Table of Contents

System Overview

Terms and Abbreviations 500
General Information 501

Components

Component Locations 600
Component Details 601
Electrical Connectors 602

Troubleshooting

Troubleshooting 700
Diagnostic Process 701
Refrigerant System Tests 702
Fault Code Driven Diagnostics 703
Approved Leak Detection Methods 704

Specifications

Specifications 800

500 — Terms and Abbreviations

ACU—Auxiliary Control Unit. This is the module that controls the rear HVAC system on vehicles with a sleeper that contains a rear HVAC unit (non-parked HVAC systems).

CGW—Central Gateway (a.k.a. Gateway Module)

Datalink— A collection of wires, connecting system components, through which data is transmitted.

ECU— Electronic Control Unit; typically connected to a datalink.

FCU—Front Control Unit. This is the module that controls the front HVAC system, including A/C compressor operation.

FMI—Failure Mode Indicator. The part of a J1587, J1939, and CAN fault code that identifies how part of a device, or item on a device, failed.

HVAC—Heating, Ventilation, and Air Conditioning

OSA—Outside Air; means that the air entering the HVAC unit comes from outside the vehicle (fresh air)

Parameter—A parameter is a predetermined variable in a set, each of which restricts or defines the specific capabilities of the system as a whole. Parameters are used to customize the configuration of the system.

RECIRC—Recirculation mode; means that the air entering the HVAC unit comes from within the Cabin space.

ROM—Rear Override Mode; allows the driver to override the sleeper HVAC settings from the front control panel.

SA—Source Address; indicates any device that communicates on J1939.

SAM—Signal detect and Actuation Module

SAM Cab—Signal Detect and Actuation Module Cab ("SAM-Cabin"); this ECU controls mainly Cab-related functionality. See **G02.04—SAM Cab** for more information.

501 — General Information

The main heating, ventilation, and air conditioning (HVAC) system consists of the following major components and subcomponents:

- Brushless direct current (BLDC) blower motor
- Evaporator core
- Heater core
- Recirculation filter
- Outside air filter
- Four electric actuators
- Evaporator temperature sensor
- Blend air temperature sensor
- Thermostatic expansion valve (TXV)
- Front climate control panel—also called Front Control Unit (FCU)

The auxiliary HVAC system consists of the following major components and subcomponents:

- Brushless direct current (BLDC) blower motor
- Evaporator core
- Heater core
- One electric actuator
- Blend air temperature sensor
- Rear climate control panel—also called Auxiliary Control Unit (ACU)
- Thermostatic expansion valve (TXV)

The following components are shared by both the main and the auxiliary HVAC systems:

- Refrigerant compressor
- Condenser
- High-side pressure transducer
- Receiver-drier

System Overview

The Cascadia heating, ventilation, and air conditioning (HVAC) system is designed to deliver air at a temperature to maintain driver comfort. It is also designed to defrost the cab windows to maintain visibility.

The system uses constant outlet temperature control (COTC) to provide discharge air temperature out the ducts that has a stable temperature based on a reference point for each temperature knob detent position. The control head will modulate the temperature door in order to reach and maintain the reference temperature. Conditioning of the air itself is accomplished by drawing air into the front HVAC unit by the blower from either outside the cab (fresh air), inside the cab (recirc air), or a mixture of the two. See "Controlled Partial Recirc" for more information. This incoming air is then directed through the evaporator coil. If the system is in air conditioning or defrost mode, the evaporator will both cool and dehumidify the incoming air. If heating is desired, some or all of the air leaving the evaporator will be routed through the heater core to reheat the air. Engine coolant is continually circulated through the heater core, which transfers engine heat to the air flowing through the heater core. The amount of air routed through the heater core depends on the position of the mix door, which is controlled by both the temperature setting on the HVAC panel as well as the heater core temperature sensor. The HVAC controller will continually adjust the temperature mix door to maintain the temperature selected by the driver. Air is then directed to the vents per the mode selection on the HVAC controller. The front HVAC unit has two air filters: one that filters outside air, and another that filters recirculated air drawn into the unit. The air conditioning system uses a brushless blower motor to circulate temperature-controlled air through the cab. The rate of airflow is controlled by a multispeed fan switch.

Electrical and Control

Figure 1 shows the electrical control topology of the HVAC system. **Figure 2** is a block diagram of the front control panel system architecture. **Figure 3** is a block diagram of the rear control panel system architecture.

