Manual Part No. 0E9267

GENERAC®
POWER SYSTEMS, INC.

3.0 LITER

FORD GAS ENGINE

SERVICE MANUAL

FOREWORD

This manual has been published by GENERAC® POWER SYSTEMS, INC. to aid our dealers' mechanics, company service personnel and general consumers when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products, manufactured and marketed by GENERAC® POWER SYSTEMS, INC. It is also assumed that they have been trained in the recommended servicing procedures for these products, which includes the use of mechanics hand tools and any special tools that might be required.

Proper service and repair is important to the safe, economical and reliable operation of the products described herein. The troubleshooting, testing, service and repair procedures recommended by GENERAC® POWER SYSTEMS, INC. and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

We could not possibly know of and advise the service trade of all conceivable procedures or methods by which a service might be performed, nor of any possible hazards and/or results of each procedure or method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or method not recommended by the manufacturer must first satisfy himself that neither his safety, nor the product's safety, will be endangered by the service or operating procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. However, GENERAC® POWER SYSTEMS, INC. reserves the right to change, alter or otherwise improve the product at any time without prior notice.

Some components or assemblies of the product described in this manual may not be considered repairable. Disassembly, repair and reassembly of such components may not be included in this manual.

The engines described herein may be used to power a wide variety of products. Service and repair instructions relating to any such products are not covered in this manual. For information pertaining to use of these engines with other products, refer to any owner's or service manuals pertaining to said products.

This engine has been engineered for use in Generac Power Systems products. The contents of this manual have been reprinted from the original manufacturer's service and repair manual.

◆ ENGINE OIL RECOMMENDATIONS

The unit has been filled with "break in" engine oil at the factory. Use a high-quality detergent oil classified "For Service CC, SD, SE or SF." Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE viscosity rating, based on the ambient temperature range anticipated before the next oil change:

Engine Lubrication System:

Type of Oil Pump .....Gear
Oil Filter .....Full Flow, Cartridge
Crankcase Oil Capacity .....4.7 liters (5.0 U.S. quarts.)

Temperature	Oil Grade (Recommended)
Above 80° F (27° C)	SAE 5W-20
32° to 86° F (0° to 30° C)	SAE 5W-20
Below 32° F (0° C)	SAE 5W-20

◆ COOLANT

Use a mixture of half low silicate, ethylene glycol base antifreeze and half soft water. Use only soft water and only low silicate antifreeze. If desired, you may add a high quality rust inhibitor to the recommended coolant mixture. When adding coolant, always add the recommended 50-50 mixture.

Cooling System:

Type.....Pressurized, Closed Recovery
Coolant Capacity
System.....11.4 liters (3.0 U.S. gallons.)

⚠ DANGER ⚠

⚠ Do not remove the radiator pressure cap while the engine is hot or serious burns from boiling liquid or steam could result.

⚠ Ethylene glycol base antifreeze is poisonous. Do not use your mouth to siphon coolant from the radiator, recovery bottle or any container. Wash your hands thoroughly after handling. Never store used antifreeze in an open container because animals are attracted to the smell and taste of antifreeze even though it is poisonous to them.

⚠ CAUTION ⚠

⚠ Do not use any chromate base rust inhibitor with ethylene glycol base antifreeze, or chromium hydroxide ("green slime") will form and cause overheating. Engines that have been operated with a chromate base rust inhibitor must be chemically cleaned before adding ethylene glycol base antifreeze. Using any high silicate antifreeze boosters or additives also will cause overheating. We also recommend that you DO NOT use any soluble oil inhibitor for this equipment.

PERIODIC MAINTENANCE SCHEDULE:

SCHEDULED MAINTENANCE

Following is a recommended maintenance schedule for Generac small standby and residential generator sets. The established intervals in the schedule are the *maximum* recommended when the unit is used in an average service application. They will need to be decreased (performed more frequently) if the unit is used in a severe application. Use the unit hour meter or calendar time, whichever occurs first, from the previous maintenance interval to determine the next required maintenance interval.

Service Maintenance Interval Information:

The various service maintenance intervals are designated by interval numbers as follows:

1 An early inspection of the generator set to ensure it is ready to operate when required and to identify any potential problem areas.

Performed monthly or following each 10 hours of operation of the unit and requires approximately ***.5 man-hours*** *per unit to complete.*

This inspection may be performed by the end user providing the following safety steps are taken to prevent the engine from starting automatically without warning:

To prevent injury, perform the following steps in the order indicated before starting any maintenance:

- **Disable the generator set from starting and/or connecting to the load by setting the control panel AUTO-OFF-MANUAL switch to the "OFF" position.**
- **Remove the control panel fuse.**
- **Turn off the battery charger.**
- **Remove the negative battery cable.**

The battery charger must be turned off BEFORE removing the battery cable to prevent an over current condition from burning out sensitive control panel components and circuits.

Following all maintenance, reverse these steps to insure the unit is returned to standby setup for normal operation when required.

2 A break-in service inspection of the generator set to ensure it is ready to operate and carry the load when required, and to identify any potential problem areas.

Performed ***ONLY ONCE*** *following the first three months or the first 30 hours of operation after purchase of the unit and requires approximately* ***2.5 man-hours*** *per unit to complete.*

This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.

3 An operational inspection of the generator set to ensure it is ready to operate and carry the load when required, and to identify any potential problem areas.

Performed semi-annually or following each 50 hours of operation of the unit and requires approximately ***1.5 man-hours*** *per unit to complete.*

This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.

4 A mid-level inspection of the generator set to ensure it is ready to operate and carry the load when required, and to identify any potential problem areas.

Performed annually or following each 100 hours of operation of the unit and requires approximately ***4.0 man-hours*** *per unit to complete.*

This inspection contains some maintenance tasks which require special tools, equipment, and/or knowledge to accomplish and should be performed only by an authorized Generac Service Dealer.

3.0 Liter Gas Engine Service Recommendations

Maintenance Tasks	Level 1 Recommended to be done monthly/ 10 hrs.	Task Comp. (Date-Initials)	Level 2 Required to be done 3 months/ Break-in 30 hrs.	Task Comp. (Date-Initials)	Level 3 Required to be done Semi-annually/ 50 hrs.	Task Comp. (Date-Initials)	Level 4 Required to be done Annually/ 100 hrs.	Task Comp. (Date-Initials)
1. Disable the unit from operating per the first page warning.	⬭		⬭		⬭		⬭	
2. Check the engine oil level. Adjust as necessary.	⬭		⬭		⬭		⬭	
3. Check the engine coolant level. Adjust as necessary.	⬭		⬭		⬭		⬭	
4. Check the engine coolant thermal protection level. Correct as necessary.							⬭	
5. Check the natural gas delivery system on gas engine driven units. Tighten connections as necessary.			⬭		⬭		⬭	
6. Check the air inlets and outlets for debris. Clean as necessary.	⬭		⬭		⬭		⬭	
7. Check the battery electrolyte level if accessible. Adjust as necessary.	⬭		⬭		⬭		⬭	
8. Check the battery posts, cables, and charger for loose connections, corrosion, and proper operation. Correct as necessary.	⬭		⬭		⬭		⬭	
9. Check the unit wiring for loose connections, corrosion, and damage. Correct as necessary.							⬭	
10. Check the engine accessory drive belts for wear, weather cracking, and damage. Replace as necessary.							⬭	
11. Visually inspect the unit looking for leaks, wear or damage, loose connections or components, and corrosion. Correct as necessary.	⬭		⬭		⬭		⬭	
12. Test the engine and transfer switch safety devices. Correct and/or adjust as necessary.							⬭	

Maintenance Tasks	Level 1 Recommended to be done monthly/ 10 hrs.	Task Comp. (Date-Initials)	Level 2 Required to be done 3 months/ Break-in 30 hrs.	Task Comp. (Date-Initials)	Level 3 Required to be done Semi-annually/ 50 hrs.	Task Comp. (Date-Initials)	Level 4 Required to be done Annually/ 100 hrs.	Task Comp. (Date-Initials)
13. Initiate an automatic start and transfer of the unit to site load and exercise it for at least 1 hour looking for leaks, loose connections or components, and abnormal operating conditions. Correct as necessary.			⬭		⬭			
14. Start and exercise the unit at full rated load (use a load bank if the site load is not enough) for at least 2 hours looking for leaks, loose connections or components, and abnormal operating conditions. Correct as necessary.							⬭	
15. Change the engine oil.			⬭				⬭	
16. Replace the engine oil filter(s).			⬭				⬭	
17. Replace the engine air filter(s).							⬭	
18. Replace the engine fuel filter(s) on diesel engine driven units and re-prime the fuel system.			⬭				⬭	
19. Check the engine spark plugs on gas engine driven units. Clean and re-gap or replace as necessary.			⬭				⬭	
20. Perform a 5 minute no-load operational run of the unit looking for any post service problems.			⬭				⬭	
21. Return the unit to standby setup for operation when required.	⬭		⬭		⬭		⬭	

Manual Table of Contents

SECTION 303-00 Engine System — General Information

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SPECIFICATIONS

General Specifications

Item	Specification
Lubricants and Sealants	
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP	WSS-M2C153-H

General Specifications (Continued)

Item	Specification
Diesel engine oil	Refer to owner literature
Gasoline Engine Oil Dye 164-R3705	ESE-M99C103-B1
Threadlock® 262 E2FZ-19554-B	WSK-M2G351-A6

DESCRIPTION AND OPERATION

Engine

NOTE: This section contains information, steps and procedures that may not be specific to your engine.

This section covers general procedures and diagnosis and testing of the engine system, except for exhaust emission control devices, which are covered in the Powertrain Control/Emissions Diagnosis Manual.

The engine incorporates the following features:

- a closed positive crankcase ventilation (PCV) system. For additional information, refer to Section 303-08.
- an exhaust emission control system. For additional information, refer to Section 303-08.
- an evaporative emission control system. For additional information, refer to Section 303-13.

Some engines incorporate a fail-safe cooling system. Refer to the appropriate section in Group 303 for the procedure.

The engine, fuel system, ignition system, emissions system and exhaust system all affect exhaust emission levels and must be maintained according to the maintenance schedule. Refer to the scheduled Maintenance Guide.

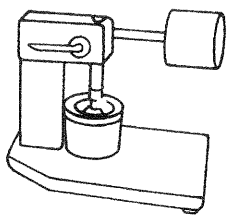
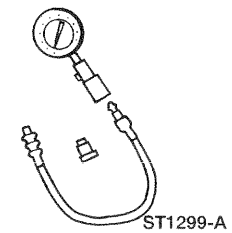
Correct engine identification is required to order parts. Refer to the appropriate section in Group 303 for the procedure.

For complete vehicle and engine identification codes, refer to Section 100-01.

DIAGNOSIS AND TESTING

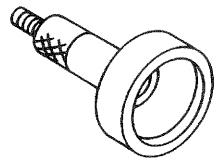
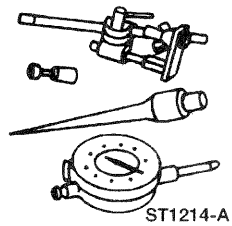
Engine

Special Tool(s)

	Commercially Available Leakdown Tester —
 ST1299-A	Quick Disconnect Compression Tester 134-R0212 or equivalent

(Continued)

Special Tool(s)

 ST1272-A	Dial Indicator Gauge Adapter 303-007 (TOOL-6565-AB) or equivalent
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

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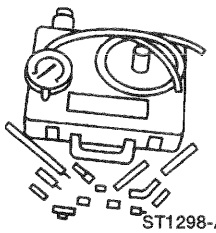
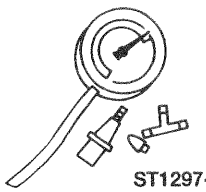
DIAGNOSIS AND TESTING (Continued)

Special Tool(s)

 ST1298-A	Engine Cylinder Leak Detection/Air Pressurization Kit 014-00708 or equivalent
 ST1296-A	Oil Pressure Gauge 303-088 (T73L-6600-A)
 ST1300-A	UV Leak Detector Kit 164-R0756 or equivalent
 ST1297-A	Vacuum/Pressure Tester 164-R0253 or equivalent

Material

Item	Specification
Gasoline Engine Oil Dye 164-R3705 or equivalent	ESE-M99C103-B1
Engine Oil	Refer to owner literature

Inspection and Verification

1. Verify the customer concern by operating the engine to duplicate the condition.
2. Visually inspect for obvious signs of mechanical damage. Refer to the following chart.

Visual Inspection Chart

Mechanical
• Engine coolant leaks • Engine oil leaks • Fuel leaks • Damaged or severely worn parts • Loose mounting bolts, studs and nuts

3. If the inspection reveals obvious concerns that can be readily identified, repair as necessary.
4. If the concerns remain after the inspection, determine the symptoms. GO to Symptom Chart.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart

Symptom Chart

Condition	Possible Sources	Action
• Difficult starting	• Damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged starting system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged charging system/battery.	• REFER to Section 414-00.
	• Burnt valve.	• INSTALL a new valve.
	• Worn piston.	• INSTALL a new piston.
	• Worn piston rings.	• INSTALL new piston rings.
	• Worn cylinder.	• REPAIR or INSTALL a new cylinder block.
	• Damaged head gasket.	• INSTALL a new head gasket.
	• Damaged cooling system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
• Poor idling	• Vacuum leaks.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or lash adjuster.	• INSTALL a new valve tappet guide or valve tappet.
	• Incorrect valve-to-valve seat contact.	• REPAIR or INSTALL a new valve or valve seat.
	• Damaged head gasket.	• INSTALL a new head gasket.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Abnormal combustion	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged air intake system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or valve tappet.	• INSTALL a new valve tappet guide or valve tappet.
	• Burnt or sticking valve.	• REPAIR or INSTALL a new valve.
	• Weak or broken valve spring.	• INSTALL a new valve spring.
	• Carbon accumulation in combustion chamber.	• ELIMINATE carbon buildup.
• Excessive oil consumption	• Leaking oil.	• REPAIR oil leakage.
	• Malfunctioning PCV system.	• REPAIR or INSTALL new necessary components.
	• Worn valve stem seal.	• INSTALL a new valve stem seal.
	• Worn valve stem or valve guide.	• INSTALL a new valve and valve guide.
	• Sticking piston rings.	• REPAIR or INSTALL new piston rings.
	• Worn piston ring groove.	• INSTALL a new piston and piston pin.
	• Worn piston or cylinder.	• REPAIR or INSTALL a new piston or cylinder block.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Engine noise	• Leaking exhaust system.	• REPAIR exhaust leakage.
	• Incorrect drive belt tension.	• REFER to Section 303-05.
	• Malfunctioning generator bearing.	• Refer to the appropriate section in Group 414 for the procedure.
	• Malfunctioning water pump bearing.	• REFER to Section 303-03.
	• Malfunctioning or damaged cooling system.	• REFER to Section 303-03.
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Loose timing chain/belt (6268).	• ADJUST or INSTALL a new timing chain/belt.
	• Damaged timing chain tensioner (6L266).	• INSTALL a new timing chain tensioner.
	• Excessive main bearing clearance.	• ADJUST clearance or INSTALL a new crankshaft main bearing (6333).
	• Seized or heat damaged crankshaft main bearing.	• INSTALL a new crankshaft main bearing.
	• Excessive crankshaft end play.	• INSTALL a new thrust bearing or crankshaft (6303).
	• Excessive connecting rod bearing clearance.	• INSTALL a new connecting rod bearing or connecting rod (6200).
	• Heat damaged connecting rod bearing (6211).	• INSTALL a new connecting rod bearing.
	• Damaged connecting rod bushing (6207).	• INSTALL a new connecting rod bushing.
	• Worn cylinder.	• REPAIR or INSTALL a new cylinder block (6010).
	• Worn piston (6108) or piston pin (6135).	• INSTALL a new piston or piston pin.
	• Damaged piston rings.	• INSTALL new piston rings.
	• Bent connecting rod.	• INSTALL a new connecting rod.
	• Malfunctioning valve tappet (6500) or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Excessive valve tappet or lash adjuster clearance.	• ADJUST clearance or INSTALL a new valve tappet guide or valve tappet.
	• Broken valve spring (6513).	• INSTALL a new valve spring.
	• Excessive valve guide clearance.	• ADJUST clearance or INSTALL a new valve guide (6510) or valve.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Insufficient power	• Malfunctioning or damaged ignition system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Malfunctioning or damaged air intake system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .
	• Damaged or plugged exhaust system.	• INSPECT exhaust system.
	• Incorrect tire size.	• REFER to Section 204-04.
	• Dragging brakes.	• REFER to Section 206-00.
	• Slipping transmission.	• Refer to the appropriate section in Group 307 for the procedure.
	• Malfunctioning valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or valve tappet.	• INSTALL a new valve tappet guide or valve tappet.
	• Compression leakage at valve seat.	• REPAIR or INSTALL a new valve, valve seat or cylinder head (6049).
	• Seized valve stem.	• INSTALL a new valve.
	• Weak or broken valve spring.	• INSTALL a new valve spring.
	• Worn or damaged camshaft.	• INSTALL a new camshaft.
	• Damaged head gasket (6051).	• INSTALL a new head gasket.
	• Cracked or distorted cylinder head.	• INSTALL a new cylinder head.
	• Damaged, worn or sticking piston ring(s).	• REPAIR or INSTALL a new piston ring(s).
	• Worn or damaged piston.	• INSTALL a new piston and piston pin.

Component Tests

Engine Oil Leaks

NOTE: When diagnosing engine oil leaks, the source and location of the leak must be positively identified prior to repair.

Prior to carrying out this procedure, clean all sealing surface areas with a suitable solvent to remove all traces of oil.

Engine Oil Leaks—Fluorescent Oil Additive Method

Use the UV Leak Detector Kit to carry out the following procedure for oil leak diagnosis.

1. Add gasoline engine oil dye. Use a minimum 14.8 ml (0.5 ounce) to a maximum 29.6 ml (1 ounce) of fluorescent additive to all engines. If the oil is not premixed, fluorescent additive must first be added to crankcase.
2. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the UV Leak Detector Kit. A clear bright yellow or orange area will identify the leak. For extremely small leaks, several hours may be required for the leak to appear.

DIAGNOSIS AND TESTING (Continued)

Leakage Points—Underhood

Examine the following areas for oil leakage:

- valve cover gaskets
- intake manifold gaskets
- cylinder head gaskets
- oil bypass filter
- oil filter adapter
- engine front cover
- oil filter adapter and filter body
- oil level indicator tube connection
- oil pressure sensor

Leakage Points—Under Engine—With Vehicle on Hoist

- oil pan gaskets (6710)
- oil pan sealer
- oil pan rear seal (6723)
- engine front cover gasket
- crankshaft front seal (6700)
- crankshaft rear oil seal (6701)
- crankshaft main bearing cap side bolts
- oil filter adapter and filter body
- oil cooler, if equipped

Leakage Points—With Transmission and Flywheel Removed

- crankshaft rear oil seal
- rear main bearing cap parting line
- rear main bearing cap and seals
- flywheel mounting bolt holes (with flywheel installed)
- camshaft rear bearing covers (6266) or pipe plugs at the end of oil passages

Oil leaks at crimped seams in sheet metal parts and cracks in cast or stamped parts can be detected when using the dye method.

Compression Test—Compression Gauge Check

1. Make sure the oil in the crankcase is of the correct viscosity and at the correct level and that the battery (10655) is correctly charged. Operate the vehicle until the engine is at normal operating temperature. Turn the ignition switch to the OFF position, then remove all the spark plugs (12405).
2. Set the throttle plates in the wide-open position.
3. Install a compression gauge such as the Compression Tester in the No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. With the ignition switch in the OFF position, and using the auxiliary starter switch, crank the engine a minimum of five compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes.

Compression Test—Test Results

The indicated compression pressures are considered within specification if the lowest reading cylinder is at least 75 percent of the highest reading. Refer to the Compression Pressure Limit Chart.

