General Information

The Blend Air heating, ventilating, and air conditioning (HVAC) system uses a brushless blower motor. The rate of airflow is controlled by an eight-speed fan switch. Air outlets are located in the instrument panel, along the bottom of the dash, at the windshield, and at the side windows.

The temperature in the driver's area can be controlled by the temperature control switch on the climate control panel.

The air selection switch on the control panel is used to select the direction of warm or cool air through the driver's area.

On vehicles with air conditioning, a recirculation button on the control panel allows the driver to recirculate the air in the driver's area and prevent fresh or outside air from entering the system. Press the recirculation button to start the recirculation mode. After 20 minutes in recirculation mode, the system will go in to partial recirculation mode. After five minutes in partial recirculation mode, the system will automatically resume full recirculation for another 20 minutes. The full and partial recirculation cycle will repeat as long as the system remains in recirculation mode. If the recirculation button is pressed when the system is in full or partial recirculation mode, the recirculation mode will be canceled. The driver may notice a slight change in the sound within the bus as the system goes in to and out of partial recirculation mode. The change in the sound is normal.

Description of Components

Climate Control Panel (control head)

The fan switch, air selection switch, and the temperature control switch are mounted on the climate control panel, which is also called the control head. On HVAC systems with air conditioning, the air recirculation button is mounted on the climate control panel.

The climate control panel is controlled by a microprocessor and backlit with LEDs (light-emitting diodes).

Refrigerant

Refrigerant absorbs heat from the air in the bus and releases it to the air outside the bus.

In an open container, refrigerants boil at temperatures below the freezing point of water. Sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

During compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the condenser passes through the expansion valve and moves into the low-pressure area of the evaporator.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator as needed.

Evaporator

Because the evaporator is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water; the air becomes dehumidified.

Refrigerant Compressor

Heat in the low-pressure gas of the evaporator is not heat that can be noticed by touch because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the heated gas in the evaporator is very cold.

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

Another function of the compressor is to move refrigerant through the system.

Condenser

A condenser turns hot refrigerant gas coming from the compressor into liquid. The condenser is mounted below the radiator. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward.

Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, a receiver-drier also removes water and acids from the refrigerant. The water-absorbing material, or desiccant, in the unit helps stop blockages from forming in the expansion valve and in other parts of the system.

Evaporator Probe

The temperature of the evaporator is monitored by a variable resistance temperature probe. As the temperature of the evaporator increases, the temperature probe resistance decreases. The evaporator temperature probe is connected to the control head, which controls operation of the refrigerant compressor through the bulkhead module in order to prevent the evaporator core from freezing. When the evaporator temperature reaches 38.3°F (3.5°C), the control head sends a message to the bulkhead module to disengage the refrigerant compressor clutch. The refrigerant compressor will not resume operation until the temperature has risen above 40.1°F (4.5°C).

Actuator

The actuator is a combined motor and gearbox and is used to drive the levers and doors within the HVAC assembly. Movement of the levers and doors is controlled by the settings on the climate control panel. A proportional feedback signal is returned from each actuator to the control panel to provide current position information. There are three actuators on the HVAC assembly: a temperature blend actuator, a recirculation actuator, and an air distribution actuator.

Fan Cycling Switch

Located on the receiver-drier, the fan cycling switch sends a ground signal to the ECM (electronic control module) to keep the fan off and takes away the ground to engage the fan. The fan will come on if the refrigerant pressure is greater than 300 ±10 psi (2070 kPa ±69 kPa). The fan turns off when the pressure drops below 250 ±10 psi (1725 kPa ±69 kPa).

Binary Switch

The binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

1. If the refrigerant system pressure is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when the pressure on the high pressure side of the system falls between 27 to 35 psi (186 to 241 kPa). Normal compressor operation resumes when the rising pressure reaches 28 to 36 psi (193 to 248 kPa) above the shutoff pressure. This occurs when the ambient temperature falls to around 36°F (2°C) or when refrigerant has leaked out of the system.

NOTE: Since the binary switch is on the high pressure side, the compressor may continue to operate (trying to cool the bus) if most, but not all, of the refrigerant leaks out of the system until the air conditioner is turned off or the vehicle is shut down for a short time. Continuing to run the compressor with a low charge can lead to a lack of lubrication and high temperatures in the compressor.

2. If the refrigerant system pressure on the high pressure side increases to between 426.5 to 483.5 psig (2941 to 3334 kPa), the binary switch shuts off the compressor clutch. Too much pressure may be caused by excess refrigerant in the system or anything that causes poor condenser performance such as poor air flow through the condenser. When the system pressure has decreased to 313 to 426 psig (2158 to 2937 kPa), the compressor resumes operation.

Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Blower Motor

The brushless blower motor forces air through the HVAC assembly and through the ductwork.

Definition of Terms

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

Actuator The actuator is a combined motor and gearbox used to drive the temperature blend, recirculation, and air distribution levers and doors within the HVAC assembly.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the driver's area.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Binary Switch Disengages the refrigerant compressor to protect it from harmful operating conditions.

Blower Motor A brushless blower motor forces air through the HVAC assembly and through the duct work.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

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

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.

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 the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid.

Condensing Pressure Pressure as read from the gauge at the discharge service valve. Pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water in the system. When water and refrigerant mix, corrosive hydrochloric acid forms.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. Normally called evacuation.

Desiccant A drying agent used in the receiver-drier to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Drive Pulley A V-pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one area to another.

Evacuate To place a high vacuum in the air-conditioning system and dehydrate or remove all traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the air.

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

Flooding A condition caused by too much liquid refrigerant going into the evaporator, usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as grit.

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

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the driver's area or to adjust the temperature produced by the air conditioner.

High-Side Service Valve A device located on the liquid line. It allows high-side pressure to be checked and other service operations to be performed.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

General Information

Liquid Pressure Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

Low-Air Pressure Switch An air operated electrical switch that is normally open, but closes when the system pressure rises to 65 to 75 psi (450 to 515 kPa). Its purpose is to prevent the refrigerant compressor from turning on if the air system pressure is too low to activate the cooling fan.

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

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 compressor.

Manifold A device to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

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

Micron A metric unit of length equal to one-millionth of a meter. The unit of measure used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

psia Pounds per square inch. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig Pounds per square inch gauge pressure. Any pressure above normal atmospheric pressure (14.7 psi) is referred to as gauge pressure.

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

Recovery Removal of the refrigerant from air conditioning systems.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant 134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. Another purpose of the compressor is to move refrigerant through the system.

Refrigerant Oil A highly refined synthetic oil used in R–134a air conditioning systems.

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

Relative Humidity The actual water content of the air in relation to the total water vapor the air can hold at a given temperature.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, internal system vacuum levels after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury with scales reading from 25,000 microns to 1 micron of mercury.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

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.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Principles of Operation

In a Blend Air system, the heater core is always filled with hot water. Air enters the HVAC assembly through the blower and is always directed through the evaporator. If the refrigerant compressor is engaged, the air is cooled. The temperature blend doors then direct the air through or around the heater core depending on the climate control settings. The temperature blend doors are used to blend the correct amount of cold and hot air to achieve the selected temperature. The temperature blend, air distribution, and recirculation levers and doors are controlled by actuators.

Heater

Moving the temperature control switch toward maximum heat allows more airflow through the heater core fins.

Air Conditioner

When the air conditioner is on, the motion of the compressor squeezes the refrigerant into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid. After it is compressed, refrigerant gas moves out of the discharge port of the compressor and on to the condenser.

At the condenser, air passing over the fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the pressure of the liquid, causing it to expand. The pressure drop lowers the boiling point of the refrigerant and causes it to evaporate quickly as it absorbs heat from air passing over the evaporator. The resulting cool air is forced into the driver’s area by the blower. The heated refrigerant gas is drawn back into the compressor where the cycle is repeated.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

R–134a refrigerant is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come in contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (38 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

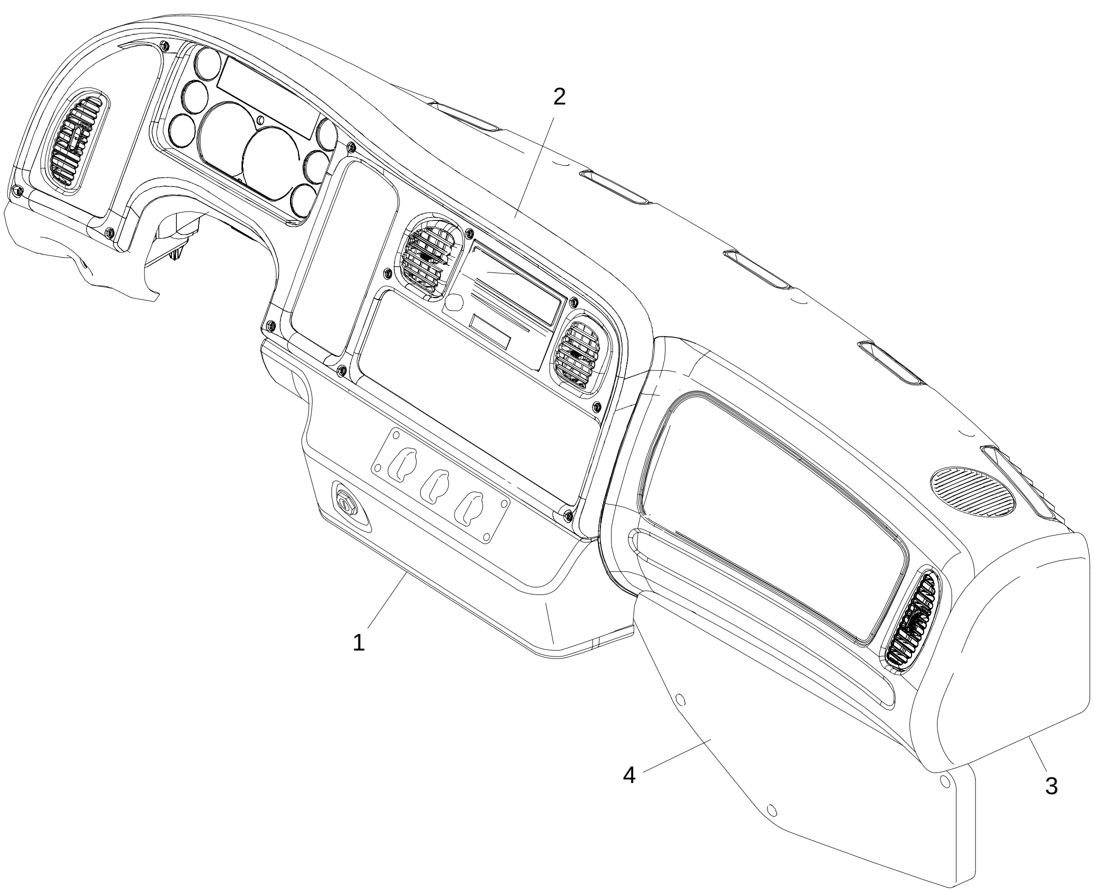
On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Heater Core Replacement

Replacement

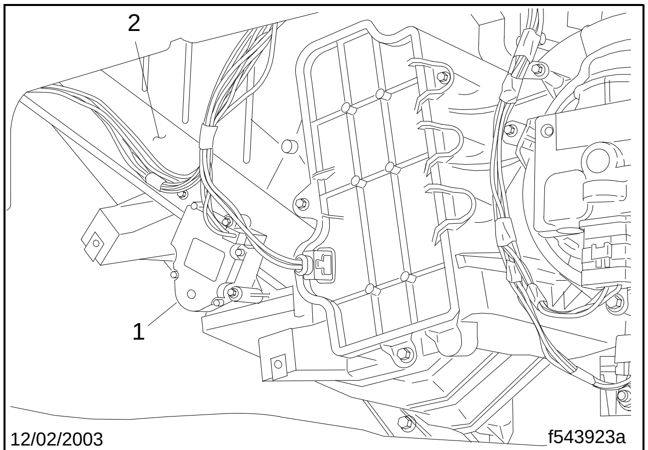
1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the air cleaner. For instructions, see **Section 09.01**, Subject 110.
4. Remove the surge tank. For instructions, see **Section 20.01**, Subject 130.
5. Remove the Torx® capscrew that attaches the coolant lines to the heater core. Remove the coolant lines from the heater core.
6. Remove the following dash panels inside the bus. See **Fig. 1**. For instructions, see **Section 75.11**.
   - lower HVAC cover
   - trim plate panel
   - lower dash panel
   - end cap
7. Remove the capscrews that attach the temperature blend actuator to the HVAC assembly and remove the temperature blend actuator. See **Fig. 2**.
8. Remove the capscrews that attach the HVAC wiring harness to the HVAC assembly.
9. If the original heater core is being replaced, use a sharp utility knife to cut within the groove on the



1. Lower Dash Panel
2. Trim Plate Panel
3. End Cap
4. Lower HVAC Cover

Fig. 1, Dash Panels

Heater Core Replacement



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1. Temperature Blend Actuator
2. Heater Core Service Cover

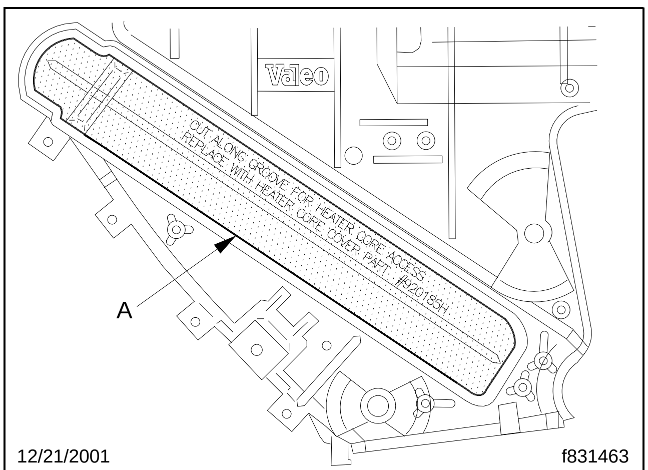
Fig. 2, HVAC Assembly

heater core access panel. Remove and discard the heater core access panel. See **Fig. 3**.