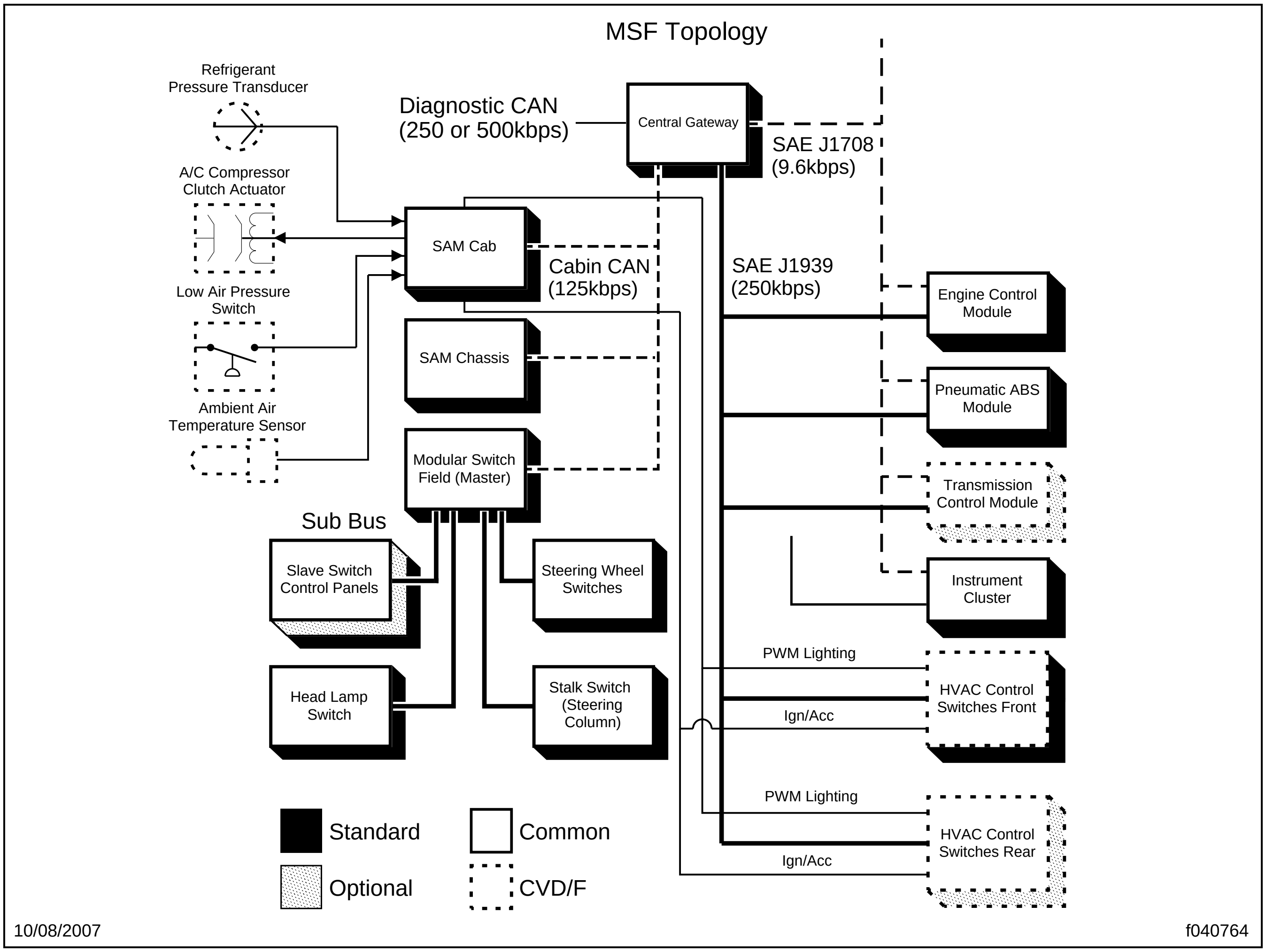


Fig. 1, HVAC System Electrical Control Topology

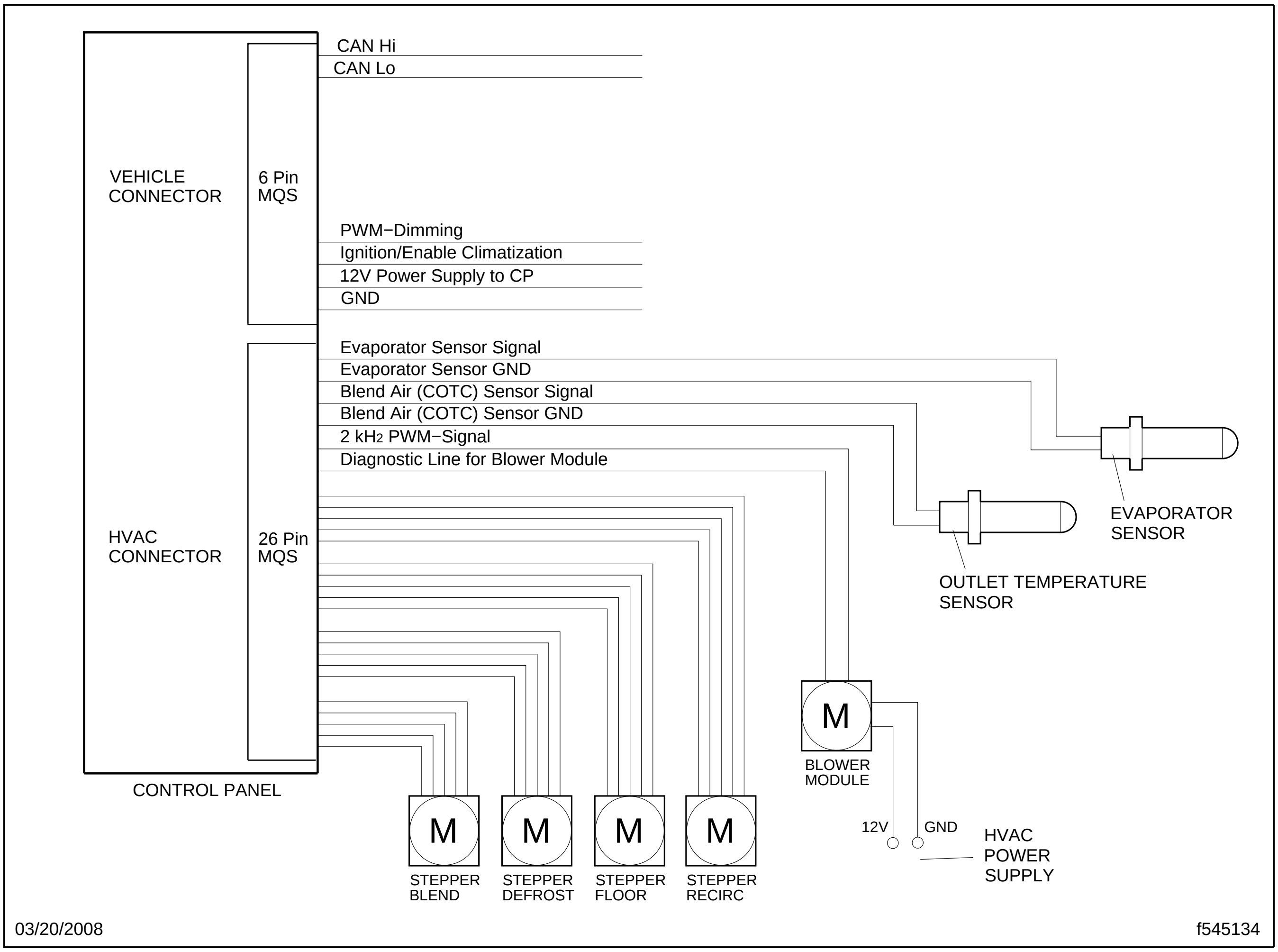


Fig. 2, Front Control Panel System Architecture

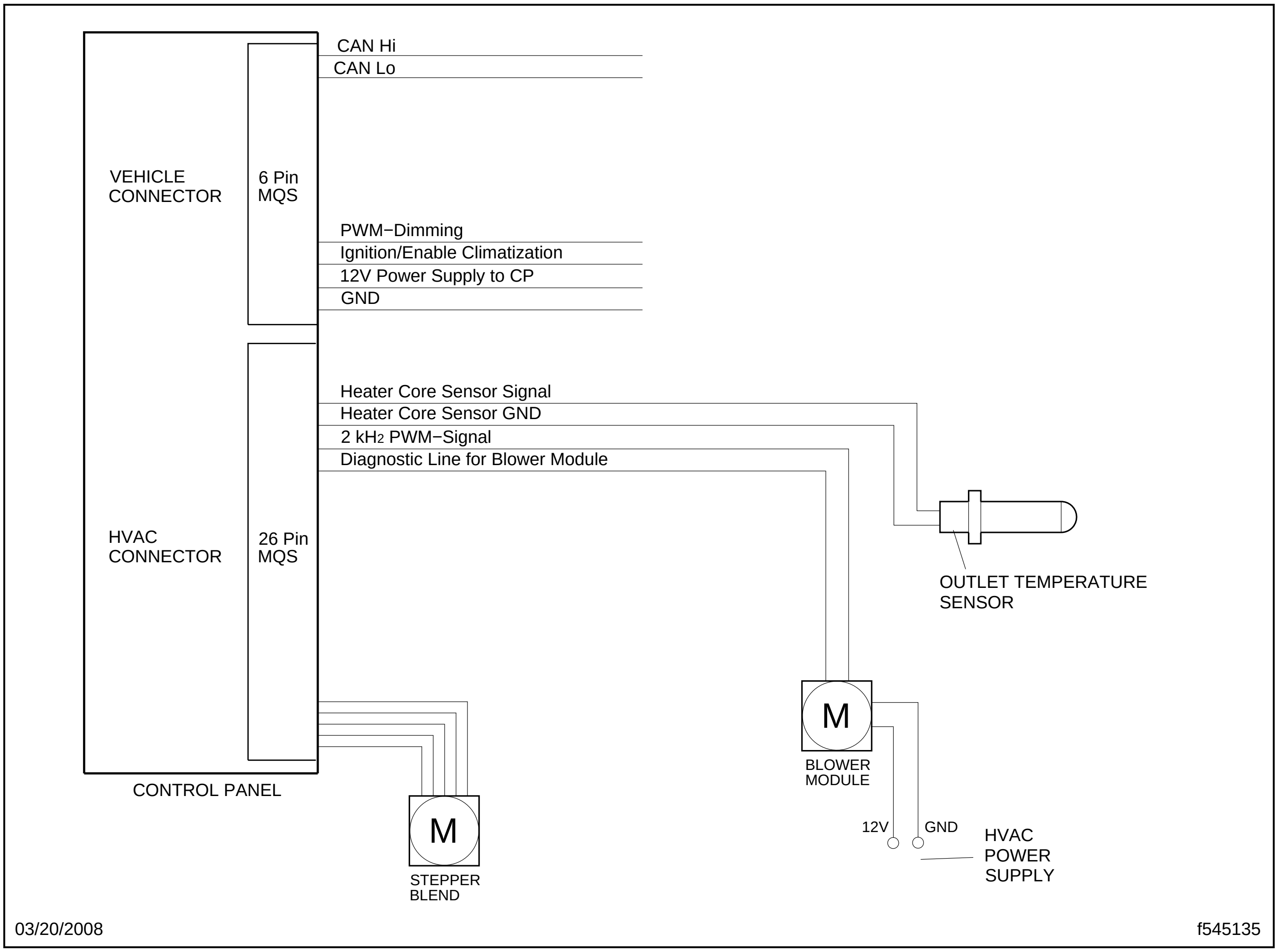


Fig. 3, Rear Control Panel System Architecture

Power Management

Battery power is supplied to the FCU and ACU from the SAM Cab through separate 15A fuses. Battery power is supplied to the front and rear blower motors from the SAM Cab through separate 30A fuses. The FCU and ACU operate normally within a range of 9 to 16 VDC. After the ignition has been off for at least 2 seconds, the FCU and ACU will turn off and go into a sleep, drawing less than 1 mA of current. The FCU will not request A/C compressor clutch engagement if the voltage message from the SAM is less than 12V. If the SAM voltage is not available, the FCU will use the voltage it senses directly.

Backlighting

The backlighting for the FCU and ACU is controlled by a pulse width modulated signal from the SAM Cab. This signal is a constant 400Hz. The duty cycle of the signal determines the illumination intensity—10% or less duty cycle (full dim) to 90% or higher duty cycle (full bright). The SAM Cab sends a message on the J1939 datalink, which is used by the FCU and ACU to control dimming for daylight and nighttime conditions.

Communication

The FCU and ACU communicate over the J1939 datalink. The FCU uses source address (SA) 25 and the ACU uses SA 58. The messaging communicated is used for operation, diagnostics, and data used to monitor the system with a Datalink Monitor.

A/C Clutch Engagement Rules

When all of the conditions in **Table 1** are met, the FCU will send a message to the SAM Cab commanding it to engage the A/C compressor clutch. Under normal operation, the A/C compressor cycles on/off based on the evaporator temperature sensor input to the FCU. See **Table 1** for the required conditions for the FCU to send an A/C clutch engagement command to SAM Cab.

Conditions for FCU To Send A/C Clutch Engagement Command to SAM Cab		
Input	**Input Type**	**Condition**
Blower switch position*	Internal to FCU	Any speed EXCEPT off
A/C switch pressed* OR Mode knob in one of the defrost positions	Internal to FCU	A/C switch LED is on (blower must be on too)
Countdown timers preventing A/C clutch engagement more than 4 times per minute.	Internal to FCU	Timers must be expired (when clutch is turned on, a 15-second timer starts, when it is turned off, a 3-second timer starts—minimum cycle time = 18 seconds)
Vehicle air pressure status	J1939 message from SAM Cab via CGW	Air pressure greater than 60 psi (415 kPa)
Engine rpm	J1939 message from ECM	rpm = 450 or higher for at least 5 seconds
Ambient temperature†	J1939 message from SAM Cab via CGW	Ambient = 40°F to 200°F (4.5°C to 93°C)
Refrigerant pressure (high side)	J1939 message from SAM Cab via CGW	Refrigerant pressure = above 34 psi (234 kPa)‡
Battery voltage	J1939 message from SAM Cab via CGW§	12.5V or higher¶
Evaporator temperature	Sensor	38.5°F (3.5°C) or higher

* If the front unit is off (blower off), the A/C can be turned on from the rear unit (minimum A/C support). When this happens, the front unit's blower speed will turn on to low, and the A/C switch LED will illuminate—all other conditions must be met in order for the A/C compressor to engage.

† Ambient temperature is not used as a condition for A/C clutch engagement on vehicles built after 6/15/2009, or prior vehicles that have previously had the front HVAC control unit replaced with an updated part. Updated parts would be the following or newer: A22-60645-101, A22-60645-501, or A22-60669-002.

‡ See table in Section 800 for high and low pressure cut in/cut out specifications. The value of 34 psi (234 kPa) is the minimum pressure for compressor engagement under normal conditions.

§ If SAM Cab battery voltage is not available, the FCU will use voltage sensed on its circuit board.

¶ If the compressor is engaged and the voltage drops below 12V, the FCU will command that it be disengaged.

Table 1, Conditions for FCU To Send A/C Clutch Engagement Command to SAM Cab

Controlled Partial Recirc

RECIRC allows the driver to choose whether air drawn into the unit comes from outside the cab (outside air) or from inside the cab (recirculated air). The HVAC controller controls an electric actuator, or stepper motor, which moves a door inside the unit, which controls the source of air entering the unit. Recirculated air will provide maximum cooling when the air conditioner is used, and it also allows the driver to prevent outside air from entering the cab under conditions when the air outside is undesirable (dust, smoke, etc.). Recirculated air is not available when the HVAC unit is in defrost mode. When the unit is in DEFROST mode, the unit will automatically disable RECIRC (if enabled) allowing 100% of the air entering the unit to come from outside of the vehicle. Outside air helps maximize defrost performance. If the driver chooses RECIRC mode, 100% of the air entering the unit will come from inside the vehicle for 20 minutes. After 20 minutes has elapsed, the unit will enter partial RECIRC mode, allowing some outside air to enter and mix with the recirculated air entering the unit from the cab, if the blower setting is on the third setting or higher as shown in **Table 2**.

The driver can press the RECIRC button and enter full RECIRC again at any time—except in defrost mode (where recirc is not available).

<table>
<tr><th colspan="4">Controlled Partial Recirc Rules</th></tr>
<tr><th>Blower Speed</th><th>Recirculation OFF</th><th>Recirculation ON (first 20 minutes)</th><th>Recirculation ON (after first 20 minutes)</th></tr>
<tr><td>OFF</td><td>100% Recirculated Air</td><td rowspan="4">100% Recirculated Air</td><td>100% Recirculated Air</td></tr>
<tr><td>1</td><td rowspan="3">100% Fresh Air</td><td rowspan="2">100% Fresh Air</td></tr>
<tr><td>2</td></tr>
<tr><td>3–8</td><td>90% Recirculated Air (Partial Recirc)</td></tr>
</table>

Table 2, Controlled Partial Recirculation Rules

ACU Override Mode

The ACU override feature allows the user to override the settings of the bunk HVAC system from the front HVAC control panel. If the prerequisite conditions are met, when the driver presses the AUX button on the front control panel, the FCU sends a J1939 message to the ACU requesting it to enter ACU override mode. If there are no conditions preventing it from entering override mode, the ACU will enter the override mode and send the FCU a J1939 message indicating that it has entered the ACU override mode. The FCU then sends a J1939 message to the ACU containing its current temperature and blower settings. The ACU will control the bunk HVAC unit to attain the temperature and blower motor set points as received in the J1939 blower motor and temperature set points message from the FCU. If the user then selects a different temperature or blower speed setting on the front control panel, the front unit’s settings will change without changing the settings previously sent to the ACU, unless the driver presses the AUX button off, then on again. Conditions that must be met in order to enter the ACU override mode are:

- FCU must be active (powered up and on the J1939 datalink)
- No active faults, in the front or auxiliary HVAC systems, that would prevent engagement
- "AUX" switch must be pressed on the front control panel

The ACU override will be disabled if any of the following occurs:

- The "AUX" button is turned off
- The FCU detects an active fault in the front system that would prevent engagement
- The FCU receives an active fault message from the ACU that would prevent engagement
- The blower speed or temperature knob settings on the bunk unit are changed (the FCU will detect this change through a J1939 message)
- Setting the parking brake

The above conditions will cause the FCU to send a J1939 message to the ACU requesting that the override mode be turned off. The ACU will respond to the FCU with a message indicating that it has turned the override mode off.

The indicator LED on the "AUX" switch will be steady ON when the FCU senses the "AUX" switch in the ON position. It will be OFF when the FCU senses the "AUX" switch in the OFF position.

FCU Override Mode

The ACU has the capability to override the FCU temperature and blower settings once the vehicle parking brake has been engaged. This is determined by a J1939 message from the SAM Cab. Once the parking brake is set, and either the blower or temperature control setting on the bunk HVAC has been changed, the FCU will then mimic the settings of the ACU temperature and blower. Both the FCU and ACU control settings will remain as they are if the ACU control settings are not changed. The FCU override can be deactivated by modifying any of the FCU functions or releasing the parking brake. The ACU override mode is still available by depressing the "AUX" switch. Once the parking brake is disengaged, the FCU override mode is disabled, and the FCU will function based on the control settings on the FCU.

Minimum A/C Support

The FCU minimum A/C support feature is intended to assist the bunk HVAC system in maintaining its temperature setting by turning on the FCU to a minimum operating mode for A/C support. This feature is only implemented when:

- the front blower motor control is turned OFF, or the A/C switch is OFF, and
- the system is not in front override mode.

If the above conditions are met, and the ACU determines that it needs the A/C compressor to operate in order for it to maintain temperature, the ACU will request the FCU to engage the A/C compressor clutch.

Mode Control

Table 3 lists the mode control settings for the different positions of the mode control knob.

Figure 4 shows the airflow through the front HVAC unit with the mode setting in the DEF/FLOOR position, and the temperature set to medium heat.

Figure 5 shows the airflow through the front HVAC unit with the mode setting in the full DEFROST position, and the temperature set to full HOT.

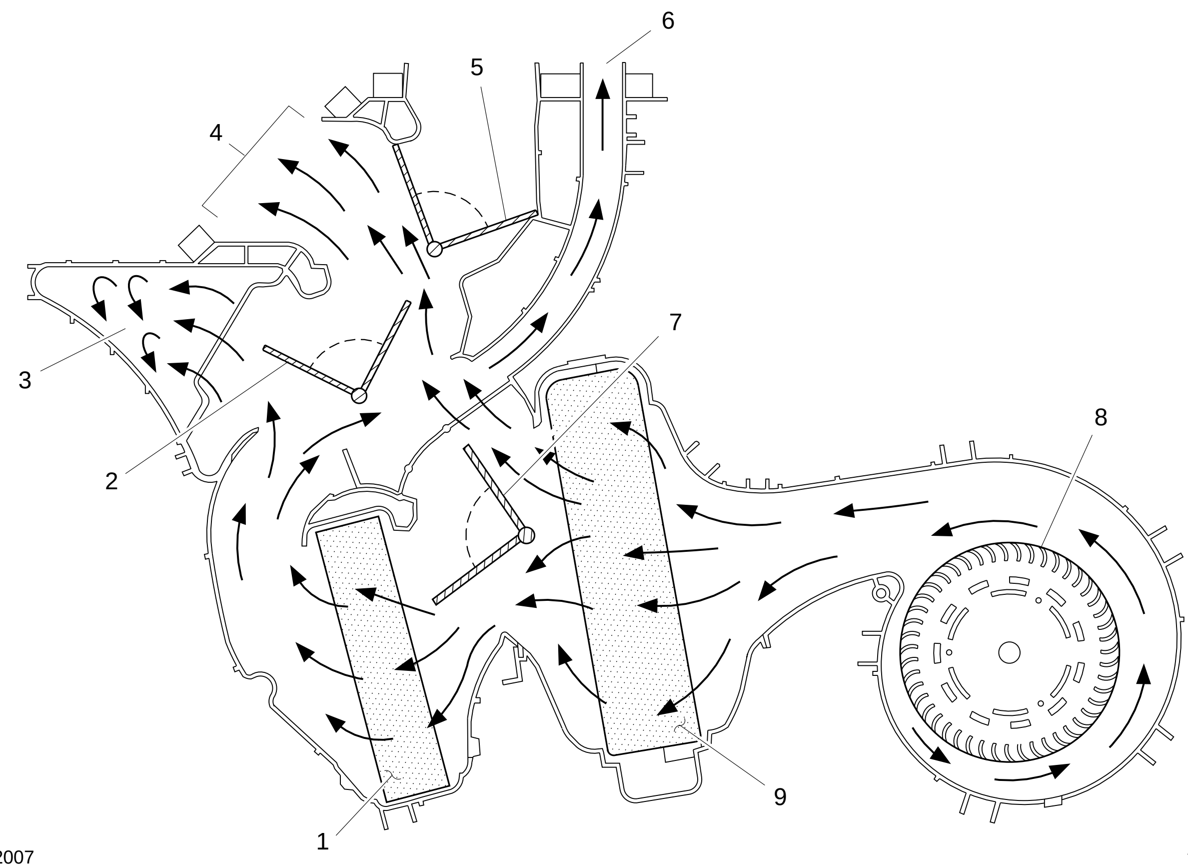
Figure 6 shows the airflow through the front HVAC unit with the mode setting in the full FLOOR position, and the temperature set to full HOT.

