FREQUENCY AND RPM CALCULATIONS

TIRE AND WHEEL

Vibration occurs at _____ mph (km/h)

Tire diameter _____

Tire speed RPM and frequency from chart	_____ RPM	_____ Hz

DRIVESHAFT

Tire/wheel frequency _____ x axle ratio =	_____ Hz
Tire/wheel RPM _____ x axle ratio =	_____ RPM

ENGINE FREQUENCIES AND ASSOCIATED RPMS

Engine RPM divided by 60 equals 1st order frequency	_____ Hz
1st order RPM x 2 = 2nd order RPM (normal for 4 cylinder engines) Cylinders fired per engine revolutions	_____ RPM
1st order Hz x 2 = 2nd order Hz (normal for 4 cylinder engines)	_____ Hz

1st order RPM x 3 = 3rd order RPM (normal for 6 cylinder engines)

1st order Hz x 3 = 3rd order Hz (normal for 6 cylinder engines)
x 4 = 4th order vibrations (normal for 8 cylinder engines)
x 5 = 5th order, x 6 = 6th order, etc.

Order of vibration x engine RPM equals cylinders fired per minute	_____ RPM
Order of vibration (2nd, 3rd, 4th etc.) x 1st order Hz equals	_____ Hz

ENGINE ACCESSORY FREQUENCIES AND RPMS

Crankshaft pulley diameter _____ divided by accessory pulley diameter _____ = _____ pulley size ratio

Engine speed _____ RPM x pulley ratio = accessory _____ RPM

Accessory pulley _____ RPM divided by 60 = _____ Hz

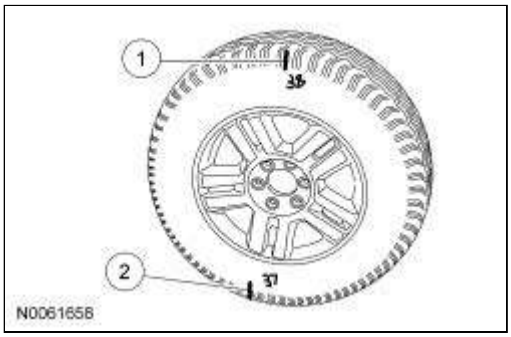
N0067079

Harshness Symptoms

Harshness is customer perception which gives the impression of no isolation from the tire/wheel and suspension system. Harshness may be caused by road conditions, temperature changes, component damage and/or incorrect customer modifications on original components/specifications. Customers usually experience harshness when the vehicle is driving over bumps or potholes and in cold weather conditions. Harshness can also be experienced with excessive tire pressure, sporty tires, heavy-duty springs and shocks, or other vehicle modifications. Some aftermarket tires, even with the correct size, may change vehicle behavior and produce customer concerns. The first step in diagnosing a harshness concern is to determine if the concern was experienced only in certain specific operating conditions, such as large potholes or

2	Second high spot on the tire

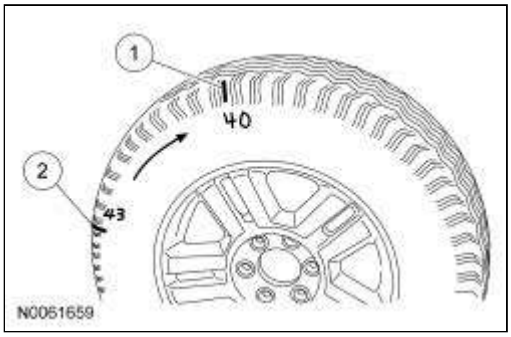
5. If the second high spot is still above specification and is within 101.6 mm (4 in) of being opposite the first high spot on the wheel, the root cause is probably the wheel (the high spot followed the wheel). Dismount the tire from the wheel, mount the wheel on a balancer and check the wheel runout. If the wheel runout exceeds 1.14 mm (0.045 in), install a new wheel, balance the assembly and install on the vehicle using the Wheel-to-Hub Optimization procedure.



Item	Description
1	First high spot on the tire
2	Second high spot on the tire

6. **NOTE:** If the second high spot did not follow the wheel or the tire and the runout is still not within specification, improvements may be made by rotating the tire 90 degrees (one-fourth turn).

   Draw an arrow on the tire sidewall from the second high spot towards the first high spot (in the shortest direction).
   - Separate the tire beads from the wheel and rotate the tire 90 degrees (one-fourth turn) in the direction of the arrow.



Item	Description
1	First high spot on the tire
2	Second high spot on the tire

Wheel-to-Hub Optimization

Wheel-to-hub optimization is important. Clearance between the wheel and hub can be used to offset or neutralize the Road Force® or run-out of the wheel and tire assembly. For every 0.001 inch of wheel-to-hub clearance, the Road Force® can be affected between 1 and 3 pounds depending on the tire stiffness.