If there is a heater core service cover in front of the heater core, remove the service cover.

WARNING

Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the heater core fins.



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A. Cut within the groove on the heater core access panel.

Fig. 3, Heater Core Access Panel

IMPORTANT: A small amount of antifreeze may be present in the heater core. Protect the interior of the vehicle to prevent any damage from an antifreeze spill.

10. Wearing protective gloves, remove the heater core and drain any remaining coolant from the heater core.
11. Remove any debris or coolant that may be in the heater core housing.
12. Wearing protective gloves, install a new heater core in the HVAC assembly.
13. Using a Torx capscrew, attach the coolant lines to the heater core.
14. Attach the heater core service cover to the HVAC assembly.
15. Using capscrews, attach the HVAC wiring harness to the heater core service cover, securing both the wiring harness and the cover.
16. Using capscrews, attach the actuator to the heater core service cover and the HVAC assembly.
17. Install the dash panels. For instructions, see **Section 75.11**.
18. Install the surge tank. For instructions, see **Section 20.01**, Subject 130.
19. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
20. Connect the batteries.
21. Remove the chocks from the tires.

Evaporator Replacement

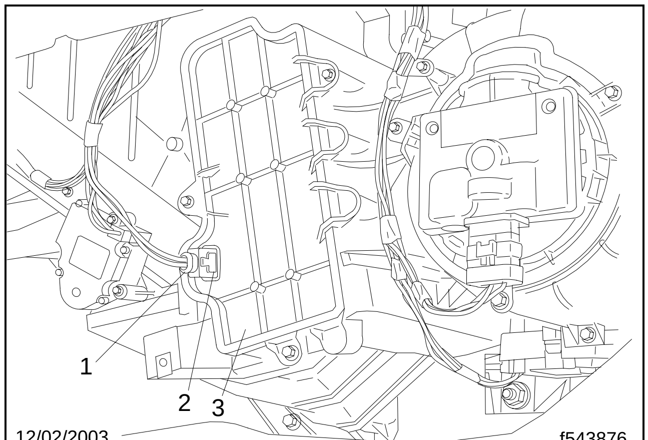
Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the air cleaner. For instructions, see **Section 09.01**, Subject 110.
5. Remove the surge tank. For instructions, see **Section 20.01**, Subject 130.
6. Remove the capscrew that attaches the refrigerant lines to the expansion valve and remove the refrigerant lines. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the capscrews that attach the expansion valve to the evaporator lines.
8. Remove the lower HVAC cover inside the bus. For instructions, see **Group 75**.
9. Rotate the evaporator probe counterclockwise and pull the evaporator probe out of the evaporator service cover. See **Fig. 1**.
10. Remove the capscrews that attach the evaporator service cover to the HVAC assembly. Remove the evaporator service cover.
11. Remove the filter and the evaporator.
12. Remove the expansion valve from the evaporator.
13. Make sure the new evaporator is covered with the evaporator liner and the evaporator grommet is installed on the evaporator.
14. Uncap the evaporator lines.
15. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the evaporator lines. Do not lubricate the Mini Stat-O-Seals prior to installation.
16. Using capscrews, install the expansion valve on the evaporator lines. Torque the capscrews 35 lbf·in (395 N·cm).
17. Install the evaporator in the HVAC assembly.
18. Uncap the refrigerant lines.
19. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate the Mini Stat-O-Seals prior to installation.
20. Connect the refrigerant lines to the expansion valve. Torque the capscrew on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
21. Remove the condensate seal from the lower portion of the evaporator service cover, and install a new condensate seal in the same location on the service cover. See **Fig. 2**.
22. Using capscrews, attach the evaporator service cover to the HVAC assembly.

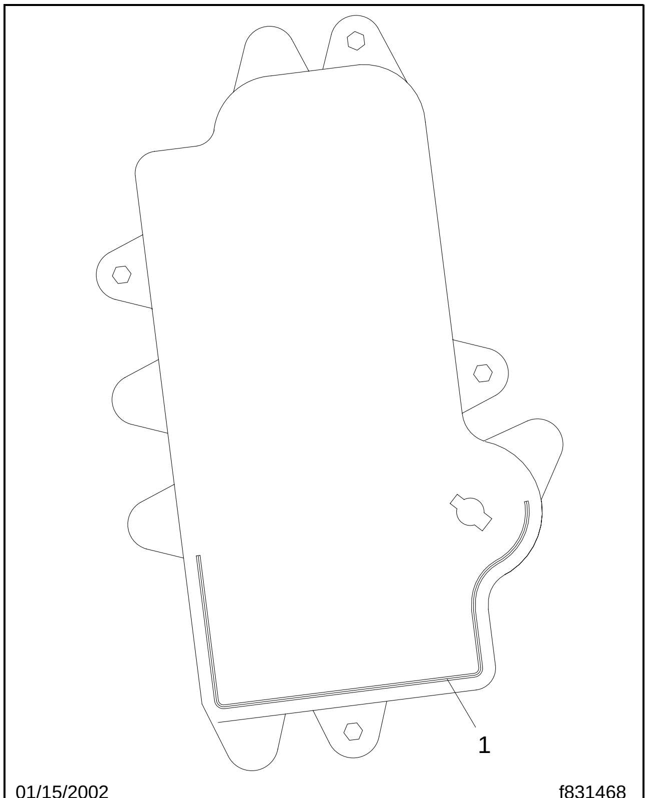
    If a tapped hole that is used to mount the evaporator service cover to the HVAC assembly becomes stripped, drill a new hole in one of the alternative mounting locations on the HVAC assembly. Use a 1/4-inch (6-mm) drill bit to make a new tapped hole. See **Fig. 3**.
23. Install the evaporator probe in the evaporator service cover.
24. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
25. Install the surge tank. For instructions, see **Section 20.01**, Subject 130.



1. Evaporator Probe Wiring Harness
2. Evaporator Probe
3. Evaporator Service Cover

Fig. 1, Evaporator Probe and Service Cover

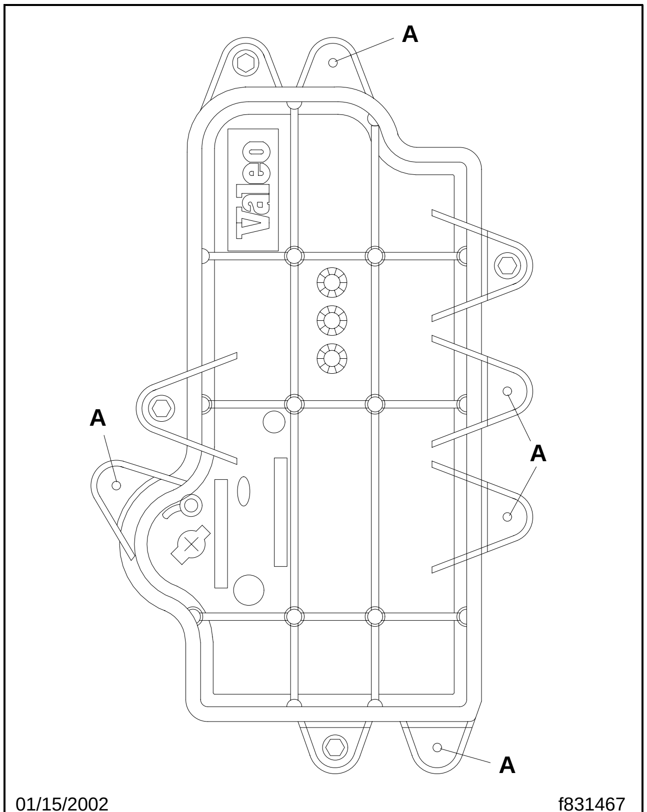
Evaporator Replacement



1. Condensate Seal

Fig. 2, Evaporator Service Cover

26. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
27. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. See **Section 83.01**, Subject 130.
28. Return the hood to the operating position.
29. Remove the chocks from the tires.



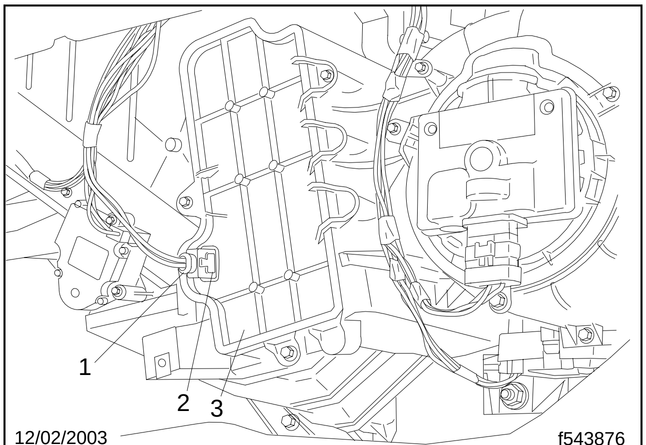
A. Drill a tapped hole in any of these alternative mounting locations.

Fig. 3, Evaporator Service Cover

Evaporator Probe Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the lower HVAC cover. For instructions, see **Group 75**.
3. Press the metal retainer on the wiring harness connector to disconnect the wiring harness from the evaporator probe. See **Fig. 1**.
4. Rotate the evaporator probe counterclockwise and pull the evaporator probe out of the evaporator service cover.
5. Install a new evaporator probe in the evaporator service cover.
6. Attach the wiring harness to the evaporator probe.
7. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
8. Remove the chocks from the tires.



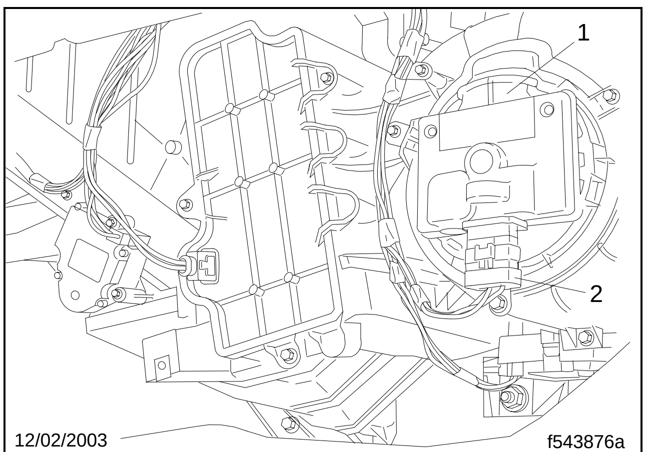
1. Evaporator Probe Wiring Harness Connector
2. Evaporator Probe
3. Evaporator Service Cover

Fig. 1, Evaporator Probe

Blower Motor Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the lower HVAC cover. For instructions, see **Group 75**.
4. Disconnect the wiring harness from the blower motor. See **Fig. 1**.
5. Remove the capscrews that attach the blower motor to the HVAC assembly and remove the blower motor.
6. Using capscrews, install the new blower motor on the HVAC assembly.
7. Attach the wiring harness to the blower motor.
8. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
9. Connect the batteries.
10. Remove the chocks from the tires.



