into the waste container, and actuating the trigger.

12. Close the supply line valve (11).

WARNING – The flush gun MUST be removed from the equipment setup before performing the purge procedures. The flush gun is not designed to be used at the pressures used for the purge procedures.

13. Connect the flushing equipment to the next component to be flushed; or, empty the flush gun tank and **remove the flush gun** from the supply line.

14. Disconnect drain hose and all fittings and adapters from the component.

15. Plug the inlet and outlet of the component until it can be purged.

NOTE – After flushing a component, that component must be purged before connecting it to the air conditioning system. Refer to PURGING PROCEDURE.

Purging Procedure

WARNING – Dry nitrogen gas is recommended for purging. Do not use nitrogen at pressures over 1378 kPa (200 psi). Personal injury or death may result from doing so. Commercial cylinders of dry nitrogen contain pressures in excess of 13780 kPa (2000 psi). This pressure must be reduced, using a pressure regulator, to 1378 kPa (200 psi) for purging.

CAUTION – Assemblies to be purged must be no larger than one component and one attached hose.

Refer to Figure 44 for all Items in parentheses.

1. Verify that the system is discharged.
2. Disconnect both ends of the component to be purged and tightly cap the rest of the system.
3. With the tank regulator (8) turned off (closed), open the main nitrogen tank valve (9), and using the input gauge on the regulator, verify that enough pressure is available to perform the purging procedure.
4. Using the correct fittings or block fitting adapters (6), connect the drain line (4) to the component to be purged. Components are purged in the opposite direction of normal refrigerant flow.
5. Using the correct fittings or block fitting adapters, connect the nitrogen supply line output to the component to be purged. A trigger type air gun (2) may be hand–held for some components.
6. Place the outlet of the drain line into a suitable waste container.
7. Set the supply line air regulator (8) to 28 kPa (4 psi).
8. Slowly open the supply line valve (11) at the output of the tank regulator. If a trigger type air gun is being used, actuate the trigger.
9. Let the dry nitrogen flow at 28 kPa (4 psi) for one to two minutes, or until there is no trace of refrigerant flushing agent or refrigerant oil flowing from the drain tube.
10. Using the pressure regulator (8), raise the pressure to 1378 kPa (200 psi) and let the dry nitrogen flow for 25 to 30 seconds.
11. Adjust the pressure regulator for 0 psi; then, close the supply line valve (11).
12. If a trigger type air gun (2) is being used, release all pressure from the hose by pointing the air gun into the waste container, and actuating the trigger.
13. Disconnect the supply and drain lines from the part, and remove all fittings and adapters (6). Tightly cap the openings of the part until you are ready to install it into the system.

IMPORTANT – When reconnecting components, always install new O-rings and C-plates on the systems equipped with Sanden compressors with peanut fittings.

NOTE – Always lubricate O-rings and threads on fittings with mineral-based oil during installation.

14. The component is now ready to be installed into the air conditioning system using new O-rings and/or C-plates.

15. After purging the system, and prior to evacuating and charging the system:
    a. Change oil in the compressor. Refer to OIL FILL GUIDELINES.
    b. Replace the receiver-dryer.
    c. Reinstall (or replace) all other components that were removed for service.

5.11. OIL FILL GUIDELINES

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

CAUTION – Do not re-use recovered oil. Be sure to dispose of recovered oil properly to avoid an environmental hazard.

CAUTION – Replacement compressors may contain a quantity of oil when shipped. The quantity of oil in the compressor must be measured (by dipstick or draining) to determine how much additional oil is needed to return the system oil level to normal.

CAUTION – During normal A/C operation, oil is circulated through the system with the refrigerant, and a small amount is retained in each component. If certain components of the system are removed, some of the refrigerant oil will go with the component. To maintain the original total oil charge, it is necessary to compensate for the oil lost by adding oil to the system with the new part.

The two compressors covered in this manual use different types of refrigerant oil. The following procedures cover both compressor types. Refer to REFRIGERANT OIL (See REFRIGERANT OIL, page 22) for information on the refrigerant oil types used with the different compressors. System oil capacities are provided in the SPECIFICATIONS (See SPECIFICATIONS, page 83) section.

The correct volume of refrigerant oil in the A/C system is critical for proper system operation. Insufficient oil will result in compressor failure. Too much oil decreases cooling efficiency, resulting in poor system cooling performance. In general, when servicing the system, ensure that the amount of oil (retained or added) in the repaired system (**compressor and components**) equals the total **SYSTEM** capacity indicated in SPECIFICATIONS (See SPECIFICATIONS, page 83). Replacement oil may be added directly into the compressor before evacuation, or injected into the system after evacuation. The following paragraphs describe how to determine the quantity of refill oil needed under the most common conditions.

IMPORTANT – Unless stated otherwise, the following procedures assume that the system is not being flushed and/or purged.

A. If the refrigerant was only recovered for the purpose of measuring the refrigerant charge, add the amount of oil removed from the system during the refrigerant recovery procedure.

- Total replacement oil quantity **=** oil from refrigerant recovery procedure.

B. If a compressor is replaced (and the system was **not** contaminated and had no leaks) fill the new compressor with the amount of oil removed from the system during the refrigerant recovery procedure, plus the quantity of oil that was contained in the old compressor. (NOTE: The amount of oil in new CCI compressors must be measured to calculate the amount of oil to add to the system. The oil in new Sanden compressors must be drained before adding the new oil to the system. Refer to CHECKING COMPRESSOR OIL LEVEL, that follows, for the procedures to check the oil level in the refrigerant compressor.) Refill the system (new compressor) as follows.

- (CCI Compressor) Total replacement oil quantity **=** oil from refrigerant recovery procedure **+** oil measured in old compressor **minus** the oil measured in the new compressor.
- (Sanden Compressor) Total replacement oil quantity **=** oil from refrigerant recovery procedure **+** oil drained from old compressor.

C. If a component other than the compressor is replaced, and there is no oil leak; add the amount of oil removed from the system during the refrigerant recovery procedure, plus the amount indicated for the replaced component in Table 5.

- Total replacement oil quantity **=** oil from refrigerant recovery procedure **+** oil indicated in component table.

D. If the amount of oil in the system is unknown (due to an oil leak, ruptured hose, etc.); refer to EXCESSIVE OIL LOSS DUE TO REFRIGERANT LEAK (See Excessive Oil Loss Due to Refrigerant Leak, page 64).

E. Whenever the refrigerant system has become contaminated: make the necessary repairs; flush and purge the system; and replace the expansion valve, receiver-dryer, and compressor. (NOTE: The amount of oil in new CCI compressors must be measured to calculate the amount of oil to add to the system. The oil in new Sanden compressors must be drained before adding new oil to the system. Refer to CHECKING COMPRESSOR OIL LEVEL, that follows, for the procedures to check the oil level in the refrigerant compressor.) Refill the system (compressor) as follows.

- (CCI Compressor) Total replacement oil quantity **=** total system capacity as specified in SPECIFICATIONS **minus** oil measured in the new compressor.
- (Sanden Compressor) Total replacement oil quantity **=** total system capacity as specified in SPECIFICATIONS **minus** 0.5 fl.oz (oil film left in new compressor).

Table 5 Oil Capacity by Component

Component	Typical oil amount	
	cc	fl.oz.
Evaporator	60	2.0
Condenser	30	1.0
Receiver-Dryer	15	0.5
Hoses (normal length)	10	0.3

Table 5 Oil Capacity by Component (cont.)

Pressure Switches	0	0
Expansion Valve	0	0

Oil Separation During Refrigerant Recovery

The oil removed from the system during the refrigerant recovery process must be replaced. Always empty the recovery station oil catch bottle before recovering the refrigerant. After recovering the refrigerant, check the calibrated bottle to determine how much oil has been removed from the system. This quantity may be used to help determine the amount of NEW oil that must be added to the system before or during the recharging of the A/C system. Do not use recovered refrigerant oil.

Excessive Oil Loss Due to Refrigerant Leak

When there is a refrigerant leak, an unknown amount of oil escapes from the system with the refrigerant. When a major leak is detected perform the following procedures to re-establish the correct system oil level.

> CAUTION – **When installing components, use new O-rings (and C-plates on Sanden compressor systems with peanut fittings) lubricated with mineral oil.**

1. Use the service equipment and observation to determine the location of the leak. Refer to LEAK DETECTION (See LEAK DETECTION, page 69).
2. Discharge the system. Refer to DISCHARGING THE SYSTEM (See DISCHARGING THE SYSTEM (REFRIGERANT RECOVERY), page 50).
3. Make any necessary repairs.
4. If the system does not appear to be contaminated, purge the system. If the system appears contaminated, such as after an internal compressor failure, it must be flushed before purging. Refer to PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM (See PURGING OR FLUSHING THE AIR CONDITIONING SYSTEM, page 56).
5. If the system **was not** contaminated:
   - A. Re-establish the correct system oil level as follows: (NOTE: The amount of oil in CCI compressors must be measured to calculate the amount of oil to add to the system. The oil in Sanden compressors must be drained before adding new oil to the system. Refer to CHECKING COMPRESSOR OIL LEVEL, that follows, for the procedures to check the oil level in the refrigerant compressor.)
     - (CCI Compressor) Total added oil quantity **=** total system capacity as specified in SPECIFICATIONS (See SPECIFICATIONS, page 83) **minus** oil measured in the compressor.
     - (Sanden Compressor) Total replacement oil quantity **=** total system capacity as specified in SPECIFICATIONS (See SPECIFICATIONS, page 83) **minus** 0.5 fl.oz (oil film left in compressor after draining).
   - B. (Sanden Compressor) Install the compressor. (Compressor was removed to drain oil.)