Steering Column

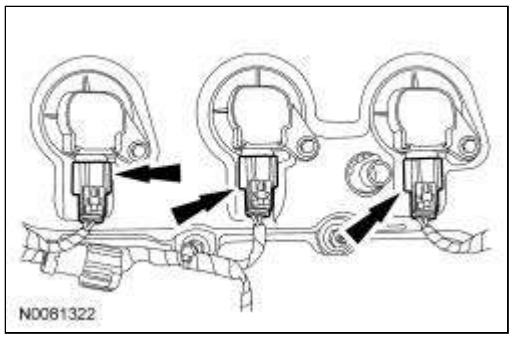
The steering column system consists of the following components:

- Steering wheel
- Steering column
- Upper and lower steering column shafts
- Steering column switches
- Ignition lock cylinder

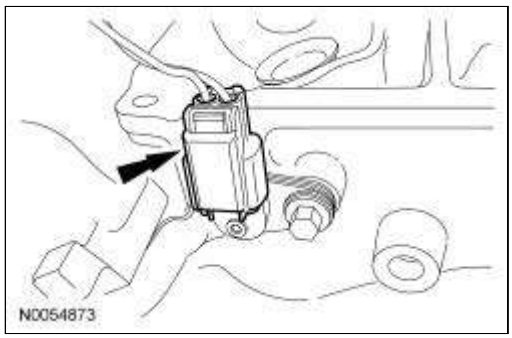
The steering column is the mechanical linkage between the steering wheel and the steering gear. The steering wheel is mounted to a shaft which passes through the center of the steering column. The shaft is centered by roller bearings within the steering column. The steering column shaft then connects the steering column to the steering gear. The steering column shaft utilizes U-joint type couplings. The tilt function of the steering column is controlled by a mechanical lever on the side of the steering column which uses a cam to lock and unlock the steering column. When the tilt lever is unlocked, the steering column can then be adjusted to various positions through a pin-type pivot. The steering column switches (multifunction and ignition) are mounted to the steering column. These switches are covered by the upper and lower steering column shrouds.

For steering column switch service information, refer to Section 211-05 .

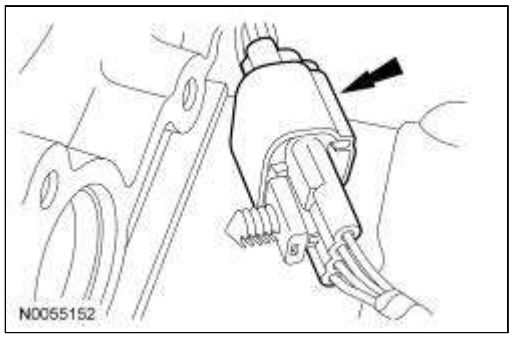
For ignition lock cylinder service information, refer to Section 501-14 .



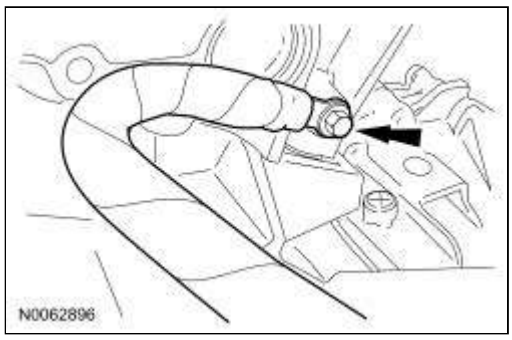
17. Detach all of the wiring harness retainers from the RH valve cover and stud bolts.
18. Disconnect the RH Camshaft Position (CMP) sensor electrical connector.