Compression Pressure Limit Chart

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
924 kPa (134 psi)	696 kPa (101 psi)	1131 kPa (164 psi)	848 kPa (123 psi)	1338 kPa (194 psi)	1000 kPa (146 psi)	1544 kPa (224 psi)	1158 kPa (168 psi)
938 kPa (136 psi)	703 kPa (102 psi)	1145 kPa (166 psi)	855 kPa (124 psi)	1351 kPa (196 psi)	1014 kPa (147 psi)	1558 kPa (226 psi)	1165 kPa (169 psi)
952 kPa (138 psi)	717 kPa (104 psi)	1158 kPa (168 psi)	869 kPa (126 psi)	1365 kPa (198 psi)	1020 kPa (148 psi)	1572 kPa (228 psi)	1179 kPa (171 psi)

DIAGNOSIS AND TESTING (Continued)

Compression Pressure Limit Chart (Continued)

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
965 kPa (140 psi)	724 kPa (106 psi)	1172 kPa (170 psi)	876 kPa (127 psi)	1379 kPa (200 psi)	1034 kPa (150 psi)	1586 kPa (230 psi)	1186 kPa (172 psi)
979 kPa (142 psi)	738 kPa (107 psi)	1186 kPa (172 psi)	889 kPa (129 psi)	1303 kPa (202 psi)	1041 kPa (151 psi)	1600 kPa (232 psi)	1200 kPa (174 psi)
933 kPa (144 psi)	745 kPa (109 psi)	1200 kPa (174 psi)	903 kPa (131 psi)	1407 kPa (204 psi)	1055 kPa (153 psi)	1055 kPa (153 psi)	1207 kPa (175 psi)
1007 kPa (146 psi)	758 kPa (110 psi)	1214 kPa (176 psi)	910 kPa (132 psi)	1420 kPa (206 psi)	1062 kPa (154 psi)	1627 kPa (154 psi)	1220 kPa (177 psi)
1020 kPa (148 psi)	765 kPa (111 psi)	1227 kPa (178 psi)	917 kPa (133 psi)	1434 kPa (208 psi)	1075 kPa (156 psi)	1641 kPa (238 psi)	1227 kPa (178 psi)
1034 kPa (150 psi)	779 kPa (113 psi)	1241 kPa (180 psi)	931 kPa (135 psi)	1448 kPa (210 psi)	1083 kPa (157 psi)	1655 kPa (240 psi)	1241 kPa (180 psi)
1048 kPa (152 psi)	786 kPa (114 psi)	1255 kPa (182 psi)	936 kPa (136 psi)	1462 kPa (212 psi)	1089 kPa (158 psi)	1669 kPa (242 psi)	1248 kPa (181 psi)
1062 kPa (154 psi)	793 kPa (115 psi)	1269 kPa (184 psi)	952 kPa (138 psi)	1476 kPa (214 psi)	1103 kPa (160 psi)	1682 kPa (244 psi)	1262 kPa (183 psi)
1076 kPa (156 psi)	807 kPa (117 psi)	1282 kPa (186 psi)	965 kPa (140 psi)	1489 kPa (216 psi)	1117 kPa (162 psi)	1696 kPa (246 psi)	1269 kPa (184 psi)
1089 kPa (158 psi)	814 kPa (118 psi)	1296 kPa (188 psi)	972 kPa (141 psi)	1503 kPa (218 psi)	1124 kPa (163 psi)	1710 kPa (248 psi)	1202 kPa (186 psi)
1103 kPa (160 psi)	827 kPa (120 psi)	1310 kPa (190 psi)	979 kPa (142 psi)	1517 kPa (220 psi)	1138 kPa (165 psi)	1724 kPa (250 psi)	1289 kPa (187 psi)
1110 kPa (161 psi)	834 kPa (121 psi)	1324 kPa (192 psi)	993 kPa (144 psi)	1631 kPa (222 psi)	1145 kPa (166 psi)	—	—

If one or more cylinders reads low, squirt approximately one tablespoon of engine oil on top of the pistons in the low-reading cylinders. Repeat the compression pressure check on these cylinders.

Compression Test—Interpreting Compression Readings

1. If compression improves considerably, piston rings are faulty.
2. If compression does not improve, valves are sticking or seating incorrectly.
3. If two adjacent cylinders indicate low compression pressures and squirting oil on each piston does not increase compression, the head gasket may be leaking between cylinders. Engine oil or coolant in cylinders could result from this condition.

   Use the Compression Pressure Limit Chart when checking cylinder compression so that the lowest reading is within 75 percent of the highest reading.

Cylinder Leakage Detection

When a cylinder produces a low reading, use of the Engine Cylinder Leak Detection/Air Pressurization Kit will be helpful in pinpointing the exact cause.

The leakage detector is inserted in the spark plug hole, the piston is brought up to dead center on the compression stroke, and compressed air is admitted.

Once the combustion chamber is pressurized, a special gauge included in the kit will read the percentage of leakage. Leakage exceeding 20 percent is excessive.

DIAGNOSIS AND TESTING (Continued)

While the air pressure is retained in the cylinder, listen for the hiss of escaping air. A leak at the intake valve (6507) will be heard in the throttle body (9E926). A leak at the exhaust valve (6505) can be heard at the tail pipe. Leakage past the piston rings will be audible at the positive crankcase ventilation (PCV) connection. If air is passing through a blown head gasket to an adjacent cylinder, the noise will be evident at the spark plug hole of the cylinder into which the air is leaking. Cracks in the cylinder block or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator (8005).

Oil Consumption Test

The following diagnostic procedure is used to determine the source of excessive internal oil consumption.

1. **NOTE:** Oil use is normally greater during the first 16,100 km (10,000 miles) of service. As mileage increases, oil use generally decreases. Vehicles in normal service should get at least 1,450 km per liter (900 miles per quart) after 16,000 km (10,000 miles) of service. High speed driving, towing, high ambient temperature and other factors may result in greater oil use.

   Define excessive oil consumption, such as the number of miles driven per liter (quart) of oil used. Also determine customer's driving habits, such as sustained high speed operation, towing, extended idle and other considerations.
2. Verify that the engine has no external oil leak as described under Engine Oil Leaks in the Diagnosis and Testing portion of this section.
3. Verify that the engine has the correct oil level dipstick (6750).
4. Verify that the engine is not being run in an overfilled condition. Check the oil level at least five minutes after a hot shutdown with the vehicle parked on a level surface. In no case should the level be above MAX or the letter F in FULL. If significantly overfilled, carry out Steps 6a through 6d.
5. Verify the spark plugs are not oil saturated. If the spark plugs are oil saturated and compression is good it can be assumed the valve seals or valve guides are at fault.
6. Carry out an oil consumption test:
   a. Drain the engine oil, remove the oil bypass filter (6714) and refill with one liter (quart) less than the recommended amount.
   b. Run the engine for three minutes (10 minutes if cold), and allow the oil to drain back for at least five minutes with the vehicle on a level surface.
   c. Remove oil level dipstick and wipe clean. (Do not wipe with anything contaminated with silicone compounds.) Reinstall the oil level dipstick, being sure to seat it firmly in the oil level indicator tube (6754). Remove the oil level dipstick and draw a mark on the back (unmarked) surface at the indicated oil level. This level should be about the same as the MIN or ADD mark on the face of the oil level dipstick.
   d. Add one liter (quart) of oil. Restart the engine and allow to idle for at least two minutes. Shut off the engine and allow the oil to drain back for at least five minutes. Mark the oil level dipstick, using the procedure above.
   e. Record the vehicle mileage.
   f. Instruct the customer to drive the vehicle as usual and perform the following:
      — Check the oil level regularly at intervals of 160 to 240 km (100-150 miles).
      — Return to the service point when the oil level drops below the lower (MIN or ADD) mark on the oil level dipstick.
      — Add only full liters (quarts) of the same oil in an emergency. Note the mileage at which the oil is added.

DIAGNOSIS AND TESTING (Continued)

g. Check the oil level under the same conditions and at the same location as in Steps 6c and 6d.
   — Measure the distance from the oil level to the UPPER mark on the oil level dipstick and record.
   — Measure the distance between the two scribe marks and record.
   — Divide the first measurement by the second.
   — Divide the distance driven during the oil test by the result. This quantity is the approximate oil consumption rate in kilometers per liter or in miles per quart.

h. If the oil consumption rate is unacceptable, go to Step 7.

7. Check the positive crankcase ventilation (PCV) system. Make sure the system is not plugged.
8. Check for plugged oil drain-back holes in the cylinder heads and cylinder block.
9. If the condition still exists after performing the above steps, go to Step 10.
10. Perform a cylinder compression test or perform a cylinder leak detection test with Engine Cylinder Leak Detection/Air Pressurization Kit. This can help determine the source of oil consumption such as valves, piston rings or other areas.
11. **NOTE:** After determining if new parts should be installed, make sure correct parts are used.

    Check valve guides for excessive guide clearance. Install new all valve stem seals (6571) after verifying valve guide clearance.
12. Worn or damaged internal engine components can cause excessive oil consumption. Small deposits of oil on the tips of spark plugs can be a clue to internal oil consumption. If internal oil consumption still persists, proceed as follows:

    a. Remove the engine from the vehicle and place it on an engine work stand. Remove the intake manifolds (9424), cylinder heads, oil pan (6675) and oil pump (6600).
    b. Check piston ring clearance, ring gap and ring orientation. Repair as necessary.
    c. Check for excessive bearing clearance. Repair as necessary.
13. Repeat the oil consumption test (Step 6) to confirm the oil consumption concern has been resolved.

Intake Manifold Vacuum Test

Bring the engine to normal operating temperature. Connect the Vacuum/Pressure Tester to the intake manifold. Run the engine at the specified idle speed.

The vacuum gauge should read between 51-74 kPa (15-22 in-Hg) depending upon the engine condition and the altitude at which the test is performed. Subtract 4.0193 kPa (1 in-Hg) from the specified reading for every 304.8 m (1,000 feet) of elevation above sea level.

The reading should be steady. If necessary, adjust the gauge damper control (where used) if the needle is fluttering rapidly. Adjust the damper until the needle moves easily without excessive flutter.

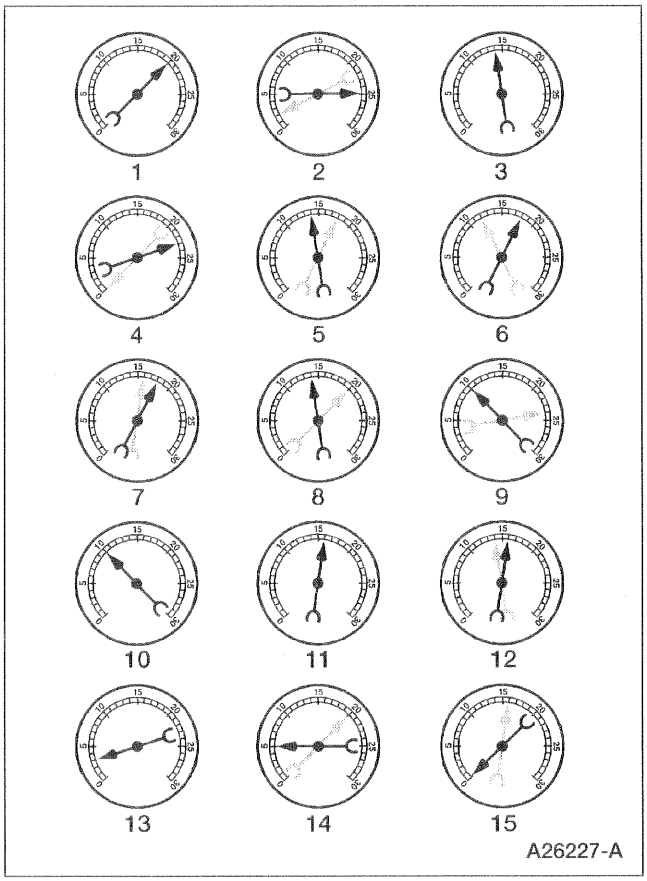
Intake Manifold Vacuum Test—Interpreting Vacuum Gauge Readings

A careful study of the vacuum gauge reading while the engine is idling will help pinpoint trouble areas. Always conduct other appropriate tests before arriving at a final diagnostic decision. Vacuum gauge readings, although helpful, must be interpreted carefully.

Most vacuum gauges have a normal band indicated on the gauge face.

DIAGNOSIS AND TESTING (Continued)

The following are potential gauge readings. Some are normal; others should be investigated further.



1. NORMAL READING: Needle between 51-74 kPa (15-22 in-Hg) and holding steady.
2. NORMAL READING DURING RAPID ACCELERATION AND DECELERATION: When the engine is rapidly accelerated (dotted needle), the needle will drop to a low reading (not to zero). When the throttle is suddenly released, the needle will snap back up to a higher than normal figure.
3. NORMAL FOR HIGH-LIFT CAMSHAFT WITH LARGE OVERLAP: The needle will register as low as 51 kPa (15 in-Hg) but will be relatively steady. Some oscillation is normal.
4. WORN RINGS OR DILUTED OIL: When the engine is accelerated (dotted needle), the needle drops to 0 kPa (0 in-Hg). Upon deceleration, the needle runs slightly above 74 kPa (22 in-Hg).
5. STICKING VALVES: When the needle (dotted) remains steady at a normal vacuum but occasionally flicks (sharp, fast movement) down and back about 13 kPa (4 in-Hg), one or more valves may be sticking.
6. BURNED OR WARPED VALVES: A regular, evenly-spaced, downscale flicking of the needle indicates one or more burned or warped valves. Insufficient hydraulic lash adjuster or hydraulic lash adjuster (HLA) clearance will also cause this reaction.
7. POOR VALVE SEATING: A small but regular downscale flicking can mean one or more valves are not seating.
8. WORN VALVE GUIDES: When the needle oscillates over about a 13 kPa (4 in-Hg) range at idle speed, the valve guides could be worn. As engine speed increases, the needle will become steady if guides are responsible.
9. WEAK VALVE SPRINGS: When the needle oscillation becomes more violent as engine rpm is increased, weak valve springs are indicated. The reading at idle could be relatively steady.
10. LATE VALVE TIMING: A steady but low reading could be caused by late valve timing.
11. IGNITION TIMING RETARDING: Retarded ignition timing will produce a steady but somewhat low reading.
12. INSUFFICIENT SPARK PLUG GAP: When spark plugs are gapped too close, a regular, small pulsation of the needle can occur.
13. INTAKE LEAK: A low, steady reading can be caused by an intake manifold or throttle body gasket leak.
14. BLOWN HEAD GASKET: A regular drop of fair magnitude can be caused by a blown head gasket or warped cylinder head-to-cylinder block surface.
15. RESTRICTED EXHAUST SYSTEM: When the engine is first started and is idled, the reading may be normal, but as the engine rpm is increased, the back pressure caused by a clogged muffler (5230), kinked tail pipe or other concerns will cause the needle to slowly drop to 0 kPa (0 in-Hg). The needle then may slowly rise. Excessive exhaust clogging will cause the needle to drop to a low point even if the engine is only idling.

DIAGNOSIS AND TESTING (Continued)

16. When vacuum leaks are indicated, search out and correct the cause. Excess air leaking into the system will upset the fuel mixture and cause concerns such as rough idle, missing on acceleration or burned valves. If the leak exists in an accessory unit such as the power brake booster (2005), the unit will not function correctly. Always fix vacuum leaks.

Excessive Engine Oil Consumption

The amount of oil an engine uses will vary with the way the vehicle is driven in addition to normal engine-to-engine variation. This is especially true during the first 16,100 km (10,000 miles) when a new engine is being broken in or until certain internal engine components become conditioned. Vehicles used in heavy-duty operation may use more oil. The following are examples of heavy-duty operation:

- trailer towing applications
- severe loading applications
- sustained high speed operation

Engines need oil to lubricate the following internal components:

- cylinder block cylinder walls
- pistons and piston, pin and rings (6102)
- intake and exhaust valve stems
- intake and exhaust valve guides
- all internal engine components

When the pistons move downward, a thin film of oil is left on the cylinder walls. As the vehicle is operated, some oil is also drawn into the combustion chambers past the intake and exhaust valve stem seals and burned.

The following is a partial list of conditions that can affect oil consumption rates:

- engine duty cycle
- operator driving habits
- ambient temperature
- quality and viscosity of the oil

Operation under varying conditions can frequently be misleading. A vehicle that has been run for several thousand miles on short trips or in below-freezing ambient temperatures may have consumed a "normal" amount of oil. However, when checking the engine oil level, it may measure up to the FULL or MAX on the oil level dipstick due to dilution (condensation and fuel) in the engine crankcase. The vehicle might then be driven at high speeds on the highway where the condensation and fuel boil off. The next time the engine oil is checked, it may appear that a liter (quart) of oil was used in about 160 km (100 miles). This perceived 160 km (100 miles) per liter (quart) oil consumption rate causes customer concern even though the actual overall oil consumption rate is about 2,400 km (1,500 miles) per liter (quart).

Make sure the selected engine oil meets the current recommended API performance category with SAE viscosity grade as shown in the vehicle Owner's Guide. It is also important that the engine oil is changed at the intervals specified. Refer to the vehicle Owner's Guide.

Oil Pressure Test

1. Disconnect and remove the oil pressure sensor (9278) from the engine.
2. Connect the Oil Pressure Gauge to the oil pressure sender oil galley port.
3. Run the engine until normal operating temperature is reached.
4. Run the engine at the specified rpm and record the gauge reading.
5. The oil pressure should be within specifications; refer to the specification chart in the appropriate engine section.
6. If the pressure is not within specification, check the following possible sources:
   - insufficient oil
   - oil leakage
   - worn or damaged oil pump
   - oil pump screen cover and tube (6622)
   - excessive main bearing clearance
   - excessive connecting rod bearing clearance

DIAGNOSIS AND TESTING (Continued)

Valve Train Analysis—Engine Off—Valve Cover Removed

Check for damaged or severely worn parts and correct assembly. Make sure correct parts are used with the static engine analysis as follows.

Valve Train Analysis—Engine Off, Rocker Arm

- Check for loose mounting bolts, studs and nuts.
- Check for plugged oil feed in the rocker arms (6564) or cylinder head.

Valve Train Analysis—Engine Off, Camshaft Roller Followers and Hydraulic Lash Adjusters, Overhead Camshaft

- Check for loose mounting bolts on camshaft carriers.
- Check for plugged oil feed in the camshaft roller followers, lash adjusters or cylinder heads.

Valve Train Analysis—Engine Off, Camshaft—Engines

- Check for broken or damaged parts.

Valve Train Analysis—Engine Off, Push Rods

- Check for bent push rods (6565) and restricted oil passage.

Valve Train Analysis—Valve Springs

- Check for broken or damaged parts.

Valve Train Analysis—Engine Off, Valve Spring Retainer and Valve Spring Retainer Keys

- Check for correct seating of the valve spring retainer key (6518) on the valve stem and in valve spring retainer (6514).
- Check for correct seating on the valve stem.

Valve Train Analysis—Engine Off, Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for worn or damaged valve tips.
- Check for missing or damaged guide-mounted valve stem seal.
- Check collapsed valve tappet gap.
- Check installed valve spring height.
- Check for missing or worn valve spring seats.
- Check for plugged oil metering orifice in cylinder head oil reservoir (if equipped).

Static checks (engine off) are to be made on the engine prior to the dynamic procedure.

Valve Train Analysis—Engine Running

- Start the engine and, while idling, check for correct operation of all parts. Check the following:

Valve Train Analysis—Engine Running, Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for missing or damaged valve stem seals or guide mounted valve stem seals.
- Check for a plugged oil metering orifice in the cylinder head oil reservoir (4.6L engine only).

If insufficient oiling is suspected, check oil passages for blockage, then accelerate the engine to 1,200 rpm with the transmission in NEUTRAL and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and camshaft roller followers are well oiled. With the valve covers (6582) off, some oil splash may overshoot camshaft roller followers.

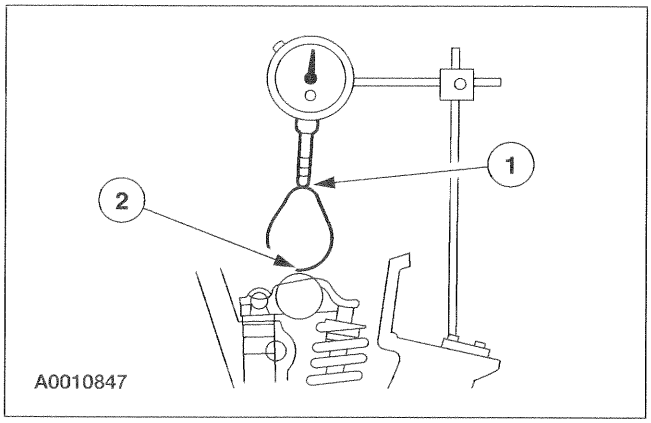
Valve Train Analysis—Engine Running, Camshaft Lobe Lift—OHC Engines

Check the lift of each camshaft lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the spark plugs.
3. Install the Dial Indicator Gauge with Holding Fixture so the rounded tip of indicator is on top of the camshaft lobe and on the same plane as the valve tappet.

DIAGNOSIS AND TESTING (Continued)

4. Rotate the crankshaft using a breaker bar and socket attached to the crankshaft pulley retainer bolt. Rotate the crankshaft until the base circle of the camshaft lobe is reached.



5. Zero the dial indicator. Continue to rotate the crankshaft until the (1) high-lift point of the camshaft lobe is in the fully-raised position (highest indicator reading).
6. To check the accuracy of the original indicator reading, continue to rotate crankshaft until the (2) base circle is reached. The indicator reading should be zero. If zero reading is not obtained, repeat Steps 1 through 6.
7. **NOTE:** If the lift on any lobe is below specified service limits, install a new camshaft, and new camshaft roller followers.

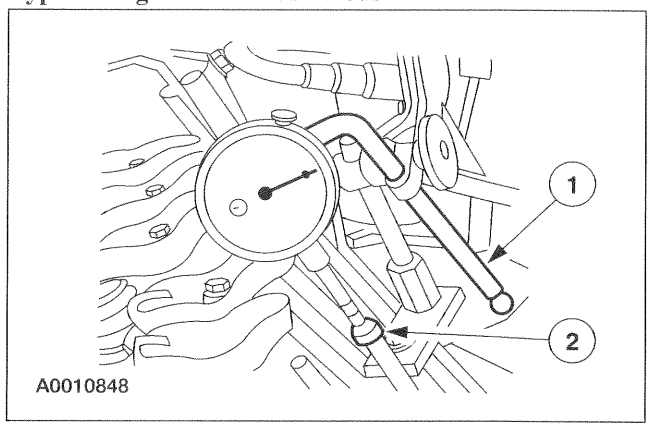
   Remove the Dial Indicator Gauge with Holding Fixture.
8. Install the spark plugs.
9. Install the valve covers.