6. If the system **was** contaminated:

   A. Replace the expansion valve.

   B. Replace the compressor and re-establish the correct system oil level, as follows: (NOTE: The amount of oil in new CCI compressors must be measured to calculate the amount of oil to add to the system. The oil in new Sanden compressors must be drained before adding new oil to the system. Refer to CHECKING COMPRESSOR OIL LEVEL, that follows, for the procedures to check the oil level in the refrigerant compressor.)

      - (CCI Compressor) Total replacement oil quantity **=** total system capacity as specified in SPECIFICATIONS (See SPECIFICATIONS, page 83) **minus** oil measured in the new compressor.
      - (Sanden Compressor) Total replacement oil quantity **=** total system capacity as specified in SPECIFICATIONS (See SPECIFICATIONS, page 83) **minus** 0.5 fl.oz (oil film left in new compressor after draining).

7. Replace the receiver-dryer.

8. Using new O-rings, and C-plates (Sanden compressor systems with peanut fittings), lubricated with mineral oil; reconnect all the components of the A/C system. Torque all joints per the TORQUE CHART (See Table 11, page 87).

9. Evacuate the system; refer to EVACUATING THE SYSTEM (See EVACUATING THE SYSTEM, page 51).

10. Charge the system; refer to CHARGING THE AIR CONDITIONING SYSTEM (See CHARGING THE AIR CONDITIONING SYSTEM (FULL CHARGE), page 54).

5.12. CHECKING COMPRESSOR OIL LEVEL

WARNING – Do not remove the oil fill plug to check the oil level in the refrigerant compressor while the A/C system is charged with refrigerant. The crankcase side of the compressor is under pressure and personal injury may result.

CAUTION – While it is possible to check the quantity of oil retained in the CCI compressor itself, maintaining the correct SYSTEM oil level is critical to system operation. After performing any service on the A/C system, insure that the system contains the correct type and volume of refrigerant oil before operating the system.

IMPORTANT – To prevent contamination, keep the compressor tightly sealed when not measuring the oil level.

It is not possible to check the oil level in the compressor on an A/C system that is under system pressure. If the compressor oil level must be checked, it will be necessary to discharge the system. Refer to DISCHARGING THE SYSTEM (See DISCHARGING THE SYSTEM (REFRIGERANT RECOVERY), page 50).

CHECKING OIL LEVEL IN CCI COMPRESSORS

The oil level in CCI compressors can be checked with the compressor mounted in the vehicle or on the bench. Whether mounted in the vehicle, or sitting on the bench, the compressor oil level can be checked by using a specially-constructed dipstick (Figure 45). When the compressor is mounted in the vertical position, the oil level may be checked from the right or left side (Figure 46). When mounted in the horizontal position, the fill plug is on the top.

The quantity of oil contained in an uninstalled replacement compressor can be checked by the dipstick method or by draining it into a calibrated container.

To check the compressor oil using the dipstick:

1. Verify that the system is discharged.

2. Remove one oil fill plug with its O-ring.

3. Insert the dipstick as shown in Figure 46. Remove dipstick and count increments of oil. The dipstick notched end is helpful in visibly determining the measured oil depth.

NOTE – Approximately 12 fl.oz. of oil is retained in the CCI compressor during normal operation.

4. With 12 fl.oz. of oil in the compressor, the dipstick will read 1-3/8 inches for vertically installed compressors and 1-7/16 inches for horizontally mounted compressors.

5. Add new oil to the compressor as determined in OIL FILL GUIDELINES. A full oil charge for a system **that has been purged** is 16 fl.oz.

6. Install the fill plug, taking care not to twist the O-ring seal. Tighten plug to 4 to 11 lbf-ft. (5 to 15 Nm). Do not over-tighten plug to stop a leak. Stop leaks first by fixing any seat damage, removing dirt and installing a new O-ring. **The system must be discharged before repairing an oil fill plug leak**.

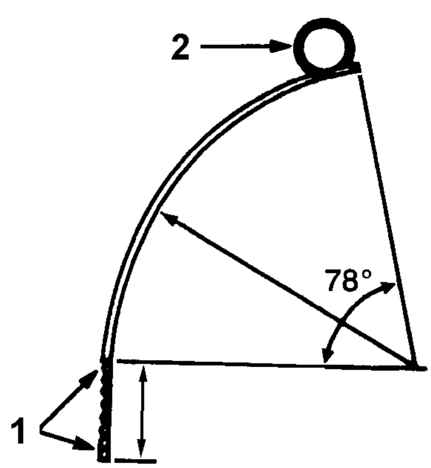


Figure 45 Specially Constructed Dipstick for CCI Compressors

1. 12 NOTCHES 1/8 INCH (3 MM) APART
2. FINGER RING

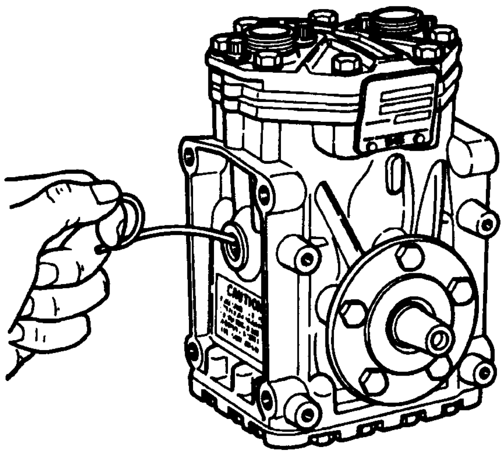


Figure 46 Checking Oil Level in CCI Compressor

CHECKING OIL LEVEL IN SANDEN COMPRESSORS

The oil level of the Sanden compressor can be accurately checked only by removing the compressor from the vehicle and draining the oil into a calibrated container.

1. Verify that the system is discharged.
2. Remove the compressor.
3. Remove the oil plug and drain as much oil as possible into a suitable calibrated container (refer to Figure 47).

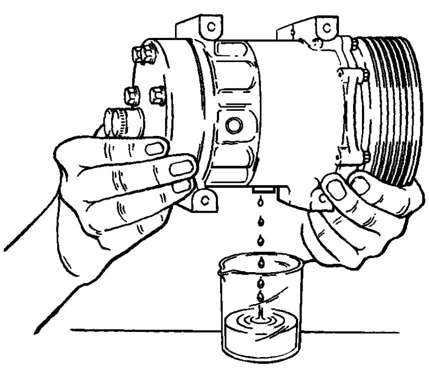


Figure 47 Drain as Much Oil as Possible

4. Remove the caps (if present) from the suction and discharge ports.
5. Drain remaining compressor oil from the suction and discharge ports, into the calibrated container, while turning the shaft (clockwise only) by hand or with a socket wrench on the armature retaining nut (refer to Figure 48). Replace the caps on the suction and discharge ports.

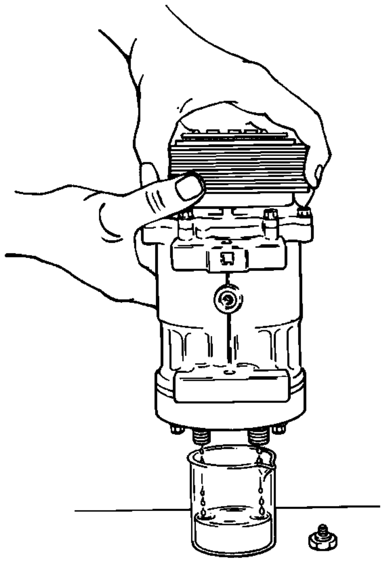


Figure 48 Drain Oil While Turning Shaft

6. Measure and record the amount of oil drained from the compressor.

7. Inspect the oil for signs of contamination such as discoloration or foreign material.

8. Add new oil to the compressor as determined in OIL FILL GUIDELINES (refer to Figure 49).

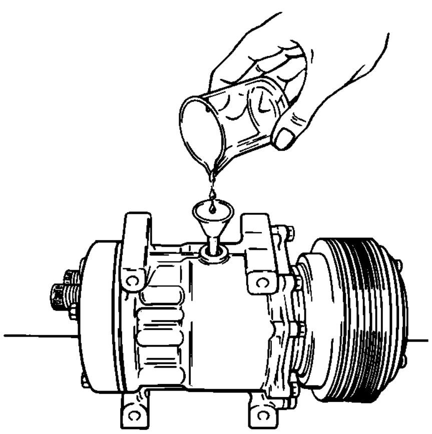


Figure 49 Add New Oil

9. Install oil fill plug taking care not to twist the O-ring seal. Replace the O-ring if damaged. Torque oil plug to 15-20 N.m (11-15 lbf-ft). Do not over-tighten plug to stop a leak. Stop leaks first by fixing any seat damage, removing dirt and installing a new O-ring.

5.13. LEAK DETECTION

WARNING – Before doing any of the work below, read the SERVICE WARNINGS (See SERVICE WARNINGS, page 40). Failure to read the Service Warnings and to be aware of the dangers involved when working with refrigerant could lead to personal injury.

NOTE – Refrigerant leaks are often indicated by an oily residue at the point of the leak.

IMPORTANT – Although your service equipment may appear physically different from the equipment shown here, the function of the equipment used to perform each service procedure is basically the same. If you are performing these service procedures using service equipment different from that shown, refer to the manufacturer's instructions supplied with that equipment.

There are several methods of refrigerant leak detection. The method used could depend on many factors including equipment availability, layout of the system being serviced, or even personal preference. The primary recommended methods are the electronic refrigerant leak detector and the phosphor dye/ultraviolet lamp method. In addition, brief descriptions are provided for two alternate methods (ultrasonic leak detection and soap solution). By using the described methods, either separately or in some combination, it should be possible to locate and verify most refrigerant leaks.