19. Disconnect the Knock Sensor (KS) electrical connector.

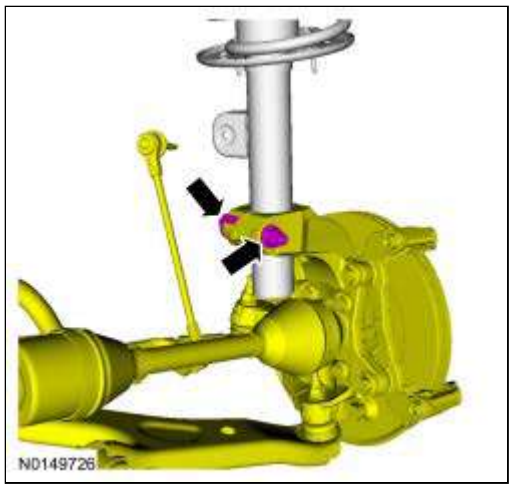


20. Remove the bolt and the ground cable from the RH cylinder.

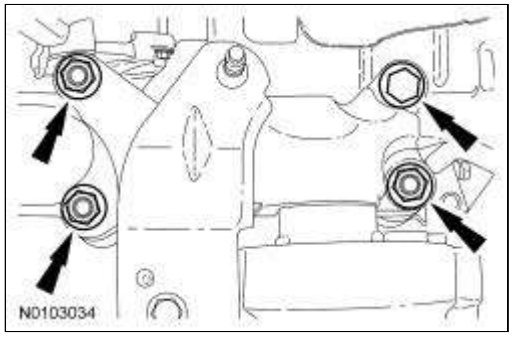


21. Disconnect the 6 fuel injector electrical connectors (3 shown).

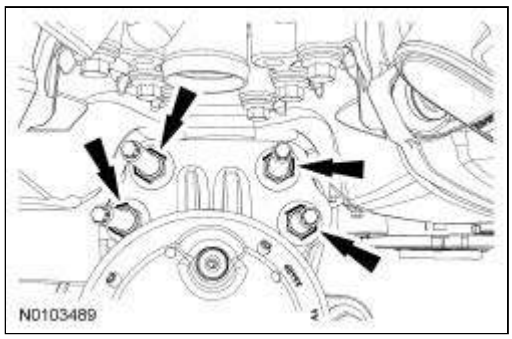
A/C tube nut	15	—	133
A/C tube retaining clamp bolt	9	—	80
A/C tube-to-compressor nut	15	—	133
A/C tube bracket-to-compressor bolt	25	18	—
Accessory drive belt tensioner bolts	11	—	97
Ball joint nuts	200	148	—
Battery cable power feed cable nut	6	—	53
Block coolant drain plug — RH [a]	—	—	—
Block coolant drain plug — LH [b]	—	—	—
Block heater	40	30	—
Block oil galley plug — LH	48	35	—
Block oil galley plug — rear	85	63	—
Block oil galley plug — RH	32	24	—
Charge Air Cooler (CAC) tube clamps	5	—	44
CAC outlet pipe clamps	5	—	44
Camshaft bearing cap bolts [c]	—	—	—
Camshaft Position (CMP) sensor bolts	10	—	89
Coolant pump bolts [c]	—	—	—
Connecting rod cap bolts [c]	—	—	—
Crankcase rear seal retainer plate bolts [c]	—	—	—
Crankshaft Position (CKP) sensor bolt	10	—	89
Crankshaft pulley bolt [c]	—	—	—
Cylinder head bolts [c]	—	—	—
Cylinder head M6 bolt	10	—	89
Cylinder Head Temperature (CHT) sensor	10	—	89
Driveshaft-to-Power Transfer Unit (PTU) bolts	70	52	—
Electronic Power Assist Steering (EPAS) wiring retainer bolt	9	—	80
Engine cover mounting stud	6	—	53
Engine front cover bolts [c]	—	—	—
Engine lifting eye bolts	24	18	—
Engine mount-to-engine nuts	63	46	—
Engine mount-to-frame bolts	90	66	—
Engine oil filter [d]	—	—	—
Engine Oil Pressure (EOP) switch [c]	—	—	—
Engine-to-transaxle bolts	48	35	—
Exhaust camshaft bolt [c]	—	—	—
Exhaust manifold heat shield bolts	14	—	124
Exhaust manifold nuts [c]	—	—	—



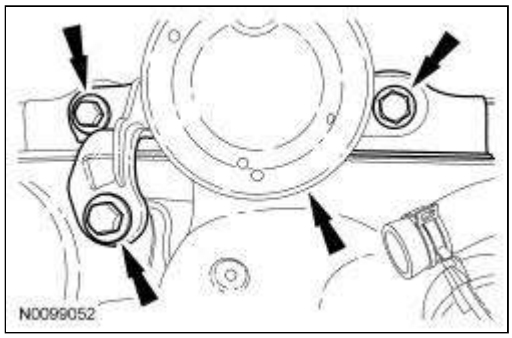
63. Remove the 3 nuts and the bolt from the transaxle support insulator bracket-to-transaxle.



64. Remove the 4 engine mount nuts.



65. Remove the 3 bolts and the engine mount.



66. **NOTE:** RH shown, LH similar.

    Remove the subframe bracket-to-body bolts.

Charge Air Cooler (CAC) Cleaning

Material

Item	Specification
Metal Brake Parts Cleaner PM-4-A or PM-4-B (US); CPM-4 (Canada)	—

Charge Air Cooler (CAC) Cleaning

1. ***NOTICE:*** **Do not use a high-pressure power washer to clean the Charge Air Cooler (CAC) or damage to the CAC may occur.**

   NOTE: Drain all contaminates such as coolant, fuel and oil prior to cleaning the Charge Air Cooler (CAC).

   NOTE: Thoroughly clean the joint clamp areas as well as the turbocharger connection, engine connection and the CAC connections, using metal brake parts cleaner.

   Lay the CAC flat with the inlet and outlet ports pointing up.

2. **NOTE:** Plug or cap the CAC openings prior to agitating.

   Add an appropriate amount of commercially available detergent cleaner such as Simple Green Pro HD, or equivalent to the CAC . Follow the manufacturer's directions for cleaning. Fill the CAC to 40% of its volume with water.

3. Raise one end of the CAC and agitate it by hand for at least 5 minutes.

4. Raise the opposite end of the CAC and agitate it by hand for at least 5 minutes.

5. Drain the CAC .

6. Flush the CAC thoroughly with clean water.

7. Repeat Steps 1 through 6 until no contaminates are found in the flush water.

8. Allow the CAC to air dry.

9. **NOTE:** The following leak test steps must by performed prior to installing the CAC .

   Install the CAC Y-pipe, gasket and bolts.
   - To install, tighten to 8 Nm (71 lb-in).

10. **NOTE:** Use a commercially available kit, such as the Johnson Manufacturing Company Charge Air Cooler Test Set Part No. 351-CAS, or equivalent.

    Install the commercially available CAC cooler tester on the CAC following the manufacturer's installation instructions.
    - Tighten the clamps to 5 Nm (44 lb-in).