Valve Train Analysis—Engine Running, Camshaft Lobe Lift—Push Rod Engine

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the rocker arm seat bolts, rocker arm seat (6A528) and rocker arms.

Typical Engine With Push Rods



3. Make sure the valve tappet is seated against camshaft (6250). Install (1) Dial Indicator Gauge with Holding Fixture so the ball socket adapter of the indicator is on top of the valve tappet or (2) Dial Indicator Gauge Adapter is on top of push rod and in same plane as valve tappet push rod movement.
4. Remove the spark plugs.
5. Connect an auxiliary starter switch in the starting circuit. Crank the engine with ignition switch in OFF position. Bump crankshaft over until valve tappet is on base circle of camshaft lobe. At this point, valve tappet will be in its lowest position. If checking during engine assembly, turn crankshaft using a socket or ratchet.
6. Zero the dial indicator. Continue to rotate crankshaft slowly until valve tappet is in fully-raised position (highest indicator reading).
7. **NOTE:** If lift on any lobe is below specified service limits, install a new camshaft, and new valve tappets.

   Remove the Dial Indicator with Holding Fixture, Dial Indicator Gauge Adapter, and auxiliary starter switch.
8. Install rocker arm seats, rocker arms and rocker arm seat bolts.
9. Install valve covers.
10. Install spark plugs.

DIAGNOSIS AND TESTING (Continued)

Valve Train Analysis—Engine Running, Valve Tappet

Valve tappet noise can be caused by any of the following:

- excessive valve tappet gap (collapsed)
- incorrectly functioning valve tappet
- air in lubrication system
- excessive valve guide wear
- low oil pressure

Excessive collapsed valve tappet gap can be caused by loose rocker arm seat bolts/nuts, incorrect initial adjustment or wear of valve tappet face, or worn roller valve tappets, push rod (6565), rocker arm (6564), rocker arm seat or valve tip. With valve tappet collapsed, check gap between the valve tip and the rocker arm to determine if any other valve train parts are damaged, worn or out of adjustment.

An incorrectly functioning valve tappet can be sticking, caused by contaminants or varnish inside the tappet. The tappet can have a check valve that is not functioning correctly, which can be caused by an obstruction, such as dirt or chips that prevent the check valve from closing, or a broken check valve spring. A tappet with a leakdown time out of specification can cause tappet noise. If no other cause for noisy valve tappets can be found, the leakdown rate should be checked and new valve tappets installed if found to be out of specification.

Assembled valve tappets can be tested with Hydraulic Tappet Leakdown Tester to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance while under a 22.7 kg (50 lb) load.

Air bubbles in the lubrication system will prevent the valve tappet from supporting the valve spring load. This can be caused by too high or too low an oil level in the oil pan or by air being drawn into the system through a hole, crack or leaking gasket on the oil pump screen cover and tube.

GENERAL PROCEDURES

Sprockets

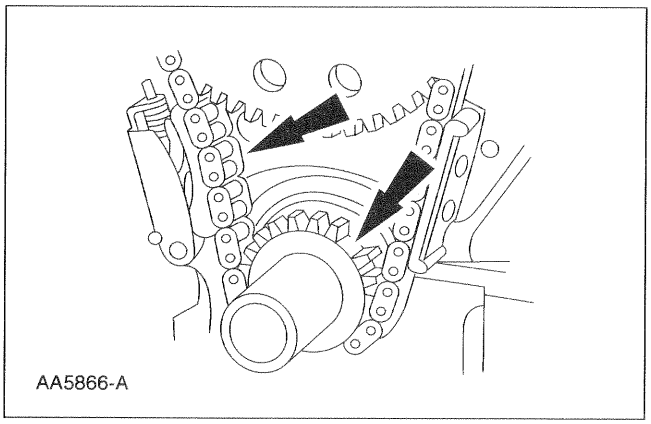
1. **⚠ WARNING: To avoid the possibility of personal injury or damage to the vehicle, do not operate the engine with the hood open until the fan blade has been examined for possible cracks and separation.**

   NOTE: Specifications show the expected minimum or maximum condition. Refer to the appropriate section in Group 303 for the procedure.

   NOTE: If a component fails to meet the specifications, it is necessary to install a new component or refinish. If the component can be refinished, wear limits are provided as an aid to making a decision. A new component must be installed for any component that fails to meet specifications and cannot be refinished.

   Inspect the timing chain/belt and the sprockets.

   - Install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Rocker Arms — Cleaning

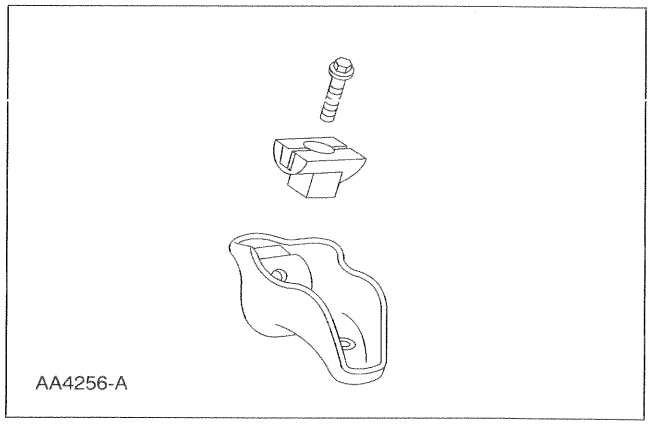
1. Clean all parts thoroughly. Make sure all oil passages are open.

2. Make sure oil passage in the push rod/valve tappet end of the rocker arm (6564) is open.

Rocker Arms — Inspection

⚠ CAUTION: Do not attempt to true surfaces by grinding. Check the rocker arm pad, side rails and seat for excessive wear, cracks, nicks or burrs. Check the rocker arm seat bolt for stripped or broken threads. Install new components as ncessary or possible damage may occur.

1. Inspect the rocker arm push rod bore for nicks, scratches, scores or scuffs. Install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



2. Inspect the pad at the valve end of the rocker arm for indications of scuffing or abnormal wear. If the pad is grooved, install a new rocker arm. Refer to the appropriate section in Group 303 for the procedure.

Push Rods — Cleaning

1. Clean the push rods (6565) in a suitable solvent. Blow out the oil passage in the push rods with compressed air.

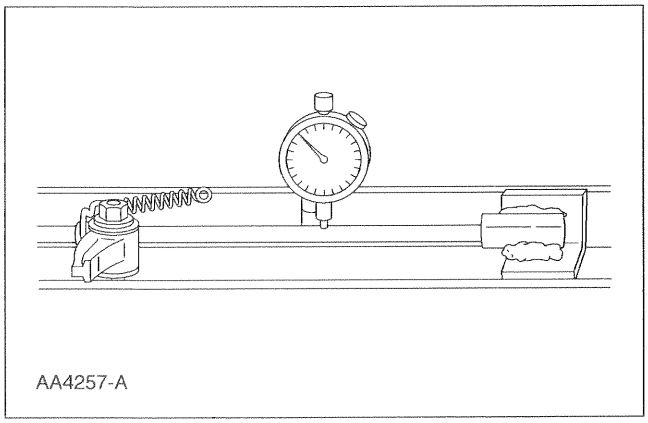
GENERAL PROCEDURES (Continued)

Push Rods — Inspection

1. ⚠ **CAUTION: Do not attempt to straighten push rods.**

   Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Install new push rods as necessary. Refer to the appropriate section in Group 303 for the procedure.

   - The push rods can be checked for straightness while they are installed in the engine by rotating them with the valve closed.
   - They also can be checked using a Dial Indicator with Bracketry.



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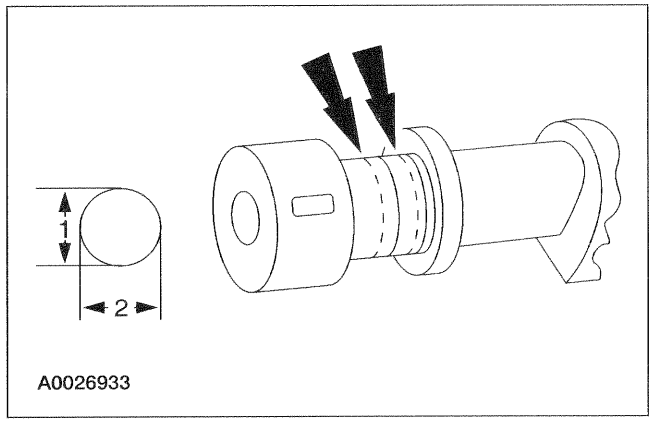
2. If the push rod is bent beyond specifications, install a new push rod. Refer to the appropriate section in Group 303 for the procedure.

Camshaft Journal — Diameter

1. Measure each camshaft journal diameter in two directions.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



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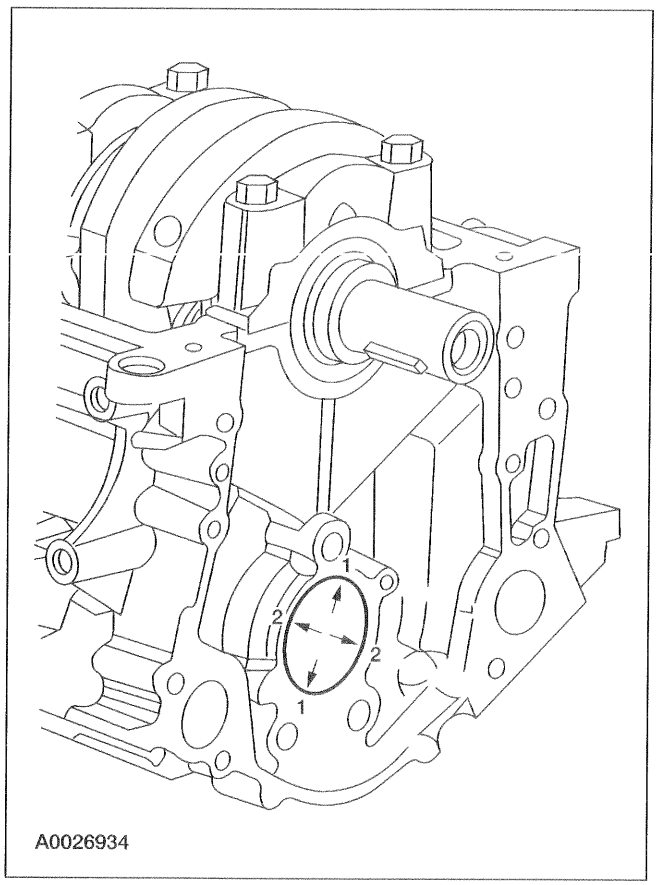
GENERAL PROCEDURES (Continued)

Camshaft Journal — Clearance, Push Rod Engines, Micrometer Method

1. **NOTE:** The camshaft journals must meet specifications before checking camshaft journal clearance.

   Measure each camshaft bearing (6261) in two directions.

   - Subtract the camshaft journal diameter from the camshaft bearing diameter.



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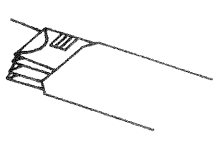
Camshaft Journal — Clearance, Plastigage Method

Special Tool(s)

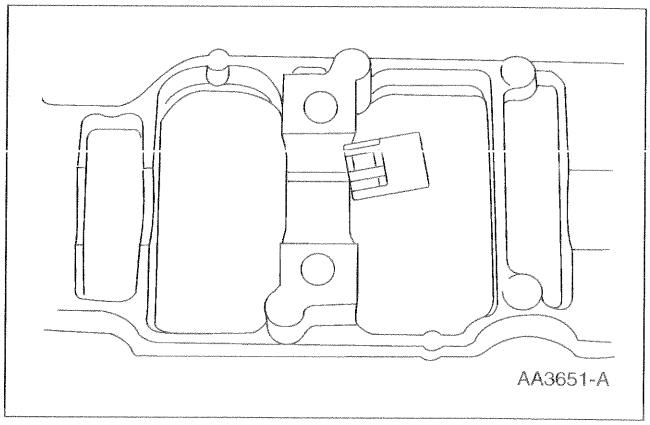
 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: The camshaft journals must meet specifications before checking camshaft journal clearance.

1. Remove the camshaft bearing cap and lay Plastigage across the surface. Refer to the appropriate section in Group 303 for the procedure.

2. **NOTE:** Do not turn the camshaft while carrying out this procedure.

   Position the camshaft bearing cap and install the bolts. Refer to the appropriate section in Group 303 for the procedure.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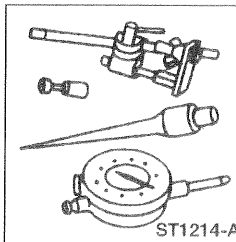
3. Use Plastigage to verify the camshaft journal clearance.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

Camshaft End Play — Push Rod Engines

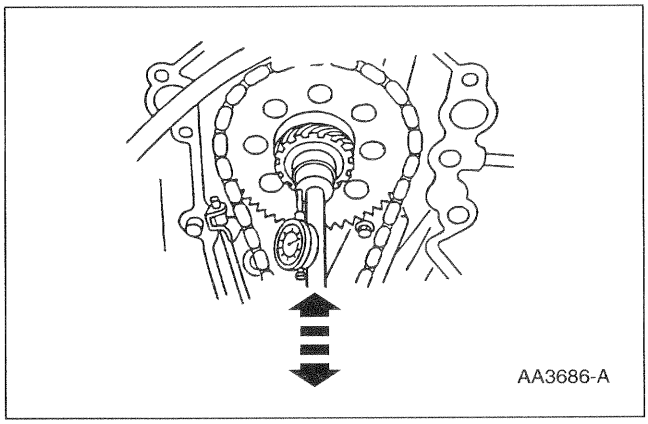
Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. Remove the valve tappets. Refer to the appropriate section in Group 303 for the procedure.

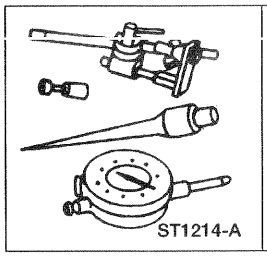
GENERAL PROCEDURES (Continued)

2. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft end play.
3. Position the camshaft to the rear of the cylinder block.
4. Zero the indicator.
5. Move the camshaft to the front of the cylinder block. Note and record the camshaft end play.
   - If the camshaft end play exceeds specifications, install a new camshaft thrust plate. Refer to the appropriate section in Group 303 for the procedure.

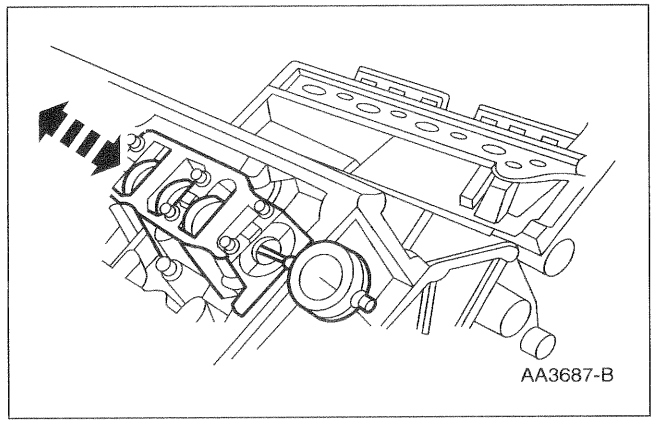


Camshaft End Play — OHC Engines

Special Tool(s)

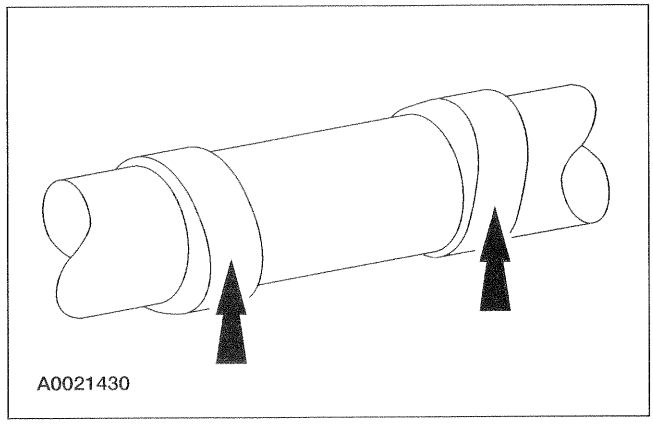
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. Remove the roller followers. Refer to the appropriate section in Group 303 for the procedure.
2. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft end play.
3. Position the camshaft to the rear of the cylinder head.
4. Zero the indicator.
5. Move the camshaft to the front of the cylinder head. Note and record the camshaft end play.
   - If camshaft end play exceeds specifications, install new camshaft and recheck end play. Refer to the appropriate section in Group 303 for the procedure.
   - If camshaft end play exceeds specification after camshaft installation, install a new cylinder head. Refer to the appropriate section in Group 303 for the procedure.



Camshaft — Lobe Surface

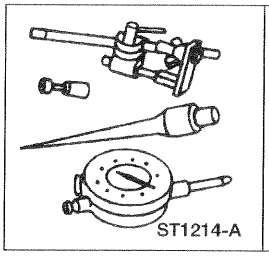
1. Inspect camshaft lobes for pitting or damage in the contact area. Minor pitting is acceptable outside the contact area.
   - If excessive pitting or damage is present, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



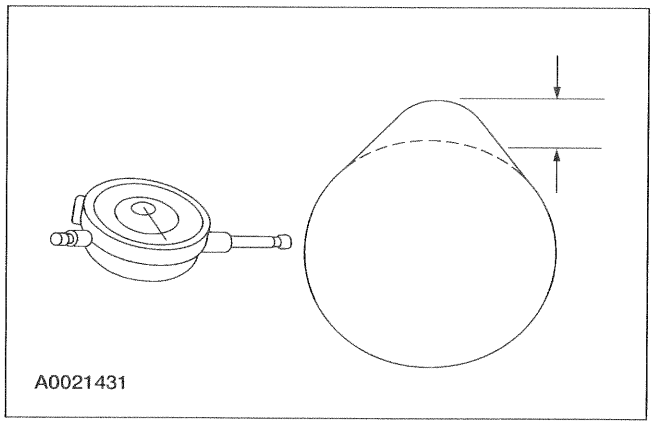
GENERAL PROCEDURES (Continued)

Camshaft Lobe Lift

Special Tool(s)

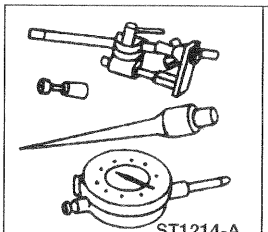
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. Use a Dial Indicator Gauge with Holding Fixture to measure camshaft intake/exhaust lobe lift.
   - Rotate the camshaft and subtract the lowest indicator reading from the highest indicator reading to figure the camshaft lobe lift.
   - Refer to the appropriate section in Group 303 for the procedure.



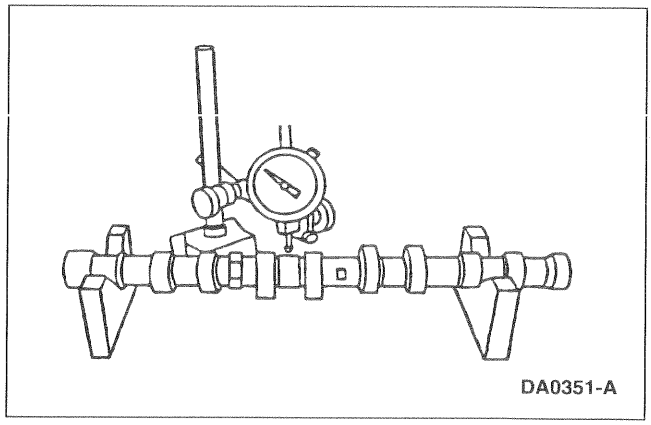
Camshaft Runout

Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. **NOTE:** Camshaft journals must be within specifications before checking runout.