Electronic Refrigerant Leak Detectors

In terms of sensitivity and safety, the electronic leak detector (Figure 50) is excellent for finding both slow and major system leaks. Ensure that the detector being used is intended for use with R134a refrigerant. Many leak detectors intended for use with R-12 cannot detect R134a leaks. The detector is also listed in the SPECIAL TOOLS section (See SPECIAL TOOLS, page 74).

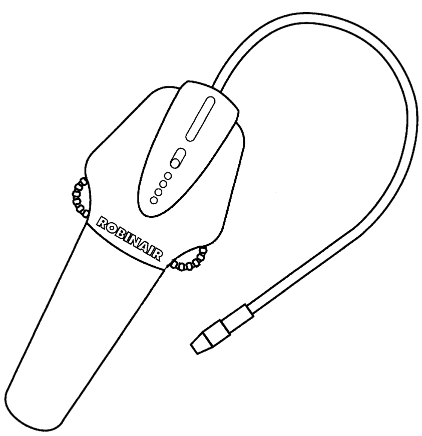


Figure 50 Electronic Leak Detector

The unit is a hand-held device having a flexible probe used to seek out refrigerant leaks. An audio leak indicator signals a warning in the presence of a leak. It is important to become familiar with the leak detector instructions for the detector being used. The speed at which the probe is moved over the component being checked is very important in locating larger than permissible leaks. Leak check procedure should be in accordance with SAE J1628.

Before starting to look for leaks, it is recommended to clean away all oil or grease, and blow away refrigerant residue from fittings and A/C components. All suspected areas should be cleaned using soap and water, not a solvent. A detected leak should be a flow of refrigerant, not a residual condition of refrigerant that is trapped under an oil film, etc. A detected leak rate in excess of 1.0 oz./year is unacceptable.

NOTE – To take advantage of the operating characteristics of the A/C system, test the high pressure part of the system with the system running. The low pressure part of the system should be tested with the system and the engine off.

Ultraviolet Lamp Leak Testing

An alternate method to electronic leak testing is ultraviolet light. A phosphor dye is added to the system and leaks are detected by the use of an ultraviolet (UV) lamp. When illuminated by the UV lamp, the phosphor dye will produce a bright yellow-green trace at the leak. It has been discovered during the use of ultraviolet light and the phosphor dye that other types of leaks may also appear as a yellow-green trace when the UV light shines on them. If phosphor dye is used for leak detection, it is recommended that an electronic leak detector also be used to verify that a detected leak is a refrigerant leak. Refer to Electronic Leak Detectors (See Electronic Refrigerant Leak Detectors, page 69).

Phosphor dye can be added to any system that is not already charged with it. The dye charging process should be performed according to the instructions provided by the manufacturer of the dye injector. The kit illustrated in Figure 51 provides the UV lamp used to illuminate the suspected leaks. The kit also contains connection hoses and a dye injector, as well as, eyeglasses used to enhance the effect of the UV light on the dye. After adding phosphor dye to an A/C system, the compressor or receiver-dryer should be labeled indicating that the system contains phosphor dye.

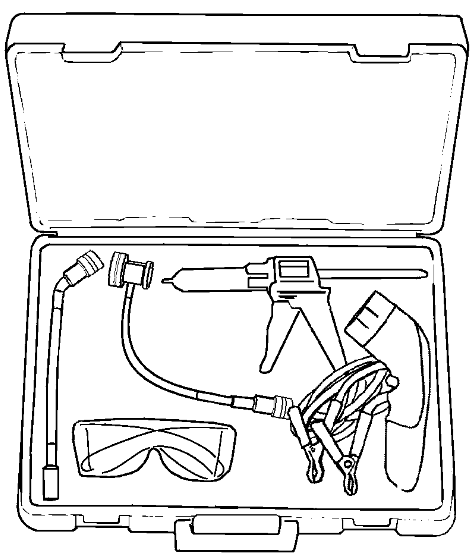


Figure 51 Ultraviolet Lamp Kit

Ultrasonic Leak Detectors

An ultrasonic leak detector listens for the distinctive ’sound’ of a gas passing through an opening. To use this type of detector effectively, the refrigerant system is first discharged, and then pressurized to 300 psi using dry nitrogen and a manifold gauge set. Refer to REFRIGERANT LEAK TESTING WITH NITROGEN. The detector is then used to scan the suspected joints or components. Depending on the detector being used, a leak may be indicated by a visual or audible signal. Suspected leaks should not be cleaned with a soap solution prior to scanning with this tool, as any solution remaining at the leak site may mask the leak.

The unit is a hand-held device and may include attachments to vary the directional sensitivity of the unit. Because this type of sensor does not sample the gas used in the system, it may be used with any refrigerant system. It may also be used to detect leaks in the vehicle air system. It is important to become familiar with the leak detector instructions for the detector being used.

Soap Solution with Nitrogen

Another alternative method of leak detection is the soap solution method. To improve the results of this method the refrigerant system is first discharged, and then pressurized to 300 psi using dry nitrogen. Refer to REFRIGERANT LEAK TESTING WITH NITROGEN. A solution of soap and water is then sprayed on the suspected joints or components. A leak is indicated by bubbles forming at the point where the pressurized nitrogen is escaping.

Refrigerant Leak Testing with Nitrogen

When checking for refrigerant leaks using an ultrasonic detector or a soap solution, the refrigerant in the system must first be recovered; then, the system must be pressurized with dry nitrogen, as follows.

1. Connect a manifold gauge set to the a/c system. Refer to FIGURE 52.
   a. Initially keep both gauge valves on manifold gauge set closed.
   b. High pressure hose (red) to high pressure port on vehicle. (Open quick connect valve.)
   c. Low pressure hose (blue) is not connected. (Keep gauge valve and quick connect valve closed.) **NOTE: Opening the low pressure gauge valve while the system is pressurized may damage the low pressure gauge.**
2. Connect pressurized nitrogen cylinder to the manifold gauge set and pressurize a/c system to 300 PSI.
   a. Connect manifold gauge set yellow hose to nitrogen source.
   b. Set output pressure at nitrogen cylinder regulator to 300 PSI.
   c. Slowly open high side gauge valve on manifold gauge set to pressurize a/c system (high side gauge should read 300 PSI).
3. Test for leaks using an ultrasonic detector or a soap solution.
4. After locating the leak, set the nitrogen cylinder regulator to 0 PSI.

> **WARNING – In the following step, the pressure must be released in a manner that does not trap pressure in the a/c system.**

5. Before disconnecting the manifold gauge set, slowly release the pressure from the a/c system by **partially** disconnecting a fitting until the pressure is released.
6. Remove the manifold gauge set from the a/c system and repair the leak.
7. Evacuate and recharge the a/c system. Refer to CHARGING THE AIR CONDITIONING SYSTEM.

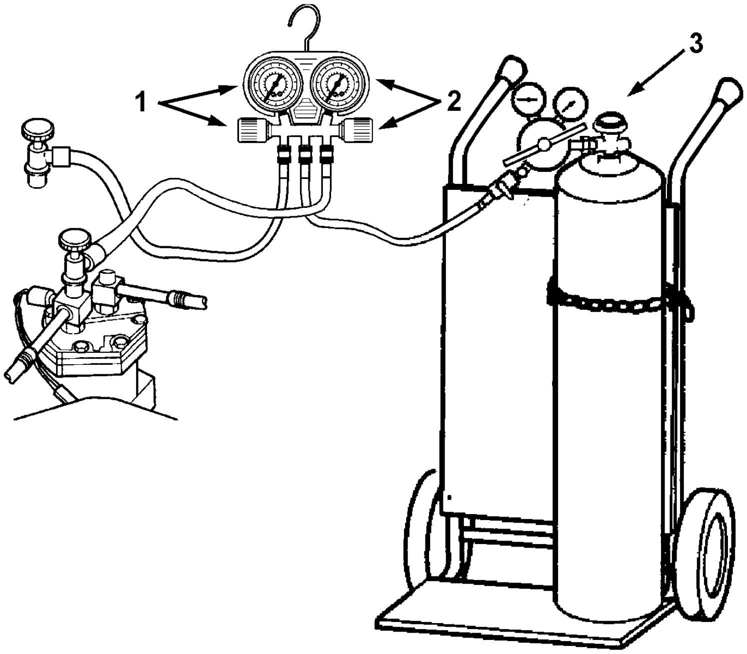


Figure 52 Using Nitrogen to Pressurize the A/C System

1. LOW PRESSURE VALVE AND GAUGE (MANIFOLD GAUGE SET)
2. HIGH PRESSURE VALVE AND GAUGE (MANIFOLD GAUGE SET)
3. NITROGEN CYLINDER AND REGULATOR

6. SYSTEM MAINTENANCE

6.1. PRE-SEASON SERVICING

Field experience has indicated that many of the problems incurred with heating and air conditioning systems are the result of lack of regular maintenance. Preventive maintenance and cleanliness of all components within the system are extremely important. A complete step-by-step pre-season checkout of the air conditioner/heater system will substantially increase satisfactory operation during the season.

Perform the following procedures:

1. Check the mounting fasteners of each component for looseness.

2. Check condition, tension and alignment of all drive belts. Refer to SPECIFICATIONS (See SPECIFICATIONS, page 83) for belt tension information.

3. Check condition of heater hoses and engine cooling system hoses. Replace if necessary.

4. Verify that the vehicle coolant level is correct.

5. Check refrigerant hose retention and condition. Look for cracks, chafing, or other damage. Inspect all tubing and hoses for dirty or loose connections. All connections must be clean and tight.