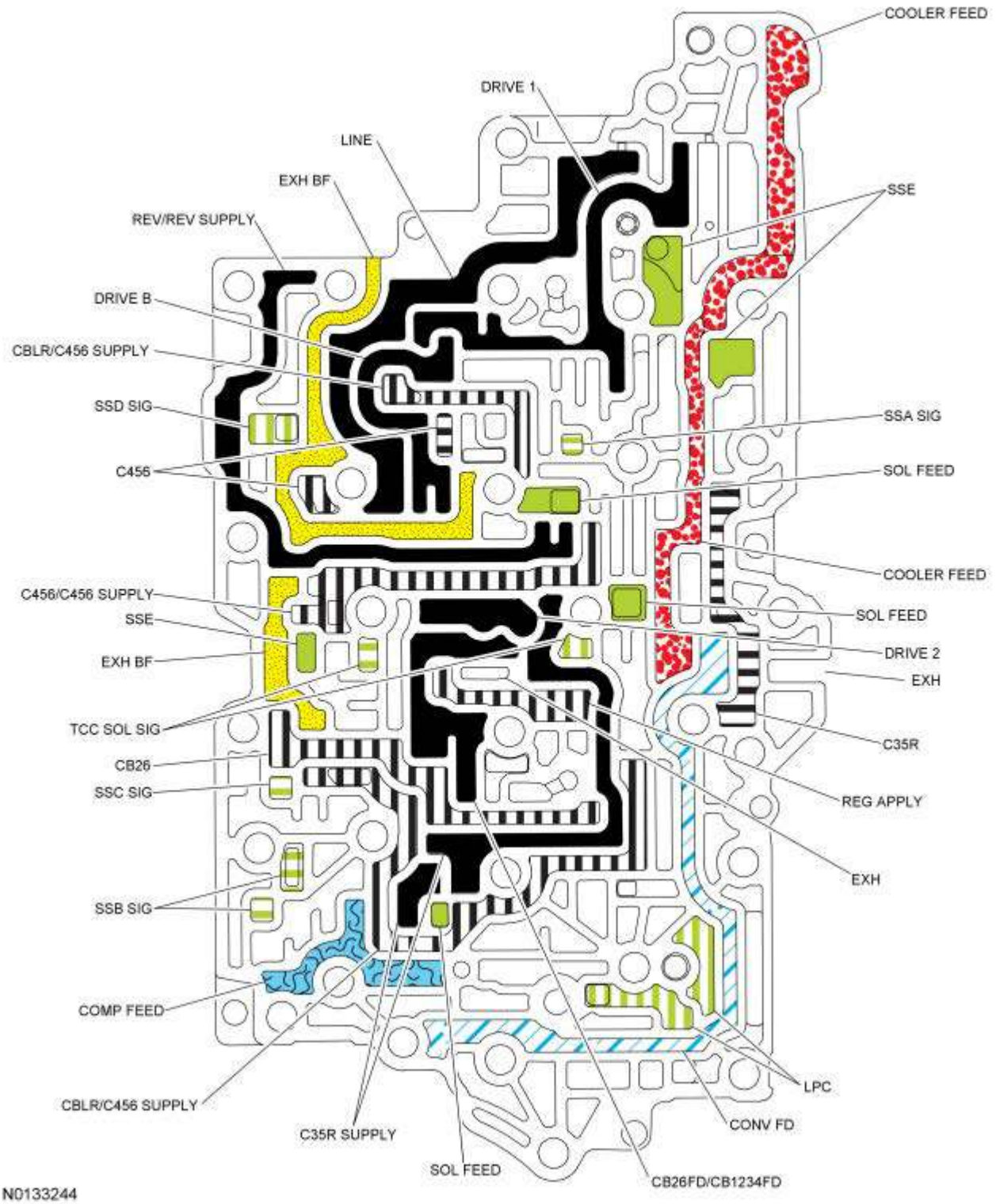
11. **WARNING: Never exceed the specified pressure. Excessive pressure may cause the test adapter to blow off or may damage the charge air cooler (CAC). Failure to follow this instruction may result in serious personal injury.**

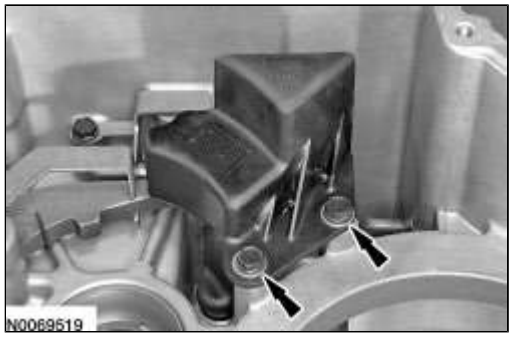
    Slowly apply air pressure to 150 kPa (22 psi).

12. Let the CAC stand for a few minutes and note any loss in pressure.
    - Release the air pressure.

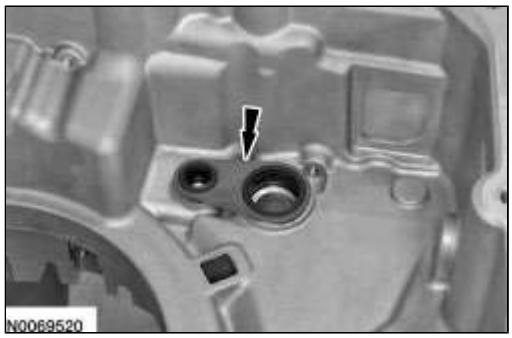
13. Repeat Steps 11 and 12 as many times as necessary to verify the readings. The reading is considered verified when 3 consecutive tests show approximately the same pressure drop.

TRANSFER PLATE HYDRAULIC PASSAGES
(BOTTOM VIEW)





200. Install a new pump-to-case seal.



201. Install the transfer shaft and gear assembly.

202. Tilt the transfer shaft and gear assembly over and install the differential assembly.

203. Install a new torque converter hub seal on the Converter Seal Installer 307-575.

204. ***NOTICE:*** **Support the torque converter housing using blocks of wood, or damage to the torque converter housing may occur.**

when the engine is not running. Failure to follow this instruction may result in serious personal injury.

WARNING: Always disconnect the battery ground cable at the battery when working on an evaporative emission (EVAP) system or fuel-related component. Highly flammable mixtures are always present and may be ignited. Failure to follow these instructions may result in serious personal injury.