Figure 7 shows the airflow through the front HVAC unit with the mode setting in full FACE position, and the temperature set to full COLD (MAX A/C Mode).

Mode Control Settings			
Knob Position	**Mode**	**Mode Door Position**	**A/C Request and A/C Indicator Lit (automatically)**
1	FACE	100% FACE	No
2	Minor detent	75% FACE + 25% FLOOR	No
3	BI-LEVEL	50% FACE + 50% FLOOR	No

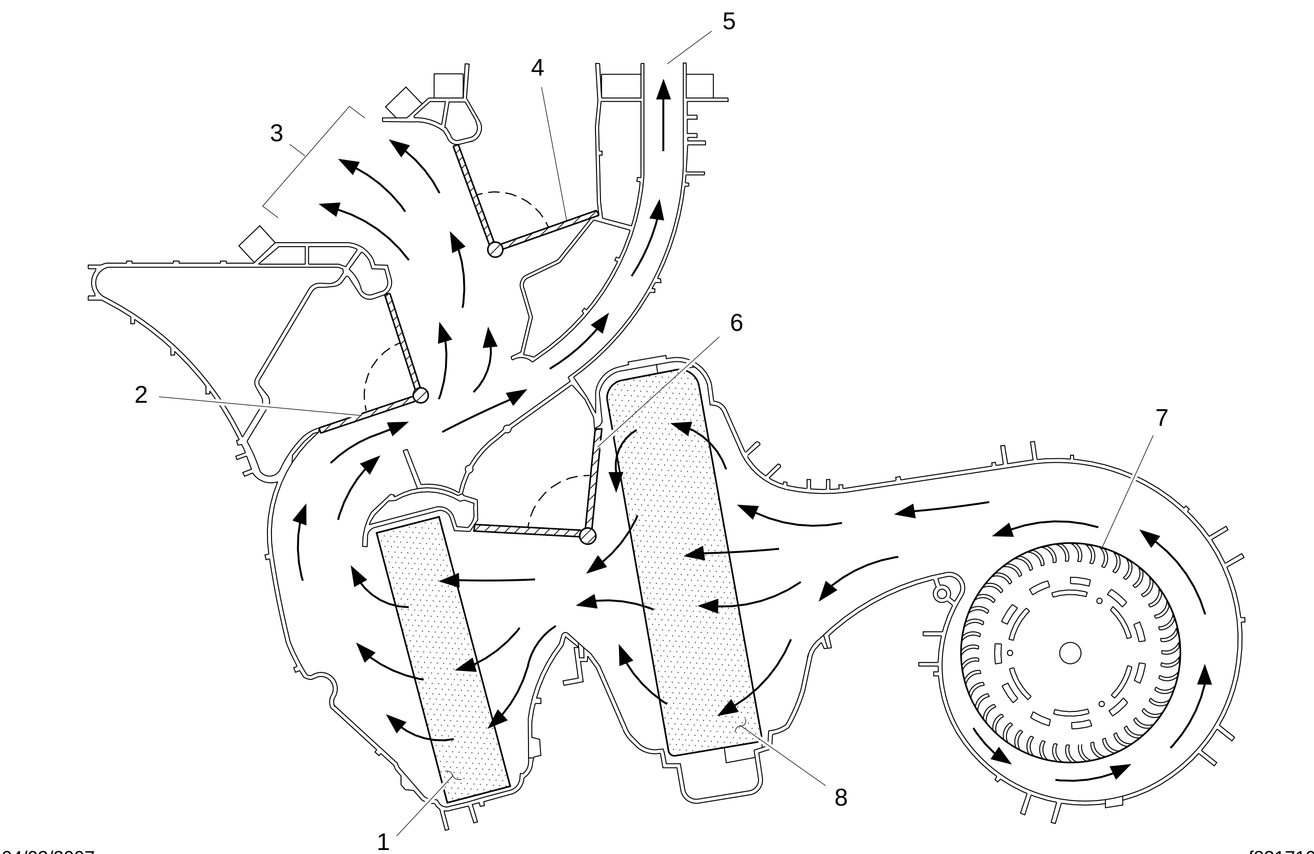
Mode Control Settings			
Knob Position	Mode	Mode Door Position	A/C Request and A/C Indicator Lit (automatically)
4	Minor detent	25% FACE + 75% FLOOR	No
5	FLOOR	100% FLOOR	No
6	Minor detent	75% FLOOR + 25% DEFROST	Yes
7	DEF/FLOOR	50% FLOOR + 50% DEFROST	Yes
8	Minor detent	25% FLOOR + 75% DEFROST	Yes
9	DEFROST	100% DEFROST	Yes

Table 3, Mode Control Settings



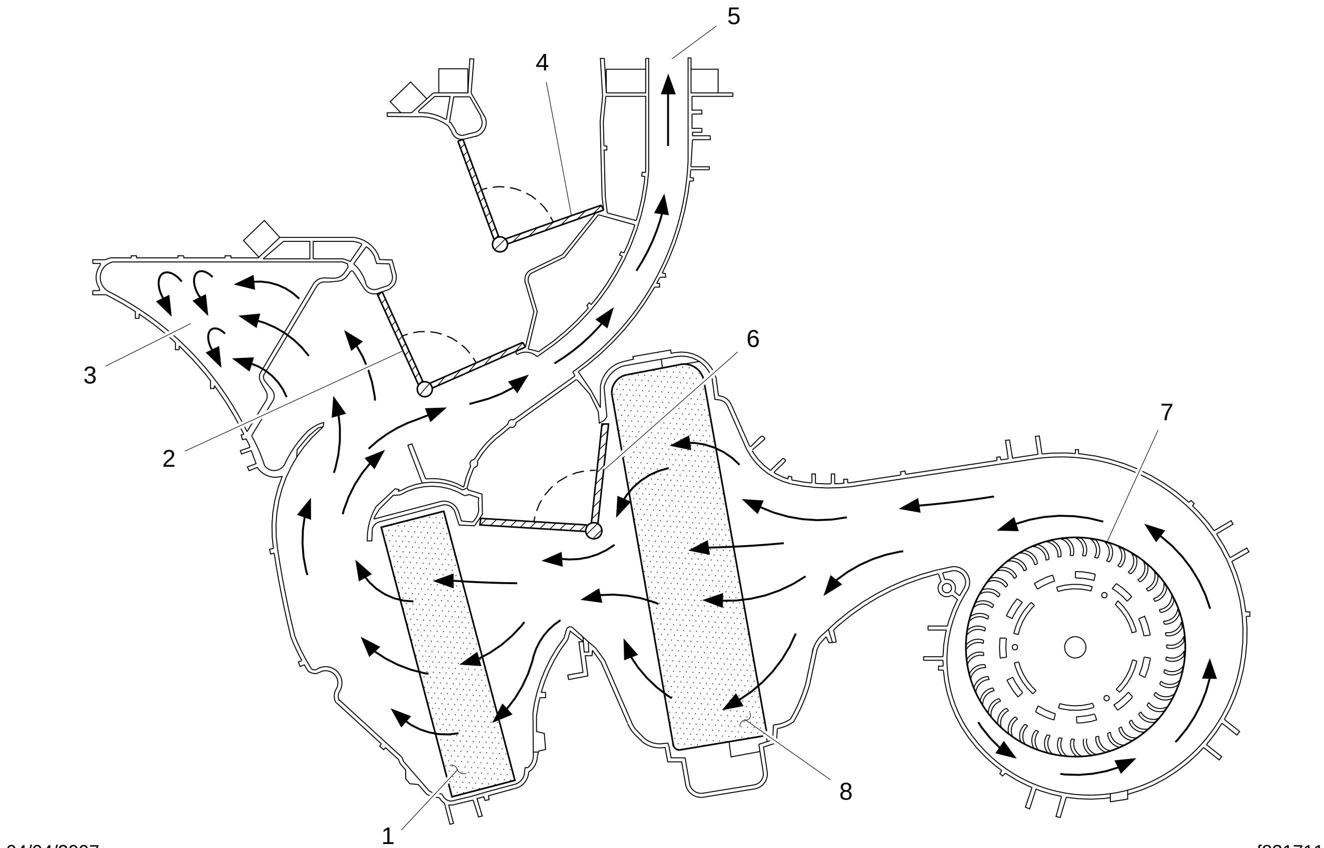
1. Heater Core
2. Floor Actuator Door (mix position)
3. Floor Duct Outlet
4. Defrost Duct Outlet
5. Face/Defrost Actuator Door (DEFROST position)
6. Side Demister Duct Outlet
7. Temperature Mix Door (mix position)
8. Blower Motor
9. Evaporator Core

Fig. 4, Airflow Through Front HVAC Unit—Mode in DEF/FLOOR Position, Temperature Set to Medium Heat



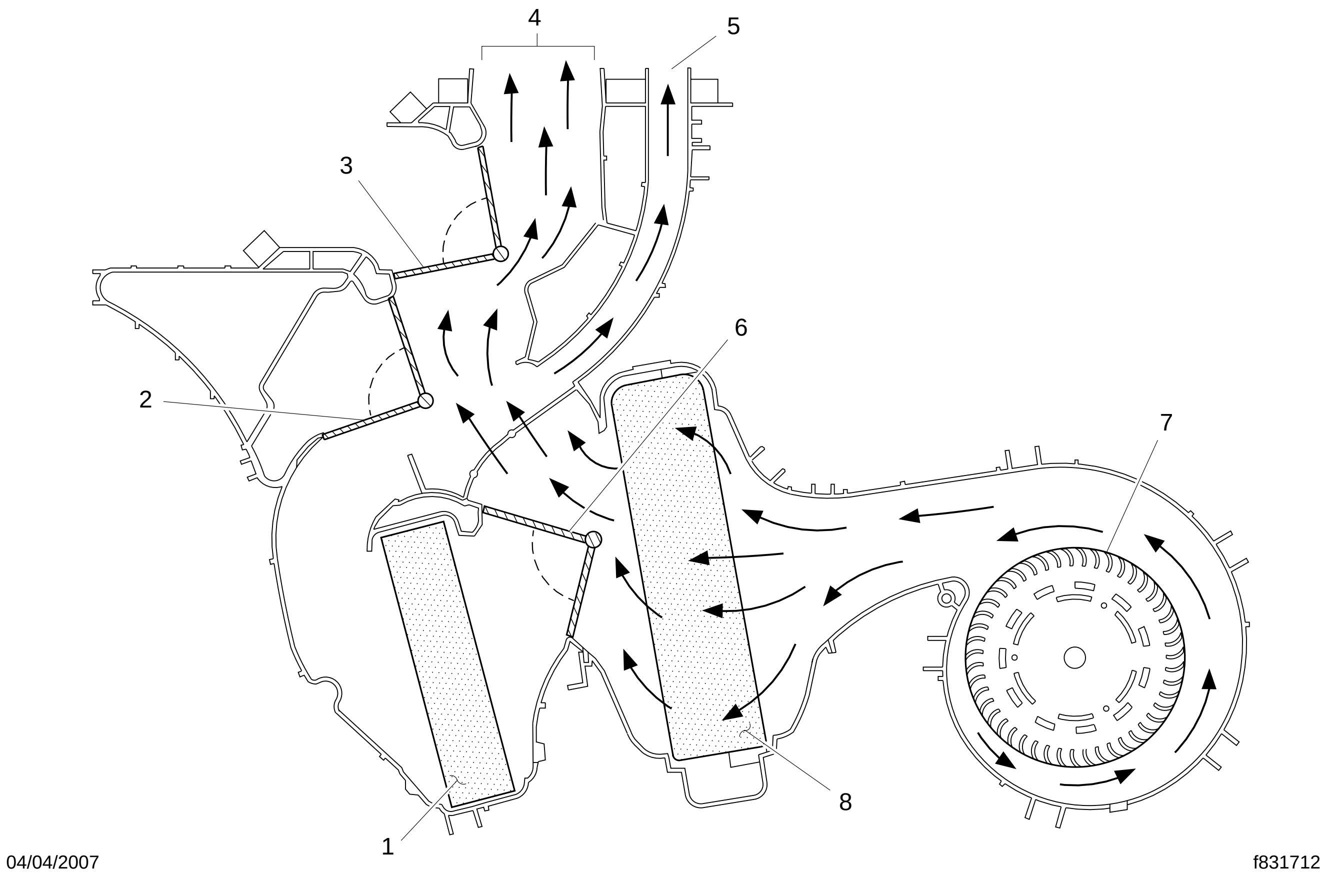
1. Heater Core
2. Floor Actuator Door (closed position)
3. Defrost Duct Outlet
4. Face/Defrost Actuator Door (DEFROST position)
5. Side Demister Duct Outlet
6. Temperature Mix Door (full HOT position)
7. Blower Motor
8. Evaporator core

Fig. 5, Airflow Through Front HVAC Unit—Mode in Full DEFROST Position, Temperature Set to Full HOT



1. Heater Core
2. Floor Actuator Door (full FLOOR position)
3. Floor Duct Outlet
4. Face/Defrost Actuator Door (DEFROST position)
5. Side Demister Duct Outlet
6. Temperature Mix Door (full HOT position)
7. Blower Motor
8. Evaporator Core

Fig. 6, Airflow Through Front HVAC Unit—Mode in Full FLOOR Position, Temperature Set to Full HOT



1. Heater Core
2. Floor Actuator Door (closed position)
3. Face/Defrost Actuator Door (full FACE position)
4. Face Duct Outlet
5. Side Demister Duct Outlet
6. Temperature Mix Door (full COLD position)
7. Blower Motor
8. Evaporator Core

Fig. 7, Airflow Through Front HVAC Unit—Mode in Full FACE Position, Temperature Set to Full COLD (MAX A/C mode)