NOTE – If a patch of oily residue is found at or near a connection it may indicate a refrigerant leak. Note its location in case a system operational test indicates a refrigerant leak or a low refrigerant condition.

IMPORTANT – Cleanliness of the air conditioner components cannot be over-emphasized. Lack of proper attention in this area is one of the major causes of costly and unsatisfactory unit operation.

6. Clean all foreign material from condenser and radiator fins. As often as necessary, squirt water through the condenser towards the radiator and through the radiator towards the condenser to flush debris from the fins. Straighten bent fins with a fin straightening tool (Figure 53).

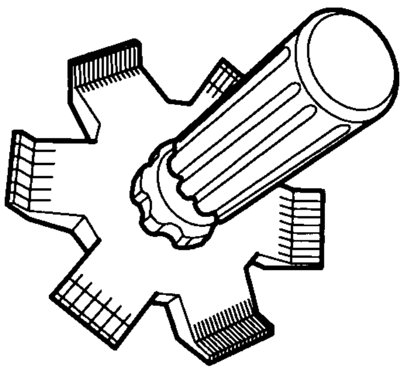


Figure 53 Fin Straightening Tool

7. Check evaporator, heater core, and blowers for material that could restrict air flow.

8. Install new air filter in air conditioning unit housing. Refer to GROUP 16-AIR CONDITIONING in the Master Service Manual for the vehicle being serviced.

9. Operate air conditioner system and check operation of controls.

10. Check operation of blower(s).

11. Check water control valve adjustment. (2000, 4000 and 8000 Series vehicles built after December 4, 1994, do not have a water valve.)

12. Check cooling system shutter operation (if installed). Refer to GROUP 12 in the Master Service Manual for the system being serviced for specific procedures and adjustment.

13. Operate the air conditioner and check the system for leaks with a leak detector, refer to LEAK DETECTION (See LEAK DETECTION, page 69).

14. Determine that the system is functioning properly. Refer to PHYSICAL CHECKS (See PHYSICAL CHECKS, page 30).

15. Verify that the system is cooling properly in the A/C modes and heating properly in the heat modes.

6.2. OFF-SEASON CARE

In general, any system containing automatic devices will function with less trouble if it is not permitted to remain idle over long periods. Therefore, the most important off-season care of the air conditioning system consists of periodic operation of the unit. Operating the unit for five minutes twice a month after engine warm-up keeps the compressor seals lubricated. If the seals dry out, they may crack and leak when the system is operated.

In addition, if the system is not operated periodically, clutch and compressor bearings could become brinneled. This is caused by the continual hammering effect on the bearing surface in the same spot from normal vibration during vehicle operation.

Do not remove compressor drive belt during the off-season, as clutch and compressor bearings may become brinneled.

7. SPECIAL TOOLS

CAUTION – The servicing tools recommended for this system were designed specifically for use with R-134a A/C systems. Servicing tools designed and/or used for R-12 A/C systems must not be used when servicing R-134a systems unless they are specifically identified as being compatible with both systems.

Servicing air conditioning efficiently and effectively requires proper tools and equipment. The recommended tools, as well as, alternate service tools are shown and discussed below.

The tools listed in the following table can be ordered through the International tool supplier. The tools shown in Figure 54 can be obtained from local sources.

Table 6 Special Service Tools

DESCRIPTION	PART NO.
Recovery/Recycling/Recharging Station (R-134a)	ZTSE4615
Manifold Gauge Set (R-134a)	ZTSE4623
Electronic Vacuum Gauge	ZTSE4620
Electronic Vacuum Gauge Manifold	ZTSE4624
Refrigerant Identifier	ZTSE4616
Electronic Leak Detector	ZTSE4617
Ultraviolet Lamp Leak Detector	ZTSE4618
Digital Thermometer	ZTSE4619
Evaporator Flush and Purge Adapter (for Systems using a Block Type Expansion Valve)	ZTSE4609
Condenser Flush and Purge Adapter (for Systems using a Block Type Expansion Valve)	
Adapter #8	ZTSE4613
Adapter #6	ZTSE4614
Block Fitting Adapters (for Systems using Sanden Compressors with 'Peanut' Fittings)	
Male Adapter, ½ Inch	ZTSE4503
Female Adapter, ½ Inch	ZTSE4504
Female Adapter, ¾ Inch	ZTSE4502
Fin Straightener	

Table 6 Special Service Tools (cont.)

DESCRIPTION	PART NO.
8, 9, 10, 12, 14, 15 Fins Per Inch	ZTSE4621
10.5, 11, 13, 18, 20, 22 Fins Per Inch	ZTSE4622
Dry Nitrogen, Cart, Regulator	Obtain Locally
Flush Gun	Obtain Locally
Ultrasonic Leak Detector (Optional)	Obtain Locally

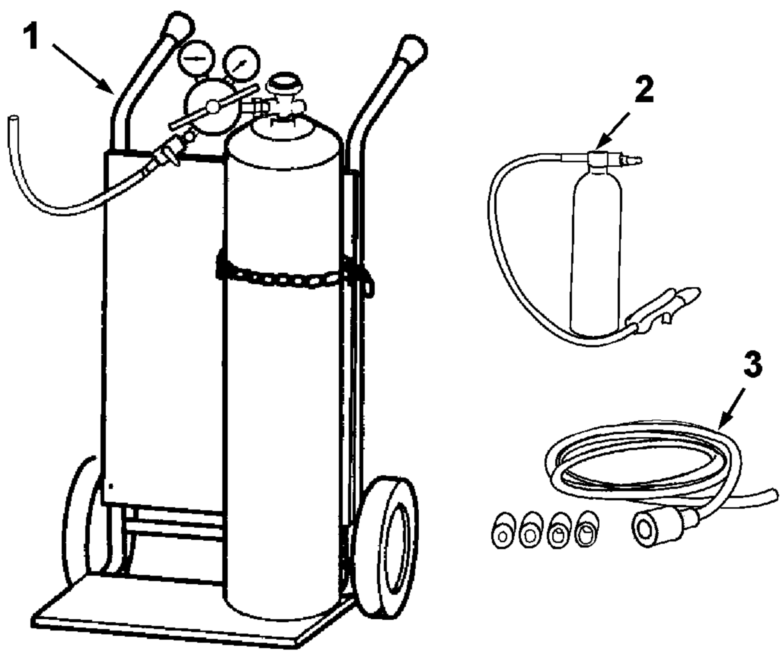


Figure 54 Service Tools that may be Obtained Locally

1. NITROGEN CYLINDER, REGULATOR AND CART
2. FLUSH GUN
3. DRAIN HOSE WITH COMPRESSION FITTING AND ADAPTERS

7.1. RECOVERY/RECYCLING/CHARGING STATION

The Recovery/Recycling/Charging Station (ZTSE4615) for R-134a is a totally integrated A/C service system, which recovers, recycles, evacuates, and charges R-134a quickly and accurately (refer to Figure 55).

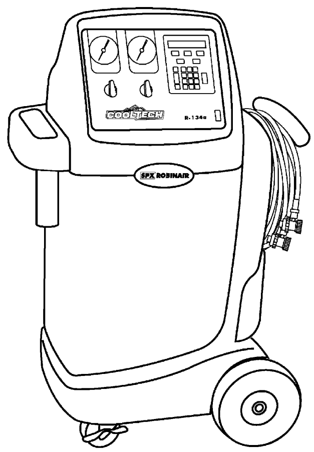


Figure 55 Recovery/Recycling and Charging Station, ZTSE4615

With its built-in manifold, all A/C service work is done with one hookup. The unit is programmed at its panel-mounted keypad. Computerized controls and solenoids precisely monitor evacuation and charging time. It is designed to automatically shut off after the recovery cycle. A moisture indicator will change from yellow to green when recycling is complete.

7.2. MANIFOLD AND GAUGE SET

The manifold gauge set (ZTSE4623) for R-134a systems consists of the necessary pressure and vacuum gauges, and control valves and fittings, for evacuating and charging air conditioning systems (refer to Figure 56). The unit features sidewheel style, color-coded valve handles, 63.5 mm (2.5 inch) vibration-free gauges, hose holders, a hanging hook, and two 183 cm (72 in) color-coded hoses with Metric SAE quick-connect fittings (with valves). The hose connection fittings on the manifold gauge set have Acme threads.

IMPORTANT – The manifold gauge set and service hoses **must be dedicated** to R-134a.

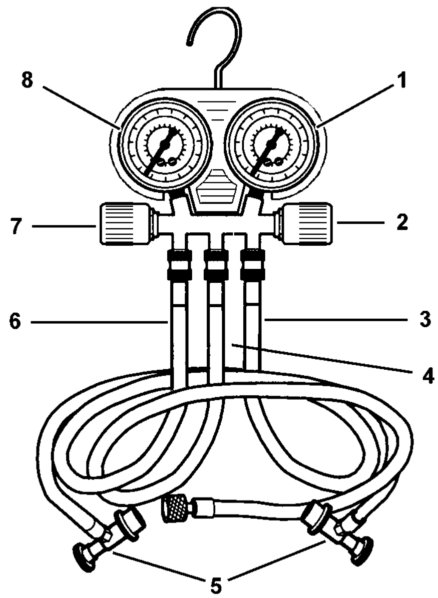


Figure 56 Manifold and Gauge Set (Shown with Hose Set and Quick-Connect Fittings)

1. HIGH PRESSURE GAUGE
2. HIGH PRESSURE VALVE
3. HIGH PRESSURE HOSE (RED)
4. SERVICE HOSE (YELLOW)
5. METRIC SAE QUICK CONNECT FITTINGS
6. LOW PRESSURE HOSE (BLUE)
7. LOW PRESSURE VALVE
8. LOW PRESSURE GAUGE

7.3. ELECTRONIC VACUUM GAUGE AND MANIFOLD

Before recharging the A/C refrigerant system, a vacuum must be drawn in the system to boil away all of the moisture in the system. A vacuum level of 500 to 1000 microns is sufficient to evacuate the system and remove all of the moisture. An accurate way to measure a vacuum at these levels is with an electronic vacuum gauge (refer to Figure 57). The electronic vacuum gauge (ZTSE4620) measures vacuum levels from 10 to 20,000 microns in twenty steps.