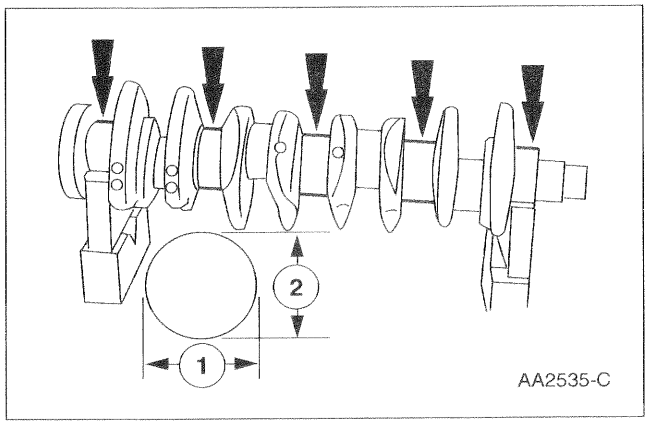
   Use a Dial Indicator Gauge with Holding Fixture to measure the camshaft runout.
   - Rotate the camshaft and subtract the lowest indicator reading from the highest indicator reading.
   - For additional information, refer to the specification chart in the appropriate engine section.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



GENERAL PROCEDURES (Continued)

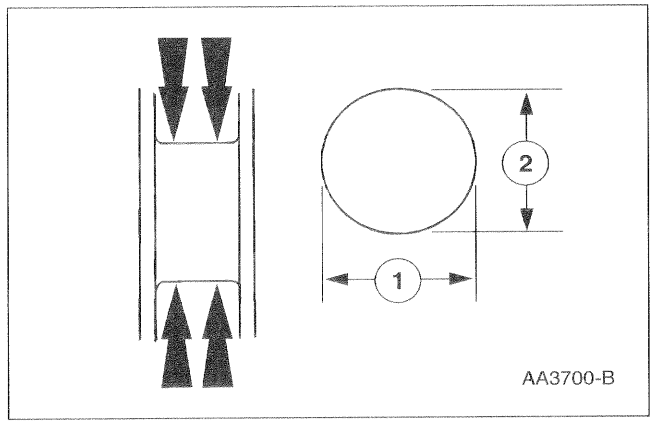
Crankshaft Main Bearing Journal — Diameter

1. Measure each of the crankshaft main bearing journal diameters in at least two directions.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



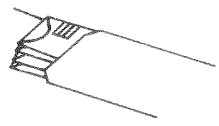
Crankshaft Main Bearing Journal — Taper

1. Measure each of the crankshaft main bearing journal diameters in at least two directions at each end of the main bearing journal.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Crankshaft Main Bearing Journal — Clearance

Special Tool(s)

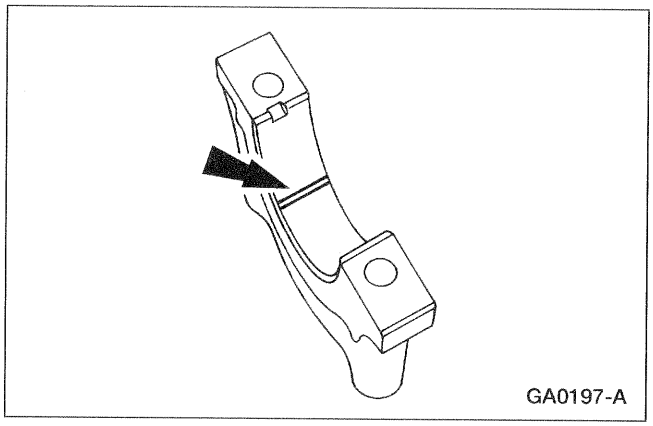
 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: Crankshaft main bearing journals must be within specifications before checking journal clearance.

1. Remove the crankshaft main bearing caps and crankshaft main bearing.

GENERAL PROCEDURES (Continued)

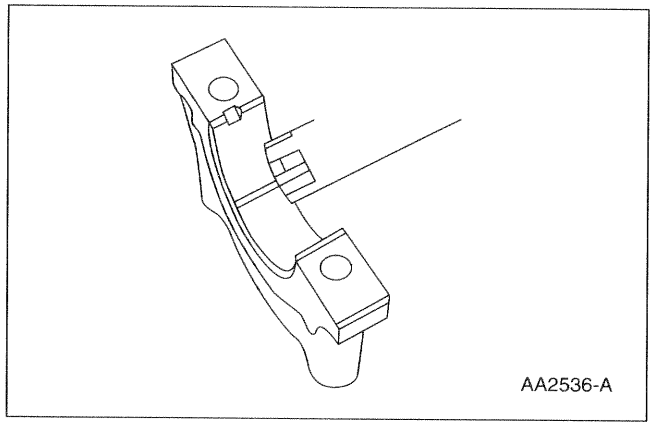
2. Lay a piece of Plastigage across the face of each crankshaft main bearing surface.



3. **NOTE:** Do not turn the crankshaft while carrying out this procedure.

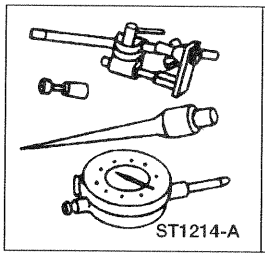
   Install and remove the crankshaft main bearing cap.

4. Verify the crankshaft journal clearance.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Crankshaft End Play

Special Tool(s)

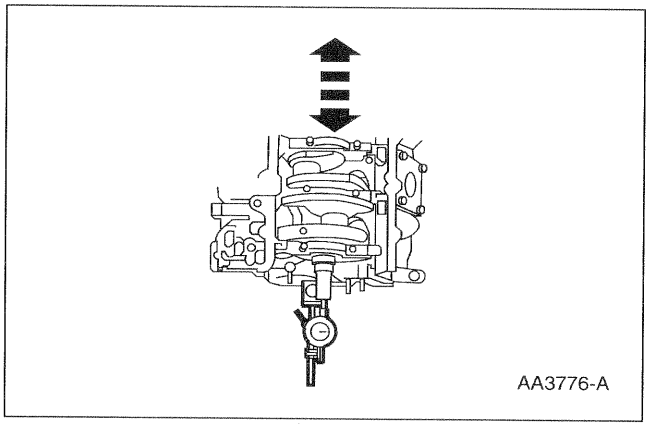
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. Measure the crankshaft end play. Use a Dial Indicator Gauge with Holding Fixture to measure crankshaft end play.

2. Position the crankshaft to the rear of the cylinder block.

3. Zero the indicator.

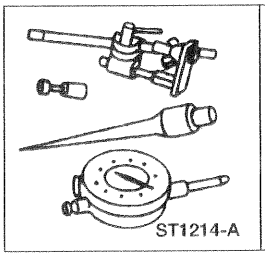
4. Move the crankshaft to the front of the cylinder block. Note and record the crankshaft end play.
   - If crankshaft end play exceeds specifications, install a new crankshaft thrust washer (6334) or crankshaft thrust main bearing (6337). Refer to the appropriate section in Group 303 for the procedure.



GENERAL PROCEDURES (Continued)

Crankshaft Runout

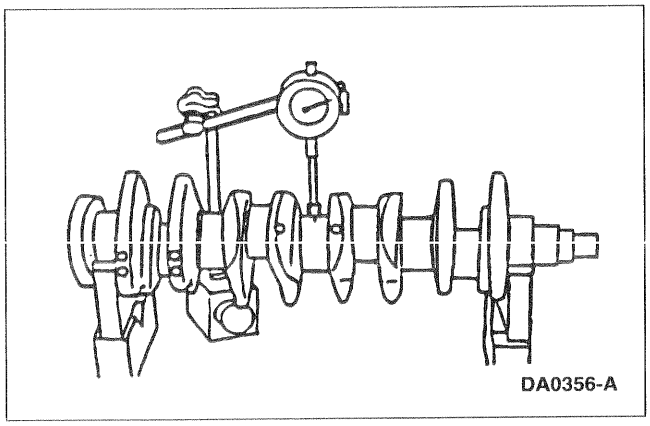
Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

1. **NOTE:** Crankshaft main bearing journals must be within specifications before checking runout.

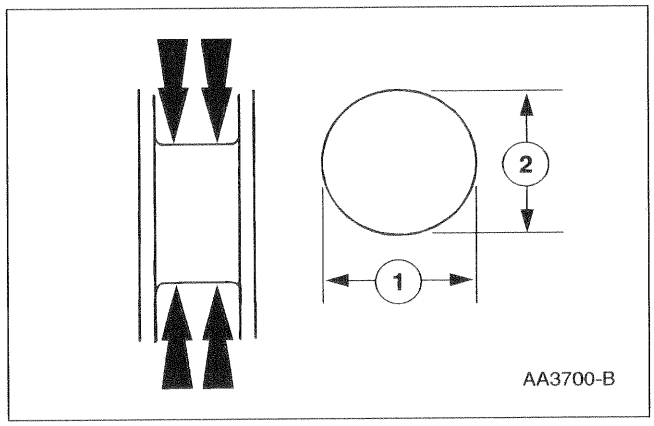
   Use the Dial Indicator Gauge with Holding Fixture to measure the crankshaft runout.

   - Refer to the appropriate section in Group 303 for the procedure.
   - Rotate the crankshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the crankshaft runout. If it is out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Crankshaft — Connecting Rod Journal Taper, Out of Round

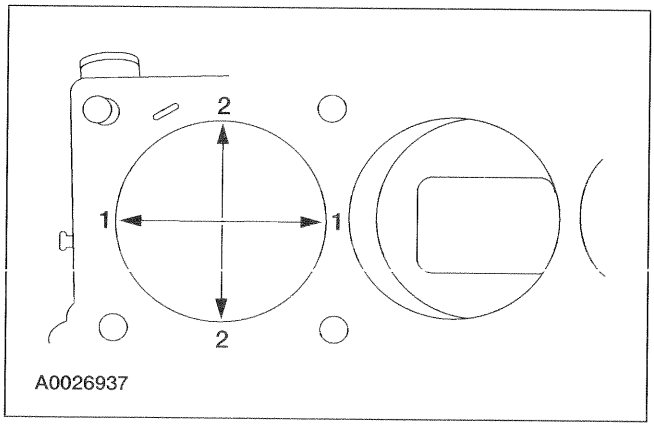
1. Measure the crankshaft connecting rod journal diameters in two directions perpendicular to one another at each end of the connecting rod journal. The difference in the measurements from one end to the other is the taper. Verify measurement is within the wear limit.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



GENERAL PROCEDURES (Continued)

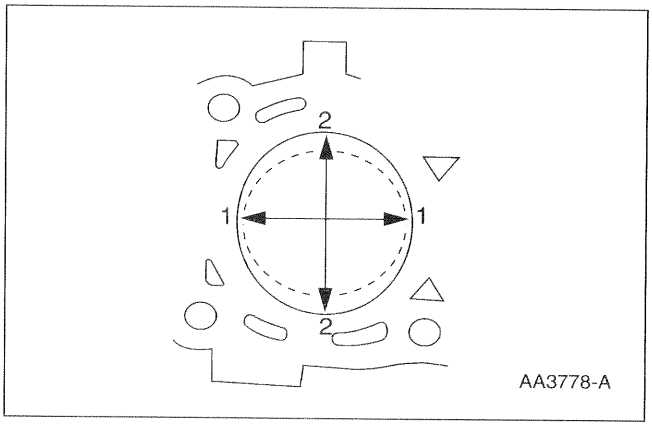
Cylinder Bore — Taper

1. Measure the cylinder bore at the top, middle, and bottom of piston ring travel in two directions as indicated. Verify the cylinder bore is within the wear limit. The difference indicates the cylinder bore taper. Bore the cylinder to the next oversize.
   - Refer to the appropriate section in Group 303 for the procedure.



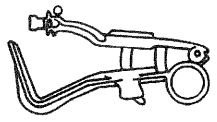
Cylinder Bore — Out-of-Round

1. Measure the cylinder bore in two directions. The difference is the out-of-round. Verify the out-of-round is within the wear limit and bore the cylinder to the next oversize limit.
   - Refer to the appropriate section in Group 303 for the procedure.



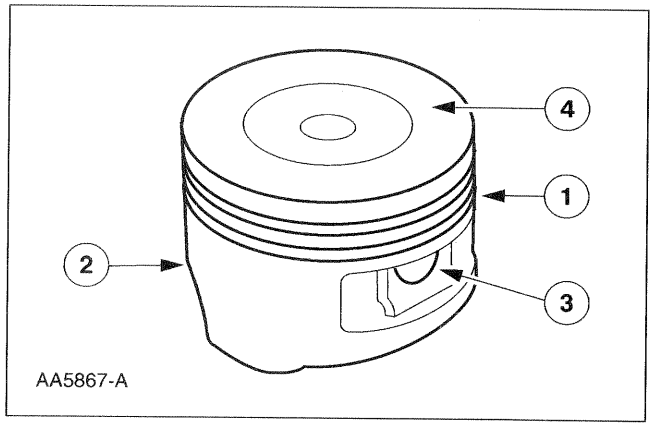
Piston Inspection

Special Tool(s)

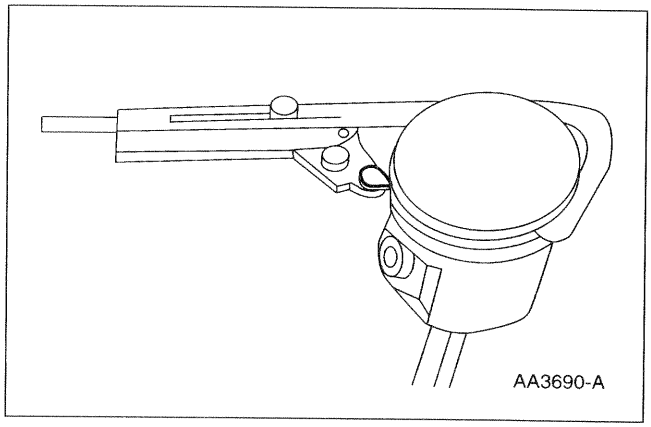
 ST1279-A	Scraper, Piston Ring Groove 303-D033 (D81L-6002-D) or equivalent

⚠ **CAUTION: Do not use a caustic cleaning solution or a wire brush to clean the pistons or damage can occur.**

1. Clean and inspect the (1) ring lands, (2) skirts, (3) pin bosses, and the (4) tops of the pistons. If wear marks, scores or glazing is found on the piston skirt, check for a bent or twisted connecting rod.



2. Use the Piston Ring Groove Scraper to clean the piston ring grooves.
   - Make sure the oil ring holes are clean.



GENERAL PROCEDURES (Continued)

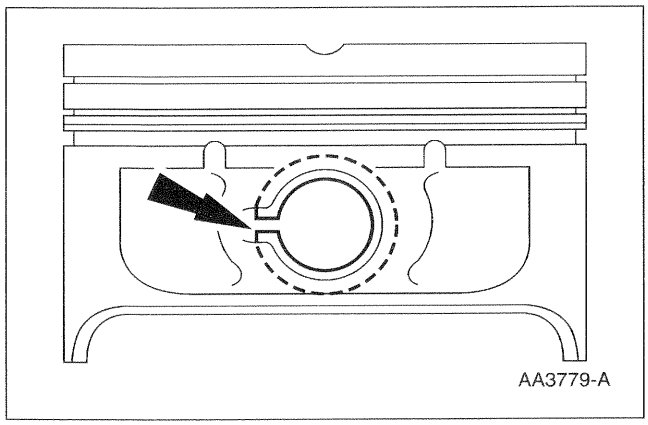
Piston — Pin to Bore Diameter

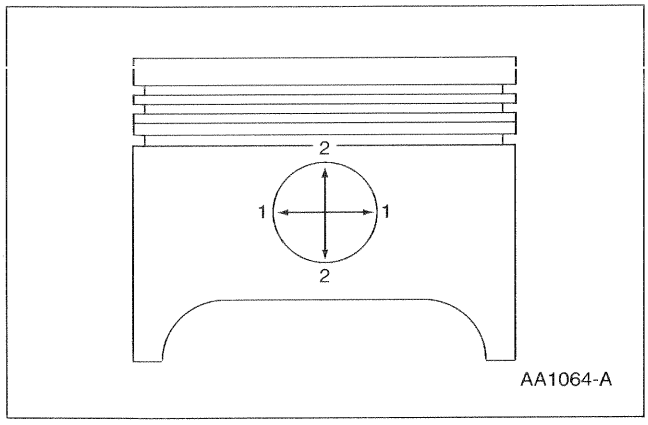
1. ⚠ **WARNING: Cover the end of the pin bore with a hand or shop rag when removing the retainer ring, since it has a tendency to spring out. Wear eye protection.**

   NOTE: Piston and piston pins are a matched set and should not be interchanged.

   Measure the piston pin bore diameter in two directions on each side. Verify the diameter is within specification.

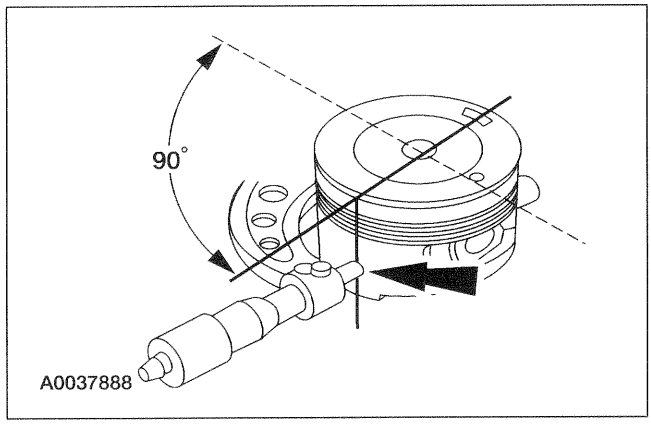
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.





Piston — Diameter

1. Measure the piston diameter 90 degrees from the piston pin at the point indicated. Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



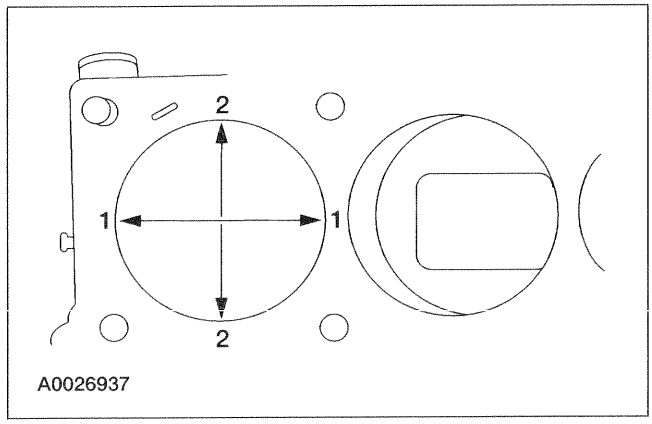
Piston — to Cylinder Bore Clearance

1. Subtract the piston diameter from the cylinder bore diameter to find the piston-to-cylinder bore clearance.

Piston — Selection

NOTE: The cylinder bore must be within the specifications for taper and out-of-round before fitting a piston.

1. Select a piston size based on the cylinder bore.

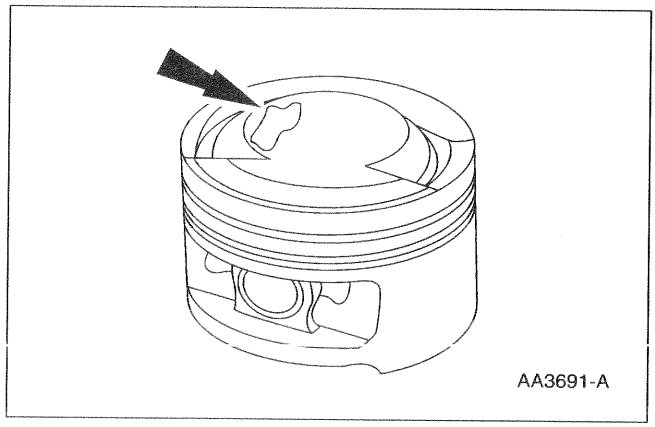


GENERAL PROCEDURES (Continued)

2. **NOTE:** For precision fit, new pistons are divided into three categories within each size range based on their relative position within the range. A paint spot on the new pistons indicates the position within the size range.

   Choose the piston with the correct paint color.

   - Refer to the appropriate section in Group 303 for the procedure.



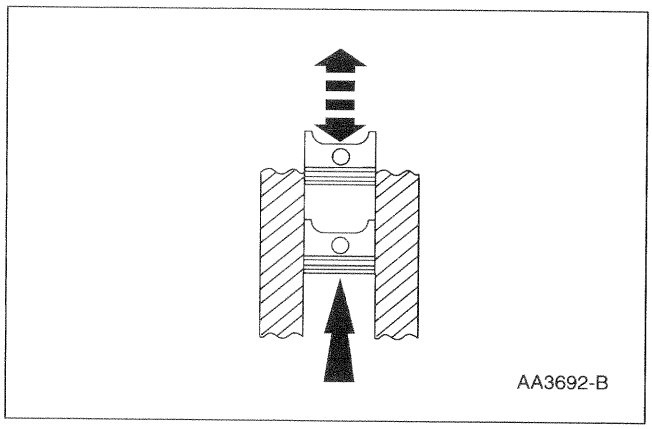
Piston — Ring End Gap

⚠ CAUTION: Use care when fitting piston rings to avoid possible damage to the piston ring or the cylinder bore.

⚠ CAUTION: Piston rings should not be transferred from one piston to another.

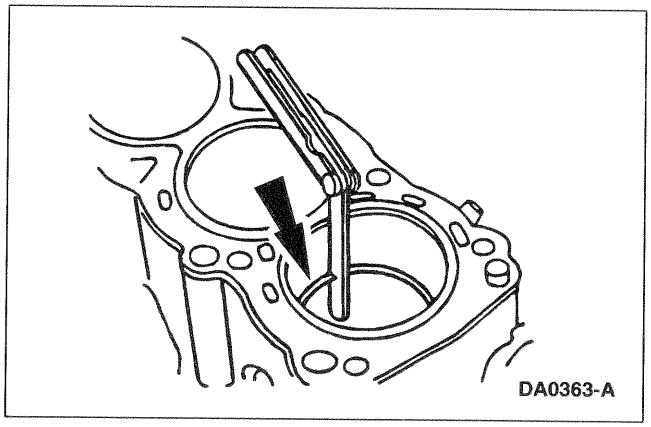
NOTE: Cylinder bore must be within specification for taper and out-of-round.