1. Blower Motor
2. Blower Motor Wiring Harness

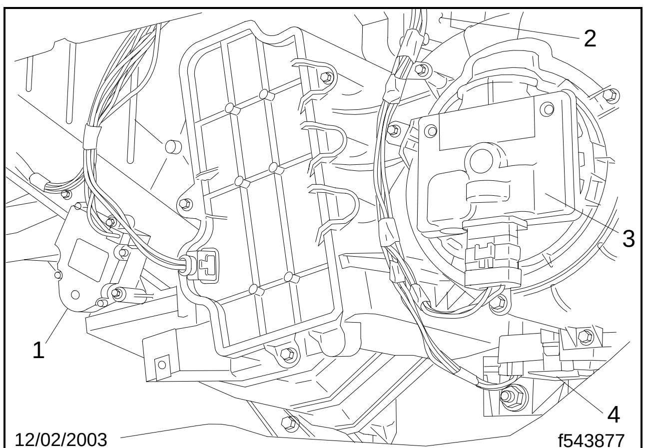
Fig. 1, Blower Motor

Temperature Blend Actuator Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the lower HVAC cover. For instructions, see **Group 75**.
3. Disconnect the wiring harness from the temperature blend actuator. See **Fig. 1**.
4. Remove the capscrews that attach the actuator to the HVAC assembly and remove the actuator.
5. Using capscrews, install the new actuator on the HVAC assembly. Make sure that the actuator is correctly aligned on the door extension.
6. Attach the wiring harness to the temperature blend actuator.
7. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
8. Remove the chocks from the tires.

Air Distribution Actuator Replacement

1. Turn off the engine, apply the brakes, and chock the tires.



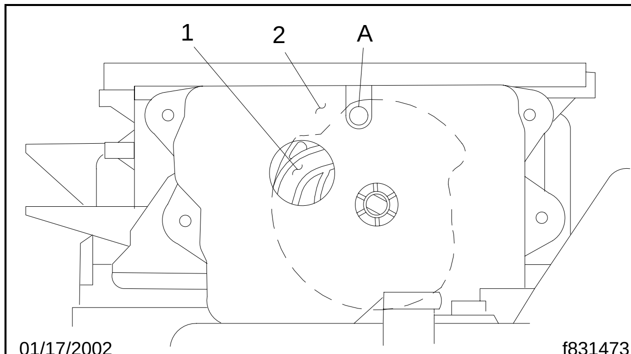
1. Temperature Blend Actuator
2. Air Distribution Actuator
3. Blower Motor
4. Recirculation Actuator

Fig. 1, Actuators

2. Remove the lower HVAC cover. For instructions, see **Group 75**.
3. Disconnect the wiring harness from the air distribution actuator. See **Fig. 1**.
4. Remove the capscrews that attach the actuator to the mounting plate and remove the actuator.
5. Before installing a new actuator, rotate the cam behind the mounting plate so that the alignment hole in the cam is aligned with the hole in the HVAC assembly. See **Fig. 2**.

IMPORTANT: If the alignment hole in the cam is not aligned with the hole in the HVAC assembly, the actuator could be installed with the cam 180 degrees from the correct position. Incorrect alignment of the cam will prevent the air distribution doors from operating correctly.

6. Using capscrews, install the new actuator on the mounting plate. Make sure that the actuator is correctly aligned on the door extension.
7. Attach the wiring harness to the air distribution actuator.
8. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
9. Remove the chocks from the tires.



A. Align the hole in the cam with the hole in the HVAC assembly.

1. Cam
2. Mounting Plate

Fig. 2, Cam Alignment for the Air Distribution Actuator

Actuator Replacement

Recirculation Actuator Replacement

NOTE: The recirculation actuator is equipped only on vehicles with air conditioning.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the lower HVAC cover. For instructions, see **Group 75**.
3. Disconnect the wiring harness from the recirculation actuator. See **Fig. 1**.
4. Remove the capscrews that attach the actuator to the HVAC assembly and remove the actuator.
5. Using capscrews, install the actuator on the HVAC assembly. Make sure that the actuator is correctly aligned on the door extension.
6. Attach the wiring harness to the recirculation actuator.
7. Attach the lower HVAC cover to the dash panel. For instructions, see **Group 75**.
8. Remove the chocks from the tires.

Heater and Air Conditioner Assembly or Heater Assembly Replacement

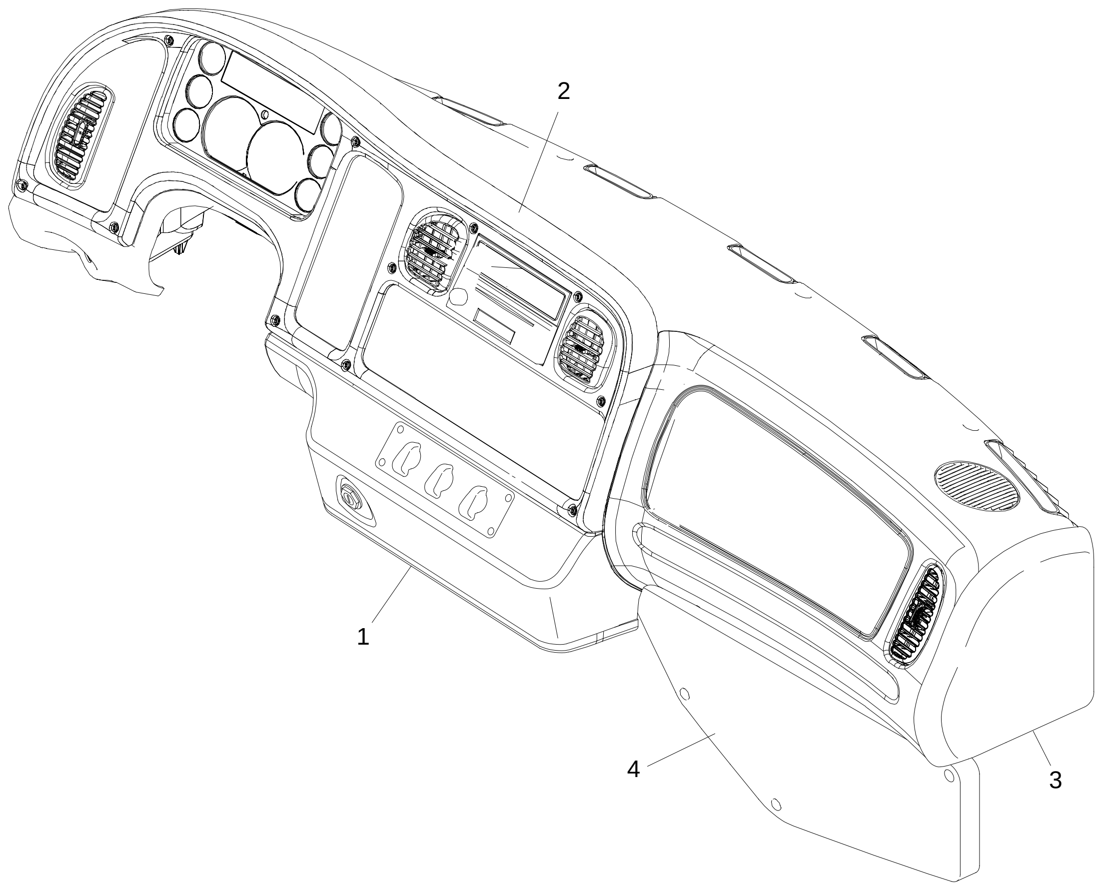
Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the surge tank. For instructions, see **Section 20.01**, Subject 130.
4. Remove the air cleaner. For instructions, see **Section 09.01**, Subject 110.
5. If equipped with an air conditioner, recover the refrigerant from the air conditioning system. For instructions, see **Section 83.00**, Subject 220.
6. Remove the Torx® capscrew that attaches the coolant lines to the heater core and remove the coolant lines.
7. Remove the capscrew that attaches the refrigerant lines to the expansion valve and remove the refrigerant lines. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through the refrigerant lines since shop air is wet (humid).

8. Remove the following dash panels inside the bus. See **Fig. 1**. For instructions, see **Section 75.11**.
    - lower HVAC cover
    - trim plate panel
    - lower dash panel
    - end cap
9. Disconnect the two HVAC wiring harnesses.
10. Remove the capscrews, nuts, and washers that attach the heater and air conditioner assembly or heater assembly to the dash and frontwall and remove the assembly.
11. Using capscrews, nuts, and washers, attach the new heater and air conditioner assembly or heater assembly to the dash and frontwall. Torque the capscrews 72 to 96 lbf·in (810 to 1080 N·cm). Torque the nuts 18 to 19 lbf·ft (24 to 26 N·m).
12. Connect the two HVAC wiring harnesses.
13. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate the Mini Stat-O-Seals prior to installation.
14. Using a capscrew, attach the refrigerant lines to the expansion valve. Torque the capscrew on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
15. Using a Torx capscrew, attach the coolant lines to the heater core.
16. Install the dash panels. For instructions, see **Section 75.11**.
17. Install the surge tank. For instructions, see **Section 20.01**, Subject 130.
18. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
19. Connect the batteries.
20. Remove the chocks from the tires.

Heater and Air Conditioner Assembly or Heater Assembly Replacement



1. Lower Dash Panel
2. Trim Plate Panel
3. End Cap
4. Lower HVAC Cover

Fig. 1, Dash Panels

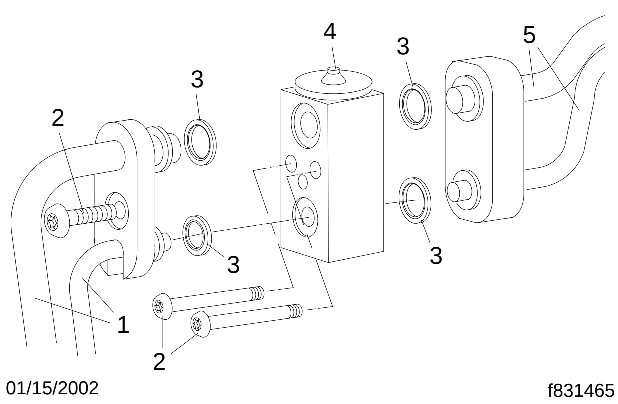
Expansion Valve Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Remove the air cleaner. For instructions, see **Section 09.01**, Subject 110.
5. Remove the surge tank. For instructions, see **Section 20.01**, Subject 130.
6. Remove the capscrew that attaches the refrigerant lines to the expansion valve and remove the refrigerant lines. Quickly cap the refrigerant lines. See **Fig. 1**.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the capscrews that attach the expansion valve to the evaporator lines and remove the expansion valve. If the evaporator lines will be exposed to air for more than five minutes, cap the evaporator lines.
8. If the evaporator lines were capped, uncap the lines.



1. Refrigerant Line
2. Capscrew
3. Mini Stat-O-Seal
4. Expansion Valve
5. Evaporator Line

Fig. 1, Expansion Valve

9. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the evaporator side of the expansion valve. Do not lubricate the Mini Stat-O-Seals prior to installation.
10. Using two capscrews, attach the expansion valve to the evaporator lines. Torque the capscrews 35 lbf·in (395 N·cm).
11. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate the Mini Stat-O-Seals prior to installation.
12. Attach the refrigerant lines to the expansion valve. Torque the capscrew on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
13. Install the surge tank. For instructions, see **Section 20.01**, Subject 130.
14. Install the air cleaner. For instructions, see **Section 09.01**, Subject 110.
15. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
16. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. See **Section 83.01**, Subject 130.
17. Return the hood to the operating position.
18. Remove the chocks from the tires.

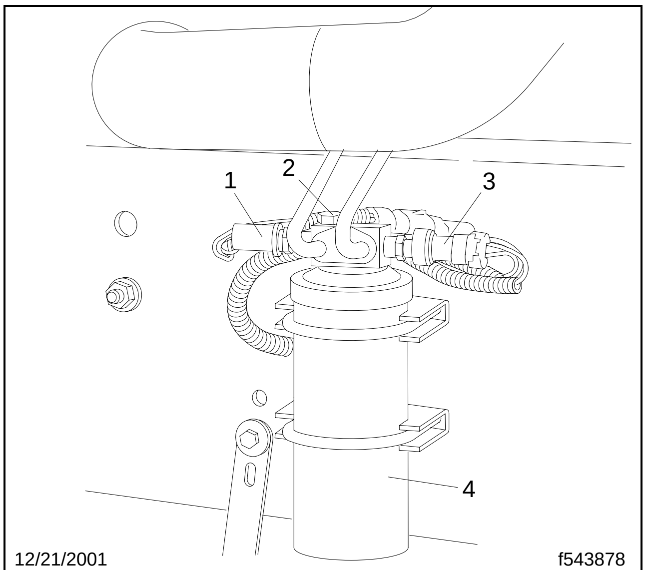
Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 220**.
4. Disconnect the wiring harness from the fan cycling switch and disconnect the wiring harness from the binary switch. See **Fig. 1**.
5. Remove the fan cycling switch and the binary switch from the receiver-drier.
6. Disconnect the refrigerant lines from the receiver-drier. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the nuts and washers that attach the U-bolts and mounting brackets to the frame rail. Remove the receiver-drier.