The vacuum gauge is susceptible to damage from high pressures. Therefore, it must be connected to the recovery station through a manifold that allows the gauge to be isolated from the recovery station low pressure line when high pressures are present (refer to Figure 58).

CAUTION – Close the valve on the electronic vacuum gauge manifold before recharging the A/C system.

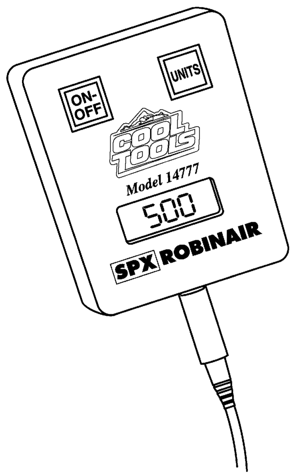


Figure 57 Electronic Vacuum Gauge, ZTSE4620

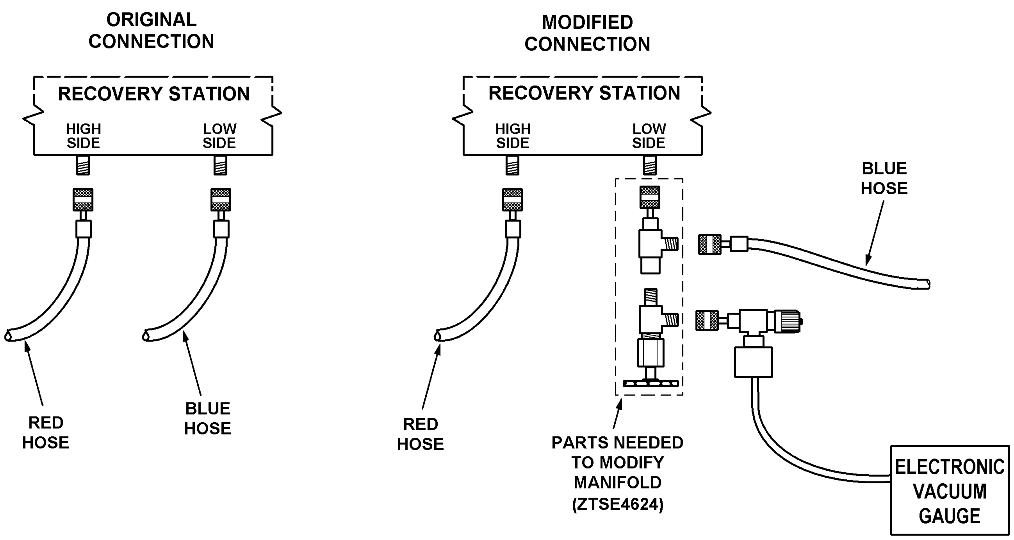


Figure 58 Electronic Vacuum Gauge Manifold, ZTSE4624

7.4. REFRIGERANT IDENTIFIER

In today's environment there are a lot of alternate and blended refrigerants. International only recognizes R-134a for the A/C systems covered in this manual. The only way to know for sure if you can safely recover the refrigerant in an A/C system is through the use of a refrigerant identifier (refer to Figure 59). The refrigerant identifier (ZTSE4616) samples the refrigerant; then displays the type and purity of the refrigerant in the system. The refrigerant identifier is supplied as part of a kit which includes the necessary hoses and fittings.

> **CAUTION – When red spots or discoloration begins to appear on the white outside diameter of the filter element, THE FILTER MUST BE REPLACED. Failure to properly maintain the sample filter may result in severe instrument damage that is not covered under warranty repairs.**

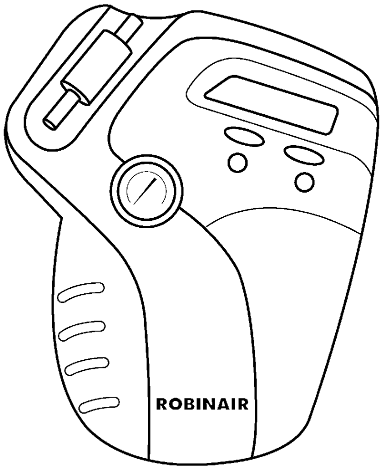


Figure 59 Refrigerant Identifier, ZTSE4616

7.5. ELECTRONIC LEAK DETECTOR

Electronic Leak Detector (ZTSE4617) detects leaks in air conditioning systems by utilizing 100 per cent solid state electronic circuitry (refer to Figure 60). An LED provides a low battery warning. The LED also indicates when calibration is accomplished without the usual, inconvenient, external reference leak source. An audio leak indicator ensures efficient operation even in bright sunlight. The power source is four "AA" alkaline batteries. This detector may be used for both R-12 and R-134a systems.

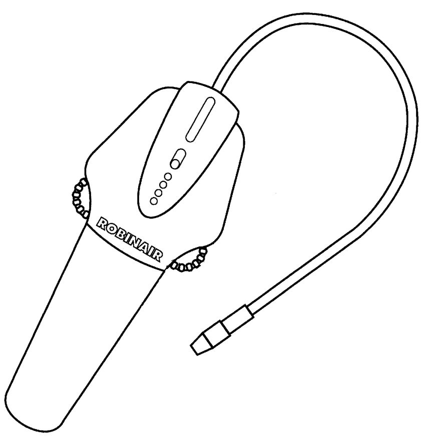


Figure 60 Electronic Leak Detector, ZTSE4617

7.6. ULTRAVIOLET LAMP LEAK DETECTOR KIT

An ultraviolet leak detector is used with phosphor dye to detect very minute leaks. Leak Detector (ZTSE4618) is for use under all ambient lighting conditions, **except** direct sunlight (refer to Figure 61). It uses a special self-ballasted bulb, which eliminates the need for an external transformer. When this light is shined on a suspected area, leaking refrigerant will be visible as a bright yellow-green glow. The leak detector kit includes the accessories needed to inject dye into other systems.

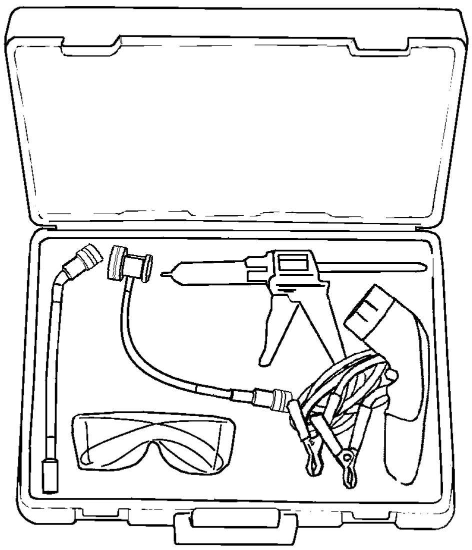


Figure 61 Ultraviolet Lamp Leak Detector Kit, ZTSE4618

7.7. DIGITAL THERMOMETER

Two thermometers are needed for A/C system testing and diagnostics. Digital thermometers provide a simple and accurate means of measuring air temperature (refer to Figure 62).

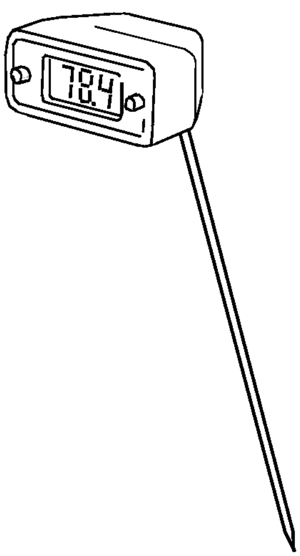


Figure 62 Digital Thermometer, ZTSE4619

7.8. FLUSH AND PURGE ADAPTERS

When performing flushing and/or purging operations, adapters are required to connect the service equipment to some of the HVAC system components. Also, using adapters provides a means of flushing and purging system components without removing them from the vehicle.

Evaporator Adapter (for Systems using a Block Type Expansion Valve)

For systems using the block type expansion valve, the evaporator adapter (Figure 63) allows flushing and purging of the evaporator without removing it from the vehicle.

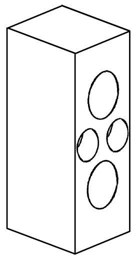


Figure 63 Evaporator Adapter

Condenser Adapter (for Systems using a Block Type Expansion Valve)

For systems using the block type expansion valve, the condenser adapter (Figure 64) allows flushing and purging of the condenser without removing it from the vehicle. Condensers with 'peanut' fittings must use the block fitting adapters listed below.

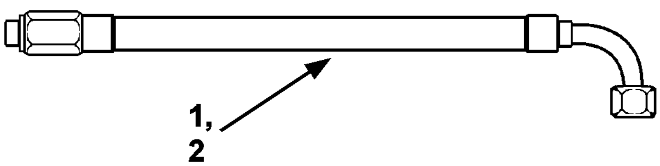


Figure 64 Condenser Adapter

1. ADAPTER #8, ZTSE4613
2. ADAPTER #6, ZTSE4614

Block Fitting Adapters (for Sanden Compressor Systems Using 'Peanut' Fittings)

For Sanden compressor systems using 'Peanut' fittings, these adapters (Figure 65) are used to flush and purge the condenser, evaporator, and refrigerant lines. The minimum quantities of each adapter, required to service the HVAC system, are indicated in the figure callout list.