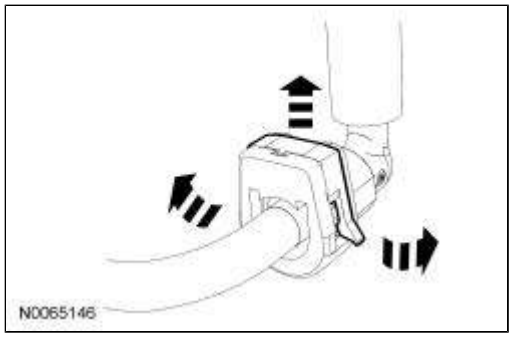
NOTICE: **When reusing liquid or vapor tube connectors, make sure to use compressed air to remove any foreign material from the connector retaining clip area before separating from the tube or damage to the tube or connector retaining clip can occur. Apply clean engine oil to the end of the tube before inserting the tube into the connector.**

NOTICE: **Fuel injection equipment is manufactured to very precise tolerances and fine clearances. It is essential that absolute cleanliness is observed when working with these components or component damage can occur. Always install plugs to any open orifices or tubes.**

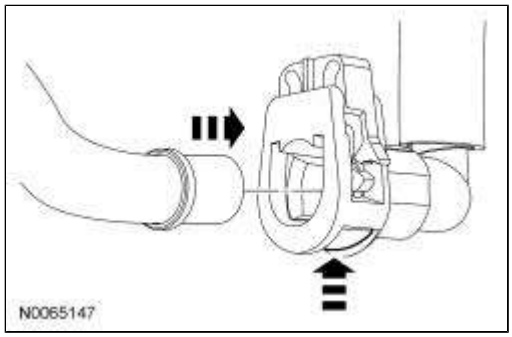
NOTICE: **Do not use any tools. The use of tools may cause a deformity in the clip components which may cause fuel leaks.**

1. If servicing a liquid fuel tube quick connect coupling, release the fuel system pressure. For additional information, refer to Fuel System Pressure Release in this section.
2. Disconnect the battery ground cable. For additional information, refer to Section 414-01 .
3. **NOTE:** When reusing liquid or vapor tube quick connect couplings, make sure to use compressed air to remove any foreign material from the retaining clip area before disconnecting from the tube. Apply clean engine oil to the end of the tube before connecting the quick connect coupling.

   Spread the legs of the retainer clip and pull it to the outward position in the quick connect coupling.



4. Depress the retainer clip and disconnect the quick connect coupling from the tube.



Connect — Type III

1. **NOTE:** Apply clean engine oil to the end of the tube and quick connect coupling O-ring seals.

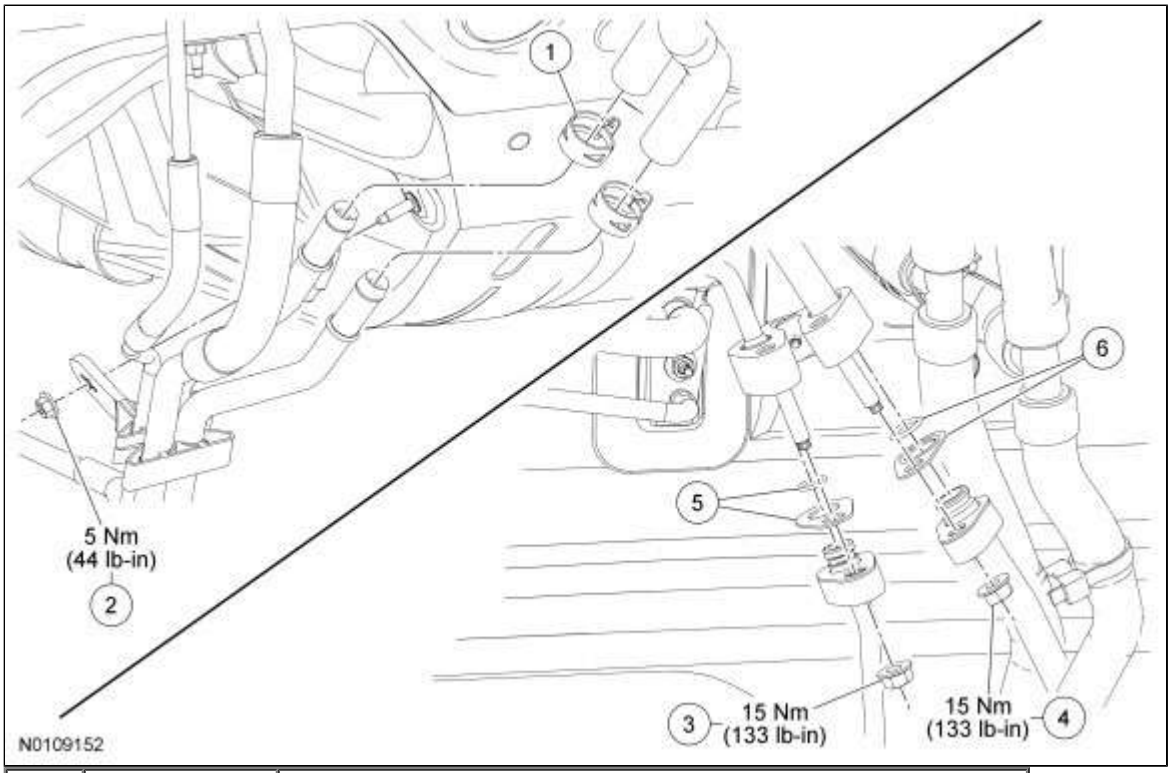
   Install the quick connect coupling onto the tube until fully seated.