1. Use a piston without rings to push a piston ring in a cylinder to the bottom of ring travel.



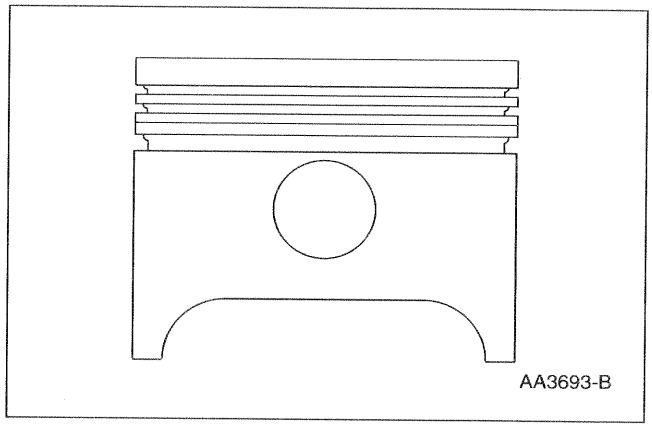
2. Use a feeler gauge to measure the top piston ring end gap and the second piston ring end gap.

   - Refer to the appropriate section in Group 303 for the procedure.



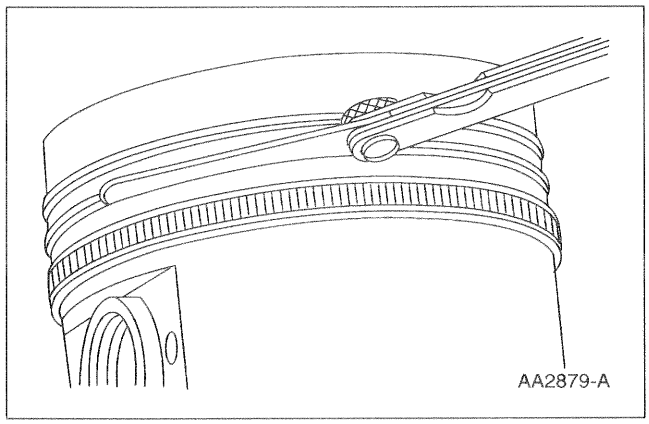
Piston — Ring-to-Groove Clearance

1. Inspect the piston for ring land damage or accelerated wear.



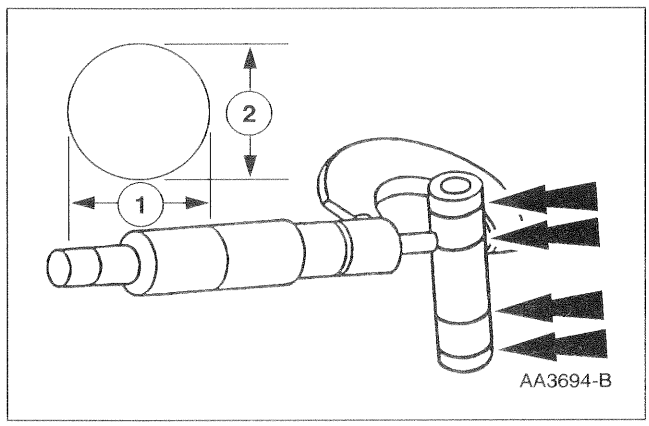
GENERAL PROCEDURES (Continued)

2. Measure the piston ring-to-groove clearance.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Piston — Pin Diameter

1. Measure the piston pin diameter in two directions at the points shown. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

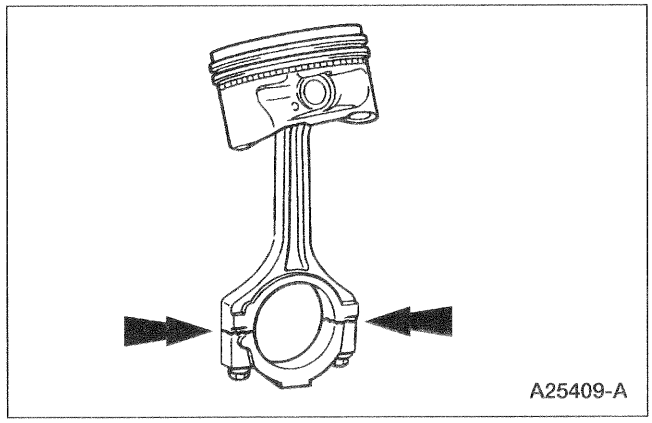


Connecting Rod — Cleaning

⚠ CAUTION: Do not use a caustic cleaning solution or damage to connecting rods can occur.

1. **NOTE:** The connecting rod large end is a matched set. The connecting rod cap must be installed on the original connecting rod in the original position. Do not reverse the cap. Parts are not interchangeable.

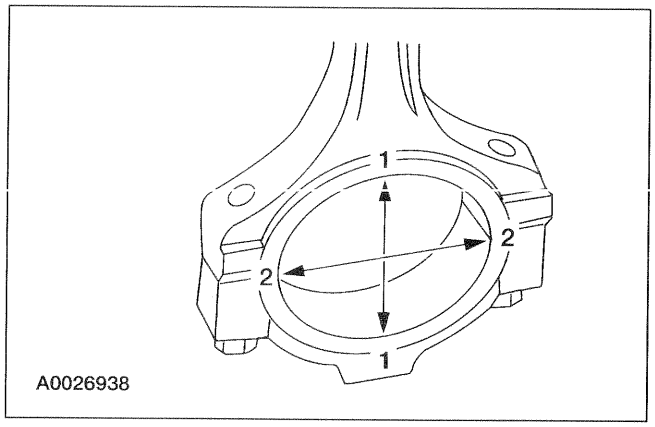
   Mark and separate the parts and clean with solvent. Clean the oil passages.



GENERAL PROCEDURES (Continued)

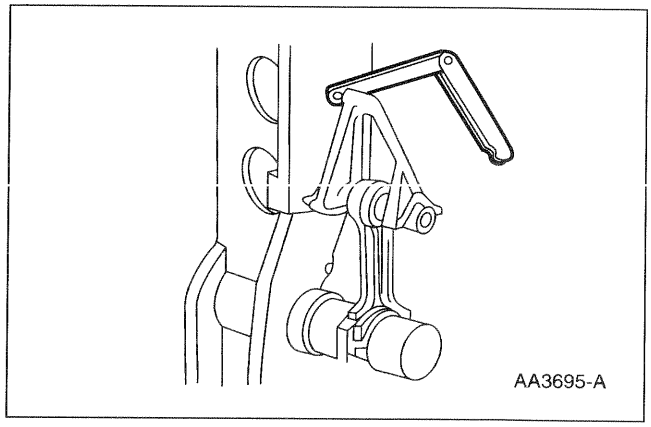
Connecting Rod — Large End Bore

1. Tighten the bolts to specification, then measure the bore in two directions. The difference is the connecting rod bore out-of-round. Verify the out-of-round is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



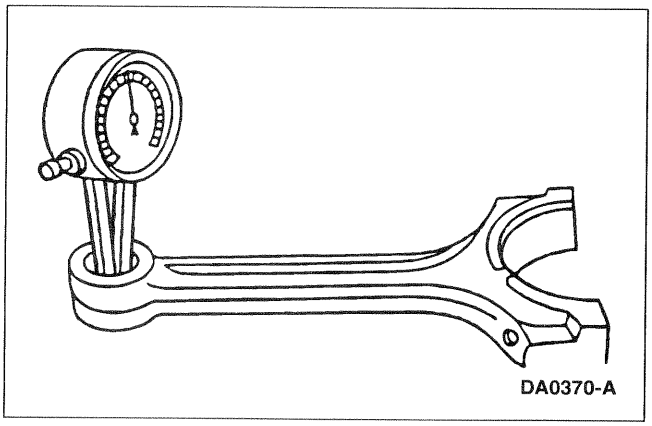
Connecting Rod — Bend

1. Measure the connecting rod bend on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the bend measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Connecting Rod — Bushing Diameter

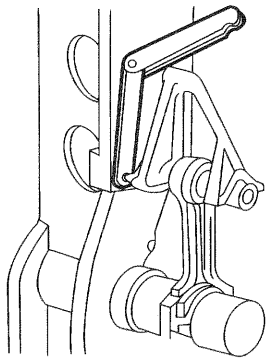
1. Measure the inner diameter of the connecting rod bushing, if equipped. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



GENERAL PROCEDURES (Continued)

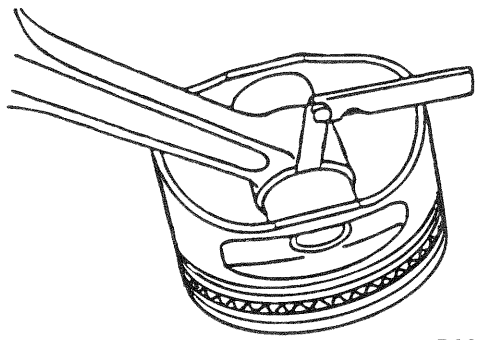
Connecting Rod — Twist

1. Measure the connecting rod twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.


AA3696-A

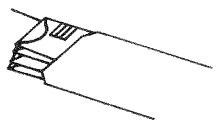
Connecting Rod — Piston Pin Side Clearance

1. Measure the clearance between the connecting rod and the piston. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.


DA0372-A

Connecting Rod — Bearing Journal Clearance

Special Tool(s)

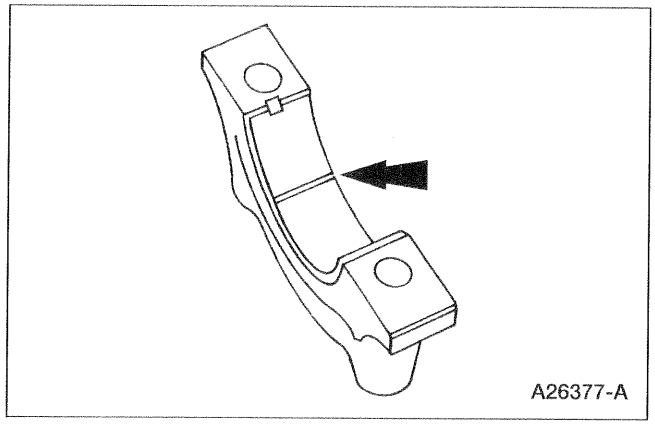
 ST1280-A	Plastigage 303-D031 (D81L-6002-B) or equivalent

NOTE: The crankshaft connecting rod journals must be within specifications to check the connecting rod bearing journal clearance.

1. Remove the connecting rod bearing cap.

GENERAL PROCEDURES (Continued)

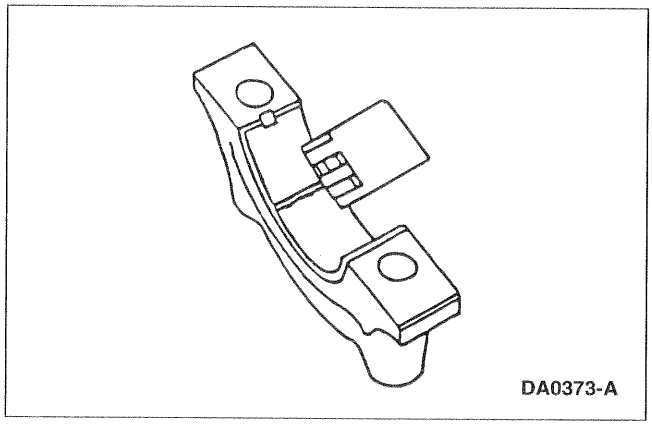
2. Position a piece of Plastigage across the bearing surface.



3. **NOTE:** Do not turn the crankshaft during this step.

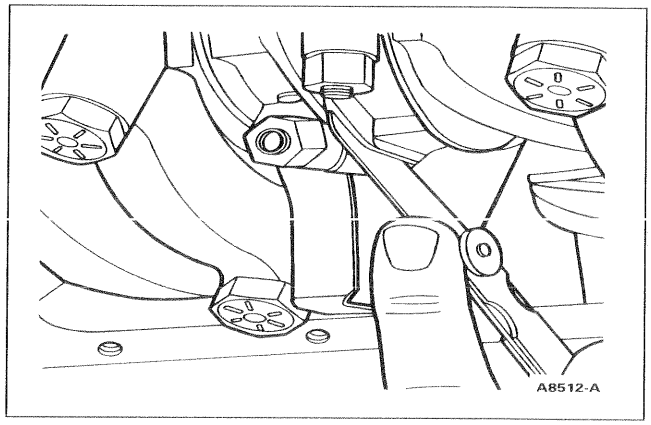
   Install and tighten to specifications, then remove the connecting rod bearing cap.

4. Measure the Plastigage to get the connecting rod bearing journal clearance. The Plastigage should be smooth and flat. A changing width indicates a tapered or damaged connecting rod or connecting rod bearing.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Connecting Rod — Side Clearance

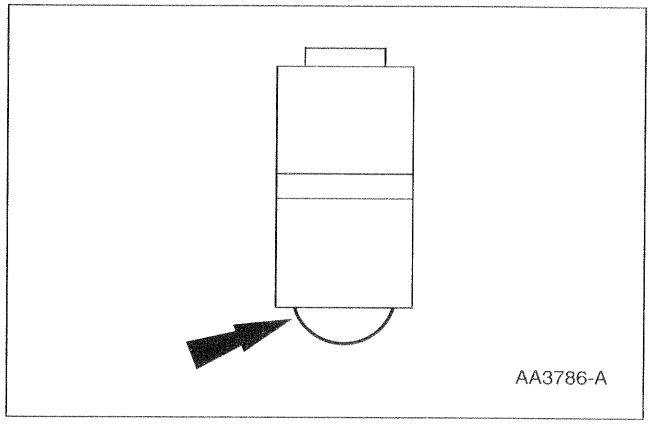
1. Measure the clearance between the connecting rod and the crankshaft. Verify the measurement is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Roller Follower — Inspection

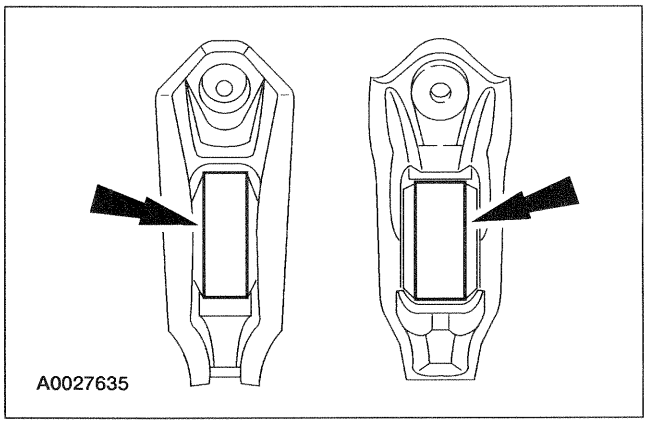
Push rod engines

1. Inspect the roller for flat spots or scoring. If any damage is found, inspect the camshaft lobes and valve tappet for damage.



GENERAL PROCEDURES (Continued)

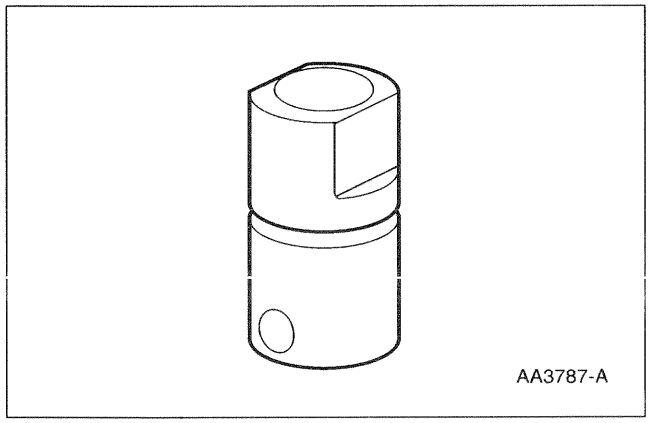
OHC engines



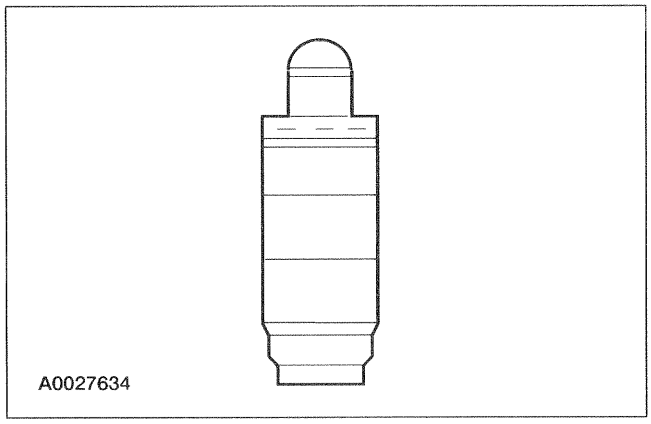
Valve Tappet — Inspection

Push rod engines

1. Inspect the hydraulic valve tappet and roller for damage. If any damage is found, inspect the camshaft lobes and valves for damage.

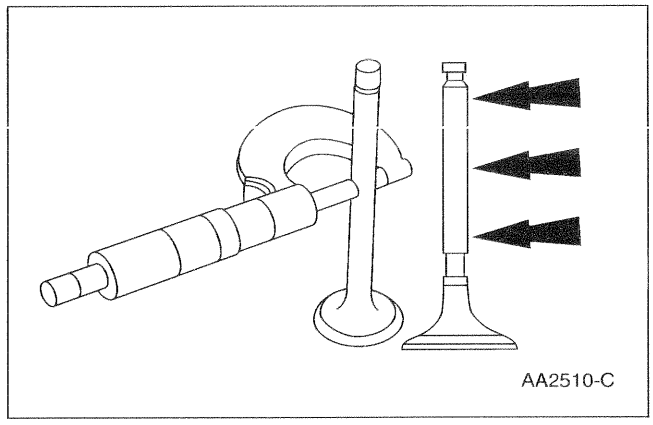


OHC engines



Valve — Stem Diameter

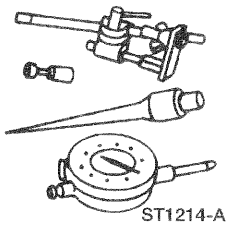
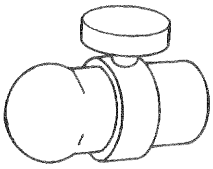
1. Measure the diameter of each intake and exhaust valve stem at the points shown. Verify the diameter is within specification.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



GENERAL PROCEDURES (Continued)

Valve Stem to Valve Guide Clearance

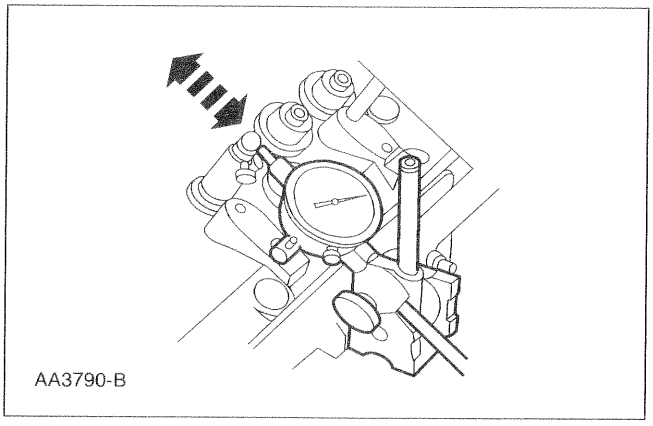
Special Tool(s)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent
 ST1251-A	Clearance Gauge, Valve Guide 303-004 (TOOL-6505-E) or equivalent

NOTE: Valve stem diameter must be within specifications before checking valve stem to valve guide clearance.

1. **NOTE:** If necessary, use a magnetic base.

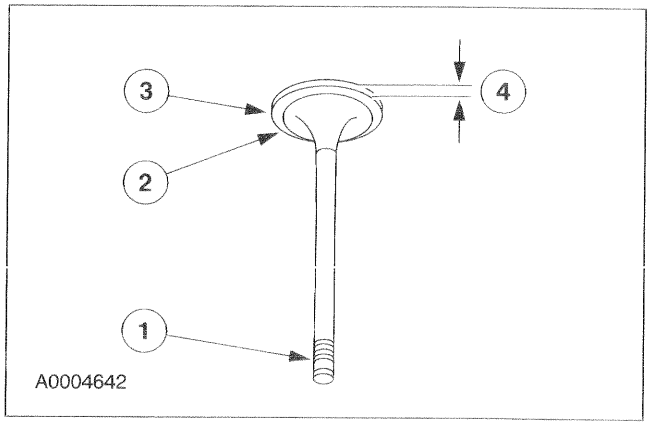
   Install a Valve Guide Clearance Gauge on the valve stem and install a Dial Indicator Gauge with Holding Fixture. Lower the valve until the Valve Guide Clearance Gauge contacts the upper surface of the valve guide.



2. Move the Valve Guide Clearance Gauge toward the indicator and zero the indicator. Move the Valve Guide Clearance Gauge away from the indicator and note the reading. The reading will be DOUBLE the valve stem-to-valve guide clearance. Valves with oversize stems will need to be installed if out of specification.