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, flush the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.



1. Fan Cycling Switch
2. Moisture Indicator
3. Binary Switch
4. Receiver-Drier

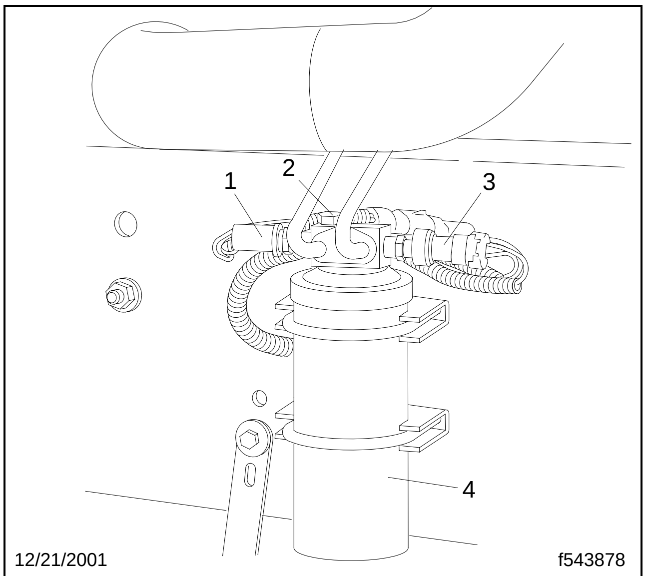
Fig. 1, Receiver-Drier

8. Using U-bolts, mounting brackets, nuts, and washers, install a new receiver-drier on the frame rail.
9. Uncap the refrigerant lines.
10. Using only Mini Stat-O-Seals, replace the Mini Stat-O-Seals on the refrigerant lines. Do not lubricate Mini Stat-O-Seals prior to installation.
11. Connect the refrigerant lines to the receiver-drier. Torque the bolt on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
12. Attach the fan cycling switch and the binary switch to the receiver-drier.
13. Attach the fan cycling wiring harness to the fan cycling switch and attach the binary switch wiring harness to the binary switch.
14. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 220**.
15. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered. See **Section 83.01**, Subject 130.
16. Return the hood to the operating position.
17. Remove the chocks from the tires.

Binary Switch Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Disconnect the wiring harness from the binary switch. See **Fig. 1**.
4. Remove the binary switch.
5. Install a new binary switch on the receiver-drier.
6. Connect the wiring harness to the binary switch.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.



1. Fan Cycling Switch
2. Moisture Indicator
3. Binary Switch
4. Receiver-Drier

Fig. 1, Receiver-Drier

Climate Control Panel Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the capscrews that attach the climate control panel to the lower dash panel. Pull the control panel away from the lower dash panel.
3. Disconnect the wiring harness from the control panel.
4. Connect the wiring harness to the new control panel.
5. Using capscrews, attach the control panel to the lower dash panel.
6. Remove the chocks from the tires.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Remove the caps from the suction and discharge service valves.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery/charge station hoses to the valves.

   IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

   4.1 Make sure that the refrigerant recovery/charge station valves are closed.

   4.2 Connect the red high-side hose to the discharge service valve.

   4.3 Connect the blue low-side hose to the suction service valve.

   4.4 Turn the knob clockwise on each coupler to open the Schrader valves.
5. Follow the refrigerant recovery/charge station manufacturer's instructions and recover all of the refrigerant from the system.

IMPORTANT: Always comply with all local regulations regarding refrigerant disposal. You may be subject to substantial penalties for improper disposal.

6. Measure the oil recovered during this procedure. The compressor will have to be refilled with the same quantity of new refrigerant oil.

   If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier.
7. Return the hood to the operating position.

Evacuating (recycling)

Moisture in a Refrigerant System

Water forms ice crystals at the thermostatic expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. This reduces the lubricating ability of the oil, which could damage the compressor and other system components.

Effects of Pressure on the Boiling Point of Water

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) (sea level). At higher elevations the atmospheric pressure is lower, which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly we can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is the lowest at the pump, water vapor is pulled out of the system. See **Fig. 1**. This process is called evacuation or dehydration. Also, most refrigerant recovery/charge stations automatically recycle refrigerant during this process to ensure the system will be charged with the cleanest refrigerant possible.

Refrigerant Service Operations

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	Absolute Pressure: psi (microns Hg)	Vacuum: inHg (mmHg)
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (14958.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (32)	0.61540 (31826.2)	28.67 (728.2)
86 (30)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

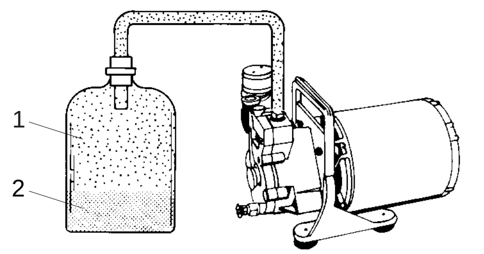
Table 1, Boiling Temperatures of Water at Converted Pressures

Vacuum Pump Selection

The purpose of a high-vacuum pump is to reduce and hold a vacuum in the air conditioning system so moisture can be boiled at ambient temperature. For example, a vacuum pump capable of pulling a vacuum of 28.89 inHg (734 mmHg) is able to boil water at 86°F (30°C). There are various types of vacuum pumps available. Only some types are recommended for truck air conditioning evacuation.

Air pump-type vacuum pumps are designed to remove large volumes of air but do not develop high vacuum. They cannot pull more than 28 inHg (711 mmHg) which boils water at 100°F (38°C).

Compressor-type vacuum pumps come in two designs: piston-type and rotary-vane type. A piston-type compressor can typically pull a vacuum of 28.2 inHg (716 mmHg) which boils water at 96°F (36°C). A rotary-vane type compressor may pull a vacuum of 29.82 inHg (757 mmHg) which boils water at 21°F

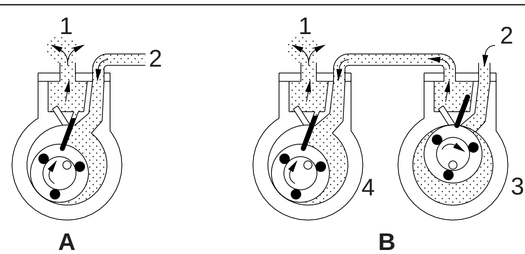


1. Vapor
2. Water

Fig. 1, Water to Vapor

(–6°C), but it is limited to pumping 0.4 to 0.8 cfm, which is too slow to handle truck air conditioners.

High-vacuum pumps are available in single-stage and two-stage models. A single-stage pump is adequate, but a two-stage pump is recommended to save time and assure complete evacuation. See **Fig. 2**.



A. Single-Stage Pump
B. Two-Stage Pump

1. Exhaust
2. Intake
3. First Stage
4. Second Stage

Fig. 2, Single- and Two-Stage Vacuum Pumps

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (758.95 mmHg) which boils water at 4°F (–16°C).

A two-stage high-vacuum pump features a second pump to reach a higher vacuum than a single-stage pump. In a two-stage pump, the exhaust of the first pump discharges into the intake of the second pump. The second stage pumps at a lower pressure and therefore pulls a higher vacuum on the system than the first pump can by itself.

Two stage high-vacuum pumps are capable of pulling down to 29.9192 inHg (759.95 mmHg) of vacuum for prolonged periods, which boils water at –60°F (–51°C).

The discharge line restriction is a factor affecting pump-down time. Pump-down time can be significantly reduced by use of larger diameter hoses, as short in length as possible.

Pumping capacity affects pump-down time. It is perfectly acceptable to use a large vacuum pump on a small system. Using too small of a pump on a large system could cause premature pump wear or require excessive time to pull a vacuum, even though the pump may be able to draw adequate vacuum.

The suggested minimum cfm for pumps on different size air conditioners are listed in **Table 2**.

Minimum CFM for Pumps on Different Size Air Conditioners	
System Size	**Suggested High-Vacuum Pump Size**
Panel Trucks Large Window Units	2.2 cfm
Tractor/Trailers, Buses Rooftop A/C Systems	3.0 cfm
Refrigeration Van	15.0 cfm

Table 2, Minimum CFM for Pumps on Different Size Air Conditioners

Measuring Vacuum

Gauges

Vacuum can be measured with:

- A standard compound gauge;
- A closed-end manometer;
- An electronic thermistor vacuum gauge.

A standard compound gauge reads low pressures in inches of mercury. It is not suitable for measuring high vacuum.

A closed-end U-tube mercury manometer can be read with good accuracy. High vacuum readings can only be read from laboratory-style U-tube manometers, which are not practical for service shops.

An electronic thermistor vacuum gauge is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can use an analog scale or a digital (LED) display.

Procedure

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower will be the reading.

Isolate the vacuum pump with a good vacuum valve and allow the pressure in the system to stabilize before taking a final reading.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum which is too high (for example, 1500 microns Hg), it is an indication of moisture and more evacuation is required.

Maintaining the Vacuum Pump

Maintenance is important for high-vacuum pumps. The oil must be changed at regular intervals to prevent moisture buildup which will cause eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil.

CAUTION

Flush the vacuum pump every fourth time it is used and before storing for long periods of time. Acid will form and corrode the pump if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Only vacuum pump oil should be used as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must have been recovered and the compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system is opened.
2. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery/charge station hoses to the valves.

   IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

   2.1 Make sure that the refrigerant recovery/charge station valves are closed.

   2.2 Connect the red high-side hose to the discharge service valve.

   2.3 Connect the blue low-side hose to the suction service valve.

   2.4 Turn the knob clockwise on each coupler to open the Schrader valves.
3. Follow the refrigerant recovery/charge station manufacturer's instructions and evacuate/recycle the refrigerant system.

Flushing

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush or replace a part depends on how much contamination there is, as previously described.

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. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor, and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Do not flush the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow.

Flushing parts with refrigerant, requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done, since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

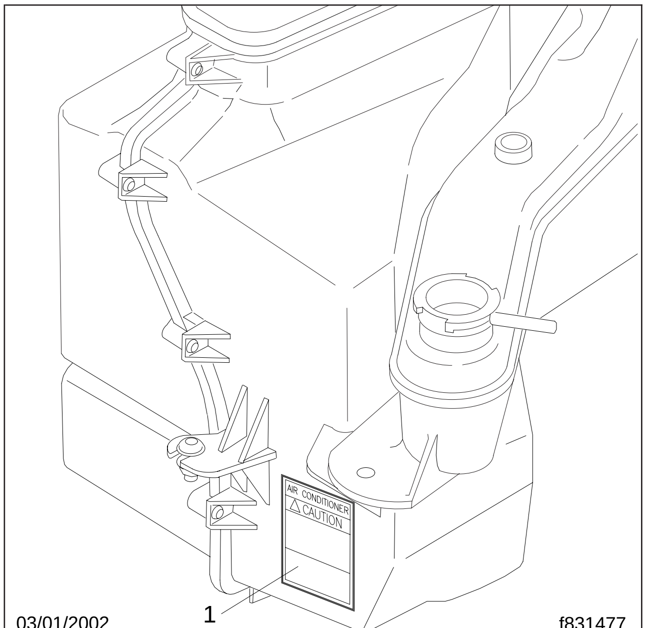
WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the refrigerant recovery/charge station connected to the service and discharge port connections.

1. The amount of refrigerant needed to fully charge the air conditioning system is printed on the "Air Conditioner" label on the air intake plenum located under the hood. See **Fig. 3**.

   Set the tank on a scale and weigh it so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.



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1. Air Conditioner Label

Fig. 3, Air Intake Plenum

2. Charge the refrigerant system.

NOTE: If equipped with a refrigerant recovery/charge station, charge the system on the high side following the manufacturer's instructions. If charging from a bulk container, do the following.

2.1 Turn the tank (bulk container) upside down. With the engine off, open the high-side hand valve. **Do not** open the low-side hand valve.

2.2 Allow refrigerant to enter the system until the correct charge, by weight, has entered. Then close the high-side hand valve.

2.3 Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage.

2.4 If a full charge did not enter the system, place the tank (bulk container) in the upright position, then open the low-side valve to draw vapor into the system. Leave the valve open until the correct weight of refrigerant has entered the system, then close the low-side valve.

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant tank in a tub of warm water no warmer than 125°F (52°C).

3. While the compressor is engaged, check the operating pressures at the suction and discharge ports. If the operating pressures are not acceptable, see **Troubleshooting 300** for possible causes.