Auxiliary Heater Outlet and Inlet Line

Material

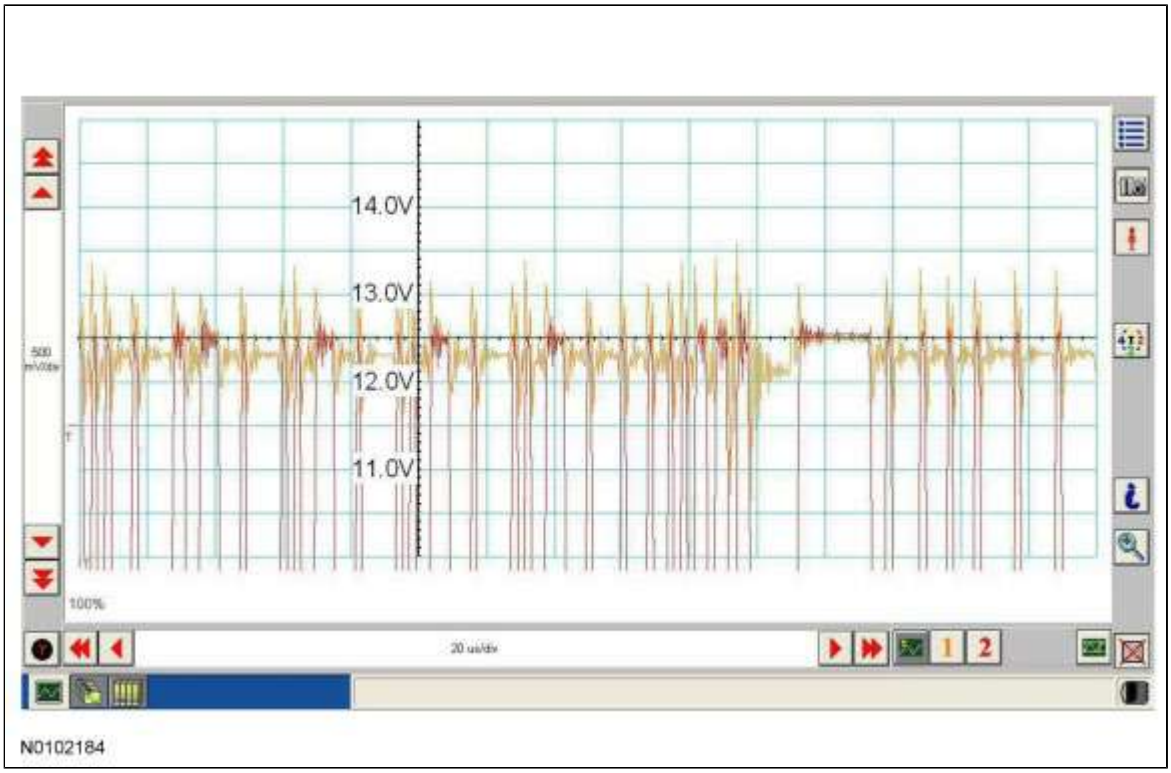
Item	Specification
Motorcraft® PAG Refrigerant Compressor Oil YN-12-D	WSH-M1C231-B

Front Auxiliary Line Connections



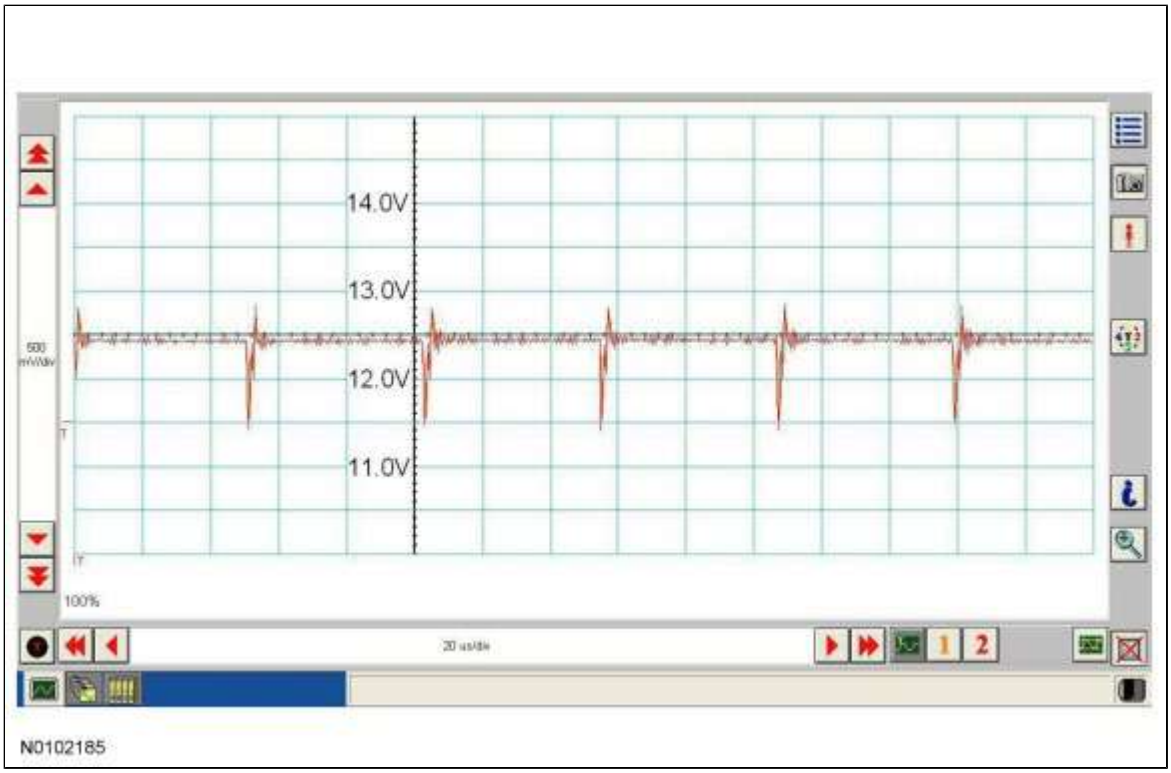
Item	Part Number	Description
1	8287	Front auxiliary heater line heater hose clamp (2 required)
2	W707137	Front auxiliary line bracket nut
3	W520413	Front auxiliary evaporator inlet line fitting nut
4	W520413	Front auxiliary evaporator outlet line fitting nut
5	19B596	O-ring seal and gasket seal kit
6	19B596	O-ring seal and gasket seal kit