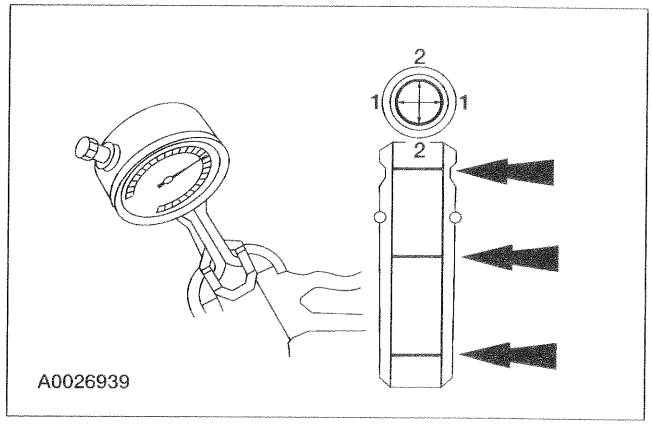
Valve — Inspection

1. Inspect the following valve areas:
   1 the end of the stem for grooves or scoring
   2 the valve face and the edge for pits, grooves or scores
   3 the valve head for signs of burning, erosion, warpage and cracking
   4 the valve margin for wear



Valve — Guide Inner Diameter

1. Measure the inner diameter of the valve guides in two directions where indicated.
   - Refer to the appropriate section in Group 303 for the procedure.

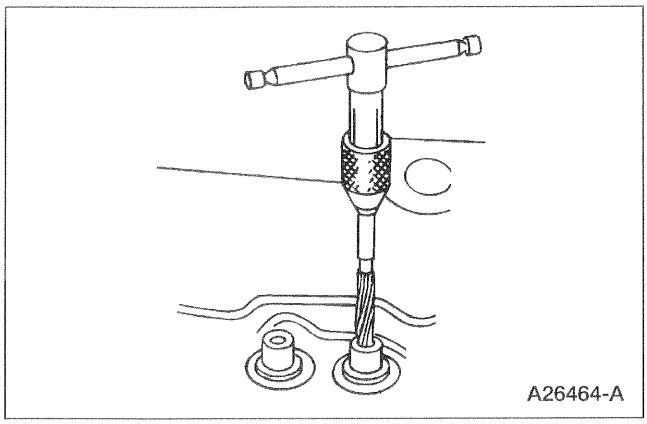


2. If the valve guide is not within specifications, ream the valve guide and install a valve with an oversize stem or remove the valve guide and install a new valve guide.

GENERAL PROCEDURES (Continued)

Valve — Guide Reaming

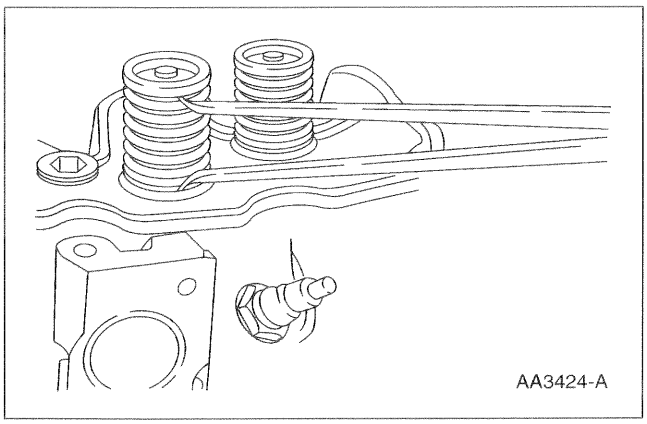
1. Use a hand-reaming kit to ream the valve guide.



2. Reface the valve seat.
3. Clean the sharp edges left by reaming.

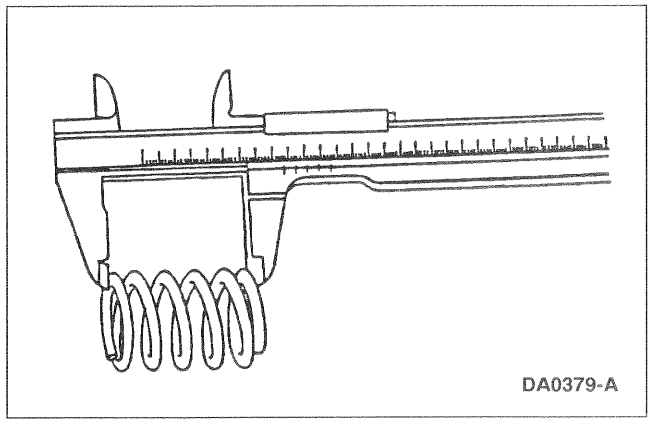
Valve — Spring Installed Length

1. Measure the installed length of each valve spring.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components. Refer to the appropriate section in Group 303 for the procedure.



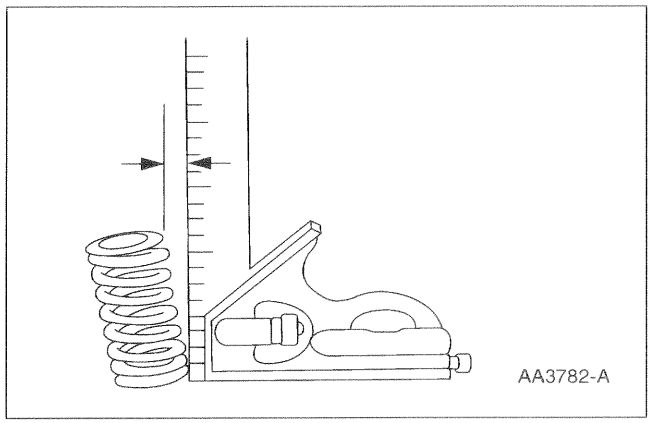
Valve — Spring Free Length

1. Measure the free length of each valve spring.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.



Valve — Spring Squareness

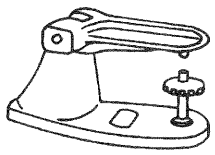
1. Measure the out-of-square on each valve spring.
   - Turn the valve spring and observe the space between the top of the valve spring and the square. Install a new valve spring if out of square. Refer to the appropriate section in Group 303 for the procedure.



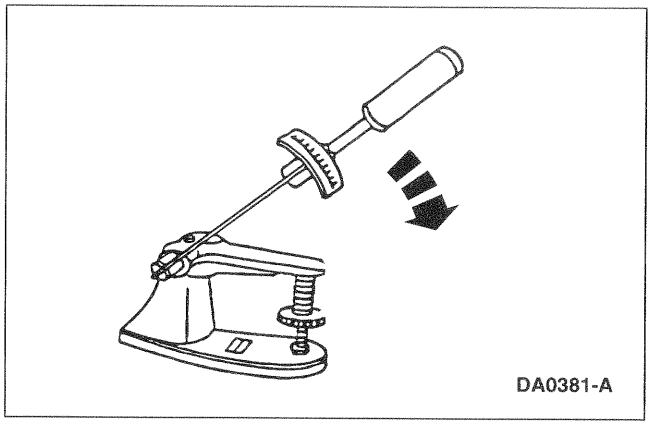
GENERAL PROCEDURES (Continued)

Valve Spring Strength

Special Tool(s)

 ST1278-A	Pressure Gauge, Valve/Clutch Spring 303-006 (TOOL-6513-DD) or equivalent

1. Use a Valve/Clutch Spring Pressure Gauge to check the valve spring for correct strength at the specified valve spring length.
   - Refer to the appropriate section in Group 303 for the procedure.
   - If out of specification, install new components as necessary. Refer to the appropriate section in Group 303 for the procedure.

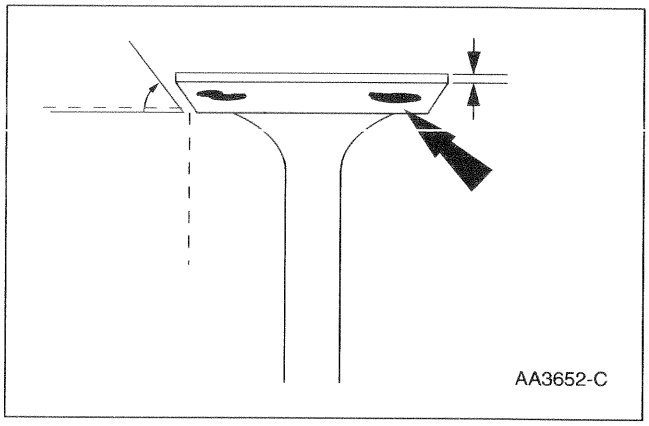


Valve — Seat Inspection

Valve and Seat Refacing Measurements

⚠ **CAUTION: After grinding valves or valve seats, check valve clearance.**

1. Check the valve head and seat.
   - Check valve angles.
   - Check margin width.
   - Refer to the appropriate section in Group 303 for the procedure.
   - Be sure margin width is within specification.

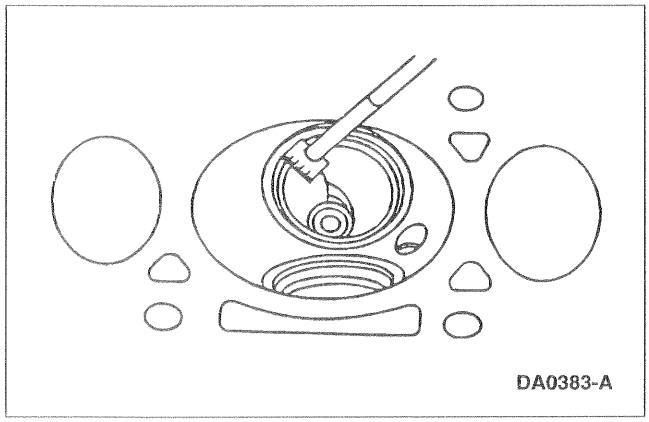


2. Inspect for abnormalities on the valve face and seat.

GENERAL PROCEDURES (Continued)

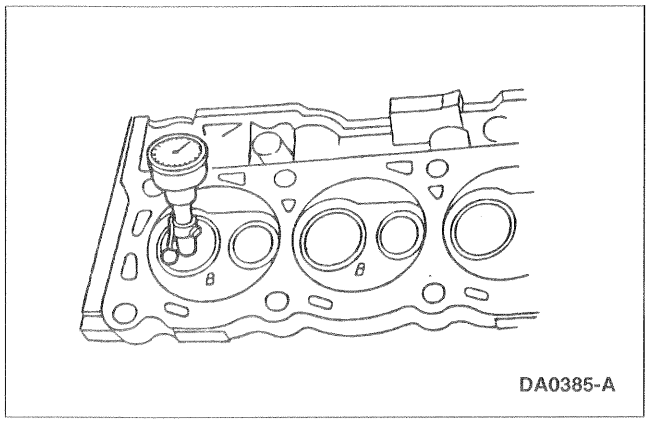
Valve — Seat Width

1. Measure the valve seat width. If necessary, grind the valve seat to specification.
   - Measure the intake valve seat width.
   - Measure the exhaust valve seat width.
   - Recheck the valve spring installed length after the seats have been ground, and shim the valve springs as necessary to achieve the correct installed spring length.
   - Refer to the appropriate section in Group 303 for the procedure.


DA0383-A

Valve — Seat Runout

1. Use the Valve Seat Runout Gauge to check valve seat runout.

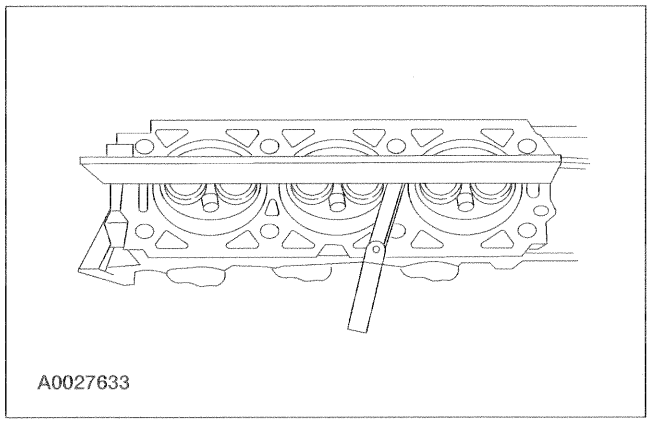

DA0385-A

Cylinder Head — Distortion

Special Tool(s)

 ST1246-A	Straight Edge 303-D039 (D83L-4201-A) or equivalent

1. Use a straight edge and a feeler gauge to inspect the cylinder head for flatness. If the cylinder head is distorted, install a new cylinder head.


A0027633

Cylinder Bore — Cleaning

1. ⚠ **CAUTION: If these procedures are not followed, rusting of the cylinder bores may occur.**

   Clean the cylinder bores with soap or detergent and water.

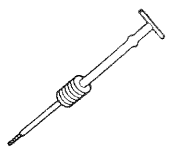
2. Thoroughly rinse with clean water and wipe dry with a clean, lint-free cloth.

3. Use a clean, lint-free cloth and lubricate the cylinder bores.
   - Use clean engine oil meeting Ford specification.

GENERAL PROCEDURES (Continued)

Cylinder Block — Core Plug Replacement

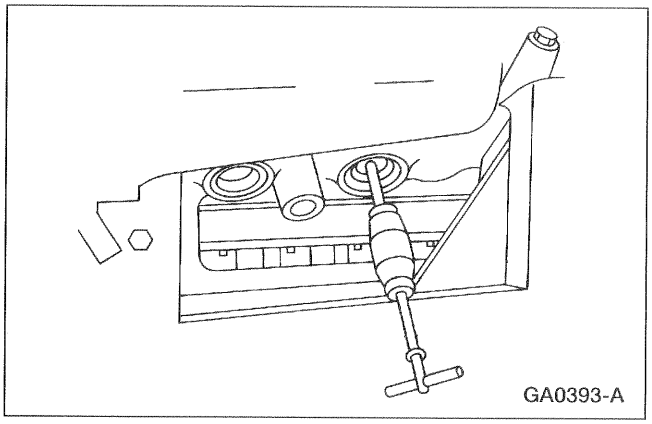
Special Tool(s)

 ST1185-A	Impact Slide Hammer 100-001 (T50T-100-A)

Material

Item	Specification
Threadlock® 262 E2FZ-19554-A or equivalent	WSK-M2G351-A6

1. Use a slide hammer or tools suitable to remove the cylinder block core plug.



2. Inspect the cylinder block plug bore for any damage that would interfere with the correct sealing of the plug. If the cylinder block plug bore is damaged, bore for the next oversize plug.

3. **NOTE:** Oversize plugs are identified by the OS stamped in the flat located on the cup side of the plug.

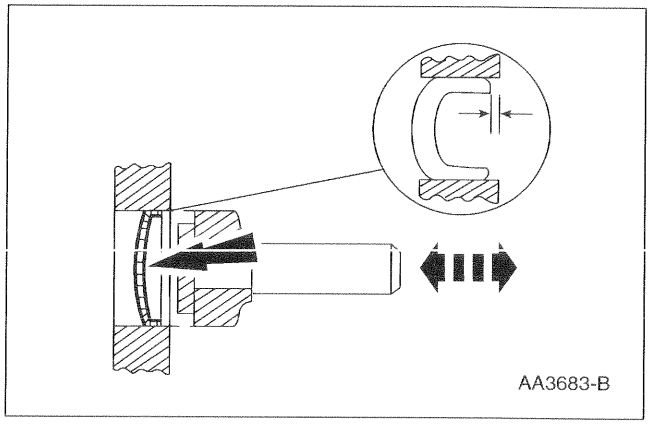
   Coat the cylinder block core plug and bore lightly with Threadlock® 262 and install the cylinder block core plug.

Cup-Type

1. ⚠ **CAUTION: Use care during this procedure so as not to disturb or distort the cup sealing surface.**

   ⚠ **CAUTION: When installed, the flanged edge must be below the chamfered edge of the bore to effectively seal the bore.**

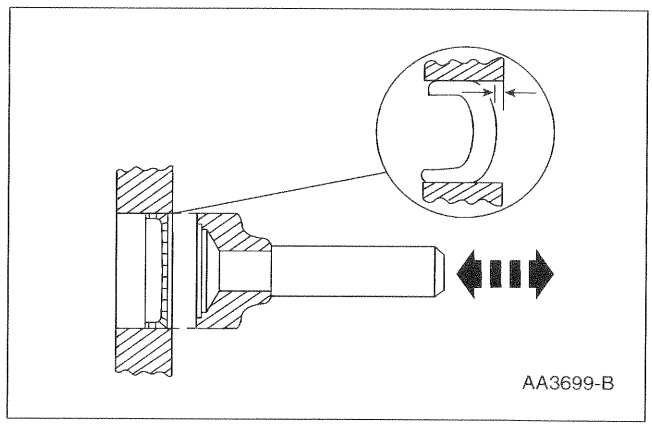
   Use a tool suitable to seat the cup-type cylinder block core plug.



Expansion-Type

1. ⚠ **CAUTION: Do not contact the crown when installing an expansion-type cylinder block core plug. This could expand the plug before seating and result in leakage.**

   Use tool suitable to seat the expansion-type cylinder block core plug.



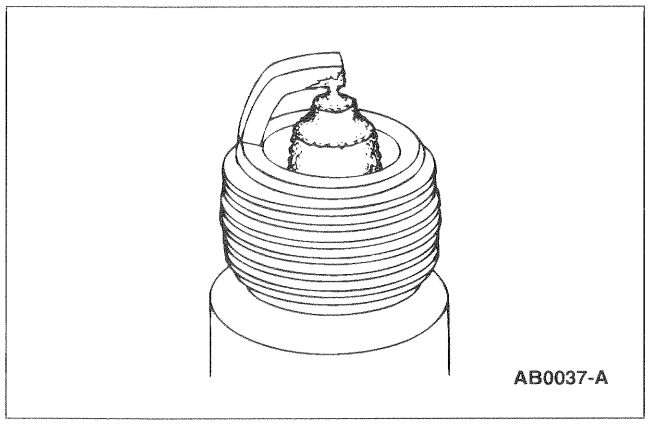
GENERAL PROCEDURES (Continued)

Spark Plug Hole Thread Repair

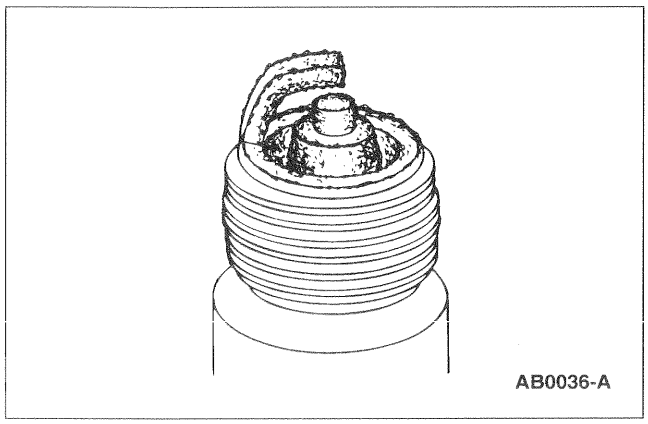
1. There is no authorized repair for spark plug hole threads. If the threads are damaged, install a new cylinder head.

Spark Plug — Inspection

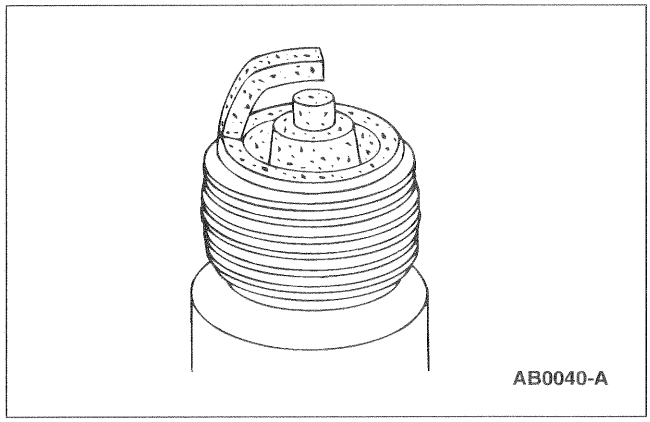
1. Inspect the spark plug for a bridged gap.
   - Check for deposit build-up closing the gap between the electrodes. Deposits are caused by oil or carbon fouling.
   - Clean the spark plug.



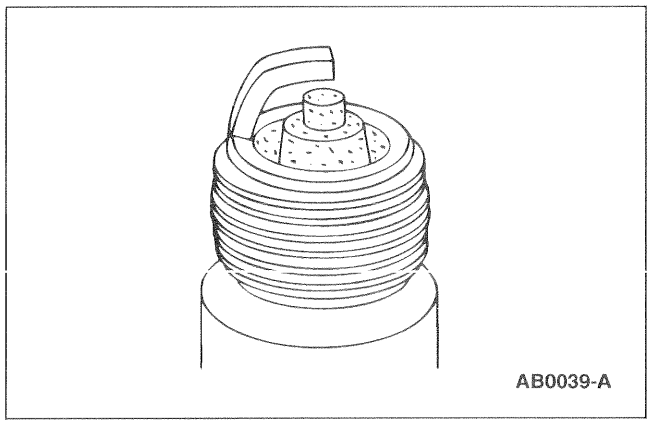
2. Check for oil fouling.
   - Check for wet, black deposits on the insulator shell bore electrodes, caused by excessive oil entering the combustion chamber through worn rings and pistons, excessive valve-to-guide clearance or worn or loose bearings.
   - Correct the oil leak concern.
   - Install a new spark plug.



3. Inspect for carbon fouling. Look for black, dry, fluffy carbon deposits on the insulator tips, exposed shell surfaces and electrodes, caused by a spark plug with an incorrect heat range, dirty air cleaner, too rich a fuel mixture or excessive idling.
   - Clean the spark plug.