4. Disconnect the high-side hose. With the engine running, open the low-side and high-side hose valves to recover the refrigerant from the lines.

5. Shut down the engine.

Leak Testing

General Information

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Refrigerant is odorless. As a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant depending on the condition of the system. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

Leak Detection

When checking for leaks, move the probe all the way around the fitting or suspected leak.

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak. Always verify a leak by blowing shop air in to the area of the suspected leak and checking the area again.

Daimler Trucks North America LLC recommends using only the Heated Diode type of electronic leak detector. This type of detector can be identified by its construction and power supply. It has a heated element which requires periodic replacement and uses either a 12V DC or 120V AC power supply, or has a rechargeable battery. The Heated Diode type detector is sensitive only to gases containing halogen such as R–134a and R–12 refrigerants. It will not detect other substances and is more likely to detect all of the leaks in a system. This type has both visual and audio indicators and self-tests to confirm operation.

Recommended electronic Heated Diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the Corona Discharge type, is the kind most commonly found in service and repair shops. This detector requires very little power and can operate on as few as four AA alkaline batteries. The Corona Discharge detector is not sufficiently sensitive and will create false alarms by detecting moisture and antifreeze or solvent vapors. This type of detector is specifically **not recommended**.

Use the following procedures to locate A/C system refrigerant gas leaks using a heated diode type electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer’s instructions.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (345 kPa) with the system not operating. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.
6. Follow the path of the refrigerant system methodically so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6 mm) from the part.

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK	Leybold Inficon 2 Technology Place East Syracuse NY 13057 (315) 434-1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan GA 30265 (800) 850-0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available

Refrigerant Service Operations

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
J 39400	SPX Kent-Moore 28635 Mound Road Warren MI 48092-3499 (800) 328-6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor block or condensate drain tube if no water is present. If this is not possible, insert the probe into the closest opening to the evaporator such as a heater or vent duct.

NOTE: The presence of water in the condensate drain tube can be determined by inserting the eraser end of a pencil in the drain tube. Inserting the pencil will break the surface tension of any water near the opening of the drain tube and allow the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip. It doesn't need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute and then test for leakage. Inspect the compressor by placing the probe near the holes at the front of the clutch.

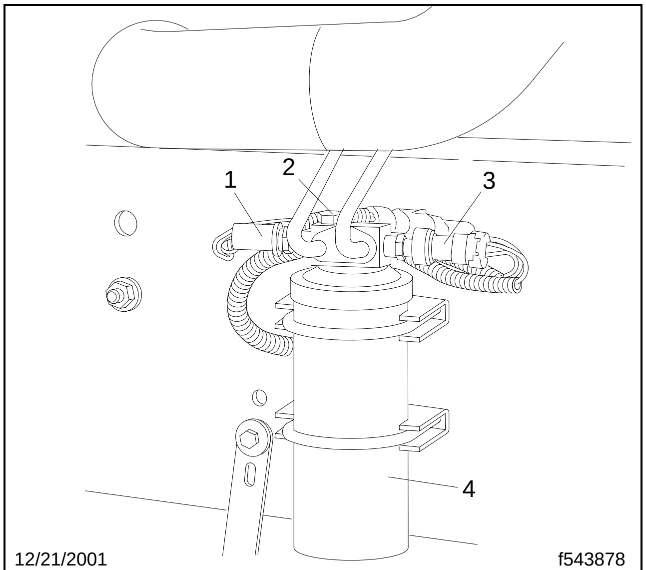
IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports with the caps installed after any service that disturbs the refrigerant system.

Fan Cycling Switch Replacement

Replacement

1. Turn off the engine, apply the brakes, and chock the tires.
2. Open the hood.
3. Disconnect the wiring harness from the fan cycling switch. See **Fig. 1**.
4. Remove the fan cycling switch.
5. Install a new fan cycling switch on the receiver-drier.
6. Connect the wiring harness to the fan cycling switch.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.



1. Fan Cycling Switch
2. Moisture Indicator
3. Binary Switch
4. Receiver-Drier

Fig. 1, Receiver-Drier

Preliminary Checks

Before testing the operation of the air conditioning system, check the following items:

1. Make sure the drive belt on the refrigerant compressor is not damaged. Make sure the compressor mounting capscrews are tight. The capscrews should be torqued 15 to 19 lbf·ft (20 to 26 N·m).
2. Using a feeler gauge, check the refrigerant compressor for correct clutch clearance. For instructions, see **Section 83.01**, Subject 140.
3. Check for broken or cut hoses. Check for loose fittings on all parts.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. If there is not enough airflow, make sure that leaves or other debris have not entered the fresh air ports under the windshield. If debris is present, it could clog the air inlet and block airflow. Remove the debris carefully.

   Be sure that all ducts are connected to the dash outlets.

Air Conditioning System Performance Test

Use the following procedure to evaluate the performance of the air conditioning system. If the system does not operate within the following guidelines, further diagnosis and repair may be necessary.

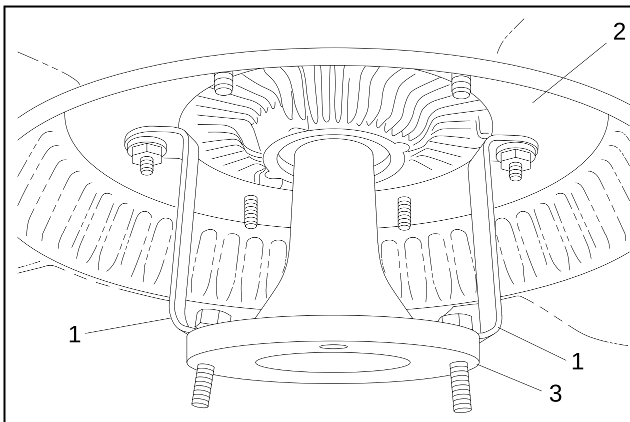
1. Park the vehicle out of direct sunlight, shut down the engine, and chock the tires.
2. Open the hood.
3. Record the ambient temperature and the relative humidity in **Table 1**.

WARNING

Use two brackets to lock the fan. If two brackets are not used, the bolts could shear or the fan could become unbalanced resulting in personal injury or damage to the fan.

4. Make sure the engine fan is engaged. If equipped with a viscous fan, the fan must be manually locked before testing the A/C system.

   To lock the fan, make two Z-shaped brackets similar to those shown in **Fig. 1**. Mount the brackets to the fan and hub 180 degrees apart. It is important to use two brackets to prevent vibration when testing. The brackets can be made by bending 3/4-inch x 1/8-inch (19 mm x 3 mm) mild steel strap in a vise.
5. Open the driver and passenger doors.
6. Connect the A/C test gauges to the refrigerant system service ports.
7. Place a thermometer in the center dash outlet.
8. Start the engine and warm it to operating temperature.
9. Set the engine speed to 1500 rpm.
10. Set the control panel to normal A/C, the recirculation to off, and the fan to the highest speed.
11. Allow the system time to stabilize (at least 5 minutes or until the dash outlet temperature is at minimum) then record the values in **Table 1** under the "Actual Readings" heading.
12. Refer to the appropriate temperature/pressure table in **Subject 400**. Using the recorded ambient temperature and relative humidity readings, locate the values in the temperature/pressure table and



1. Z-Shaped Bracket
2. Fan
3. Hub

Fig. 1, Viscous Fan

Troubleshooting

record them in **Table 1** under the "Published Readings" heading.

13. If the actual dash outlet temperature is within the range of the published values, then the system is performing satisfactorily. If the actual temperature is not within the published value, use the other readings such as high side or low side pressures and compressor cycling information to begin diagnosing the system.

14. If Z-shaped brackets were used to lock the viscous fan, remove the brackets.

A/C Performance Test Data		
	Published Readings (see step 12)	**Actual Readings**
Ambient Temperature Relative Humidity (RH)		_____°F (°C) _____% RH
Center Dash Outlet Temperature	_____°F (°C) to _____°F (°C)	_____°F (°C)
High Side Pressure	_____ psi (kPa) to _____ psi (kPa)	_____ psi (kPa)
Low Side Pressure	_____ psi (kPa) to _____ psi (kPa)	_____ psi (kPa)
Compressor Cycling	yes/no	yes/no
Compressor On/Off Time (only if cycling)	on _____ sec off _____ sec	on _____ sec off _____ sec

Table 1, A/C Performance Test Data

Fault Analysis Flow Chart

See **Fig. 2** for the fault analysis flow chart.

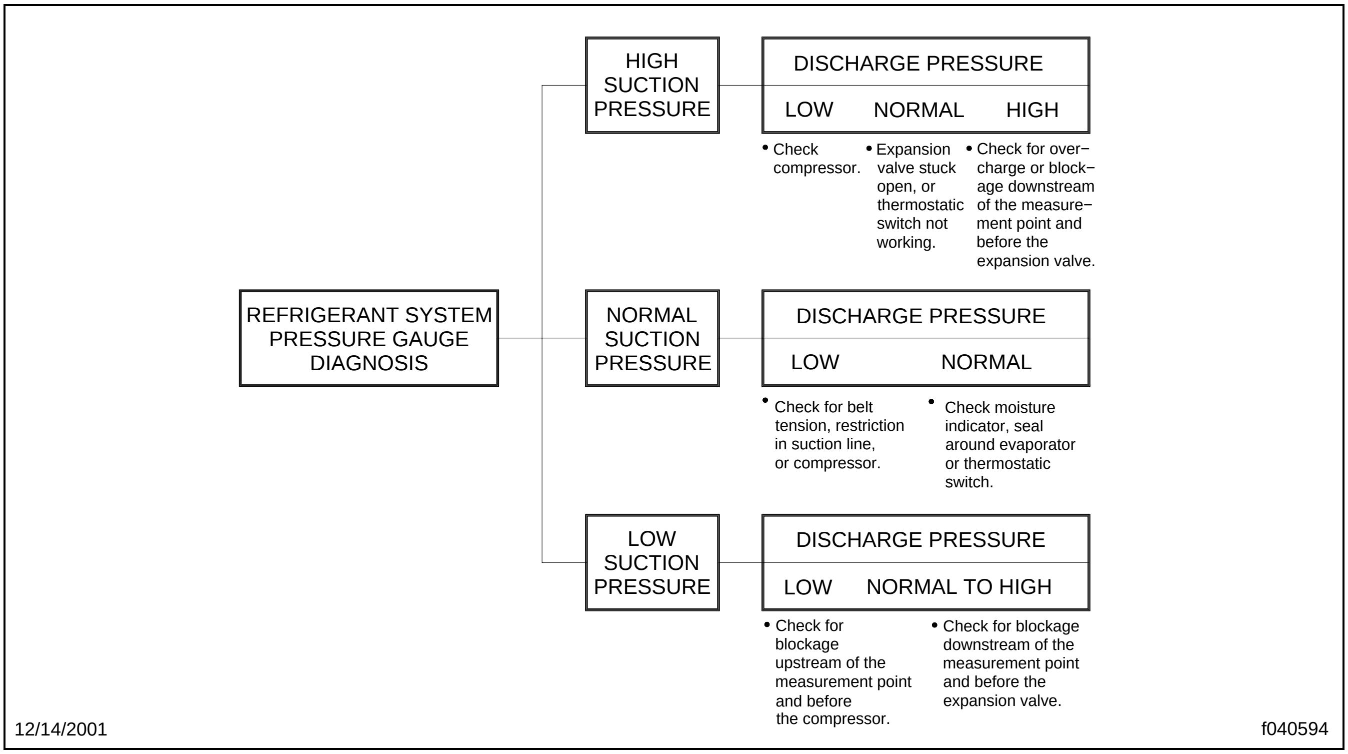


Fig. 2, Fault Analysis Flow Chart

System Troubleshooting Tables

Problem—No Fresh Air (nonrecirculation mode)

Problem—No Fresh Air (nonrecirculation mode)	
Possible Cause	**Remedy**
Mechanical problem with the recirculation door actuator.	Inspect the recirculation door actuator for obstructions or mechanical damage. Correct as necessary.
Problem with the wiring.	Refer to "Recirculation Door Actuator Circuit Tests" for diagnosis.
The control head is not working.	
The blower motor is in protection mode.	Refer to "Blower Motor Circuit Tests" for diagnosis.

Problem—Warm Airflow When the Air Conditioner is On, A/C is Not Working, or Poor Performance of A/C

Problem—Warm Airflow When the Air Conditioner is On, A/C is Not Working, or Poor Performance of A/C	
Possible Cause	**Remedy**
Low refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Too much refrigerant in the system.	Evacuate the system, then add a full charge of refrigerant.