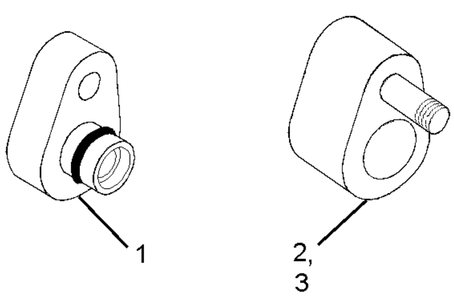


Figure 65 Block Fitting Adapters

1. MALE ADAPTER (1/2 INCH), ZTSE4503 (Minimum Required Quantity: 2)
2. FEMALE ADAPTER (1/2 INCH), ZTSE4504 (Minimum Required Quantity: 2)
3. FEMALE ADAPTER (3/4 INCH), ZTSE4502 (Minimum Required Quantity: 1)

7.9. FIN STRAIGHTENER

A fin straightener is a six-in-one tool used to clean and straighten condenser and evaporator coil fins (refer to Figure 66). Each comb section is identified with a number indicating the spacing of the fins (fins/inch) to be straightened with that section. Two fin straighteners are available to cover 16 different fin spacings. Part number ZTSE4621 is designed for 8, 9, 10, 12, 14, and 15 fins per inch. Part number ZTSE4622 is designed for 10.5, 11, 13, 18, 20, and 22 fins per inch.

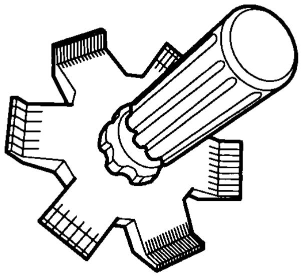


Figure 66 Fin Straightening Tool, ZTSE4621 and ZTSE4622

7.10. FLUSH GUN

If the refrigerant system has been contaminated, such as due to an internal compressor failure, it must be flushed and purged before it can be repaired and recharged. A flush gun (refer to Figure 67) is used, along with compressed dry nitrogen, to force a flushing agent through the hoses and components of the refrigerant system. The flush gun and drain hose with compression fitting/adapter can be obtained locally.

> **WARNING – The nitrogen supplied to the flush gun must not exceed 75 psi.**

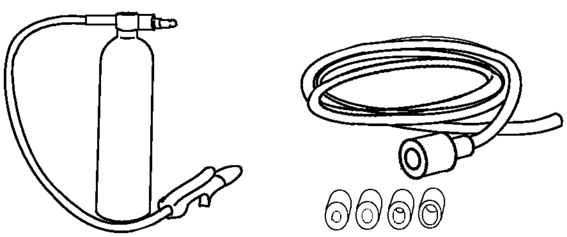


Figure 67 Flush Gun and Drain Hose (Obtain Locally)

7.11. ULTRASONIC LEAK DETECTOR (OPTIONAL)

An ultrasonic leak detector locates a leaking gas by the sound it makes as it passes through an opening. This hand-held device may include attachments to vary the directional sensitivity of the unit. Depending on the detector being used, a leak may be indicated by a visual or audible signal. Because this type of sensor does not sample the gas used in the system, it may be used with any refrigerant system. It may also be used to detect leaks in the vehicle air system.

8. SPECIFICATIONS

8.1. AIR CONDITIONING SYSTEM

Table 7 Air Conditioning System

Specification	CCI Compressor System	Sanden Compressor System
Refrigerant Type	R-134a	R-134a
Refrigerant Quantity (Full Charge)	8000 Series models with sleeper boxes: • 4.5 lbs. (2.0 kg) All 5000i/9000i models and all Pro Sleeper models with the side mounted filter access panel: • 4.0 lbs. (1.8 kg) All other models/configurations: • 3.5 lbs. (1.6 kg)	All 5000i/9000i models and all Pro Sleeper models with the side mounted filter access panel: • 3.0 lbs. (1.4 kg)
Compressor Oil Type	Synthetic Ester Oil - P/N ZGGR725007 Non-Synthetic Ester Oil - P/N ZGG19356	Polyalkylene Glycol (PAG) Oil International P/N: ZGGR6822
System Oil Capacity	16.0 fl.oz. (473 cc) NOTE: This is a reference value only. Refer to OIL FILL GUIDELINES to determine oil quantities during service (See OIL FILL GUIDELINES, page 62).	10.1 fl.oz. (300 cc) NOTE: This is a reference value only. Refer to OIL FILL GUIDELINES to determine oil quantities during service (See OIL FILL GUIDELINES, page 62).
Compressor Oil Level* (Vertical Mounting)	1 to 1-3/8 inch** (25.4 to 34.9 mm)	Compressor must be removed and drained to measure oil level.
Compressor Oil Level* (Horizontal Mounting)	1 to 1-7/16 inch** (25.4 to 36.5 mm)	Compressor must be removed and drained to measure oil level.
Compressor Oil Level* (45 Degree Mounting)	1-13/16 to 2-7/32 inch** (46.0 to 56.3 mm)	Compressor must be removed and drained to measure oil level.

Table 7 Air Conditioning System (cont.)

Specification	CCI Compressor System	Sanden Compressor System
Lubricating Oil Type (for O-rings, threads, etc.) **CAUTION – Do not use this oil as refrigerant oil.**	Mineral Oil International P/N: ZGGR6912	
Compressor Belt Drive Tension (Except Vehicles Equipped with Auto-Tensioner) Initial Tension (New Belt)	130 lbs. (578 N)	
Compressor Belt Drive Tension (Except Vehicles Equipped with Auto-Tensioner) Normal Tension (Used Belt)	100 lbs. (445 N)	
Low Pressure Switch (Normally Closed)*** Opens At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
Low Pressure Switch (Normally Closed)*** Closes At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
High Pressure Switch (Normally Open)*** Closes At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
High Pressure Switch (Normally Open)*** Opens At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
Shutter Switch (Normally Closed)*** Opens At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
Shutter Switch (Normally Closed)*** Closes At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
Fan Drive Switch (Normally Closed)*** Opens At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	
Fan Drive Switch (Normally Closed)*** Closes At:	Value varies by vehicle model and year; refer to the Group 8 ELECTRICAL CIRCUIT DIAGRAMS, in the MASTER SERVICE MANUAL, for the vehicle being serviced.	

Table 7 Air Conditioning System (cont.)

Specification	CCI Compressor System	Sanden Compressor System
* Measuring the compressor oil level with a dipstick, provides a rough measure of the quantity of oil in the compressor only. NOTE: Compressor oil level is a reference value only, used to determine the total system oil level. Refer to OIL FILL GUIDELINES to determine the correct oil quantities required when servicing the system (See OIL FILL GUIDELINES, page 62).		
** This level equals approximately 12 fl.oz. (355 cc) of oil: the amount present in the compressor during normal operation. Another 4 fl.oz. (118 cc) of additional oil is distributed throughout the system when the system is operating with the full 16 fl.oz. (473 cc) system capacity.		
*** Normally open or closed means the state of the device not being installed. The operating condition may or may not be the same. Normally open in a switch is opposite that in a valve. In a switch, the contacts are open and no current is conducted. In a valve, the poppet is open and air flows from the inlet port to the outlet port.		

Table 8 System Pressure Test Chart (for Models 1000, 2000, 4000, 5000, 8000, and All 9000 Models WITHOUT the Lowered Heater Box and Side Filter Access Cover)

Relative Humidity	Ambient Temperature		Refrigerant Pressure (PSI)		Register Temperature	
(Percent)	(°F)	(°C)	High	Low	(°F)	(°C)
Below 30%	70*	21.1*	125 - 155	7 - 11	36 - 42	2.2 - 5.6
	80	26.7	150 - 180	9 - 13	39 - 45	3.9 - 7.2
	90	32.2	165 - 200	10 - 16	40 - 48	4.4 - 8.9
	100	37.8	190 - 230	12 - 18	42 - 55	5.6 - 12.8
	110	43.3	230 - 275	13 - 21	43 - 58	6.1 - 14.4
Above 30%	70*	21.1*	135 - 165	8 - 14	36 - 44	2.2 - 6.7
	80	26.7	155 - 185	10 - 15	41 - 47	5.0 - 8.3
	90	32.2	170 - 205	11 - 17	42 - 52	5.6 - 11.1
	100	37.8	215 - 255	15 - 22	45 - 60	7.2 - 15.6
	110	43.3	250 - 295	18 - 27	50 - 65	10.0 - 18.3
*System may cycle at these ambient temperatures. Above readings will occur prior to compressor cycling.						