Manual Calibration Mode

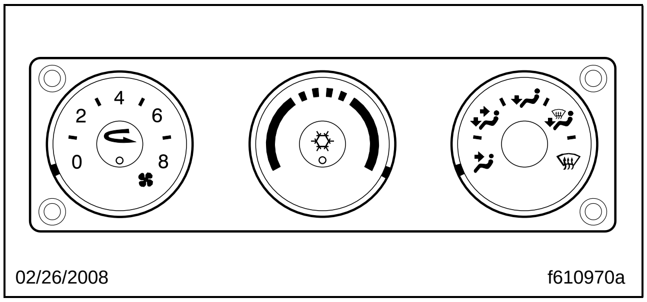


Fig. 8, Manual Calibration Mode Knob Positions

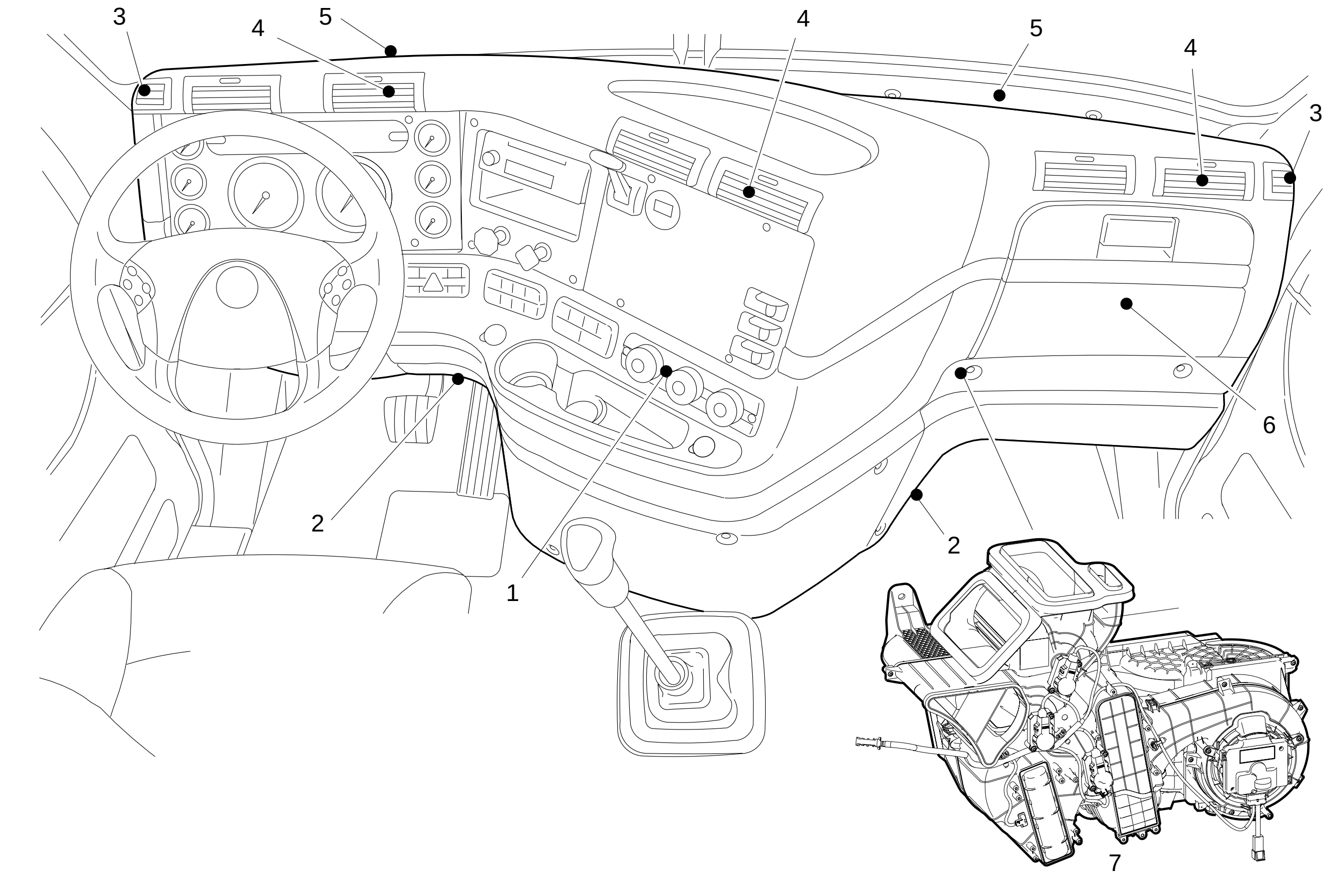
It is necessary to calibrate the actuators if they are removed or replaced. To enter calibration mode, perform the following steps:

1. Turn the ignition ON (engine OFF).
2. Set the blower speed control to OFF (full counterclockwise position).
3. Set the temperature control knob to the full clockwise position (HOT).
4. Set the mode control knob to the full counterclockwise position (FACE).
5. Press the A/C and RECIRC buttons simultaneously until the A/C and RECIRC indicators begin flashing simultaneously.

   The calibration process will begin and will continue until the A/C and RECIRC indicators stop flashing.

600 — Component Locations

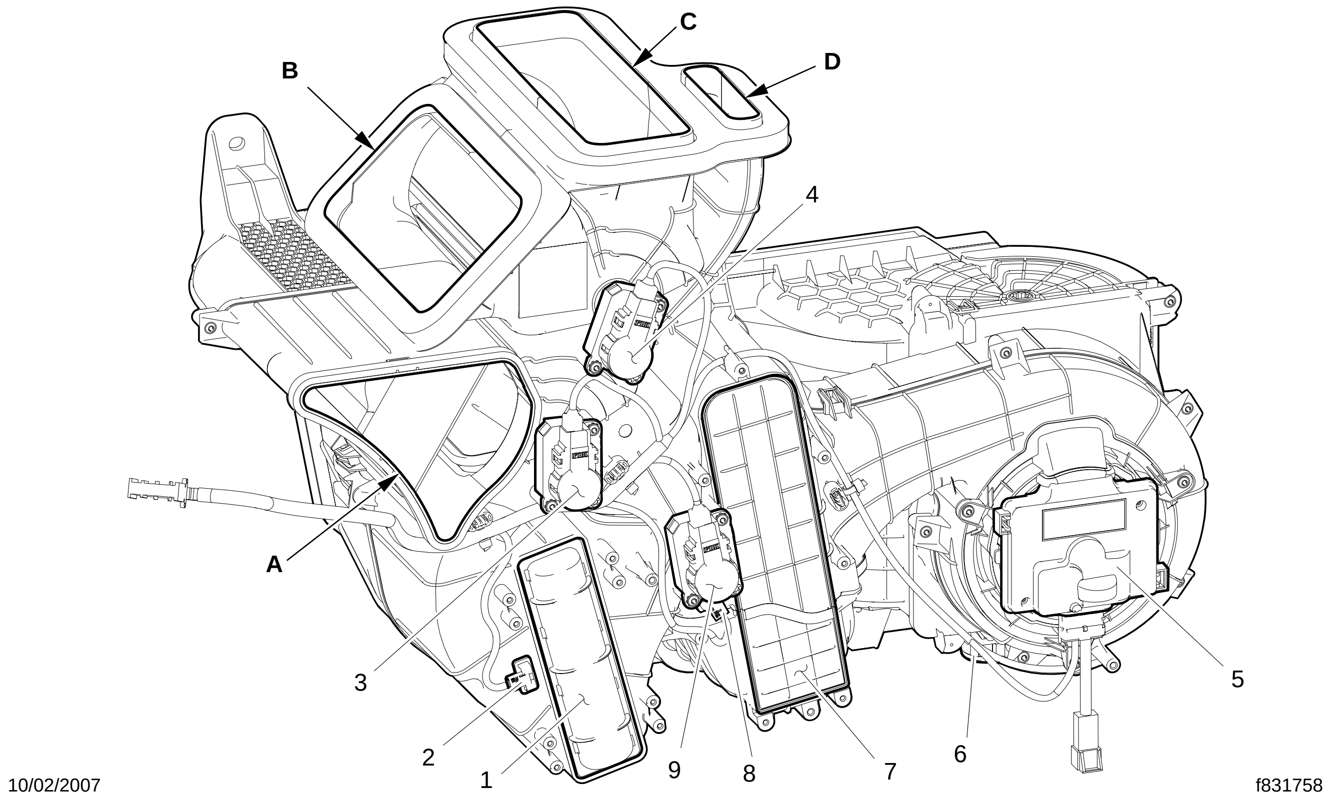
HVAC Component Locations (general)



1. Front Control Unit (FCU)—Climate Control Panel
2. Floor Vents
3. Side Demister Vents
4. Face Vents
5. Defrost Vents
6. SAM Cab
7. Front HVAC Unit Assembly

Fig. 9, HVAC Component Locations (general)

Component Locations—Front HVAC

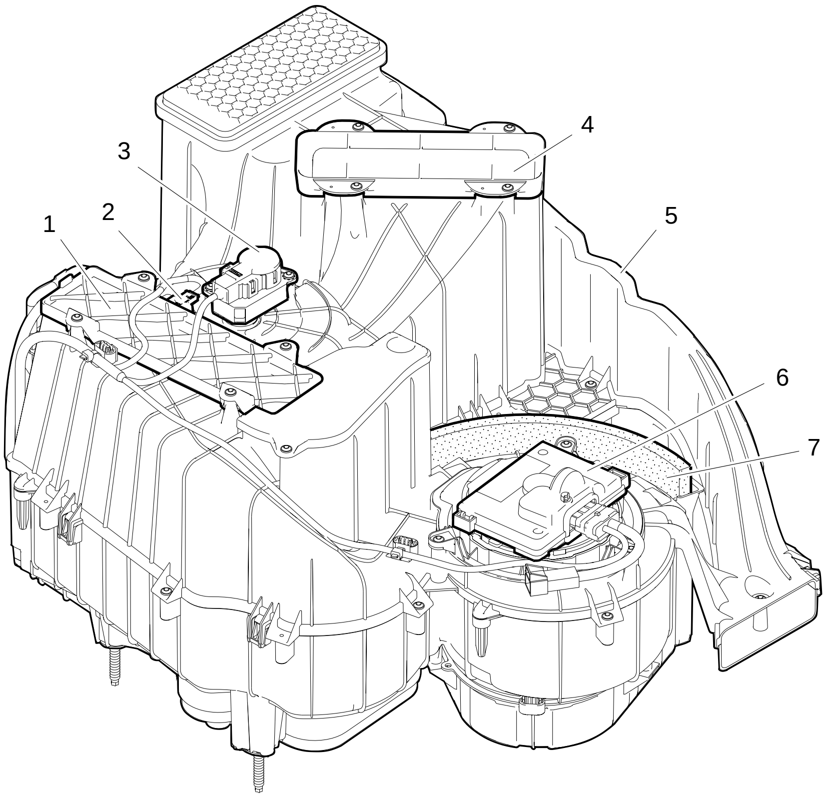


A. Floor Vent Outlet
B. Defrost Vent Outlet
C. Face (dash) Vent Outlet
D. Driver Side Demister (side vent) Outlet

1. Heater Core (service access)
2. Temperature Sensor (blend air)
3. Floor Vent Actuator Stepper Motor
4. Panel/Defrost Vent Door Actuator Stepper Motor
5. Blower Motor
6. Fresh/Recir Air Actuator Stepper Motor
7. Evaporator (service access)
8. Evaporator Temperature Sensor
9. Temperature Blend Door Actuator Stepper Motor

Fig. 10, Component Locations, Front HVAC

Component Locations—Sleeper HVAC



1. Evaporator
2. Temperature Sensor
3. Temperature Mix Door Actuator
4. Heater Core
5. Auxiliary HVAC Unit
6. Blower Motor
7. Filter

Fig. 11, Component Locations, Sleeper HVAC

601 — Component Details

Front Control Unit (FCU)

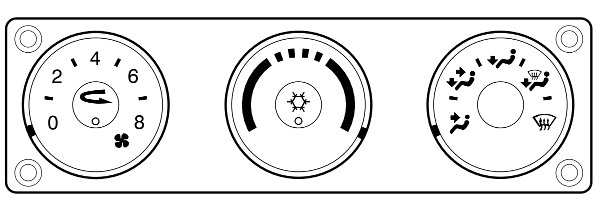


Fig. 12, Day Cab FCU

The front control unit (FCU), also known as the climate control panel, is the brain of the front HVAC system. It also houses the knobs and switches that allow the driver to select various modes of operation, such as temperature, blower speed, air conditioning, etc. The SAM Cab provides the FCU with battery power, ignition power, and ground. It also supplies the signal to control backlighting. The FCU communicates with other ECUs on the J1939 datalink. The FCU controls all of the HVAC unit's four actuator stepper motors. Two of these are used to control airflow out of the vents (see "Mode Control"), one is used to control temperature by directing how much air flows through the heater core, and one is used to control whether recirculated or fresh air enters the unit (see "Controlled Partial Recirculation Rules"). The FCU controls the blower motor by providing a pulse width modulated signal to indicate set speed. It also monitors the blower motor feedback for actual blower speed and blower motor faults. The FCU determines when the A/C compressor should operate, and sends a request to the SAM Cab. The FCU can remotely control the bunk HVAC unit.

Auxiliary Control Unit (ACU)

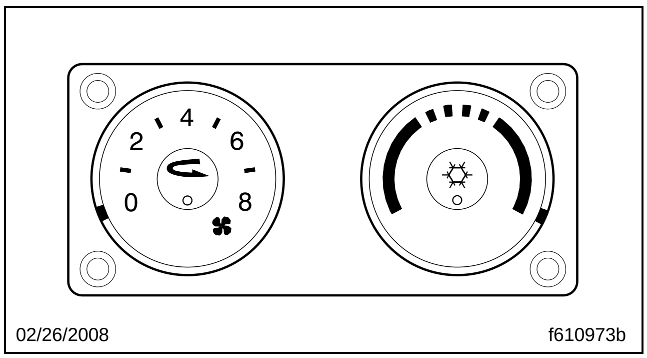


Fig. 14, Auxiliary Control Unit

The auxiliary control unit (ACU), is the brain of the bunk HVAC system. It is also known as the bunk climate control panel. It also houses the knobs and switches that allow the bunk occupant to select various modes of operation such as temperature, blower speed, air conditioning, etc. The SAM Cab provides the ACU with battery power, ignition power, and ground. It also supplies the signal to control backlighting. The ACU communicates with other ECUs on the J1939 datalink. The ACU controls an actuator stepper motor in the bunk HVAC unit, which operates a temperature mix door that directs how much air flows through the bunk heater core. The ACU controls the bunk unit blower motor by providing a pulse width modulated signal to indicate set speed. It also monitors the blower motor feedback for actual blower speed, and blower motor faults. The ACU can remotely control the front HVAC unit when the parking brake is set. See "FCU Override Mode".