Troubleshooting

Problem—Warm Airflow When the Air Conditioner is On, A/C is Not Working, or Poor Performance of A/C	
Possible Cause	**Remedy**
Moisture in the system.	If moisture is in the system, ice crystals may form and block the flow of refrigerant at the expansion or other places in the system. Recover the refrigerant, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
The refrigerant compressor is not working.	The refrigerant charge is low or high.
	The refrigerant compressor clutch or drive belt needs repair or replacement.
	Refer to "A/C Clutch Circuit Tests for Diagnosing No A/C Clutch Engagement" in this subject.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Refer to "Evaporator Probe Circuit Tests" in this subject for diagnosis.
Temperature blend door actuator is not working.	Refer to "Temperature Blend Door Circuit Tests" in this subject for diagnosis.
	Mechanical problem with temperature blend door actuator.
Blockage in A/C system such as lines, evaporator, condenser, or expansion valve.	Remove the blockage.
The blower motor is in protection mode.	Refer to "Blower Motor Circuit Tests" for diagnosis.

Problem—Low Side Pressure Too Low

Problem—Low Side Pressure Too Low	
Possible Cause	**Remedy**
The expansion valve is not working.	Check the expansion valve for blockage and function. Blockage may be due to moisture causing ice formation.
There are line or component restrictions.	Remove the line restrictions.
The refrigerant charge is low.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full refrigerant charge.

Problem—High Side Pressure Too High

Problem—High Side Pressure Too High	
Possible Cause	**Remedy**
Airflow through the condenser is restricted.	Check for and remove dirt or debris in front of the condenser and radiator.
	Check the engine fan operation.
There is an internal restriction in the condenser indicated by ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier.	Replace the condenser. If compressor failure recently occurred, the blockage may be due to debris from a failed compressor.
Air is in the refrigerant.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier if necessary, and add a full charge of refrigerant.
The engine is overheated.	Check the engine cooling system.
Restriction in the compressor discharge line.	Replace the line.

Troubleshooting

Problem—Compressor Runs Continuously

Problem—Compressor Runs Continuously	
Possible Cause	**Remedy**
Low refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
The evaporator probe isn't working.	Refer to "Evaporator Probe Circuit Tests."

Problem—Little or No Heat

Problem—Little or No Heat	
Possible Cause	**Remedy**
Low engine coolant.	Check coolant level. If low, check for source of leak and repair as necessary.
Plugged heater core.	Flush or replace the heater core as necessary.
Engine thermostat is not working.	Check to see if the engine thermostat is stuck open. Refer to **Section 20.00**, Subject 300 for diagnosis.
Engine fan on all the time.	Refer to **Group 20** for diagnosis.
Mechanical problem with temperature blend door actuator.	Inspect the temperature blend door actuator for obstructions or mechanical damage. Correct as necessary.
Problem with the wiring.	Refer to "Temperature Blend Door Actuator Circuit Tests" for diagnosis.
The control head is not working.	

Problem—Water or Liquid Leaking from the Air Conditioner

Problem—Water or Liquid Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain tubes.
Heater core is leaking.	Leak test and replace the heater core if necessary.

Problem—Recirculation Mode Not Working

Problem—Recirculation Mode Not Working	
Possible Cause	**Remedy**
Air selection switch is set to full or partial defrost.	Recirculation mode is not available in any of the defrost settings. This is not a problem.
Mechanical problem with the recirculation door actuator.	Inspect the recirculation door actuator for obstructions or mechanical damage. Correct as necessary.
Problem with the wiring.	Refer to "Recirculation Door Actuator Circuit Tests" for diagnosis.
The recirculation door actuator is not working.	
The control head is not working.	

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Problem—Air Selection Switch Not Working

Problem—Air Selection Switch Not Working*	
Possible Cause	**Remedy**
Mechanical problem with the air distribution door actuator.	Inspect the air distribution door actuator for obstructions or mechanical damage. Correct as necessary.
Problem with the wiring.	Refer to "Air Distribution Door Actuator Circuit Tests" for diagnosis.
The control head is not working.	

* Not able to control where the air is directed.

Problem—No Cool Vent Air on a Heater Only System

Problem—No Cool Vent Air on a Heater Only System	
Possible Cause	**Remedy**
Mechanical problem with the temperature blend door actuator.	Inspect the temperature blend door actuator for obstructions or mechanical damage. Correct as necessary.
Problem with the wiring.	Refer to "Temperature Blend Door Actuator Circuit Tests" for diagnosis.
The control head is not working.	

Problem—No Backlighting on the Control Head

Problem—No Backlighting on the Control Head	
Possible Cause	**Remedy**
Problem with the wiring.	Refer to "Backlighting Circuit Tests" for diagnosis.
The control head is not working.	

Problem—Blower Not Working

Problem—Blower Not Working	
Possible Cause	**Remedy**
Problem with the wiring.	Refer to "Blower Motor Circuit Tests" for diagnosis.
The control head is not working.	
A fuse is blown.	
The blower motor is not working.	

Component and System Tests

Use the following component and system tests to diagnose an HVAC problem.

Receiver-Drier

To the touch, the entire length of the receiver-drier should be the same temperature. If the receiver-drier is not the same temperature, it may indicate a blockage or low charge. Any blockage can cause high head pressures.

Cooling System

Although they are not physically connected, there is a close tie between the air conditioner and the cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the bus. The added heat makes it necessary for the air conditioner to work harder and reduces the ability of the air conditioner to cool down the air in the driver's area.

See **Group 20** for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Expansion Valve

Problems with the expansion valve may be caused by the valve being stuck closed or open. When the valve is stuck closed, the evaporator coil and the expansion valve will be at outside temperature. When the valve is stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here. The valve is very sensitive to contamination. The contaminant is usually water. Less than a drop of water is all it takes to make the valve stop working. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts and the valve operates again only to freeze up when the moisture returns.

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

Refrigerant Compressor

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. The filter next to the evaporator removes debris. If the filter is installed, no blockage can occur.

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.

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, the airflow over the condenser fins is blocked. Air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution. Be careful not to bend the fins.

High head pressures will also occur if the condenser tubing is abnormally bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages, such as bits of foreign material or metallic grit buildup, will stop the flow of refrigerant.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. See **Group 20** of this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other information about cooling system problems.

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 insufficient cooling.

Areas of ice or frost buildup usually mean a blockage. Parts that often freeze-up are probably corroded or inoperative and should be replaced. Parts, such as the expansion valve, that freeze-up once in a while may do so because of moisture in the system. If this happens, recover the refrigerant charge, evacuate/ recycle the system refrigerant, replace the receiver-drier, and recover, evacuate, and charge the system with refrigerant.

Temperature Blend Door Actuator Circuit Tests

The temperature blend door actuator controls the amount of air that is routed through the heater core. The temperature blend door actuator is controlled by the temperature control switch on the control head (climate control panel). The control head senses the door position by reading the feedback voltage from the actuator position sensor. The feedback voltage will be less than the 5V reference voltage sent by the control head to the sensor.

The target position is based on the temperature control switch setting and internal control head algorithms. The desired position is considered reached when one of the following conditions is true, although this does not necessarily mean that the position actually corresponds to the desired temperature setting. For example, if the actuator movement is limited due to an obstruction.

- The actuator feedback position has been reached.
- The actuator is stalled for more than 1 second; the actuator feedback position does not change for more than 1 second.
- The target position corresponds to an end stop and an additional 1 second extra drive in the same direction (to guarantee sealing) has been performed.

The temperature blend door should move from one extreme position to the other when turning the temperature control switch from cold to hot or from hot to cold.

Follow the tests in **Table 2** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified. If the temperature blend door actuator passes the tests in **Table 2** and the actuator still does not operate properly, check for mechanical problems with the actuator.

Temperature Blend Door Actuator Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Actuator motor drive circuit	key on, engine off temperature blend door actuator connector removed fan (blower) switch on low Change temperature setting while observing the digital multimeter (DMM).	9V+ for about 1 second*	measured across pins 5 and 6 of the temperature blend door actuator connector	Check wiring between control head and temperature blend door actuator. If wiring is okay, replace the control head.
Actuator position sensor reference voltage circuit	key on, engine off temperature blend door actuator connector removed	5V	measured between pin 7 of the temperature blend door actuator connector and the battery negative post	
Actuator position sensor reference ground circuit	key on, engine off temperature blend door actuator connector removed	12V*	measured between pin 8 of the temperature blend door actuator connector and the battery positive post	
Actuator position sensor feedback signal circuit	key on, engine off all connectors connected	0.50V (full hot) to 4.00V (full cold)†	backprobe pins B11 and B5 at control head connector	Check wiring between control head and temperature blend door actuator.‡ If wiring is okay, replace the actuator.‡

* The voltage should be approximately the same as the battery voltage.
† Values are approximate.
‡ It is assumed that reference voltage and ground circuits are functioning.

Table 2, Temperature Blend Door Actuator Circuit Tests

Air Distribution Door Actuator Circuit Tests

The air distribution (mode) door actuator controls the direction the air is routed through the HVAC ducts in the cab. The air distribution door actuator is controlled by the air selection switch on the control head (climate control panel). The control head senses the air distribution door position by reading the feedback voltage from the actuator position sensor. The feedback voltage will be less than the 5V reference voltage sent by the control head to the sensor.

The target position is based on the air selection switch setting and internal control head algorithms. The desired position is considered reached when one of the following conditions is true, although this does not necessarily mean that the position actually corresponds to the desired air selection setting. For example, if the actuator movement is limited due to an obstruction.

- The actuator feedback position has been reached.
- The actuator is stalled for more than 1 second; the actuator feedback position does not change for more than 1 second.
- The target position corresponds to an end stop and an additional 1 second extra drive in the same direction (to guarantee sealing) has been performed.

The air distribution door should move from one extreme position to the other when turning the air selection switch from the far left to the far right or from the far right to the far left.

Follow the tests in **Table 3** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified. If the air

Troubleshooting

distribution door actuator passes the tests in **Table 3** and the actuator still does not operate properly, check for mechanical problems with the actuator. To quickly check for normal operation, feel for air flowing from the correct outlet in each air selection setting.

Air Distribution Door Actuator Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Actuator motor drive circuit	key on, engine off air distribution door actuator connector removed fan (blower) speed on low Change the air selection setting while observing digital multimeter (DMM).	9V+ for about 1 second*	measured across pins 5 and 6 of the air distribution door actuator connector	Check wiring between control head and air distribution door actuator. If wiring is okay, replace the control head.
Actuator position sensor reference voltage circuit	key on, engine off air distribution door actuator connector removed	5V	measured between pin 10 of the air distribution door actuator connector and the battery negative post	
Actuator position sensor reference ground circuit	key on, engine off air distribution door actuator connector removed	12V*	measured between pin 8 of the air distribution door actuator connector and the battery positive post	
Actuator position sensor feedback signal circuit	key on, engine off all connectors connected	0V (far right) to 5V (far left)	backprobe pins B10 and B5 at control head connector	Check wiring between control head and air distribution door actuator.† If wiring is okay, replace the actuator.†

* The voltage should be approximately the same as the battery voltage.
† It is assumed that reference voltage and ground circuits are functioning.

Table 3, Air Distribution Door Actuator Circuit Tests

Recirculation Door Actuator Circuit Tests

The recirculation door actuator controls the source of the air, fresh or recirculated, that is routed through the HVAC ducts in the bus. The recirculation door actuator is controlled by the recirculation button on the control head (climate control panel).

Saf-T-Liner C2 school buses have partial recirculation. For information on this feature, see **Subject 050**.

The control rules for the recirculation mode are as follows:

- The recirculation mode is not available in the defrost settings.
- The default at power up is fresh air unless the fan switch is in the off position. When the fan switch is in the off position, the recirculation mode is the default mode, but the LED is not illuminated.
- When the recirculation mode is enabled, it will remain on until one of the following occurs:
  - the air selection switch is moved to a defrost mode;
  - the recirculation button is pressed;
  - the ignition is cycled;
  - 20 minutes have passed and the recirculation timer has expired. After 20 minutes, the system enters partial recirculation mode for five minutes, then resumes

full recirculation mode for 20 minutes. This cycle repeats as long as the system remains in recirculation mode.

The control head senses the recirculation door position by reading the feedback voltage from the actuator position sensor. The feedback voltage will be less than the 5V reference voltage sent by the control head to the sensor.

The target position is based on the recirculation button setting and internal control head algorithms. The desired position is considered reached when one of the following conditions is true, although this does not necessarily mean that the position actually corresponds to the desired recirculation button setting. For example, if the actuator movement is limited due to an obstruction.