Table 9 System Pressure Test Chart (for 5000i/9000i Models and All 9000 Models WITH the Lowered Heater Box and Side Filter Access Cover)

Relative Humidity	Ambient Temperature		Refrigerant Pressure (PSI)		Center Air Duct Temperature	
(Percent)	(°F)	(°C)	High	Low	(°F)	(°C)
Below 30%	70	21.1	125 - 155	6 - 12	46 - 50	7.8 - 10.0
	80	26.7	150 - 180	10 - 14	52 - 56	11.1 - 13.3
	90	32.2	165 - 200	12 - 18	56 - 61	13.3 - 16.1
	100	37.8	190 - 230	16 - 20	60 - 64	15.6 - 17.8
	110	43.3	230 - 275	20 - 28	68 - 73	20.0 - 22.8
Above 30%	70	21.1	135 - 175	10 - 15	51 - 56	10.6 - 13.3
	80	26.7	155 - 185	12 - 18	53 - 57	11.7 - 13.9
	90	32.2	170 - 205	14 - 20	60 - 64	15.6 - 17.8
	100	37.8	215 - 255	20 - 25	68 - 73	20.0 - 22.8
	110	43.3	250 - 295	25 - 35	77 - 81	25.0 - 27.2

Table 10 Thermostatic Control Switch Cycle Points (Maximum A/C Setting)

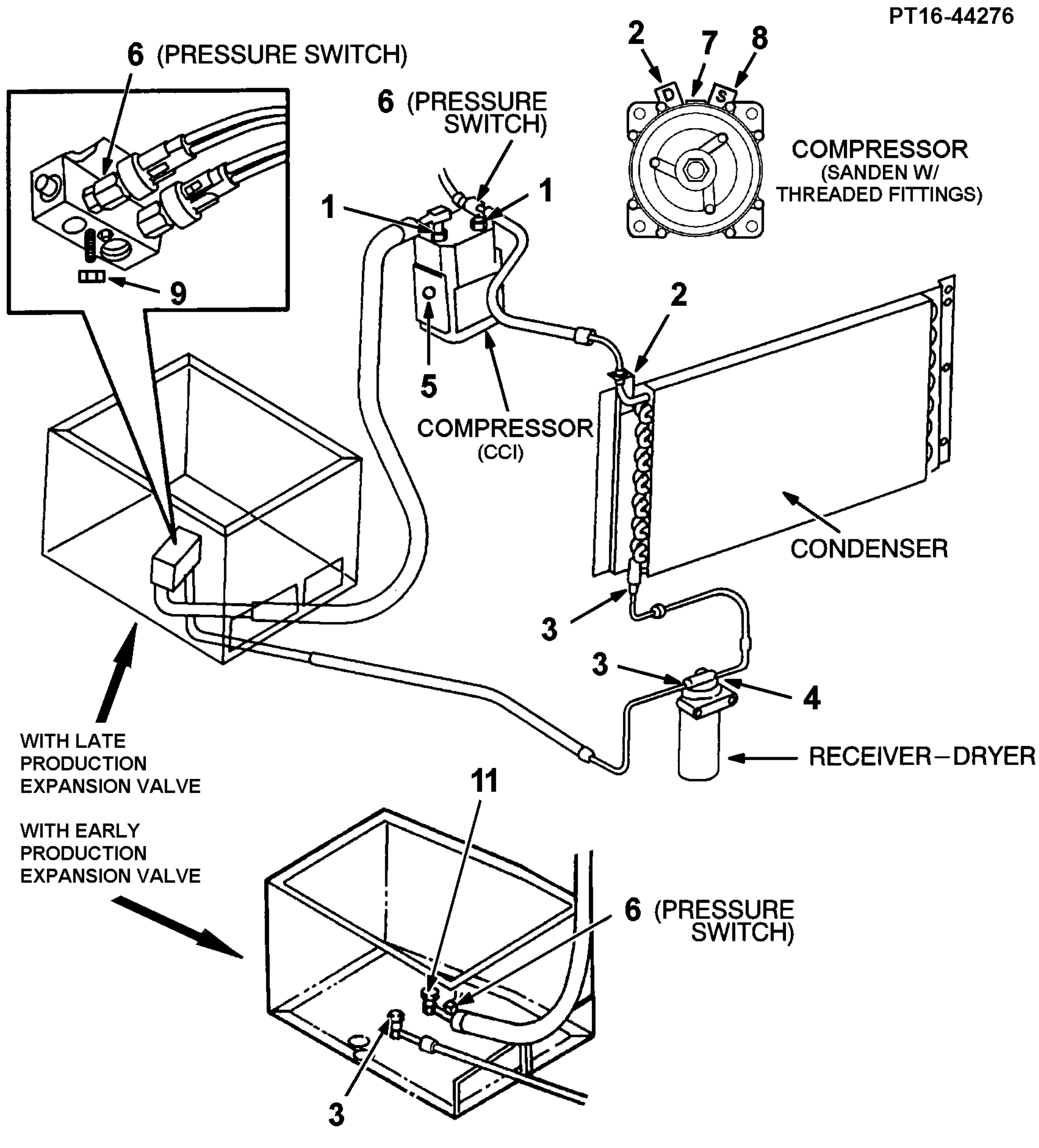
Models	A/C ON Temperature (Switch Closes)	A/C OFF Temperature (Switch Opens)
2000, 4000, 8000	≥42° to 46°F	≤32° to 36°F
5000, 5000i, 9000, 9000i, 9900ix	≥34° to 38°F	≤28° to 32°F

8.2. TORQUE CHART

Table 11 Torque Chart

Joint No. - Refer to Figure 68, Figure 69, and/or Figure 70	Thread Size	Torque		
		Lbf-ft	Lbf-in	Nm
1	1-14	40 to 44		54 to 60
2	3/4-16	22 to 26		30 to 35
3	5/8-18	15 to 19		20 to 26
4	11/16-16	15 to 19		20 to 26
5	3/8-24	4 to 11		5 to 15
6	7/16-20	7 to 11		9 to 15
7	Oil Fill Plug	11 to 15		15 to 20
8	7/8-14	22 to 26		30 to 35
9	6 mm		80 to 90	9 to 10
10	8 mm		170 to 190	19 to 21
11	1 1/16-14	46 to 50		63 to 68

Lubricate all O-rings and fitting threads with MINERAL-BASED oil.



A/C SYSTEMS BEFORE NOV. 1, 2002 (5000 AND 9000 SERIES MODELS)

Figure 68 Torque Location Diagram (5000 and 9000 Models Before Nov. 1, 2002)

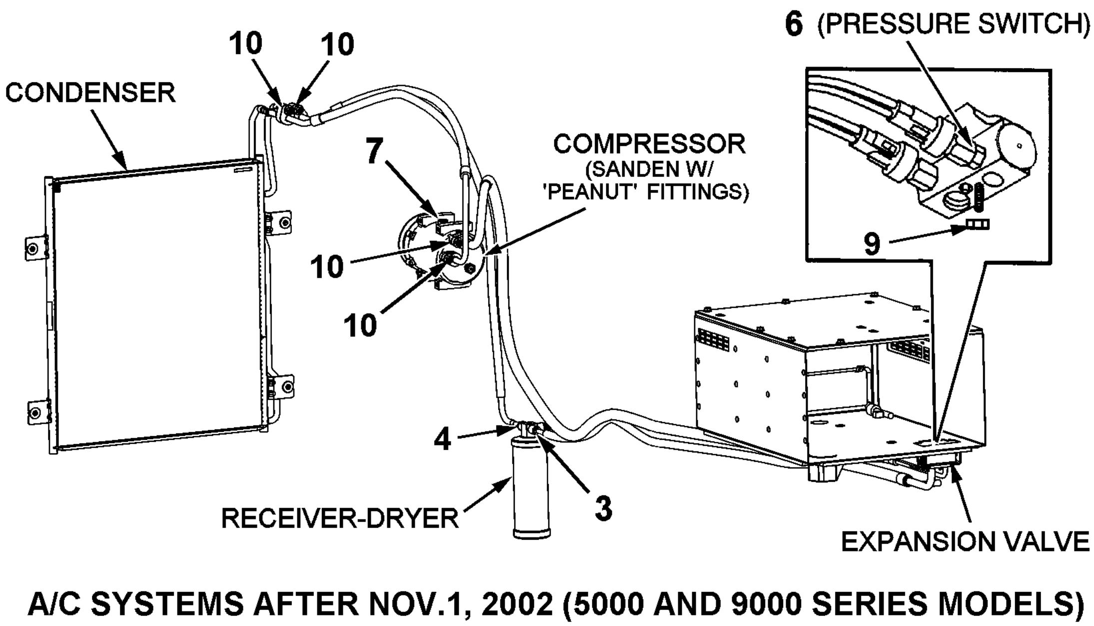


Figure 69 Torque Location Diagram (5000 and 9000 Models After Nov. 1, 2002)