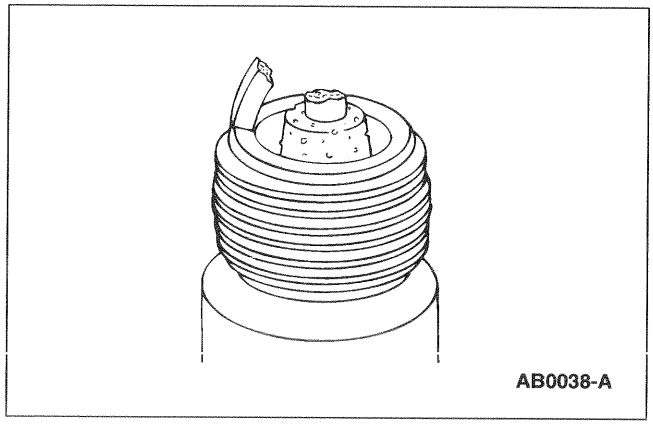


4. Inspect for normal burning.
   - Check for light tan or gray deposits on the firing tip.

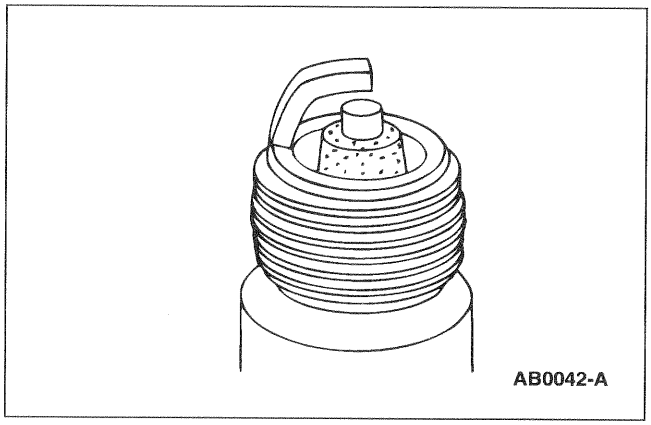


GENERAL PROCEDURES (Continued)

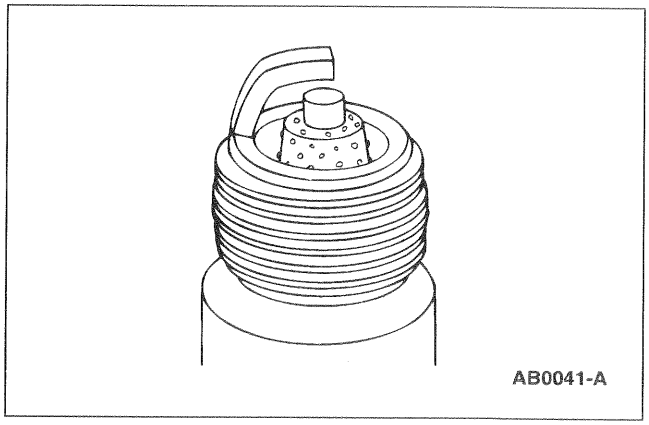
5. Inspect for pre-ignition, identified by melted electrodes and a possibly damaged insulator. Metallic deposits on the insulator indicate engine damage. This may be caused by incorrect ignition timing, wrong type of fuel or the unauthorized installation of a heli-coil insert in place of the spark plug threads.
   - Install a new spark plug.



6. Inspect for overheating, identified by a white or light gray spots and with bluish-burnt appearance of electrodes. This is caused by engine overheating, wrong type of fuel, loose spark plugs, spark plugs with an incorrect heat range, low fuel pump pressure or incorrect ignition timing.
   - Install a new spark plug.



7. Inspect for fused deposits, identified by melted or spotty deposits resembling bubbles or blisters. These are caused by sudden acceleration.
   - Clean the spark plug.

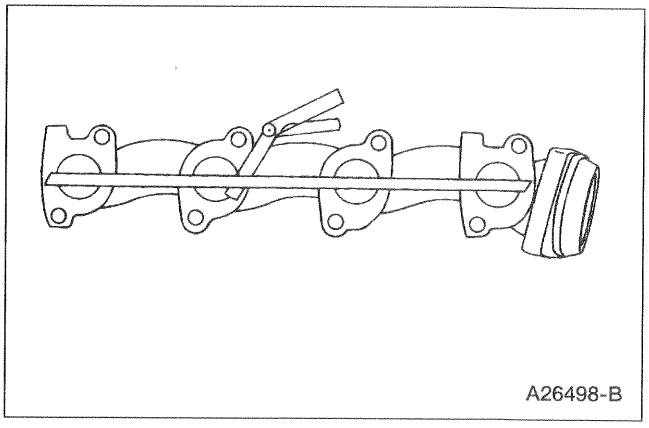


Exhaust Manifold — Inspection

Special Tool(s)

 ST1246-A	Straight Edge 303-D039 (D83L-4201-A) or equivalent

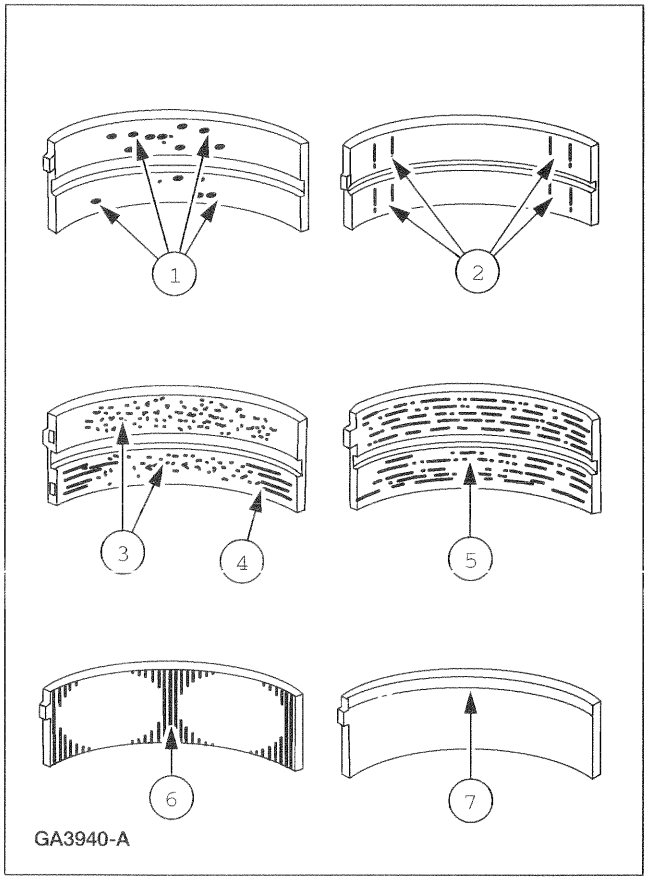
1. Place a straight edge across the exhaust manifold flanges and check for warping with a feeler gauge.



GENERAL PROCEDURES (Continued)

Bearing — Inspection

1. Inspect bearings for the following defects. Possible causes are shown:
   1 Cratering — fatigue failure.
   2 Spot polishing — incorrect seating.
   3 Imbedded dirt engine oil.
   4 Scratching — dirty engine oil.
   5 Base exposed — poor lubrication.
   6 Both edges worn — journal damaged.
   7 One edge worn — journal tapered or bearing not seated.



SECTION 303-01A Engine — 3.0L (2V)

CONTENTS PAGE

SPECIFICATIONS

General Specifications

Item	Specification
Lubricants and Sealants	
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP	WSS-M2C153-H
Silicone Gasket and Sealant F7AZ-19554-EA	WSE-M4G323-A4
Pipe Sealant with Teflon® D8AZ-19954-A	WSK-M2G350-A2
Gasket Maker F8AZ-19B508-AB	WSK-M2G348-A5
Weatherstrip Adhesive E8AZ-19552-A	ESB-M2G14-A
Engine	
Displacement	3.0L
Number of cylinders	6
Bore	89.0 mm (3.50 in)
Stroke	80.00 mm (3.14 in)
Firing order	1-4-2-5-3-6
Oil pressure (Hot 2,500 rpm)	276-414 kPa (40-60 psi)
Oil capacity	4.25 L (4.5 qts) with filter change
Cylinder Head and Valve Train	
Combustion chamber volume	47.1-50.1 cm (2.874 in)
Valve guide bore diameter	7.042-7.017 mm (0.2772-0.2763 in)
Valve stem diameter — intake (standard)	6.971-6.991 mm (0.2744-0.2752 in)
Valve stem diameter — exhaust (standard)	6.959-6.979 mm (0.2740-0.2748 in)
Valve stem diameter — oversize (intake)	7.351-7.371 mm (0.289-0.290 in)
Valve stem diameter — oversize (exhaust)	7.339-7.359 mm (0.289-0.290 in)
Valve stem diameter — oversize (intake)	7.731-7.751 mm (0.304-0.305 in)
Valve stem diameter — oversize (exhaust)	7.719-7.739 mm (0.304-0.305 in)
Valve stem-to-guide clearance — intake	0.026-0.071 mm (0.001-0.0028 in)
Valve stem-to-guide clearance — exhaust	0.038-0.083 mm (0.0015-0.0033 in)

General Specifications (Continued)

Item	Specification
Valve head diameter — intake	40.0 mm (1.57 in)
Valve head diameter — exhaust	33.0 mm (1.30 in)
Valve face runout	0.05 mm (0.002 in)
Valve face angle	45 degrees
Valve seat width — intake	1.5-2.0 mm (0.06-0.08 in)
Valve seat width — exhaust	2.0-2.5 mm (0.08-0.10 in)
Valve seat runout (TIR)	0.078-0.098 mm (0.003-0.004 in)
Valve seat angle	45 degrees
Valve spring free length (approx.)	46.4 mm (1.85 in)
Valve spring compression pressure — valve open to maximum lift	857.0 - 967.0 N (193 - 217 lb) 29.74 mm (1.17 in)
Valve spring compression pressure — valve closed	285 - 323 N (64 -72 lb) 40.52 mm (1.60 in)
Valve spring installed height	41.98-44.17 mm (1.650-1.736 in)
Valve spring installed height — service limit	10% force loss @ specified height
Rocker arm ratio	1:61
Hydraulic Lash Adjuster	
Diameter	22.206 mm (0.874 in)
Clearance-to-bore	0.018-0.069 mm (0.0007-0.0027 in)
Service limit	0.127 mm (0.005 in)
Hydraulic leakdown rate	20-200 seconds to leakdown 3.18 mm (0.125 in) with 225 N (50 lbs) load and tappet filled with leak-down fluid
Collapsed lash adjuster gap	2.23-4.77 mm (0.088-0.189 in)
Camshaft	
Theoretical valve lift @ 0 lash — intake	10.26 mm (0.404 in)
Theoretical valve lift @ 0 lash — exhaust	10.77 mm (0.424 in)
Lobe lift — intake	6.38 mm (0.25 in)
Lobe lift — exhaust	6.72 mm (0.26 in)
Allowable lobe lift loss	0.127 mm (0.005 in)

SPECIFICATIONS (Continued)

General Specifications (Continued)

Item	Specification
Journal diameter	50.987-51.013 mm (2.0074 - 2.0084 in)
Camshaft journal bore inside diameter — No. 1 and No. 4	54.668-54.713 mm (2.1531-2.1541 in)
Camshaft journal bore inside diameter — No. 2 and No. 3	54.188-54.213 mm (2.1334-2.1344 in)
Camshaft journal-to-bearing clearance	0.025-0.076 mm (0.001-0.003 in)
Runout	0.05 mm (0.002 in) Runout of No. 2 or No. 3 relative to No. 1 and No. 4
End play	0.003 mm (0.007 in)
Cylinder Block	
Cylinder bore diameter	89.00 mm (3.504 in)
Cylinder bore maximum taper	0.050 mm (0.002 in)
Cylinder bore maximum out-of-round	0.025 mm (0.001 in)
Cylinder bore maximum out-of-round — service limit	0.050 mm (0.002 in)
Main bearing bore inside diameter	68.905 mm (2.713 in) 68.885 mm (2.712 in)
Head gasket surface flatness	0.08 mm (0.003 in) 152.0 mm (6.00 in)
Crankshaft	
Main bearing journal diameter	63.983-64.003 mm (2.5190-2.5198 in)
Main bearing journal maximum taper	0.06 mm (0.0006 in) Total 0.013 mm (0.0003 in) per 25 mm (1 in)
Main bearing journal maximum out-of-round	0.0003 in
Connecting rod journal diameter	53.983-54.003 mm (2.1253-2.1261 in)
Connecting rod journal maximum taper	0.008 mm per 25 mm (0.0003 in per in)
Connecting rod journal maximum out-of-round	0.006 mm (0.0003 in) max. 0.015 mm (0.0006 in) total
Crankshaft maximum end play	0.10-0.20 mm (0.004-0.008 in)

General Specifications (Continued)

Item	Specification
Thrust bearing journal length	25.775-25.825 mm (1.0148-1.067 in)
Piston and Connecting Rod	
Piston diameter — coded red	88.962-88.978 mm (3.5024-3.5031 in)
Piston diameter — coded blue	88.988-89.004 mm (3.5035-3.5041 in)
Piston diameter — coded yellow	89.014-89.030 mm (3.5045-3.5051 in)
Piston-to-cylinder bore clearance	0.030-0.056 mm (0.0012-0.0022 in)
Piston-to-cylinder bore clearance — service limit	0.081 mm (0.031 in) max.
Piston ring end gap — compression (top and bottom, in gauge)	0.25-0.50 mm (0.01-0.02 in)
Piston ring end gap — oil ring (steel rail, in gauge)	0.25-1.25 mm (0.010-0.049 in)
Piston ring groove width — compression (top and bottom)	1.530-1.555 mm (0.0602-0.0612 in)
Piston ring groove width — oil	4.030-4.055 mm (0.1587-0.1596 in)
Piston ring width — compression (top and bottom)	1.460-1.490 mm (0.0575-0.0587 in)
Piston ring width — oil ring	Side seal—snug fit
Piston ring width — service limit	Side clearance 0.015 mm (0.0006 in) max.
Piston pin bore diameter	Service piston grade required
Piston pin bore diameter — red	89.009-89.035 mm (3.5043-3.5053 in)
Piston pin bore diameter — blue	89.035-89.060 mm (3.5053-3.5063 in)
Piston pin bore diameter — yellow	89.060-89.086 mm (3.5063-3.5073 in)
Piston pin diameter	23.162-23.175 mm (0.9119-0.9124 in)
Piston pin length	57.12-57.88 mm (2.248-2.278 in)
Connecting rod pin bore diameter	23.105-23.145 mm (0.9096-0.9112 in)
Connecting rod length (center-to-center)	140.46-140.54 mm (5.530-5.533 in)

SPECIFICATIONS (Continued)

General Specifications (Continued)

Item	Specification
Connecting rod maximum allowed bend	0.04 per 25 mm (0.0016 per in)
Connecting rod maximum allowed twist	0.075 per 25 mm (0.003 per in)
Connecting rod bearing bore diameter	57.15-57.17 mm (2.250-2.251 in)
Connecting rod bearing-to-crankshaft clearance — desired	0.025-0.035 mm (0.001-0.0014 in)
Connecting rod bearing-to-crankshaft clearance — allowable	0.020-0.066 mm (0.00086-0.0027 in)
Connecting rod side clearance (assembled to crank) — standard	0.15-0.35 mm (0.006-0.014 in)
Connecting rod side clearance (assembled to crank) — service limit	0.36 mm (0.014 in) max.

Torque Specifications

Description	Nm	lb-ft	lb-in
A/C compressor-to-A/C compressor bracket bolts	25	18	—
A/C compressor bracket-to-cylinder block bolts	47	35	—
A/C compressor bracket stabilizer bracket bolt	25	18	—
A/C compressor bracket stabilizer bracket nut	25	18	—
A/C manifold and tube nut	10	—	89
Accelerator cable bracket-to-throttle body bolts	17	13	—
Accessory drive belt tensioner/idler assembly cover bolts	48	35	—
Camshaft position sensor (CMP)-to-camshaft synchronizer bolts	2	—	18
Camshaft sprocket-to-camshaft bolt	63	46	—

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Camshaft synchronizer clamp bolt	24	18	—
Camshaft thrust plate-to-cylinder block bolt	10	—	89
Crankshaft damper-to-crankshaft bolt	145	107	—
Crankshaft main bearing cap stud bolt[a]	—	—	—
Crankshaft pulley-to-crankshaft damper bolts	48	35	—
EGR tube-to-RH exhaust manifold nut	40	30	—
EGR tube-to-EGR valve nut	40	30	—
EGR valve-to-upper intake manifold bolts	25	18	—
EGR vacuum regulator solenoid-to-upper intake manifold nuts	6	—	53
Engine control sensor wire harness 42-pin connector bolt	10	—	89
Engine coolant temperature (ECT) sensor	20	15	—
Engine coolant temperature sender	20	15	—
Engine front cover-to-cylinder block bolts	25	18	—
Engine ground strap nut	25	18	—
Engine oil cooler adapter mounting bolt	54	40	—
Engine rear insulator-to-front subframe bolts	88	65	—
Engine rear insulator-to-transaxle bracket nut	98	72	—
Engine rear plate-to-transaxle bolt.	12	9	—
Engine roll restrictor bolts	48	35	—

SPECIFICATIONS (Continued)

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Engine roll restrictor brace nuts	48	35	—
Engine roll restrictor bracket-to-engine front cover nut	25	18	—
Engine roll restrictor-to-generator bolt	25	18	—
Exhaust manifold heat shield-to-RH exhaust manifold bolts	10	—	89
Flywheel-to-crankshaft bolts	80	59	—
Front subframe-to-body insulator bolts	103	76	—
Fuel injection supply manifold-to-lower intake manifold bolts	10	—	89
Generator output nut	8	—	71
Halfshaft-to-steering knuckle nuts	257	190	—
Ignition coil-to-valve cover	6	—	53
LH cylinder head-to-cylinder block bolts[a]	—	—	—
LH engine insulator-to-A/C compressor bracket bolts	62	46	—
LH engine insulator-to-front subframe nut	90	66	—
LH exhaust manifold-to-LH cylinder head bolts[a]	—	—	—
LH exhaust manifold-to-Y-pipe flange nuts	40	30	—
LH valve rocker arm cover-to-cylinder head bolts	12	9	—
LH valve rocker arm cover-to-cylinder head stud bolts	12	9	—
Lower control arm-to-steering knuckle nuts	80	59	—

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Lower intake manifold-to-cylinder head bolts[a]	—	—	—
Oil filter[a]	—	—	—
Oil filter mounting boss	34	25	—
Oil level indicator tube-to-exhaust manifold stud bolt nut	18	13	—
Oil pan-to-cylinder block bolts[a]	—	—	—
Oil pan drain plug	13	10	—
Oil pressure switch	19	14	—
Oil pump-to-crankshaft main bearing cap bolt	48	35	—
Piston rod cap-to-piston connecting rod nuts	35	26	—
Power steering pressure line-to-exhaust manifold stud bolt nut	27	20	—
Power steering pressure line-to-power steering pump nut	48	35	—
Power steering pressure line-to-transaxle nut	27	20	—
Power steering pump bracket-to-cylinder head bolt	48	35	—
Power steering pump bracket-to cylinder head nuts	48	35	—
Power steering pump bracket-to-generator stud bolt	48	35	—
Powertrain control module (PCM) connector bolt	4	—	35
RH catalytic converter heat shield-to-cylinder head bolt	20	15	—
RH catalytic converter heat shield nuts	20	15	—
RH cylinder head-to-cylinder block bolts[a]	—	—	—
RH engine insulator-to-front subframe nut	90	66	—

SPECIFICATIONS (Continued)

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
RH engine insulator bracket-to-transaxle bolts	60	44	—
RH engine insulator through bolt	120	89	—
RH exhaust manifold-to-RH cylinder head bolts[a]	—	—	—
RH exhaust manifold-to-RH catalytic converter flange bolts	40	30	—
RH secondary air injection valve bracket-to-ignition coil bracket stud bolt nuts	17	13	—
RH valve rocker arm cover-to-cylinder head bolts	12	9	—
RH valve rocker arm cover-to-cylinder head stud bolts	12	9	—
Secondary air injection tube-to-LH exhaust manifold nut	40	30	—
Secondary air injection tube-to-secondary air injection valve nuts	40	30	—
Spark plugs	15	11	—
Stabilizer bar link-to-stabilizer bar nuts	55	41	—
Starter motor-to-transaxle bolts	25	18	—

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Starter motor electrical connector nuts	12	9	—
Steering column-to-steering gear input shaft pinch bolt	25	18	—
Steering column boot nuts	6	—	53
Thermostat housing-to-lower intake manifold bolts	12	9	—
Tie rod end-to-steering knuckle nuts	55	41	—
Transaxle-to-engine bolts	50	37	—
Transaxle manual control cable nut	17	13	—
Upper intake manifold-to-lower intake manifold bolts	10	—	89
Upper intake manifold support bracket bolt	48	35	—
Upper intake manifold support bracket nut	6	—	53
Valve rocker arm bolts[a]	—	—	—
Valve tappet guide plate retainer bolts	12	9	—
Water pump pulley-to-water pump bolts	25	18	—
Wire harness ground-to-cowl screw	10	—	89

a Refer to the procedure in this section.