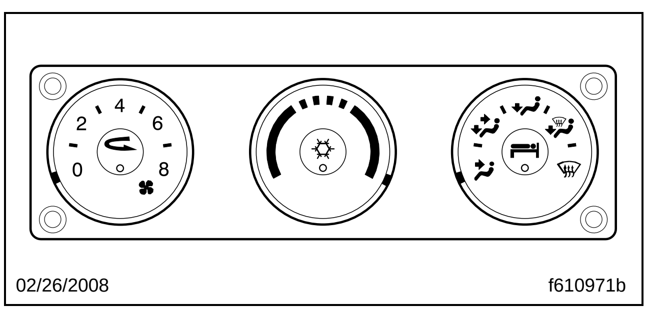
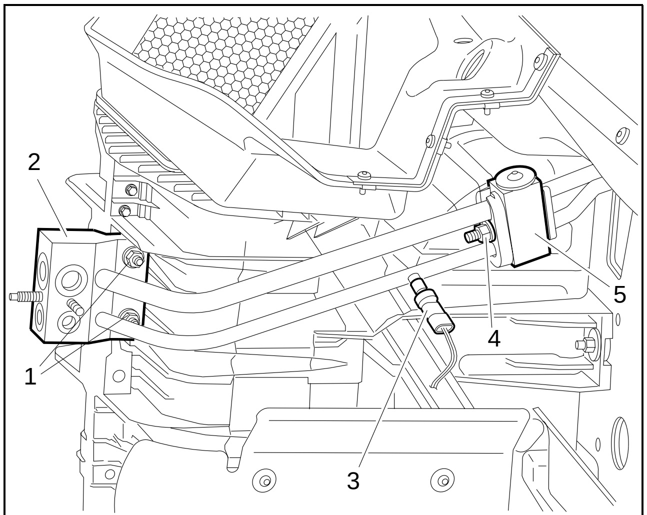


Fig. 13, Sleeper Cab FCU

Compressor

The primary purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and compress it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. The secondary purpose of the compressor is to move refrigerant through the air conditioning system.

Pressure Transducer



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1. J-Block Mounting Nuts and Bolts
2. J-Block
3. Pressure Transducer
4. Thermostatic Expansion Valve Nut, Washer, and Stud
5. Thermostatic Expansion Valve

Fig. 15, Pressure Transducer

A pressure transducer, located in the high side of the refrigerant system close to the TXV, is used in place of the conventional binary and fan cycling switches. The transducer is connected to the SAM Cab.

Actuators

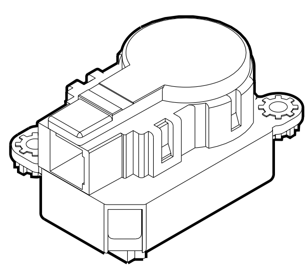

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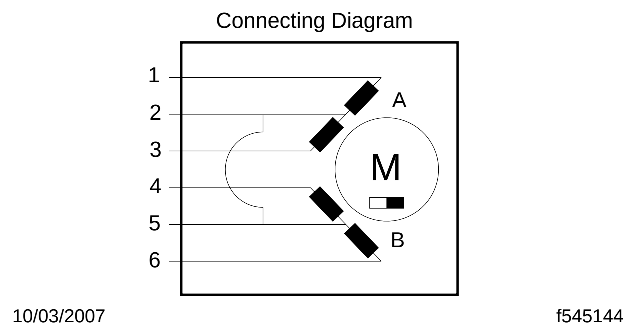
Fig. 16, Actuator

Each actuator has a stepper motor in it that operates by switching 4 wires (the other two pins, 2 and 5, are tied to ignition level) in a proper sequence to cause rotation. The four wires are each switched on and off at 50Hz rate by the control panel, resulting in 200 "steps" per second. There is essentially 10 degrees of door rotation per second. There is no feedback to the FCU or ACU because the actuator moves a fixed angle for each step.

Actuator Connection and Drive Sequence



	0	I	II	III
1			—	—
3	—	—		
4		—	—	
6	—			—
2+5	+	+	+	+
1		—	—	
3	—			—
4			—	—
6	—	—		
2+5	+	+	+	+

Table 4, Actuator Connection and Drive Sequence

COTC Sensor

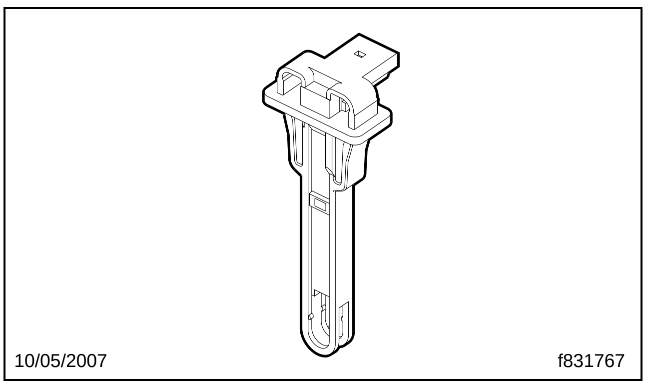


Fig. 17, COTC Temperature Sensor

The constant duct outlet temperature sensor (COTC) is used by the FCU to control the blend door position, to maintain temperature within the FCU set-points. It is a negative temperature coefficient (NTC), meaning that its resistance decreases as temperature increases.

Evaporator Sensor

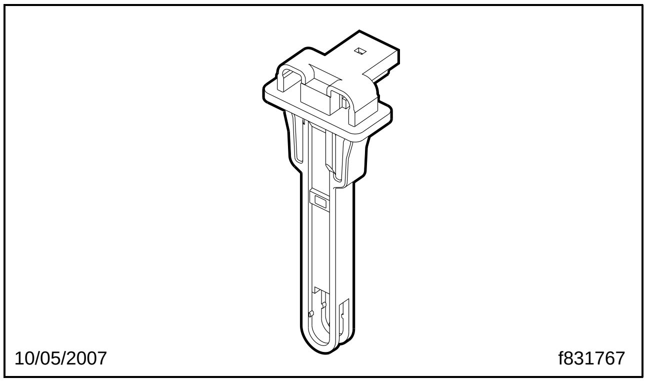


Fig. 18, Evaporator Temperature Sensor

The evaporator temperature sensor is used by the FCU to control the refrigerant compressor, to maintain temperature within its set-points, and to prevent evaporator freezing. It is a negative temperature coefficient (NTC), meaning that its resistance decreases as temperature increases. The FCU turns the compressor on when the temperature sensed by the evaporator temperature sensor is at or above 38.5°F (3.5°C). The FCU cycles the compressor off when the temperature sensed by the evaporator temperature sensor is at or below 38.0°F (3°C).

NOTE: There are other things that can prevent the compressor from engaging, regardless of whether the temperature sensed by the evaporator temperature sensor is within the range in which the compressor should engage. See "A/C Clutch Engagement".

Blower Motor

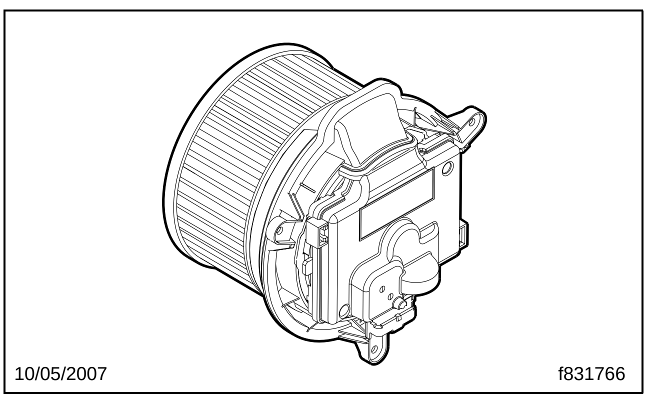


Fig. 19, Blower Motor

The Cascadia uses a brushless direct current (BLDC) blower motor in both the front and rear HVAC units. Both the front and rear BLDC blower motors have four circuits connected to them as follows:

- Battery power supplied directly from the SAM Cab through separate 30A fused circuits
- Ground supplied directly from the SAM Cab

- Pulse Width Modulated (PWM) speed control signal from the FCU and ACU
- Feedback signal to the FCU and ACU indicating rotational speed and fault diagnostics

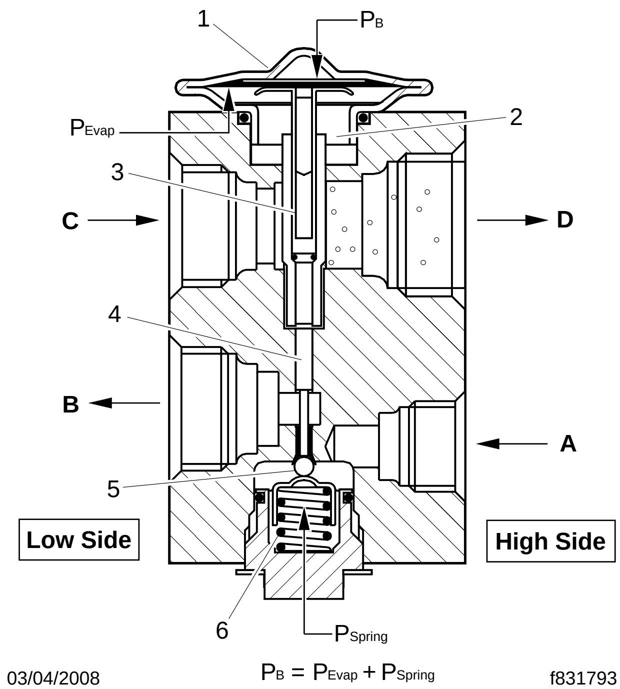
The blower speed is controlled by the fan switches on the front and rear climate control panels (FCU and ACU). The control head sends a PWM signal to the blower motor at a frequency of 2000 Hz. The pulse width varies with the fan switch speed selection. The blower operates from within a speed ranging from approximately 400 to 3850 rpm.

Under normal operation, the feedback signal to the FCU and ACU indicates blower speed by varying the frequency. **rpm = 20 X Frequency**. The BLDC blower motor has built-in protections that will cause the motor to operate at reduced speed or shut down to prevent damage. Any of the following conditions will cause the blower to enter protection mode:

- Over/Under Voltage—If the voltage supply to the blower motor is less than 8.5V or more than 17V, the blower motor will enter protection mode and shut down. The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- Reverse Voltage Protection—The motor will not operate if the polarity of the motor power and ground leads are reversed.
- Current Protection—If the motor exceeds the maximum current, the speed will be reduced until the current is within the normal range (under 23.5A). The blower feedback circuit will indicate a fault, and a fault will be logged in the FCU or ACU.
- 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. The blower feed-back circuit will indicate a fault, and a fault will be logged in the FCU or ACU.

If the BLDC blower motor has entered protection mode due to one of the conditions listed above, the blower speed feedback signal becomes a diagnostic signal to the FCU and ACU by setting its frequency at 10Hz and varying the duty cycle of the signal to indicate the cause of the protection mode. Refer to **Table 27**. A fault will be logged by the FCU or ACU.

Thermostatic Expansion Valve



A. High Pressure Subcooled Liquid
B. Low Pressure Liquid To Evaporator Inlet
C. Evaporator Outlet
D. Superheated Vapor to Compressor Suction

1. Power Element
2. Internal Equalization Passage
3. Sealed Temp Sensing Bulb
4. Operating Pin
5. Metering Orifice
6. Spring

Fig. 20, Thermostatic Expansion Valve (cutaway)

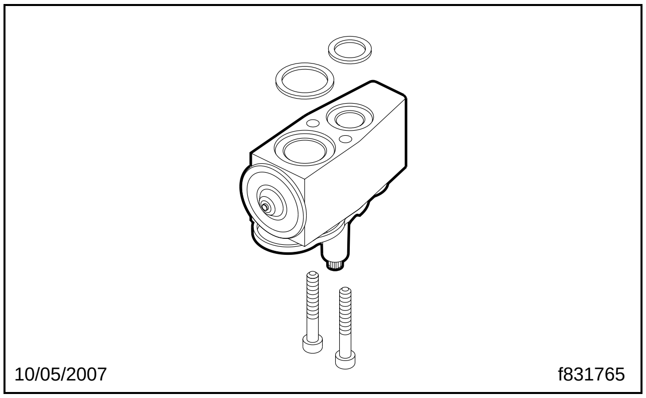


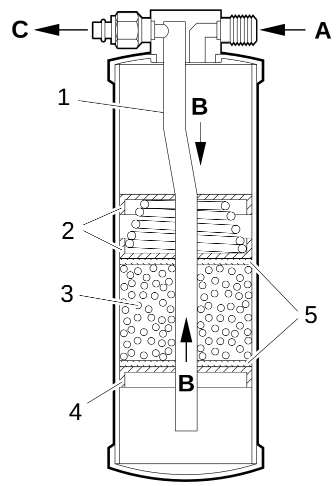
Fig. 21, Thermostatic Expansion Valve

The Thermostatic Expansion Valve (TXV) is a controlling device that regulates the flow of refrigerant into the evaporator. It is actuated by changes in evaporator pressure and the superheat of the refrigerant gas leaving the evaporator. Superheat is defined as any temperature of a gas above the boiling point for that liquid. For example, when a refrigerant liquid boils at a low temperature of 40°F (4.5°C) in the evaporator and then the refrigerant gas increases in temperature, superheat has been added. If this refrigerant changed from a liquid to a gas or vapor at 40°F (4.5°C) and then the refrigerant vapor increased in temperature to 50°F (10°C), then it has been superheated by 10°F (6.5°C). The refrigerant entering the evaporator is metered at a rate that matches the amount of refrigerant being boiled off in the evaporator. In addition to metering refrigerant, the TXV also provides a pressure drop in the system, separating the high-pressure side of the system from the low-pressure side.