- The actuator feedback position has been reached.
- The actuator is stalled for more than 1 second; the actuator feedback position does not change for more than 1 second.
- The target position corresponds to an end stop and an additional 1 second extra drive in the same direction (to guarantee sealing) has been performed.

The recirculation door should move from one extreme position to the other when the recirculation button is pressed on and then pressed off.

Perform the tests in **Table 4** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified. If the recirculation door actuator passes the tests in **Table 4** and the actuator still does not operate properly, check for mechanical problems with the actuator. To quickly check for normal operation, set the fan switch to high and listen for a change in the sound of the blower near the HVAC unit while pressing the recirculation button on and off. The blower will be louder when recirculation is enabled.

Troubleshooting

Recirculation Door Actuator Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Actuator motor drive circuit	key on, engine off recirculation door actuator connector removed fan (blower) speed on low Change the recirculation setting while observing digital multimeter (DMM).	9V+ for about 1 second*	measured across pins 5 and 6 of the recirculation door actuator connector	Check wiring between control head and recirculation door actuator. If wiring is okay, replace the control head.
Actuator position sensor reference voltage circuit	key on, engine off recirculation door actuator connector removed	5V	measured between pin 10 of the recirculation door actuator connector and the battery negative post	
Actuator position sensor reference ground circuit	key on, engine off recirculation door actuator connector removed	12V*	measured between pin 8 of the recirculation door actuator connector and the battery positive post	
Actuator position sensor feedback signal circuit	key on, engine off all connectors connected	0.8V (recirc. on) to 4.7V (recirc. off)	backprobe pins A11 and B5 at control head connector	Check wiring between control head and recirculation door actuator.† If wiring is okay, replace the actuator.†

* The voltage should be approximately the same as the battery voltage.
† It is assumed that reference voltage and ground circuits are functioning.

Table 4, Recirculation Door Actuator Circuit Tests

Blower Motor Circuit Tests

The blower motor power and ground are supplied directly to the blower motor assembly. The blower speed is controlled by the fan switch on the control head (climate control panel). The control head sends a pulse width modulated (PWM) signal to the blower motor. The frequency of this signal is 2000 Hz. The pulse width varies with the fan switch selection.

The protection modes for the blower motor are as follows:

- Reverse Voltage Protection—The motor will not operate if the polarity of the motor leads, circuits 98F and ground, are reversed.
- Current Protection—If the motor exceeds the maximum limit, the speed will be reduced until the current is within the limits (23.5A maximum).
- Temperature Protection—If the motor’s internal temperature sensor senses that the temperature is too high, the blower speed is reduced to 1000 rpm to reduce the load on the motor and a comparison is made between the sensor reading and the maximum limit. If the temperature is still too high, the blower speed is further reduced to the minimum value of approximately 500 rpm and a temperature comparison is made to the maximum. If after the second comparison the temperature is still too high, the motor will shut down until it has cooled sufficiently.

Perform the tests in **Table 5** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified. If the blower motor passes the tests in **Table 5** and the blower still does not operate properly, check the blower motor. To quickly check for normal operation, set the fan switch to high and listen for a change in the sound of the blower near the HVAC unit while pressing the recirculation button on and off. The blower will be louder when recirculation is enabled.

Blower Motor Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Main power to blower motor	battery switch on (if equipped) key off blower motor connector removed	12V*	measured between pin 4 of blower motor connector and negative battery post	Check fuse F2 in the PDM under the hood. If the fuse is blown, check for shorted wiring or a damaged blower motor. Check for open in circuit 98F.
Blower motor ground circuit	battery switch on (if equipped) key off blower motor connector removed	12V*	measured between pin 3 of blower motor connector and the positive battery post	Check for open in blower motor ground circuit.
PWM signal from control head	battery switch on (if equipped) key on, engine off blower motor connector disconnected Change the fan (blower) speed setting on the control head and observe frequency using digital multimeter (DMM).	0 Hz fan off 0 Hz fan on high 2000 Hz all other speeds	probe pins 4 and 5 of the blower motor connector, harness side (DMM set to measure frequency)	check circuit 338H check control head
Voltage drop (power circuit)	battery switch on (if equipped) key on, engine off all connectors connected fan (blower) speed on high	less than 0.5V	backprobe pin 4 at the blower motor connector, other lead on positive battery post	Locate high resistance or open in circuit 98F.
Voltage drop (ground circuit)	battery switch on (if equipped) key on, engine off all connectors connected fan (blower) speed on high	less than 0.5V	backprobe pin 3 at the blower motor connector, other lead on negative battery post	Locate high resistance or open in blower motor ground circuit.
Blower motor current draw	battery switch on (if equipped) keys on, engine off all connectors connected fan (blower) speed on high	less than 23.5A	Use current clamp around circuit 98F or blower motor ground wire.	check blower motor

* The voltage should be approximately the same as the battery voltage.

Table 5, Blower Motor Circuit Tests

Evaporator Probe Circuit Tests

The evaporator temperature sensor is a resistive element where the resistance increases as the temperature decreases. The control head (climate control panel) uses this sensor to determine the evaporator temperature. The control head uses the temperature information to determine if the A/C compressor should be engaged or not in order to prevent the evapora-

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tor core from freezing. As refrigerant flows through the evaporator, condensation will form on the surface of the evaporator. If this condensation freezes because the evaporator temperature is too low, airflow will be restricted through the core and poor cooling will result.

The control head will shut off the compressor when the evaporator temperature is near the point where freezing may occur. See **Table 6** for the evaporator probe temperature versus resistance values.

Evaporator Probe Temperature Versus Resistance						
Temperature: °F	**Temperature: °C**	**Resistance: ohms**		**Temperature: °F**	**Temperature: °C**	**Resistance: ohms**
5	–15	36,780		75	24	5189
14	–10	27,830		77	25	4964
23	–5	21,250		79	26	4751
32	0	16,360		81	27	4548
41	5	12,690		82	28	4354
50	10	9927		84	29	4170
59	15	7823		86	30	3995
61	16	7466		88	31	3828
63	17	7125		90	32	3669
64	18	6805		91	33	3518
66	19	6500		93	34	3373
68	20	6210		95	35	3236
70	21	5935		97	36	3104
72	22	5673		99	37	2979
73	23	5426		100	38	2860

Table 6, Evaporator Probe Temperature Versus Resistance

Perform the tests in **Table 7** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified.

Evaporator Probe Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Evaporator temperature probe	key off, engine off sensor probe removed and disconnected Fill a cup with ice then add water to make an ice-water bath. Place the tip of the evaporator probe in the ice-water bath for 5 minutes before testing. Leave the tip immersed while taking the resistance measurement. Be sure the meter reading is stable before noting the final measurement.	16,000 to 16,730Ω at 32°F (0°C)	across pins on the temperature probe	Replace temperature probe
Evaporator temperature probe circuit test	battery switch on (if equipped) key on, engine off sensor probe installed, but connector is disconnected	5V	across temperature probe connector terminals	Check for open in circuits 338K and 338GP. If wiring is okay, replace the control head.

Table 7, Evaporator Probe Circuit Tests

A/C Clutch Circuit Tests for Diagnosing No A/C Clutch Engagement

The A/C compressor clutch is controlled by the control head (climate control panel). When the control head determines that the A/C compressor is required, it grounds the A/C request input to the bulkhead module (BHM). The BHM acts as a relay; when it receives the A/C request ground input from the control head, it sends +12V of power through its output to the A/C compressor through the binary switch. If the refrigerant pressure is too high or too low, the binary switch will break the circuit between the bulkhead module and the A/C compressor to prevent damage to the A/C system.

When **all** of the following conditions are met, the control head will send the A/C request signal to the bulkhead module:

- The air selection switch is in one of the A/C or defrost settings, or the recirculation mode is on.
- The fan switch is on any setting other than off.
- The evaporation sensor temperature is above 40.1°F (4.5°C).
- The countdown timer has expired, which prevents the A/C compressor from cycling more than four times per minute.

When these conditions exist, the control head sends the A/C request signal to the bulkhead module. See **Fig. 3**.

NOTE: The A/C signal will remain active until the evaporator sensor reaches 38.3°F (3.5°C), the fan is turned off, or the air selection switch is taken out of defrost or A/C mode.

See **Table 8** for the A/C clutch circuit tests. Perform the tests in **Table 8** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified.

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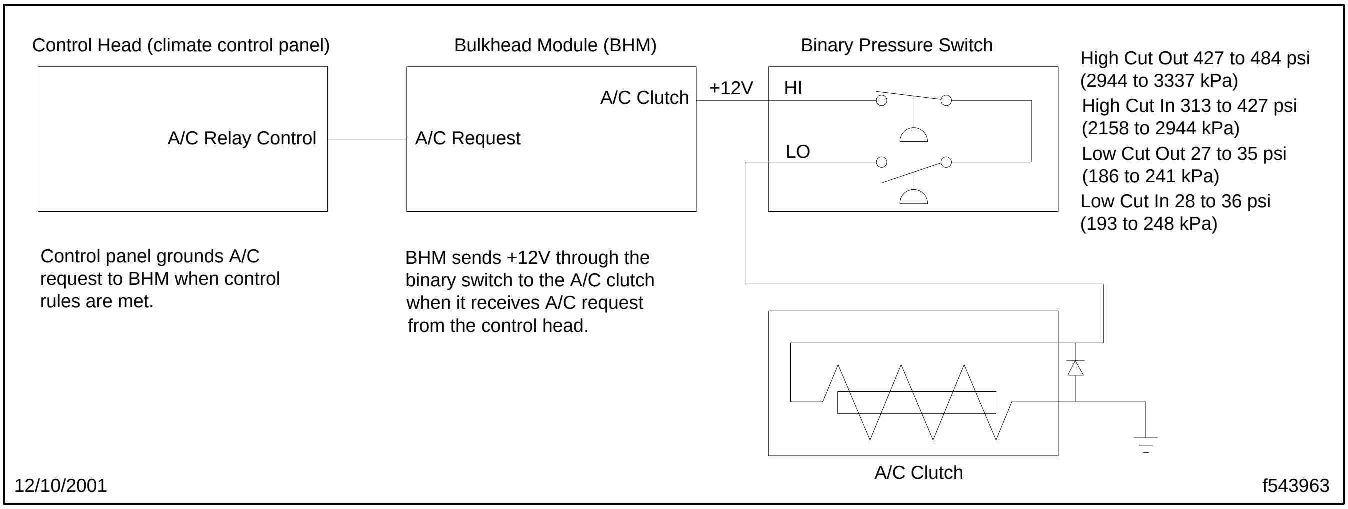

Fig. 3, A/C Clutch Control Circuit

A/C Clutch Circuit Tests for Diagnosing No A/C Clutch Engagement				
Test	**Conditions**	**Good Result**	**Test Point/Method**	**What to Check if Test Fails**
A/C request input	key on, engine on air selection switch in one of A/C settings fan (blower) speed on any setting but off Connect ServiceLink and use the "A/C Clutch Function" Datalink Monitor template to see if the A/C request is seen by the BHM.	A/C request is received by the BHM.	ServiceLink/Datalink Monitor NOTE: Make sure the Datalink Monitor template is **not** in Test Mode. The control head should request A/C. This will cause the "A/C Request" annunciator on the template to indicate that the request is on. If the annunciator does not indicate that a request for A/C is received, check the settings on the control head before proceeding with "What to Check if Test Fails."	Perform the "Evaporator Probe Circuit Tests." Check wiring between the control head and the bulkhead module. Check for open circuit. Check the control head. Check the bulkhead module. Try to manually ground the A/C request input while observing the template to confirm.
A/C clutch circuit*	key on, engine off Connect ServiceLink and use the "A/C Clutch Function" Datalink Monitor template to manually actuate the A/C clutch output.	A/C clutch should engage.	ServiceLink/Datalink Monitor NOTE: Put the template in "Test Mode" and actuate the A/C clutch by selecting the button for "Clutch On." You should hear a distinct click when the clutch engages. The A/C clutch annunciator (BHM to clutch) should turn on when the output is energized. If this annunciator indicates that the output is on but the clutch does not engage, then the problem is in the A/C clutch circuit and not with the BHM. If the A/C clutch annunciator does not indicate that the output is energized when the output is turned on and the clutch does not engage, then the problem is with the BHM.	Check continuity across the binary switch. If the circuit is open, check if the refrigerant pressure is within operating range of the binary switch. (Refrigerant pressure may be very low or too high). If pressures are okay, replace binary switch. faulty wiring faulty A/C clutch ground circuit faulty A/C clutch coil (Coil resistance should be 3Ω ±0.5Ω). faulty BHM (See note in Test Point/Method column)

* Circuit faults with the A/C clutch output may generate bulkhead module fault codes.