Rear Auxiliary Line Connections



In the event that the data (+) circuit becomes shorted to battery voltage, the data (+) circuit is pulled high (12V) and the data (-) circuit falls to abnormally high voltage (above 5V) during communication and reaches battery voltage (12V) for peak voltage. Communication may continue but at a degraded level.

CAN (-) Circuit Shorted To Battery Voltage



In the event that the data (-) circuit becomes shorted to battery voltage, both the data (+) and data (-) circuits are pulled high (12V) and all communication capabilities are lost.

CAN Circuit Signal Corruption

original headliner.

4. ***NOTICE:*** **Make sure not to damage the wire harness when cutting the excess adhesive from the wire harness.**

   Cut and remove any excess adhesive from the wire harness.
5. Position the wire harness onto the new headliner and check that the harness has enough length to be connected to the body/roof connectors using the tape indicator that was applied in Step 1. Apply tape to temporarily hold the wire harness in position on the headliner.

6. **NOTE:** The 3M™ Duramix™ 4747 Super Fast Adhesive will set in 20 seconds. Continually make sure that the wire harness is routed correctly when applying the adhesive.

   Apply the 3M™ Duramix™ 4747 Super Fast Adhesive in the same location as the factory-installed adhesive along the full length of the wire harness-to-headliner to avoid any NVH concerns.
7. Transfer all necessary components.

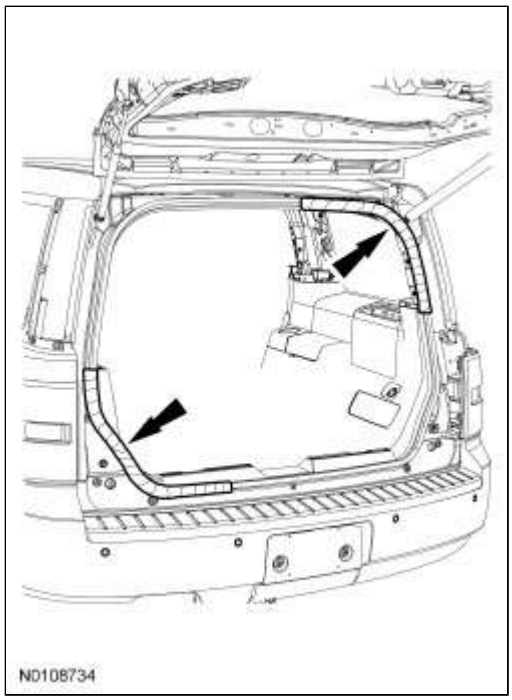
Vehicles equipped with a glass roof

2. Install the new assembled headliner through the windshield opening.

All vehicles except vehicles with a glass roof

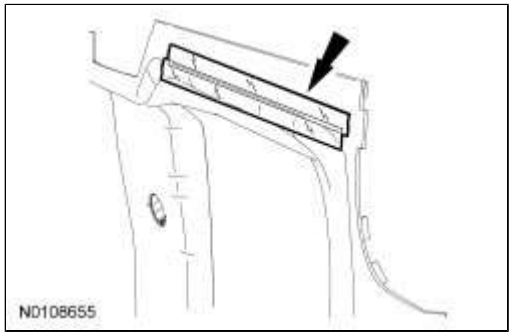
3. **NOTE:** The use of duct or masking tape is not recommended when covering the weatherstrip. Use only clear shipping/packing tape with a smooth surface to avoid marking or damaging the new headliner.

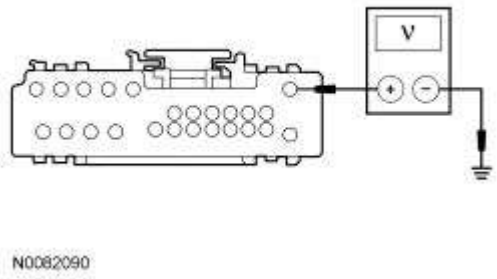
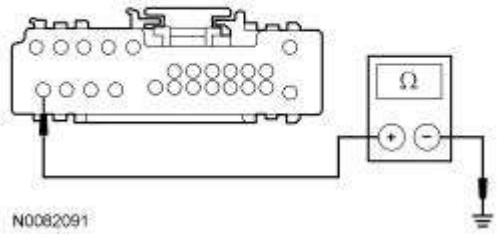
   Position several strips of clear shipping/packing tape onto the rear liftgate opening weatherstrip at the lower LH and upper RH corner of the liftgate opening. Make sure that the tape is attached securely to the body and to the weatherstrip.



4. **NOTE:** LH shown, RH similar.