To operate properly, the TXV must have a steady flow of liquid refrigerant supplied to it by the high side of the system. Issues such as an excessively low refrigerant charge, or contaminates in the system can interrupt this flow of liquid to the valve. In these cases, symptoms may surface making it seem as if the valve is inoperative or plugged. These symptoms can include poor performance, low low-side pressures (even a vacuum), etc. Before replacing a TXV, it is important to verify that there are no contaminates in the system and that the refrigerant charge is correct, by performing a refrigerant identification and thorough leak check of the entire system.

The TXV is often incorrectly replaced as the primary failed part, but is rarely the cause of a performance issue. In rare instances the power element of the TXV can lose its charge causing the valve to close, but there is no other situation that can be considered a failure of the TXV. Due to the similarity of symptoms that these root causes have on A/C performance, proper diagnosis is essential to making the correct repairs to the A/C system. It is for this reason that Freightliner requires refrigerant identification and leak checking prior to replacement of any TXV.

Receiver-Drier



A. Inlet
B. Flow
C. Outlet

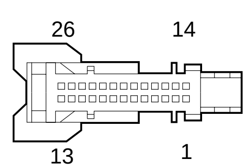
1. Pick-Up Tube
2. Steel Baffles
3. Desiccant Beads
4. Steel Baffle
5. Fiberglass Filter Pads

Fig. 22, Receiver-Drier

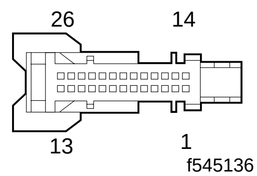
The receiver-drier is used as a reservoir and filter for liquid refrigerant from the condenser. A receiver-drier also removes moisture from the refrigerant. The moisture absorbing material, or desiccant, in the unit helps prevent ice blockages from forming in the expansion valve and in other parts of the system.

602 — Electrical Connectors

Electrical Connectors—Front HVAC



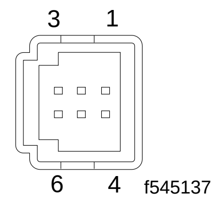
FCU 26-Pin Connector			
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338A1-4	Light Blue	Blend actuator–ground (–) #4
2	338A1-2	Light Blue	Blend actuator–ground (–) #2
3	338A2-3	Light Blue	Defrost actuator–ground (–) #3
4	338A2-1	Light Blue	Defrost actuator–ground (–) #1



Pin	Circuit #	Wire Color	Circuit Description
	FCU 26-Pin Connector		
5	338A3-3	Light Blue	Floor actuator–ground (–) #3
6	338A3-1	Light Blue	Floor actuator–ground (–) #1
7	338A1-2	Light Blue	Recirc actuator–ground (–) #3
8	338A4-1	Light Blue	Recirc actuator–ground (–) #1
9	338K	Light Blue	Evaporator sensor signal
10	338L	Light Blue	Heater core sensor signal
11	338G2	Light Blue	Sensor ground (–)
12	338A1+	Light Blue	Blend actuator–supply (+)
13	338A2+	Light Blue	Defrost actuator–supply (+)
14	338A1-3	Light Blue	Blend actuator–ground (–) #3
15	338A1-1	Light Blue	Blend actuator–ground (–) #1
16	338A2-4	Light Blue	Defrost actuator–ground (–) #4
17	338A2-2	Light Blue	Defrost actuator–ground (–) #2
18	338A3-4	Light Blue	Floor actuator–ground (–) #4
19	338A3-2	Light Blue	Floor actuator–ground (–) #2
20	338A4-4	Light Blue	Recirc actuator–ground (–) #4
21	338A4-2	Light Blue	Recirc actuator–ground (–) #2
22	—	—	Not Used
23	338M	Light Blue	Blower motor diagnostic (PWM)
24	338H	Light Blue	Blower motor control (PWM)
25	338A3+	Light Blue	Floor actuator–supply (+)
26	338A4+	Light Blue	Recirc actuator–supply (+)

Table 5, FCU 26-Pin Connector

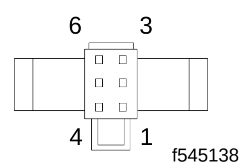
FCU 6-Pin Connector



Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(–) datalink
3	29A	Brown	Backlighting input (PWM)
4	98	Light Blue	+12V battery
5	GND	Black	Ground
6	81C	Pink	+12V ignition/acc

Table 6, FCU 6-Pin Connector

Actuator Stepper Motor 6-Pin Connector (Front Unit Actuators)



Pin	Circuit No.				Wire Color	Circuit Description
	Fresh/Recirc	Temperature Blend	Floor	Defrost/Face		
1	338A4-1	338A1-1	338A3-1	38A2-1	Light Blue	Ground #1
2	338A4+	338A1+	338A3+	338A2+	Light Blue	Supply (+)
3	338A4-3	338A1-3	338A3-3	338A2-3	Light Blue	Ground #3
4	338A4-4	338A1-4	338A3-4	338A2-4	Light Blue	Ground #4
5	—	—	—	—	—	Not used
6	338A4-2	338A1-2	338A3-2	338A2-2	Light Blue	Ground #2

Table 7, Actuator Stepper Motor 6-Pin Connector (front unit actuators)

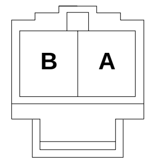
Blower Motor 2-Pin Connector (Front Unit)			 f545139
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
A	98F	Light Blue	+12V battery
B	GND	Black	Ground

Table 8, Blower Motor 2-Pin Connector (Front Unit)

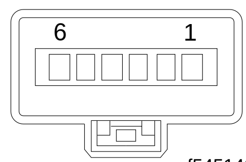
Blower Motor 6-Pin Connector (Front Unit)			 f545140
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338M	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDH	Black	Ground
4	98F	Light Blue	+12V battery
5	338H	Light Blue	Blower motor speed control signal
6	—	—	Not used

Table 9, Blower Motor 6-Pin Connector (Front Unit)

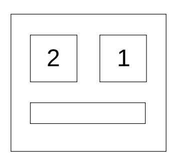
Heater Core Temperature Sensor, COTC (Front Unit)			 f545141
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338L	Light Blue	—
2	338G1	Light Blue	—

Table 10, Heater Core Temperature Sensor, COTC (Front Unit)

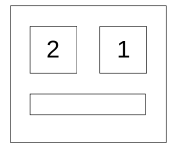
Evaporator Temperature Sensor (Front Unit)			 f545141
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338K	Light Blue	Evaporator Sensor Signal
2	338G	Light Blue	Ground

Table 11, Evaporator Temperature Sensor (Front Unit)

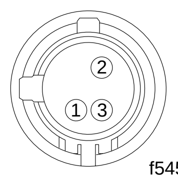
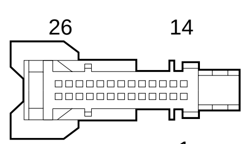
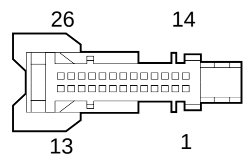
High-Side Pressure Transducer Connector			 f545142
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	440	Gray	Sensor +5V supply
2	440Y	Gray	Sensor feedback
3	440G	Black	Sensor ground

Table 12, High-Side Pressure Transducer Connector

Electrical Connectors–Sleeper HVAC

Auxiliary HVAC to Control Panel 26-Pin Connector			 f545136
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338SA1-4	Light Blue	Blend actuator–ground (–) #4
2	338SA1-2	Light Blue	Blend actuator–ground (–) #2
3–9	—	Light Blue	Not used
10	338SK	Light Blue	Heater core sensor signal
11	338SG	Light Blue	Sensor ground (–)
12	338SA1+	Light Blue	Blend actuator–supply (+)

Auxiliary HVAC to Control Panel 26-Pin Connector

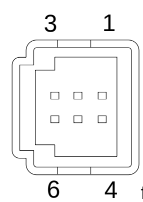


f545136

Pin	Circuit #	Wire Color	Circuit Description
13	—	Light Blue	Not used
14	338SA1-3	Light Blue	Blend actuator–ground (–) #3
15	338SA1-1	Light Blue	Blend actuator–ground (–) #1
16–22	—	Light Blue	Not used
23	338SM	Light Blue	Blower motor diagnostic (PWM)
24	338SH	Light Blue	Blower motor control (PWM)
25–26	—	Light Blue	Not used

Table 13, Auxiliary HVAC to Control Panel 26-Pin Connector

Auxiliary HVAC to Control Panel 6-Pin Connector



f545137

Pin	Circuit #	Wire Color	Circuit Description
1	1939+	Yellow	J1939(+) datalink
2	1939-	Dark Green	J1939(–) datalink
3	29A	Brown	Backlighting input (PWM)
4	98G	Light Blue	+12V battery
5	GND	Black	Ground
6	220	Pink	+12V ignition/acc

Table 14, Auxiliary HVAC to Control Panel 6-Pin Connector

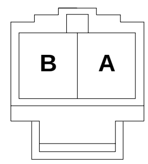
Blower Motor 2-Pin Connector (Sleeper Unit)			f545139
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
A	98G	Light Blue	+12V battery
B	GNDF	Black	Ground

Table 15, Blower Motor 2-Pin Connector (Sleeper Unit)

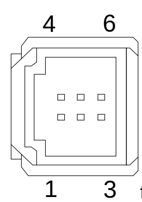
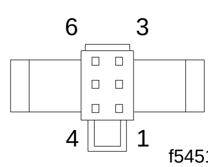
Blower Motor 6-Pin Connector (Sleeper Unit)			f545143
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338SM	Light Blue	Blower motor diagnostic feedback
2	—	—	Not used
3	GNDF	Black	Ground
4	98G	Light Blue	+12V battery
5	338SH	Light Blue	Blower motor speed control signal
6	—	—	Not used

Table 16, Blower Motor 6-Pin Connector (Sleeper Unit)

Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)			f545138
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338SA1-1	Light Blue	Blend actuator–ground (–) #1
2	338SA1+	Light Blue	Blend actuator–supply (+)
3	338SA1-3	Light Blue	Blend actuator–ground (–) #3
4	338SA1-4	Light Blue	Blend actuator–ground (–) #4

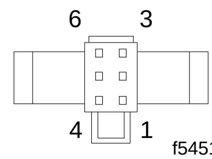
Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)			f545138
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
5	—	—	Not used
6	338SA1-2	Light Blue	Blend actuator–ground (–) #2

Table 17, Blend Actuator Stepper Motor 6-Pin Connector (Sleeper Unit)

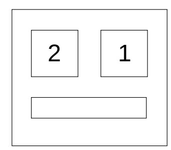
Heater Core Temperature Sensor, COTC (Sleeper Unit)			f545141
Pin	**Circuit #**	**Wire Color**	**Circuit Description**
1	338SK	Light Blue	—
2	338SG	Light Blue	—

Table 18, Heater Core Temperature Sensor, COTC (Sleeper Unit)

700 — Troubleshooting

Diagnostic Overview

For system performance testing, ambient temperature must be above 70°F (21°C) to produce reliable results. In order to quickly determine if the symptoms are related to refrigerant or electrical, two main tools should be utilized by the technician: ServiceLink and a refrigerant gauge set.

General Diagnostic Procedure

1. Perform the preliminary checks.
2. Perform an initial system inspection.
3. Make a determination about which system is suspected (refrigerant or electrical), and follow the symptoms through to a suspected part.
4. Repair the problem.
5. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
6. Verify that the problem has been resolved.

701 — Diagnostic Process

Preliminary Checks

NOTE: Pay attention to the refrigerant system components for evidence of oil seepage and other potential leaks that will be checked during subsequent diagnostic steps.

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

1. Inspect the drive belt and mounting fasteners for signs of wear or looseness.
2. Visually inspect the clutch for signs of overheating, damage, or wear. If necessary, check the clutch gap. For instructions, see **Section 83.04**, Subject 140.
3. 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.
4. Inspect the fresh and recirculation air filter elements, and inspect the intake-air ducting for debris.
5. With the engine off, and Optimized Idle (if applicable) disabled, turn the compressor drive plate by hand to feel for grinding or harshness inside the compressor.

Initial Inspection

1. Connect the refrigerant pressure gauges and ServiceLink to the vehicle.
2. Start the vehicle and select A/C mode and a cold temp setting to request compressor engagement. If the following conditions are met, the clutch should engage.
   - The engine is running at or above 450 RPM for at least five seconds.
   - Refrigerant system high side pressure is above 20 psi (140 kPa). Pressure reading is taken at the pressure transducer.
   - Refrigerant system high side pressure is below 450 psi (3100 kPa). Pressure reading is taken at the pressure transducer.
   - Ambient temperature is between 40°F and 200°F (°4.5C to 93°C). **NOTE:** Ambient temperature is not used as a condition for A/C clutch engagement on vehicles built after 6/15/2009, or prior vehicles that have previously had the front HVAC control unit replaced with an updated part. Updated parts would be the following or newer: A22-60645-101, A22-60645-501, or A22-60669-002.
   - Vehicle compressed air system is above 60 psi (414 kPa). Pressure is taken at the dash ECU, and transmitted on the J1587 databus.
   - Evaporator core temperature sensor is above 44°F (6.5°C). Temperature is taken in the main heater box, as a direct input to the front control unit (FCU).
   - The blower feedback from the main HVAC unit is connected, and the signal is meeting the minimum RPM requirements for each knob position.

At this point you should be seeing some indication of a problem, either electrical or refrigerant.

Electrical—If there are any faults that affect the FCU or any of the parallel systems that provide input information to the FCU, or if the system requirements are being met, but the clutch is still not engaging, there may be an electrical problem related to the FCU, or the voltage signal to the compressor.