Table 8, A/C Clutch Circuit Tests for Diagnosing No A/C Clutch Engagement

Backlighting Circuit Tests

See **Table 9** for the backlighting circuit tests. Perform the tests in **Table 9** in the sequence presented. The directions under the column "What to Check if the Test Fails" are sometimes dependent on good results from previous tests. If any of the tests fail, stop and perform the repair or check specified. If all of the tests pass and the backlighting at the control head still does not operate properly, check the control head.

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Backlighting Circuit Tests				
Test	**Conditions**	**Good Result**	**Test Point**	**What to Check if Test Fails**
Backlighting circuit ground test	battery switch on (if equipped) key off, engine off control head connector disconnected	12V*	measured between pin B8 of the control head connector and the positive battery post	Check for open in the control head ground circuit.
Backlighting power test	battery switch on (if equipped) key off, engine off control head connector disconnected headlight switch on	Voltage should be about 1.2V at full dim and 10.8V at full bright.	Measure voltage between pins A2 (positive lead) and B8 (negative lead) on the control head connector while toggling the dimmer switch between full dim and full bright.	Check circuit 29A for open/ short. If okay, refer to **Group 54** for further diagnosis.
Backlighting pulse width modulated (PWM) signal test	battery switch on (if equipped) key off, engine off control head connector disconnected headlight switch on	400 Hz	Measure frequency between pins A2 and B8 on the control head connector.	Check circuit 29A for open/ short. If okay, refer to **Group 54** for further diagnosis.

* The voltage should be approximately the same as the battery voltage.

Table 9, Backlighting Circuit Tests

Fault Codes

If the A/C clutch is not working, use ServiceLink to check for fault codes. See **Table 10** and **Table 11** for a description of the fault codes.

J1587 Fault Codes, HVAC (bulkhead module related) MID 164				
MID	**SID**	**FMI**	**Fault Description**	**Action**
164	057	05	A/C clutch output open circuit (low current)	•Check circuit 98A for open circuit. •Check binary switch; it may be open. If open, check for low or high refrigerant pressure. Also check the switch itself. •Check A/C clutch coil for open circuit.
		06	A/C clutch output shorted to ground (high current)	•Check circuit 98A for short to ground.

Table 10, J1587 Fault Codes, HVAC (bulkhead module related) MID 164

J1939 Fault Codes, HVAC (bulkhead module related) Source Address (SA) 33				
SA	**SPGN**	**FMI**	**Fault Description**	**Action**
33	1550	05	A/C clutch output open circuit (low current)	•Check circuit 98A for open circuit. •Check binary switch; it may be open. If open, check for low or high refrigerant pressure. Also check the switch itself. •Check A/C clutch coil for open circuit.
		06	A/C clutch output shorted to ground (high current)	•Check circuit 98A for short to ground.

Table 11, J1939 Fault Codes, HVAC (bulkhead module related) Source Address (SA) 33

Refrigerant recovery/charge stations can be purchased from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
(800) 328-6657

See **Fig. 1** and **Fig. 2** for the HVAC wiring diagram.

Refrigerant Charge Specification
The amount of refrigerant needed to fully charge the air conditioning system is printed on the "Air Conditioner" label on the air intake plenum located under the hood. See **Fig. 3**.

Table 1, Refrigerant Charge Specification

Refrigerant Oil Specification	
Refrigerant Oil	**Capacity**
Sanden SP–15	10 fl oz (300 mL)

Table 2, Refrigerant Oil Specification

Stat-O-Seal Assembly Bolt Torque Specs	
HVAC Component	**Torque: lbf·ft (N·m)**
Refrigerant Compressor	11 to 15 (15 to 20)
Condenser	11 to 15 (15 to 20)
Receiver-Drier	11 to 15 (15 to 20)
Expansion Valve*	11 to 15 (15 to 20)
Evaporator	11 to 15 (15 to 20)
Junction Block	11 to 15 (15 to 20)

* Torque the two small screws that attach the expansion valve to the evaporator lines at the frontwall 35 lbf·in (395 N·cm).

Table 3, Stat-O-Seal Assembly Bolt Torque Specs

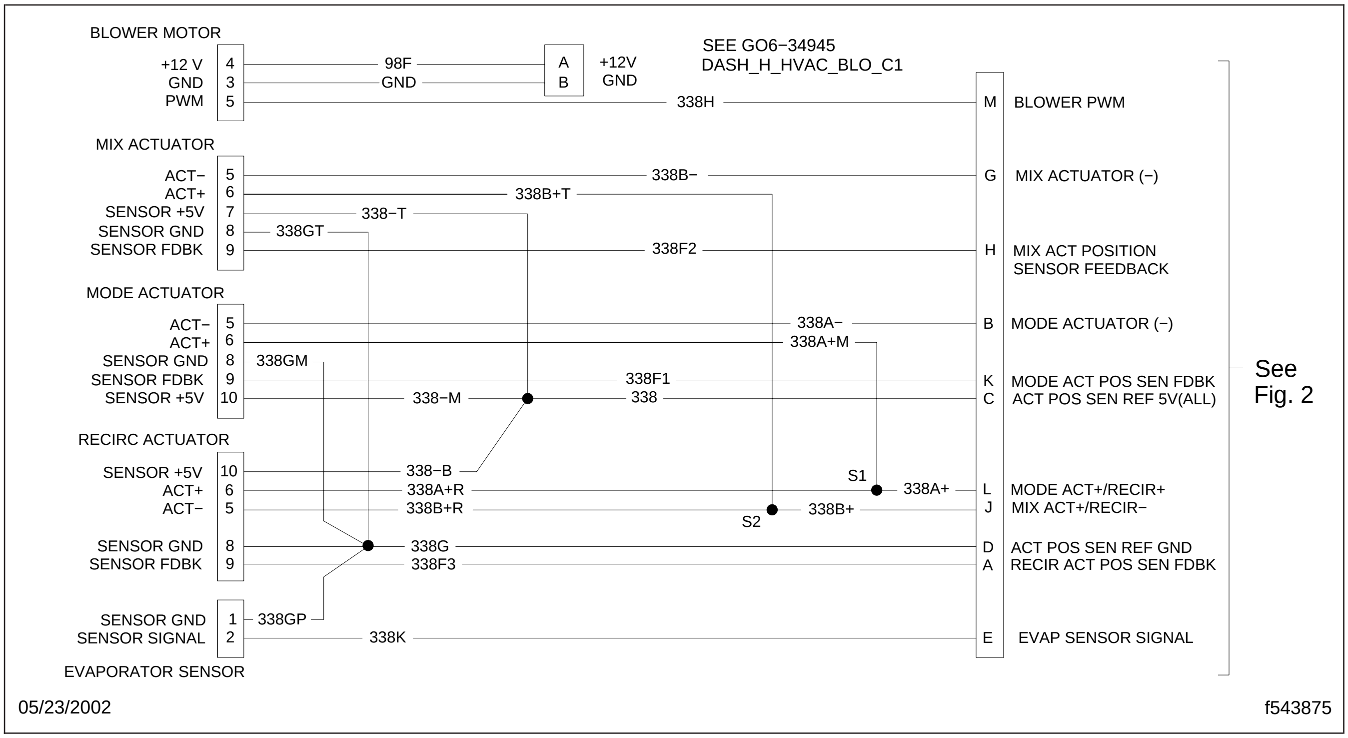


Fig. 1, HVAC Wiring Diagram, Part 1

Specifications

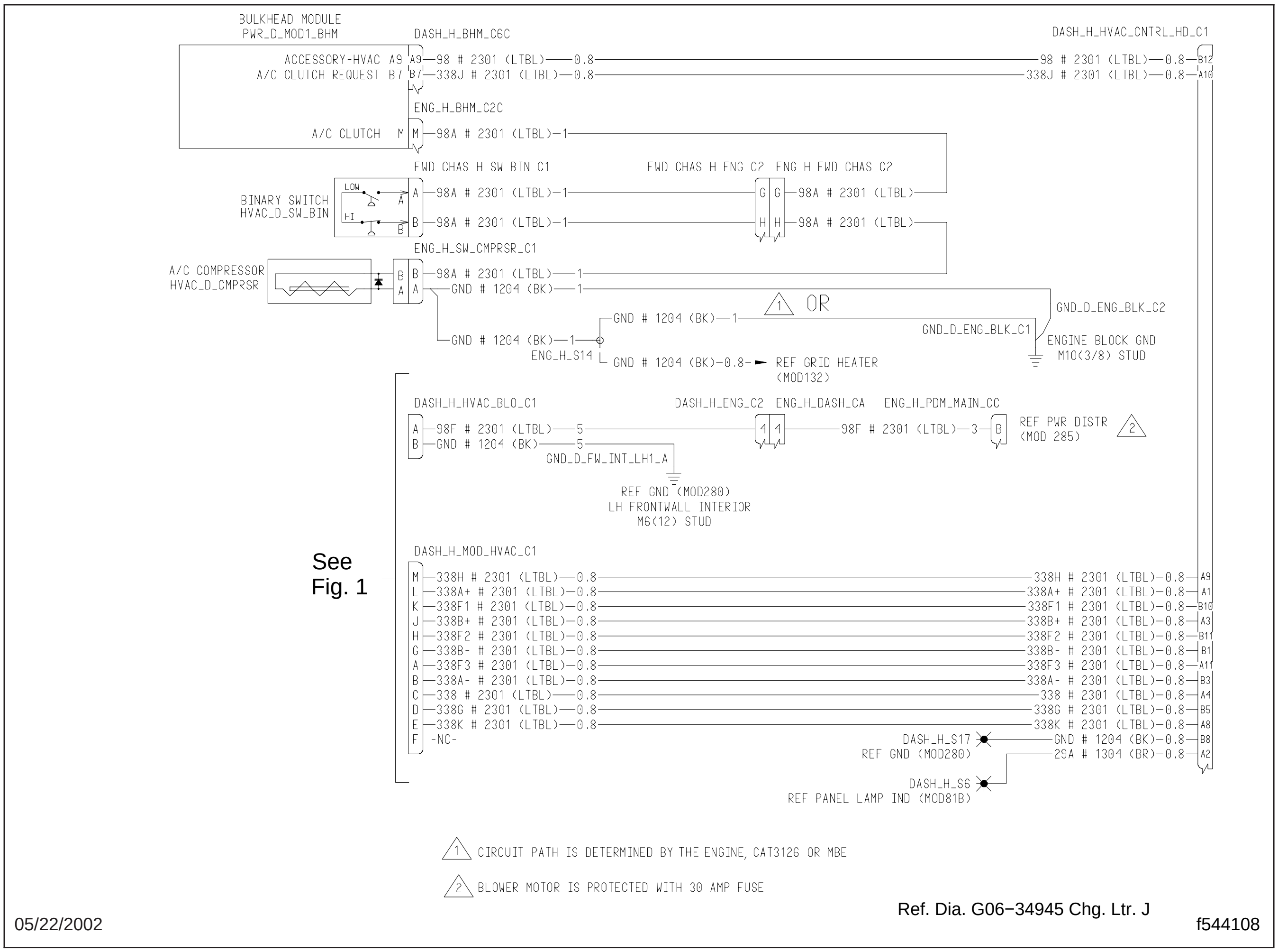
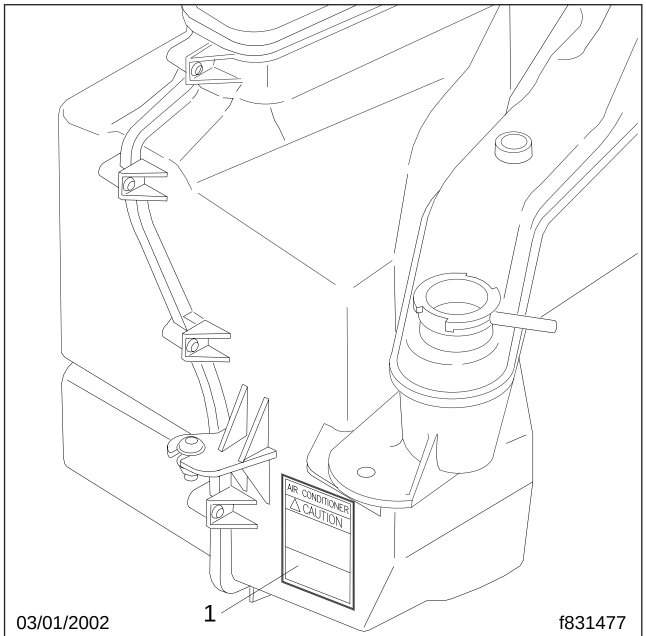


Fig. 2, HVAC Wiring Diagram, Part 2



1. Air Conditioner Label

Fig. 3, Air Intake Plenum