   Place several strips of clear shipping/packing tape horizontally on the LH and RH wing section of the headliner.



C341b-1, circuit CBX03 (BU/RD), harness side and ground.  N0082090 • **Is the voltage within 0.2 volts of the recorded battery voltage?**	the self-test.
AN5 CHECK THE DSM GROUND CIRCUIT	
• Ignition OFF. • Disconnect: Negative Battery Cable . • Measure the resistance between the DSM C341b-24, circuit GD905 (BK/GN), harness side and ground.  N0082091 • **Is the resistance less than 5 ohms?**	**Yes** CONNECT the negative battery cable. GO to AN6 . **No** REPAIR the circuit for high resistance. CONNECT the negative battery cable. TEST the system for normal operation.
AN6 CHECK FOR CORRECT DSM OPERATION	

• Disconnect all the DSM connectors.
• Check for:
  ▪ corrosion
  ▪ damaged pins
  ▪ pushed-out pins
• Connect all the DSM connectors and make sure they seat correctly.
• Operate the system and verify the concern is still present.
• **Is the concern still present?**
	Yes
	INSTALL a new DSM . REFER to Driver Seat Module (DSM) in this section. TEST the system for normal operation.
	
	No
	The system is operating correctly at this time. The concern may have been caused by a loose or corroded connector.

Pinpoint Test AO: DTC U0140

Refer to Wiring Diagrams Cell 14 , Module Communications Network for schematic and connector information.

Normal Operation

The Driver Seat Module (DSM) and the Smart Junction Box (SJB) communicate using the Medium Speed Controller Area Network (MS-CAN). Messages are exchanged between the modules on the MS-CAN for the purposes of determining what functions are being carried out.

- DTC U0140 (Lost Communication With Body Control Module (GEM)) — set by the DSM whenever it has lost

Engine Off Natural Vacuum (EONV) EVAP Leak Check Monitor

The EONV EVAP leak check monitor is executed during ignition OFF, after the engine on EVAP leak check monitor is completed. The EONV EVAP leak check monitor determines a leak is present when the naturally occurring change in fuel tank pressure or vacuum does not exceed a calibrated limit during a calibrated amount of time. A separate, low power consuming, microprocessor in the PCM manages the EONV leak check. The engine OFF EVAP leak check monitor is executed by the individual components of the enhanced EVAP system as follows:

1. The EVAP purge valve is normally closed at ignition OFF.

2. The normally open EVAP canister vent valve remains open for a calibrated amount of time to allow the fuel tank pressure to stabilize with the atmosphere. During this time period the FTP sensor is monitored for an increase in pressure. If pressure remains below a calibrated limit the EVAP canister vent valve is closed by the PCM (100% duty cycle) and seals the EVAP system from the atmosphere.

3. The FTP sensor is used by the EONV EVAP leak check monitor to determine if the target pressure or vacuum necessary to complete the EONV EVAP leak check monitor on the fuel tank is reached. Some vehicle applications with the EONV EVAP leak check monitor use a remote inline FTP sensor. If the target pressure or vacuum on the fuel tank is achieved within the calibrated amount of time, the test is complete.

4. The EONV EVAP leak check monitor uses the naturally occurring change in fuel tank pressure as a means to detect a leak in the EVAP system. At ignition OFF, a target pressure and vacuum is determined by the PCM. These target values are based on the fuel level and the ambient temperature at ignition OFF. As the fuel tank temperature increases, the pressure in the tank increases and as the temperature decreases a vacuum develops. If a leak is present in the EVAP system the fuel tank pressure or vacuum does not exceed the target value during the testing time period. The EONV EVAP leak check monitor begins at ignition OFF. After ignition OFF the normally open EVAP canister vent valve remains open for a calibrated amount of time to allow the fuel tank pressure to stabilize with the atmosphere. During this time period the FTP sensor is monitored for an increase in pressure. If pressure remains below a calibrated limit the EVAP canister vent valve is closed by the PCM (100% duty cycle) and seals the EVAP system from the atmosphere.

   If the pressure on the fuel tank decreases after the EVAP system is sealed, the EONV EVAP leak check monitor begins to monitor the fuel tank pressure. When the target vacuum is exceeded within the calibrated amount of time the test completes and the fuel tank pressure and time since ignition OFF information is stored. If the target vacuum is not reached in the calibrated amount of time, a leak is suspected and the fuel tank pressure and time since ignition OFF information is stored.

   If the pressure on the fuel tank increases after the EVAP system is sealed, but does not exceed the target pressure within a calibrated amount of time, the EVAP canister vent valve is opened to allow the fuel tank pressure to again stabilize with the atmosphere. After a calibrated amount of time the EVAP canister vent valve is closed by the PCM and seals the EVAP system. When the fuel tank pressure exceeds either the target pressure or vacuum within the calibrated amount of time, the test completes and the fuel tank pressure and time since ignition OFF information is stored. If the target pressure or vacuum is not reached in the calibrated amount of time, a leak is suspected and the fuel tank pressure and time since ignition OFF information is stored.

   On ISO 14229 vehicles, a fast initial response occurs during the first 4 tests after the battery is disconnected or the DTCs are cleared. The PCM processes unfiltered data to quickly indicate a fault is present. The MIL illuminates if the PCM suspects a leak within 2 consecutive trips after a DTC clear or a battery disconnect using the fast initial response logic.

   A step change logic becomes active after the 4th EONV monitor test. The step change logic detects an abrupt change from a no leak condition to a suspected leak condition. The MIL