Refrigerant—If the low side pressure is drawing down far below 20 psi (140 kPa), or if the high side pressure is rising above 450 psi (3100 kPa), there is a refrigerant-related problem.

Post-Repair Procedures

After repair work is completed, verify that the repair resolved the problem.

1. Verify that all of the refrigerant connections removed during the service are properly sealed using an approved refrigerant leak detector.
2. Check for fault codes. There should be no active fault codes that indicate the problem still exists.
3. If there is still a problem, repeat the appropriate tests, and make repairs as needed.
4. Verify again.

702 — Refrigerant System Tests

Test Procedure

Use the following procedure to evaluate the performance of the air conditioning system. If the system does not perform as stated below, further diagnosis and repair may be necessary.

NOTE: The dash outlet temperature will fluctuate during each clutch cycle, and the temperature reading should be taken at the lowest value.

1. Park the vehicle out of direct sunlight, shut down the engine, and set the parking brakes. Chock the tires.
2. Open the hood and leave the hood open for the entire test.
3. Open the driver and passenger doors and leave the doors open for the entire test.
4. Note the current ambient air temperature.

NOTE: High relative humidity reduces cooling and could increase the dash outlet temperatures, and high-side system pressures.

5. Using the ambient air temperature readings noted in the previous step, find the temperature/pressure specifications in **Table 22** that best match your ambient conditions.
6. Connect the test gauges to the high and low side service ports.
7. Place a thermometer in the center dash outlet. If the vehicle is a SleeperCab, place another thermometer in the lower sleeper outlet.

NOTE: EPA10 and owner-set idle limits may prevent the warm-up run from continuing without occasional throttle inputs.

8. Start the engine and run the A/C for 15 minutes.
9. Set the engine speed to 1500 rpm and engage the engine fan.
10. Set the cab climate control panel to the following settings:
    - air selection switch to face mode
    - air conditioning on
    - blower speed switch to high
    - temperature control switch to full cold
    - recirculation switch off

11. On SleeperCabs, set the sleeper climate control panel to the following settings (or initiate "bunk override" mode):
    - blower speed switch to high
    - temperature control switch to full cold
12. Allow the system to stabilize at least five minutes or until the dash and sleeper outlet temperatures have reached a minimum, then compare the system values to the information in **Table 22** in **800—Specifications**. The results should be close to those listed, but minor discrepancies are not a guarantee that the system has a refrigerant system problem.

    Possible causes of refrigerant system complaints:
    - Too much oil - High high-side pressure, poor heat rejection at the condenser
    - Too much refrigerant - High high-side pressure, good cooling
    - Not enough refrigerant - Low high-side pressure, low low-side pressure, poor cooling
    - Debris in the system - TXV plugged or uncontrollable, compressor turns hard, receiver/drier is icing
    - Contaminated or incorrect refrigerant - Very inconsistent system pressures and duct temps

Thermal Expansion Valve (TXV) Testing

To determine if the TXV is functioning, watch the low-side pressure while the compressor is engaged. The influence from the TXV modulating can be seen as the low-side gauge needle "wags." As the load on the system changes from ambient conditions, the TXV may not wag as much, and care must be taken to prevent false diagnosis. The function of the individual TXVs in a dual evaporator system will be combined to produce the total pressure needle wagging that is observed. If a TXV failure is suspected, connect the gauge set to the properly charged refrigerant loop, and run the compressor. Watch for the low-side gauge needle to wag, indicating that the TXV is working. Depending on the load, the low-side pressure may progress from moderate to high, but the needle will simultaneously wag as the average pressure changes.

Sanden A/C Compressor Testing, Pressure or Pumping Test

NOTE: This test is meant to be performed after a failure has been repaired, which may have caused damage to the compressor due to low refrigerant or oil levels.

Compressors cause refrigerant to flow through the system by creating a pressure differential, high and low pressures. If the compressor can be forced to produce a high pressure in excess of 350 psi (2415 kPa), it is a good compressor.

IMPORTANT: The compressor pumping test must be performed with the refrigerant system charged to the factory specifications, and functioning properly. This test should only be run for a short time period. Shut the system down immediately once 350 psi (2415 kPa) is achieved.

1. Confirm the system is charged per the OEM requirement before proceeding.
2. Disable the engine cooling fan. The condenser can also be blocked with a sheet of cardboard. The purpose is to limit heat removal from the system and build compressor discharge pressure.
3. Start the engine and engage the compressor clutch.

   Compressors operating within specification should be capable of reaching 350 psi (2415 kPa).
4. Shut the system down immediately, once 350 psi (2415 kPa) is achieved.

Denso A/C Compressor Pressure Test

NOTE: This test can be performed after a failure has been repaired, or on compressors experiencing a low "high side" pressure, or a high "low side" symptoms, when properly charged. The compressor pressure test must be performed with the refrigerant system discharged and the refrigerant lines disconnected.

Test the performance of the compressor as follows.

1. Place your thumb over the suction port of the compressor and slowly rotate the compressor. An even suction should be felt as the compressor is turned.
2. Place your thumb over the discharge port and slowly rotate the compressor. An even pressure should be felt as the compressor is turned.
3. If an uneven pressure is felt on either the suction or discharge port while turning the compressor, internal damage has occurred, and the compressor will not perform properly.

703 —Fault Code Driven Diagnostics

Fault Codes–HVAC

J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	**SPN**	**FMI**	**Fault Description**	**Fault Trigger**
25	70	9	Parking Brake Switch Status Message—abnormal update rate	FCU does not receive J1939 parking brake switch status from SAM Cab.
25	84	9	Vehicle Speed—abnormal update rate	FCU does not receive J1939 vehicle speed message from engine ECM.
25	110	9	Engine Coolant Temperature Message—abnormal update rate	FCU does not receive J1939 engine coolant temperature message from engine ECM.
25	158	3	FCU—voltage above normal	FCU voltage is too high or voltage is applied when it should not be.
		4	FCU—voltage below normal	FCU voltage is too low.
25	168	9	SAM Cab Battery Voltage Message—abnormal update rate	FCU does not receive J1939 battery voltage message from SAM Cab.
25	171	9	Ambient Air Temperature—abnormal update rate	Data from SAM?
25	190	9	Engine Speed Message—abnormal update rate	FCU does not receive J1939 engine speed message from engine ECM.
25	629	12	FCU—bad intelligent device or component	—
25	639	2	J1939 Datalink—intermittent or incorrect data	FCU attempts to broadcast this fault if all J1939 receive messages are corrupt continuously for a period of 1.5 seconds.
25	876	1	A/C Clutch—protection mode (voltage too low)	Based on battery volt message from SAM allowing for line loss to clutch (11.5V minimum).
		2	A/C Clutch—data erratic, intermittent, or incorrect	—
		9	A/C Clutch—abnormal update rate	—
		10	A/C Clutch—root cause not known	—

J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	SPN	FMI	Fault Description	Fault Trigger
25	1547	4	Evaporator Sensor-short to ground	—
		5	Evaporator Sensor—short to battery or open circuit	—
25	1548	4	COTC Sensor—short to ground	—
		5	COTC Sensor—short to battery or open circuit	—
25	522510	0	High Pressure Sensor—data valid, but above normal operating range.	Pressure above 530 psi.
		1	High Pressure Sensor—data valid, but below normal operating range.	Pressure 18–30 inHg (vac).
		2	High Pressure Sensor—data erratic, intermittent, or incorrect	—
		9	High Pressure Sensor—abnormal update rate	—
		11	High Pressure Sensor—root cause not known	—
25	523307	9	Low Air Pressure Switch Status Message—abnormal update rate	FCU does not receive J1939 low air pressure switch status message from SAM Cab.
25	523318	2	Blower Motor—protection mode (voltage out of range)	—
		6	Blower Motor—protection mode (overcurrent or thermal protection)	—
		7	Blower Motor—protection mode (speed mismatch or blocked rotor)	—
25	523329	2	Defrost Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Defrost Door Actuator—voltage above normal or shorted to battery	—
		4	Defrost Door Actuator—voltage below normal, open circuit	—
25	523330	2	Blend Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Blend Door Actuator—voltage above normal or shorted to battery	—
		4	Blend Door Actuator—voltage below normal, open circuit	—
25	523331	2	Recirc Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Recirc Door Actuator—voltage above normal or shorted to battery	—
		4	Recirc Door Actuator—voltage below normal, open circuit	—

J1939 FCU Fault Codes—Troubleshooting: FCU J1939 Source Address (SA) = 25				
SA	**SPN**	**FMI**	**Fault Description**	**Fault Trigger**
25	523332	2	Floor Door Actuator—data mismatch	All output data is read high; not matching low input from microprocessor.
		3	Floor Door Actuator—voltage above normal or shorted to battery	—
		4	Floor Door Actuator—voltage below normal, open circuit	—

Table 19, J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 25

J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 58				
SA	**SPN**	**FMI**	**Fault Description**	**Fault Trigger**
58	158	3	ACU—voltage above normal	—
		4	ACU—voltage below normal	—
58	609	12	ACU—bad intelligent device or component	Replace ACU.
58	639	2	J1939 Datalink—intermittent or incorrect data	ACU attempts to broadcast this fault if all J1939 receive messages are corrupt continuously for a period of 1.5 seconds.
58	1548	4	COTC Sensor—short to ground	—
		5	COTC Sensor— short to battery or open circuit	—
58	523318	2	Blower Motor—protection mode (voltage out of range)	—
		6	Blower Motor—protection mode (overcurrent or thermal protection)	—
		7	Blower Motor—protection mode (speed mismatch or blocked rotor)	—
58	523330	2	Blend Door Actuator—data mismatch	All output data is read high not matching low input from microprocessor.
		3	Blend Door Actuator—voltage above normal or shorted to battery	—
		4	Blend Door Actuator—voltage below normal, open circuit	—

Table 20, J1939 ACU Fault Codes—Troubleshooting ACU J1939 Source Address (SA) = 58

SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33				
SA	**SPN**	**FMI**	**Fault Description**	**Fault Trigger**
33	170	2	Interior Ambient Air Temperature Sensor—data erratic	—
		3	Interior Ambient Air Temperature Sensor—short to battery	—
		4	Interior Ambient Air Temperature Sensor—short to ground	—
33	876	3	A/C Compressor Output—short to battery	—
		4	A/C Compressor Output—short to ground	—

SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33				
SA	**SPN**	**FMI**	**Fault Description**	**Fault Trigger**
33	521510	3	High-Side Pressure Transducer Feedback—short to battery	SAM Cab detects above normal voltage on pressure feedback circuit.
		4	High-Side Pressure Transducer Feedback—short to ground	SAM Cab detects below normal voltage on pressure feedback circuit.
33	521515	4	Cabin HVAC Power—short to ground	—

Table 21, SAM Cab Fault Codes Related to HVAC—Troubleshooting SAM Cab Source Address (SA) = 33

704 — Approved Leak Detection Methods

General Information

The information in this section is intended to convey a general method of leak detecting that should be used to enhance the usefulness of a leak detector being used in accordance with operator’s instructions provided by the manufacturer. No technician should attempt to perform leak detection without reading and understanding the owner’s manuals for the tools being used, and should expect to review those instructions from time to time, to ensure the proper care was developed using the published list of recommended tools and warranty evaluation guides as a basis for the expectations for repair competence. The only way to confirm that a refrigerant leak exists is by finding a failed or damaged component. A UV flashlight and goggles can be used to provide an indication of a leak, but an approved electronic leak detector must be used to confirm the existence of a leak, and to approximate the leak rate. The connections used for A/C refrigerant are intended to seal properly, but given the high level of sensitivity provided by current leak detecting equipment, the detector may indicate a leak even though the connection meets the design specifications. To balance this, the "Acceptable Leak Rates by Component", **Table 34**, in Specifications contains the qualifying leak rates for the components used on Cascadia vehicles. The leak rates, in oz/yr, correspond to the sensitivity values required for all detectors that meet the SAE J2791 functional specifications. By switching between the sensitivity levels, it is possible to discern between leaks of varying sizes and qualify each potential leak. It is expected that a leak rate relates to each component, as it arrives at the factory, but the Mini-Statoseals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multi-port connection, the leak rate for two Mini-Statoseals should be considered a condemning value if it is not completely clear which seal is leaking.

Method

IMPORTANT: The refrigerant system should be warmed up from completion of the initial inspection, but the engine is off.

1. Shut down the engine.
2. Before testing for compressor leaks, blow shop air near the compressor shaft seal to clear any refrigerant that may have collected.
3. Install caps before testing the service ports.
4. Minimize the amount of wind blowing through the test area, as wind will make small leaks harder to find.
5. Set the detector on the most sensitive setting.
6. Start at a point along the refrigerant loop, and methodically follow the refrigerant path. Test all around O-ring connections and crimped ends until you reach the starting point.

7. When the detector indicates a suspected leak, move the detector away from the suspect area, then recheck to the location after the detector has cleared. If the detector continues to indicate a leak, adjust the sensitivity of the detector to match the designed leak specifications shown in "Acceptable Leak Rates by Component", **Table 34**, in **800—Specifications**, and retest the suspected area to confirm the leak. Mark any confirmed leaks, then change the sensitivity back to high and continue checking the system.
8. After the entire system has been checked, recover the refrigerant, investigate each leak point to determine what component failed, and how, then repair the leak.
9. Recharge the refrigerant system, then use the electronic leak detector to confirm that each connection opened during the repair is sealed within the design specifications provided in the "Acceptable Leak Rates by Component," **Table 34**, in **800—Specifications**.

Diagnostic Tools Required

The following diagnostic tools are required to perform troubleshooting procedures on Cascadia vehicles.

- Servicelink
- Digital multimeter
- Approved refrigerant leak detector

800 — Specifications

The following test conditions should be established prior to checking the A/C temperature and pressure.

- engine @ 1500 rpm
- engine fan locked on
- normal A/C mode – Outside air (not recirc mode)
- blower speed set to high
- driver and passenger doors open
- hood open
- not in direct sunlight
- no wind speed
- allow conditions to stabilize

See **Table 22** for temperature and pressure specifications for a day cab with a HD-1 condenser.