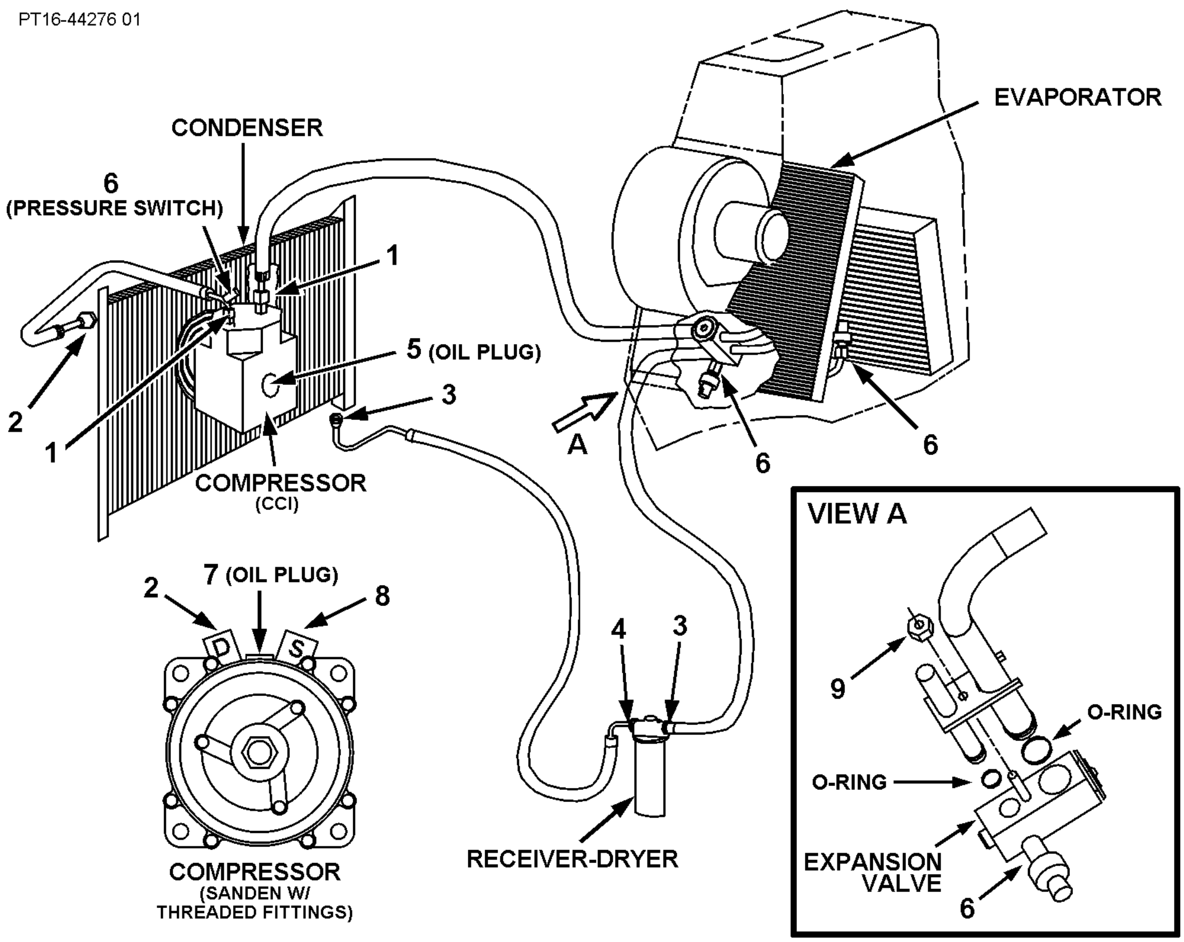


Figure 70 Torque Location Diagram (2000, 4000, and 8000 Series Models)

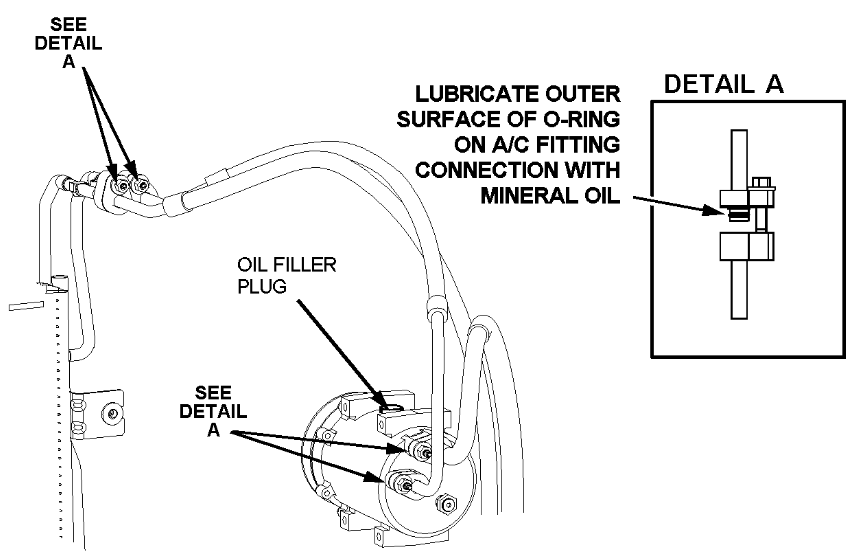


Figure 71 A/C ’Peanut’ Joint Assembly – Sanden Compressor Systems After November 1, 2002

9. GLOSSARY OF TERMS

Refer to the following terms for a better understanding of the heater/air conditioning system.

AIR CONDITIONING

- A device used to control the temperature, humidity, cleanliness and movement of air.

AIR PRESSURE

- The pressure exerted in every direction at any given point. Normal atmospheric pressure (that is, the pressure caused by the weight of the atmosphere) at sea level is 14.696 psi (101.60 kPa).

AMBIENT AIR TEMPERATURE

- The temperature of air around an object; the outside temperature.

BLOWER

- A motor and fan used to draw air through the evaporator, and force it through the heater core and into the cab.

BLOWER SPEED CONTROL RESISTORS

- Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the speed.

BOILING POINT

- The temperature at which a liquid changes to a gas, at a certain pressure.

BULK CHARGING

- Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

CFM

- Cubic feet per minute.

CHARGE

- A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

COLD

- The absence of heat. (The lowest possible temperature is believed to be -459 degrees F (-273 degrees C.).

COMPRESSOR

- An assembly used to draw low pressure, low temperature refrigerant gas from the evaporator and squeeze it into a high pressure, high temperature gas. This causes the refrigerant to have a higher temperature than the surrounding air, allowing the condenser to change the gas back into a liquid. A secondary purpose of the compressor is to move refrigerant and oil through the system.

CONDENSATE

- Water, taken from the air, which forms on the outer surface of the evaporator.

CONDENSER

- A heat exchanger that is used to remove heat from refrigerant, changing it from a high temperature, high pressure gas into a high temperature, high pressure liquid.

CONDENSING PRESSURE

- Pressure, as read from the gauge at the discharge service port; pressure from the discharge side of the compressor into the condenser; high side pressure; discharge pressure.

CONTAMINANTS

- Anything other than refrigerant or refrigerant oil in the system. Usually means water in the system.

DEHUMIDIFY

- To remove water from the air, at the evaporator coils.

DESICCANT

- A drying agent used in the refrigerant system (in the receiver-dryer) to remove moisture.

DISCHARGE

- To remove some or all of the refrigerant from the air conditioning system using a recovery/recycling station.

DISCHARGE LINE

- Connects the refrigerant compressor outlet to the condenser inlet.

DISCHARGE PRESSURE

- Pressure of the refrigerant leaving the compressor; high side pressure; condensing pressure.

DISCHARGE SERVICE PORT

- A device typically located in the refrigerant line attached to the discharge side of the compressor; it allows high side pressure to be checked.

DRYING AGENT

- See "Desiccant."

ELECTRONIC VACUUM GAUGE

- A high vacuum gauge sensitive to pressures ranging from atmospheric pressure to 10 microns, with scales reading from 20,000 microns to 10 microns.

EVACUATE

- Evacuation places a vacuum in the refrigerant system, it dehydrates all traces of moisture and is used to determine if the system has any leaks before installing a charge of refrigerant in the system.

EVAPORATE

- A change of state from a liquid to a gas.

EVAPORATOR CORE

- A component of the air conditioning system in which liquid refrigerant changes to a gas after it absorbs heat from the air. Also collects cab moisture.

EXPANSION VALVE

- A device that causes a pressure drop of the refrigerant and also regulates flow.

FLUSHING

- A process of forcing a flushing agent through a contaminated system component. Flushing is used to remove heavy contaminants that cannot be removed by purging.

FREEZE-UP

- Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator coils or fins.

HEAD PRESSURE

- Refrigerant pressure from the discharge side of the compressor to the condenser and expansion valve.

HUMIDITY

- The amount of water vapor in the air.

HYDRAULIC LOCK

- The return of liquid refrigerant to the compressor which could damage the compressor.

LEAK DETECTOR

- A device used to detect a leak in the air conditioning system.

LOW SUCTION PRESSURE

- Low side pressure that is lower than normal due to a system problem.

MAGNETIC CLUTCH

- An electrical coupling device used to engage or disengage the refrigerant compressor.

MANIFOLD GAUGE SET

- A manifold that is complete with gauges and charging hoses and used to measure or test pressure.

MICRON

- A metric measurement of mercury, (1.0 mm/Hg = 1000 microns and 0.1 in/Hg = 2540 microns). Measurement in microns is the only accurate way to determine the amount of pressure that is left in a refrigerant system by a high vacuum pump.

NITROGEN

- A colorless, orderless, dry, inert gas that can be used to purge light contaminants from air conditioning parts.

OVERCHARGED

- Too much refrigerant or oil in the system.

PURGE

- To remove damp air, traces of refrigerant, and loose dirt by purging with dry nitrogen.

RECEIVER-DRYER

- A combination desiccant, filter, and storage container for liquid refrigerant.

REFRIGERANT (R-134a)

- The cooling agent used in automotive air conditioning systems.

REFRIGERATION CYCLE

- The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

RESISTOR

- A voltage dropping device, usually wire wound, for controlling fan speed.

SENSOR (TEMPERATURE)

- A temperature-sensing unit that is used to sense air temperatures and provide a control voltage for operation of automatic temperature control units.

SUCTION PRESSURE

- Compressor inlet pressure (the system low side pressure).

SUCTION SIDE SERVICE PORT

- A device located in the refrigerant line connected to the suction side of the compressor that allows low side pressure to be checked, and other service operations to be performed.

THERMOSTATIC SWITCH

- A temperature sensitive switch used to control system temperature and prevent evaporator freeze-up; it does this by controlling compressor operation.

VACUUM

- Refers to pressure that is less than atmospheric pressure.

VACUUM PUMP

- A mechanical device used to evacuate and place a high vacuum in the refrigerant system.

VAPOR

- The gaseous state of material.

WATER VALVE

- A valve, mechanically operated to control the flow of hot coolant to the heater core.