See **Table 23** for temperature and pressure specifications for a SleeperCab with a HD-2 condenser.

A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	Low	25	40–54 (4–12)	78–118 (540–815)	9–43 (62–300)	Cycling—On 5 sec; Off 11 sec
70 (21)	Med	50	44–54 (7–12)	77–120 (530–825)	10–46 (70–315)	Cycling—On 6 sec; Off 10 sec

A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	High	70	46–56 (8–13)	75–120 (515–825)	10–50 (70–345)	Cycling—On 6 sec; Off 9 sec
80 (27)	Low	25	42–56 (8–14)	94–139 (650–960)	11–48 (75–330)	Cycling—On 7 sec; Off 9 sec
80 (27)	Med	50	46–58 (8–14)	97–148 (670–1020)	13–51 (90–350)	Cycling—On 9 sec; Off 6-9 sec
80 (27)	High	70	45–63 (7–17)	99–147 (685–1015)	9–55 (60–380)	Cycling—On 7–27 sec; Off 4–8 sec
90 (32)	Low	25	46–58 (8–14)	109–159 (750–1095)	13–51 (90–350)	Cycling—On 9 sec; Off 6 sec
90 (32)	Med	50	47 (8)	165 (1140)	19 (130)	On steady
90 (32)	High	70	53 (12)	171 (1180)	23 (160)	On steady
100 (38)	Low	10	44–62 (7–17)	129–177 (890–1220)	14–49 (95–340)	Cycling—On 8–15 sec; Off 4–8 sec
100 (38)	Med	25	46 (8)	174 (1200)	18 (125)	On steady
100 (38)	High	40	53 (12)	180 (1240)	22 (150)	On steady

Table 22, A/C Temperature/Pressure Specifications—Day Cab With HD-1 Condenser

A/C Temperature/Pressure Specifications—SleeperCab With HD-2 Condenser						
Ambient Air Temp: °F (C)	Humidity		Dash Louver Temp: °F (C)	Service Port Pressures		A/C Compressor
	Level	%RH		High: psi (kPa)	Low: psi (kPa)	
70 (21)	Low	25	43–55 (6–13)	73–130 (505–895)	16–48 (110–330)	Cycling—On 7 sec; Off 8sec
70 (21)	Med	50	46–54 (8–12)	73–131 (505–905)	19–48 (130–330)	Cycling—On 8 sec; Off 8 sec
70 (21)	High	70	46–55 (8–13)	74–133 (510–915)	17–48 (115–330)	Cycling—On 10 sec; Off 6 sec
80 (27)	Low	25	45–53 (7–12)	95–147 (655–1015)	19–46 (130–315)	Cycling—On 9 sec; Off 6 sec
80 (27)	Med	50	45–55 (7–13)	95–150 (655–1035)	20–47 (140–325)	Cycling—On 40–180 sec; Off 3–6 sec
80 (27)	High	70	50 (10)	149 (1025)	25 (170)	On steady
90 (32)	Low	25	46 (8)	165 (1140)	23 (160)	On steady
90 (32)	Med	50	53 (12)	171 (1180)	28 (195)	On steady
90 (32)	High	70	59 (15)	177 (1170)	32 (220)	On steady
100 (38)	Low	10	46 (8)	185 (1275)	24 (165)	On steady
100 (38)	Med	25	52 (11)	192 (1325)	28 (195)	On steady
100 (38)	High	40	57 (14)	194 (1340)	32 (220)	On steady

Table 23, A/C Temperature/Pressure Specifications—SleeperCab With HD-2 Condenser

FCU/ACU Electrical Specifications	
Specification	**Value**
Normal operating voltage range	9–16V
FCU/ACU max parasitic draw (ignition off)	1mA
FCU/ACU maximum current draw (battery input)	1.5A
FCU/ACU maximum current draw (ignition input)	50mA
Blower Motor maximum current draw	23A

Table 24, FCU/ACU Electrical Specifications

Default Datalink Values If the FCU does not receive some or all of the necessary parameters from other ECUs, the default values in this table are used.	
Parameter	**Default Value**
Vehicle Speed (from engine)	60 mph
Ambient Temperature (from SAM Cab)	70°F (21°C)
High-Side Refrigerant Pressure (from SAM Cab)	10 psig
Low Air Pressure (from ICU)	OK (<60 psig)
Engine rpm (from engine)	0 rpm
Override Message (from ACU)	none
Vehicle voltage (SAM Cab)	Same as FCU voltage
Engine Coolant Temp (from engine)	170°F (58°C)

Table 25, Default Datalink Values

Pressure Relief Valve	
Specification	**Value: psi (kPa)**
Opening Pressure	508–595 (3505–4100)
Minimum Closing Pressure*	439 (3025)

* Minimum closing pressure is the minimum pressure at which the valve will close after it has been opened by high pressure.

Table 26, Pressure Relief Valve

Blower Motor Protection Modes (as Indicated On Speed/Diagnostics Circuit)			
Protection Mode	**Frequency**	**Duty Cycle**	**Notes**
Voltage too low	10 Hz	50%	If the blower is in protection mode, it communicates this via the speed feedback/diagnostic circuit to the control head, by varying the duty cycle of a 10 Hz signal. The duty cycle will correspond to the protection mode entered. Use the Datalink Monitor template to monitor for protection mode. Protection mode may generate a fault code.
Voltage too high	10 Hz	50%	
Locked rotor	10 Hz	75%	
Overcurrent or thermal protection	10 Hz	25%	

Table 27, Blower Motor Protection Modes

Engine Fan Engagement Request Specifications Based on High-Side Pressure (as measured by high-side pressure transducer)			
Engine Fan State	**Nominal Pressure: psi (kPa)**	**Pressure Range: psi (kPa)**	**Notes**
ON	300 (2070)	281–318 (1940–2190)	If the high-side pressure reaches this range, engine fan engagement will be requested.
OFF	250 (1725)	231–268 (1590–1850)	Once engine fan engagement has been requested, it will remain on until the high-side pressure drops to within this range.*

* Although an engine fan request is made by the HVAC controller, based on high-side pressure, the fan is controlled by the engine ECU, which considers a number of other factors and parameters that are specific to each engine.

Table 28, Engine Fan Engagement Request Specifications Based on High-Side Pressure

Minimum Time HVAC Sends Engine Fan Request Based on High-Side Pressure (as measured by high-side pressure transducer)			
Vehicle Speed: mph	**Parking Brake Status**	**Minimum Time Engine Fan Request Is Active**	**Notes**
0	ON	Continuously	HVAC sends engine fan request continuously as long as A/C compressor engagement has been initiated in the last 90 seconds. NOTE: It is normal for the engine fan to run continuously when the vehicle is parked, with the parking brake set, and the A/C on.
0–20	OFF	180 sec	Minimum time HVAC sends engine fan request.
20–40	OFF	90 sec	
Above 40	OFF	30 sec	

Table 29, Minimum Time HVAC Sends Engine Fan Request Based on High-Side Pressure

Compressor High and Low Pressure Cut-Out (as measured by high-side pressure transducer)			
—	Nominal Pressure: psi (kPa)	Pressure Range: psi (kPa)	Notes
High Pressure Cut-Out	437 (3015)	418–455 (2880–3140)	If high side pressure rises to within this range, the compressor with disengage and not re-engage until within the high pressure cut-in range.
High Pressure Cut-In*	288 (1985)	270–306 (1860–2110)	High side pressure range that compressor will re-engage after high pressure cut-out.
Low Pressure Cut-Out	34 (235)	26–41 (180–285)	If high side pressure drops to within this range, the compressor will disengage or be prevented from engaging if not previously engaged. Compressor will not re-engage until pressure is above the low pressure cut-in.
Low Pressure Cut-In*	36 (250)	28–43 (195–295)	High side pressure at which the compressor will re-engage after low pressure cut-out.

* Assumes all other A/C compressor clutch engagement rules have been met to allow compressor engagement.

Table 30, Compressor High and Low Pressure Cut-out

Evaporator Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	19721	20485
23	-5	11512	11816
32	0	8910	9090
68	20	3374	3512
77	25	2694	2820
86	30	2165	2277
95	35	1751	1849
104	40	1425	1511

Table 31, Evaporator Temperature Sensor Resistance

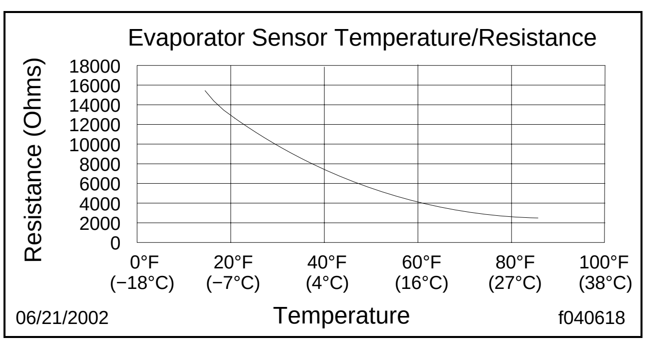


Fig. 23, Evaporator Sensor Resistance Specifications

COTC Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
5	-15	69193	76665
32	0	31254	34046
59	15	15156	16260
68	20	12081	12899
77	25	9700	10300
86	30	7793	8321
95	35	6304	6759
104	40	5130	5524

Table 32, COTC Temperature Sensor Resistance

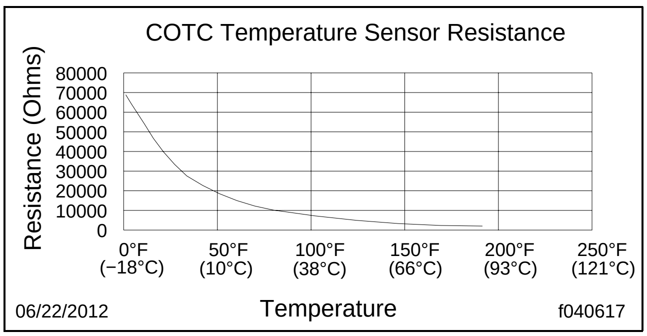


Fig. 24, COTC Sensor Resistance Specifications

Outside Air Temperature Sensor Resistance			
Temperature		Resistance (Ohms)	
°F	°C	Minimum	Maximum
-40	-40	97894	103950
14	-10	16285	16849
23	-5	12485	12839
32	0	9656	9890
41	5	7480	7708
50	10	5852	6054
68	20	3659	3815
77	25	2922	3060
95	35	1905	2003
104	40	1551	1637
113	45	1270	1344

Table 33, Outside Air Temperature Sensor Resistance

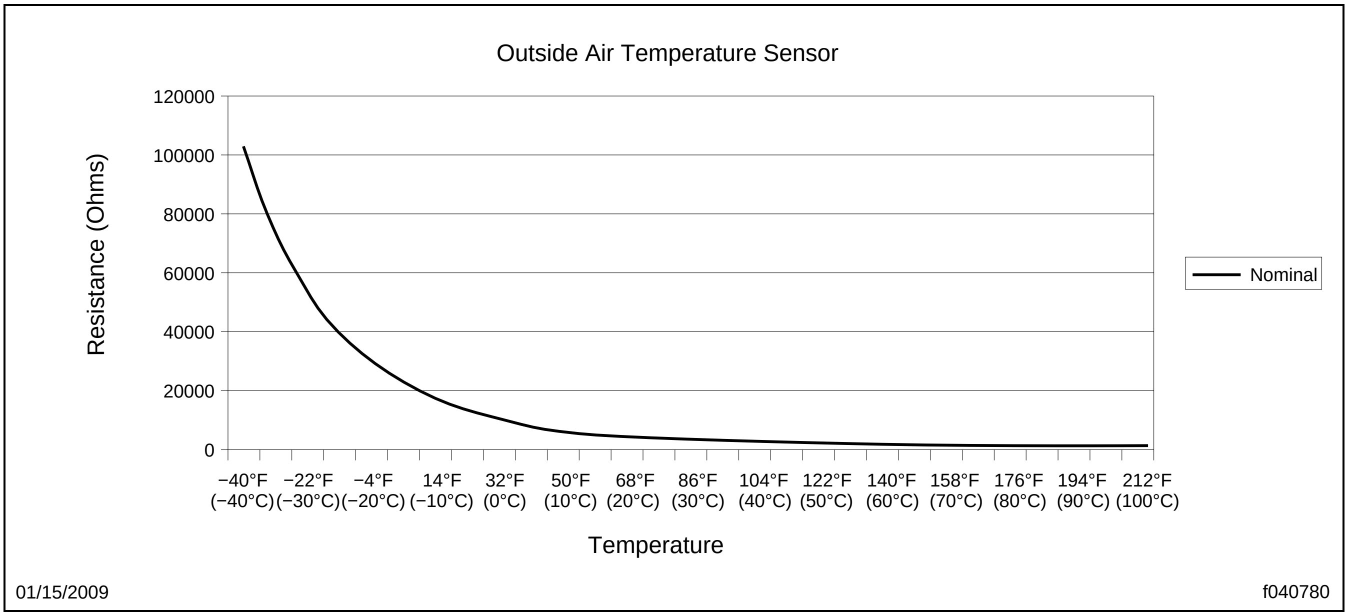


Fig. 25, Outside Air Temperature Sensor Resistance Specifications

Acceptable Leak Rates by Component	
Component	**Acceptable Leak Rates**
J-Block Body	0.25 oz/yr and greater condemns these components
Evaporators (main and auxiliary)	
Condenser	
Receiver-Drier (body)	
Lines/Hoses	
Capped Charge Ports	
Mini-Statoseal (1 - when the leak can be tied to a single seal)	
Mini-Statoseals (2 - when the leak cannot be tied to a single seal)	0.50 oz/yr and greater condemns these components
Compressor (shaft seal, housing, etc.)	
TXV (Power Valve and Super Heat Cap)	
Sensor/Switches (O-ring and crimped body connections)	

Table 34, Acceptable Leak Rates by Component