DESCRIPTION AND OPERATION

Engine

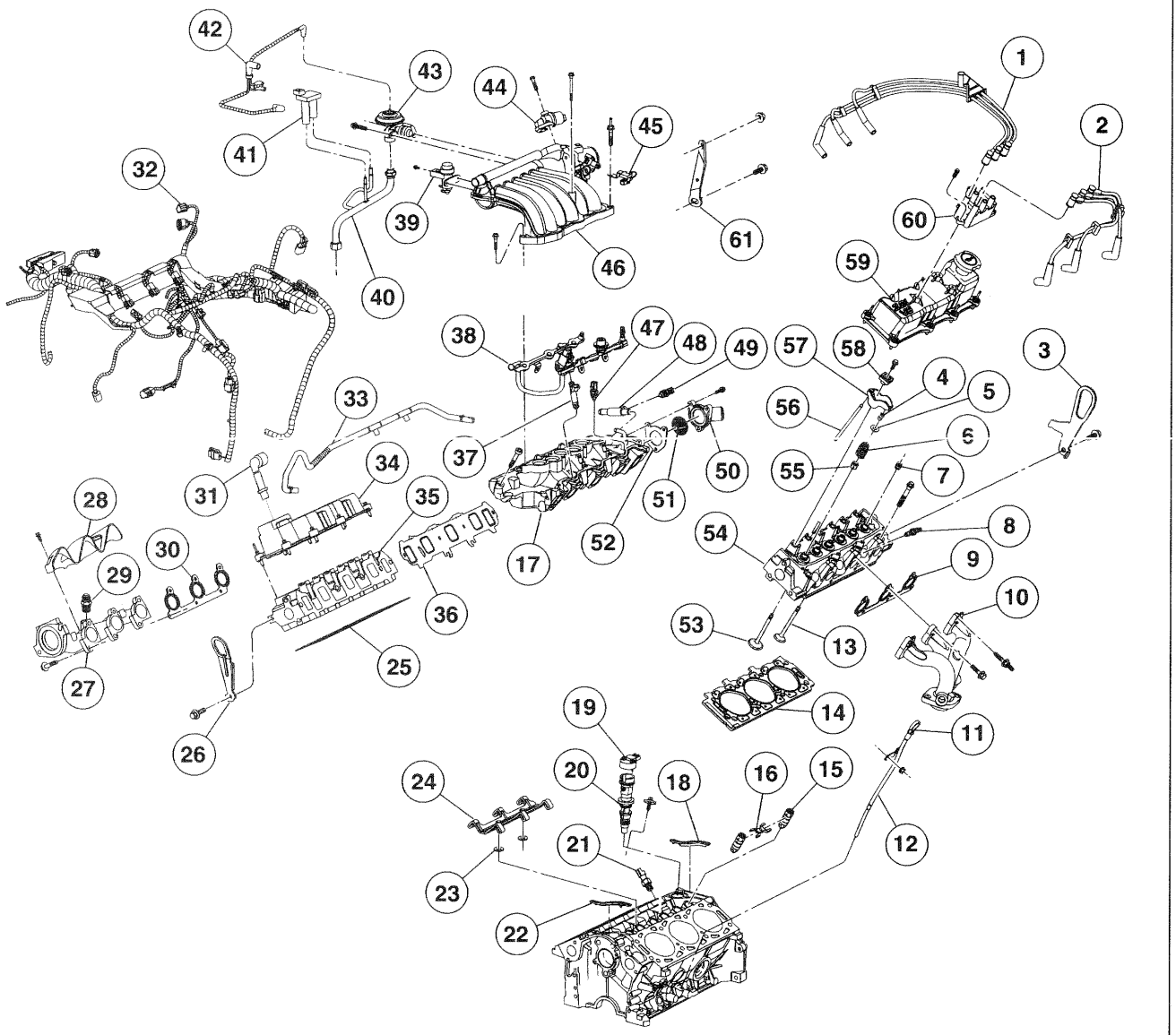
The 3.0L engine has:

- a V-block with six cylinders and splayed crankpins
- a distributorless ignition system
- a multiport, sequential fuel injection (SFI) system
- overhead valves
- hydraulic valve tappets (6500) for automatic lash adjustment
- connecting rod parting faces that are unique with an interference fit

For removal and installation of the water pump, refer to Section 303-03.

DESCRIPTION AND OPERATION (Continued)

Major Upper Engine Components



Item	Part Number	Description
1	12280	Ignition wire set — RH
2	12281	Ignition wire set — LH
3	17084	Engine lifting bracket
4	6518	Valve spring retainer key
5	6514	Valve spring retainer
6	6513	Valve spring
7	6A517	Valve seal — exhaust
8	12405	Spark plug

(Continued)

Item	Part Number	Description
9	9448	Exhaust manifold gasket
10	9431	Exhaust manifold — LH
11	6750	Oil level indicator
12	6754	Oil level indicator tube
13	6505	Exhaust valve
14	6051	Cylinder head gasket — LH
15	6500	Valve tappet
16	6K512	Valve tappet guide plate

(Continued)

DESCRIPTION AND OPERATION (Continued)

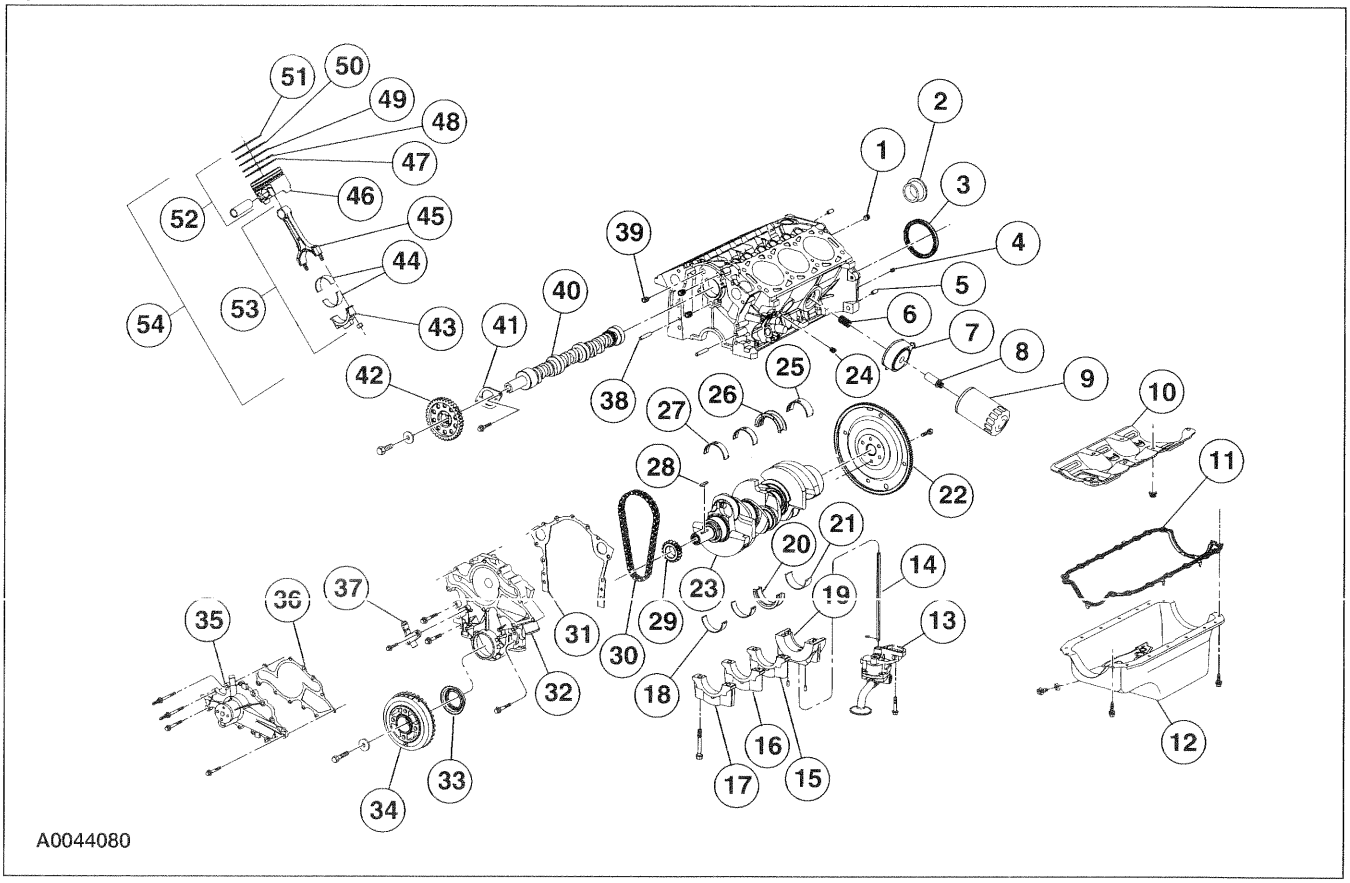
Item	Part Number	Description
17	9J447	Intake manifold — lower
18	9A424	Lower intake manifold gasket
19	6B288	Camshaft position sensor
20	12A362	Camshaft synchronizer
21	9278	Oil pressure switch
22	9A425	Lower intake manifold gasket
23	6K564	Washer
24	6K564	Valve tappet guide plate
25	6051	Cylinder head gasket — RH
26	17A084	Lifting eye bracket
27	9430	Exhaust manifold — RH
28	9A462	Exhaust manifold heat shield
29	9F485	Exhaust manifold to EGR tube connector
30	9448	Exhaust manifold gasket — RH
31	6K817	Crankcase ventilation hose
32	12B637	Engine wiring harness assembly
33	8C351	Engine vent hose
34	6582	Valve cover — RH
35	6049	Cylinder head — RH
36	6051	Cylinder head gasket — RH
37	9F593	Fuel injector
38	6049	Fuel injection supply manifold
39	9J459	Vacuum regulator solenoid

(Continued)

Item	Part Number	Description
40	9D477	EGR valve-to-exhaust manifold tube
41	9J433	Differential pressure feedback EGR sensor
42	9E498	Engine vacuum harness
43	9D460	Exhaust gas recirculation (EGR) valve
44	9F715	Idle air control valve (IAC)
45	18801	Radio suppressor
46	9K479	Intake manifold — upper
47	12A648	Engine coolant temperature (ECT) sensor
48	18599	Engine coolant hose connection
49	10884	Coolant temperature indicator
50	8594	Thermostat housing
51	8575	Thermostat
52	8255	Thermostat housing gasket
53	6507	Intake valve
54	6049	Cylinder head — LH
55	6A517	Valve seal — intake
56	6565	Push rod
57	6564	Rocker arm
58	6A528	Rocker arm pivot
59	6582	Valve cover — LH
60	12A310	Ignition coil
61	9J444	Intake manifold support bracket

DESCRIPTION AND OPERATION (Continued)

Cylinder Block — Lower



Item	Part Number	Description
1	9A424	Pipe plug
2	6266	Camshaft rear bearing cover
3	6701	Rear main seal
4	87838	Pipe plug
5	6397	Dowel
6	6890	Oil filter mounting insert
7	6B856	Oil cooler
8	6L626	Oil cooler mounting insert
9	6714	Oil filter
10	6687	Windage tray
11	6710	Oil pan gasket
12	6675	Oil pan
13	6600	Oil pump assembly
14	6A605	Oil pump drive
15	6327	Crankshaft thrust bearing cap
16	6334	Crankshaft main bearing cap
17	6329	Crankshaft front main bearing caps
18	6333	Crankshaft main bearing

(Continued)

Item	Part Number	Description
19	6325	Crankshaft rear main bearing cap
20	6337	Crankshaft thrust bearing (lower)
21	6W331	Crankshaft rear main bearing (lower)
22	6375	Flywheel
23	6303	Crankshaft
24	87838	Pipe plug
25	6W332	Crankshaft rear main bearing (upper)
26	6A339	Crankshaft thrust bearing (upper)
27	6A338	Crankshaft main bearings (upper)
28	W705401	Key
29	6306	Crankshaft timing sprocket
30	6268	Timing chain
31	6020	Engine front cover gasket
32	6059	Engine front cover
33	6700	Crankshaft front seal

(Continued)

DESCRIPTION AND OPERATION (Continued)

Item	Part Number	Description
34	6316	Crankshaft pulley (harmonic balancer)
35	8501	Water pump
36	8507	Water pump gasket
37	6C315	Crankshaft position (CKP) sensor
38	390146	Dowel
39	87838	Pipe plug
40	6250	Camshaft
41	6269	Camshaft thrust plate
42	6256	Camshaft sprocket
43	6210	Connecting rod bearing cap

(Continued)

Item	Part Number	Description
44	6211	Connecting rod bearing
45	6214	Piston connecting rod
46	6210	Piston
47	6159	Oil ring (lower)
48	6161	Oil ring baffle
49	6159	Oil ring (upper)
50	6152	Compression ring (lower)
51	6150	Compression ring (upper)
52	6110	Piston assembly
53	6200	Connecting rod assembly
54	6100	Piston and connecting rod assembly

DIAGNOSIS AND TESTING

Engine

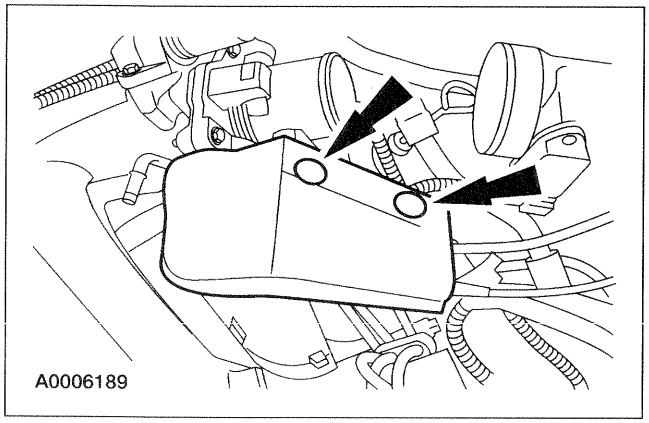
Refer to Section 303-00.

IN-VEHICLE REPAIR

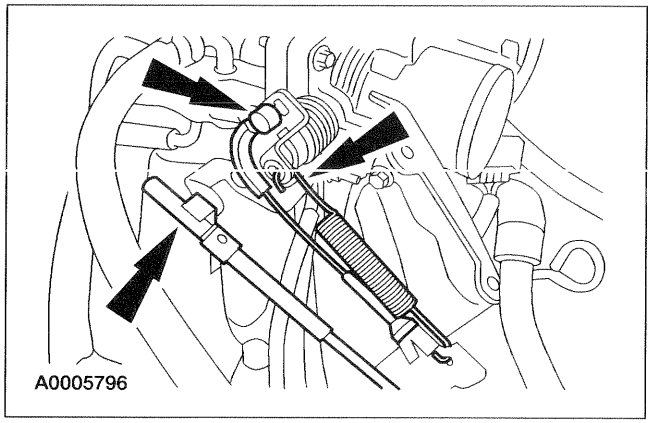
Upper Intake Manifold

Removal

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Remove the air cleaner assembly and the air cleaner outlet tube. For additional information, refer to Section 303-12.
3. Remove the pin-type retainers and the snow shield.

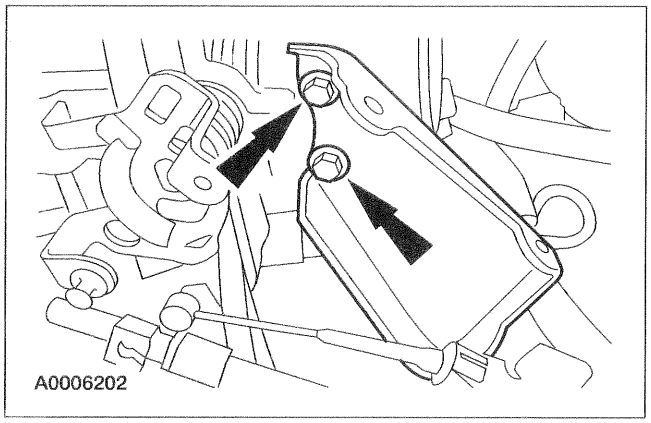


4. Disconnect the accelerator cable, speed control actuator cable and the throttle return spring from the throttle body.

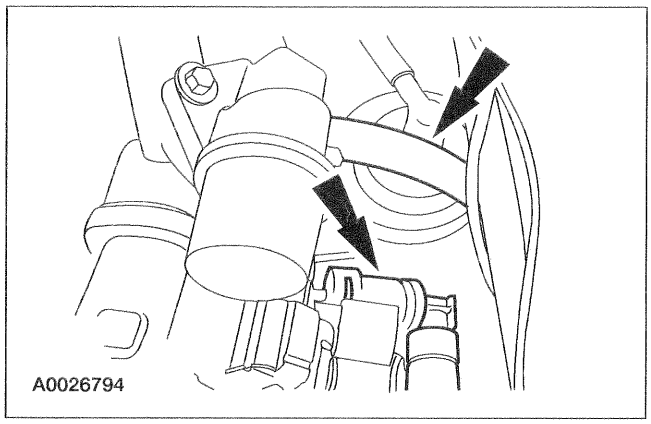


IN-VEHICLE REPAIR (Continued)

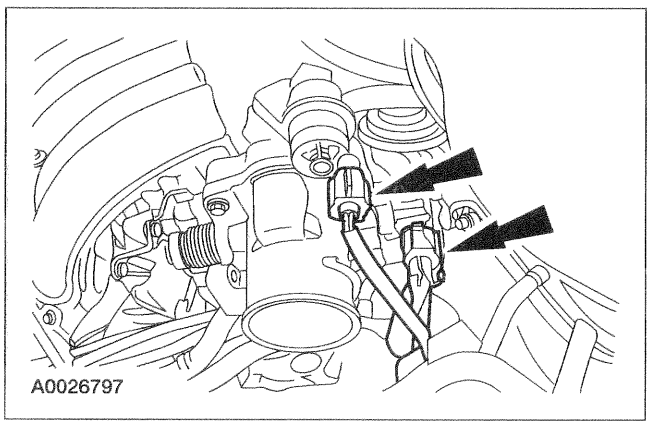
5. Remove the bolts, then position the accelerator cable bracket aside.



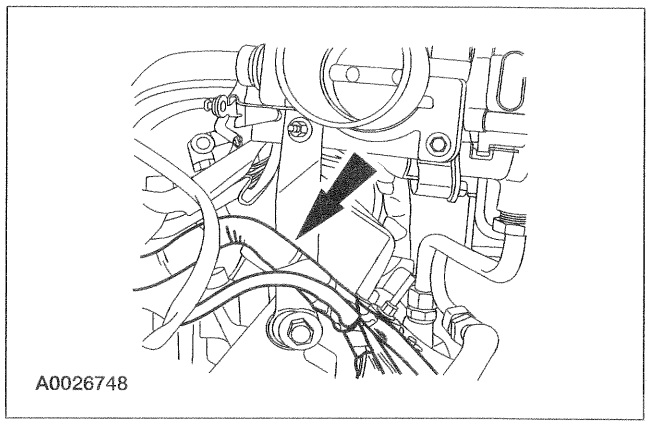
6. Disconnect the hoses.
   - Disconnect the vacuum hose.
   - Disconnect the evaporative emissions (EVAP) return tube.



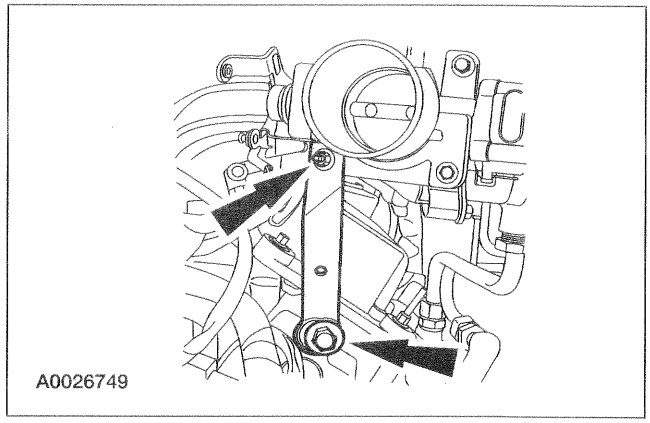
7. Disconnect the idle air control (IAC) valve and the throttle position (TP) sensor electrical connectors.



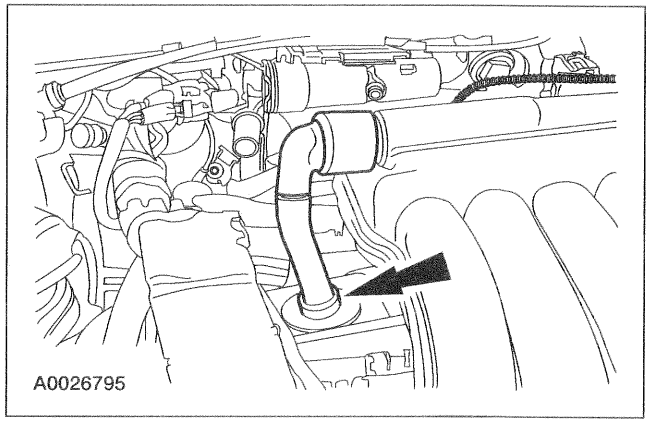
8. Disconnect the engine wiring harness from the intake manifold support bracket.



9. Remove the upper intake manifold support bracket.

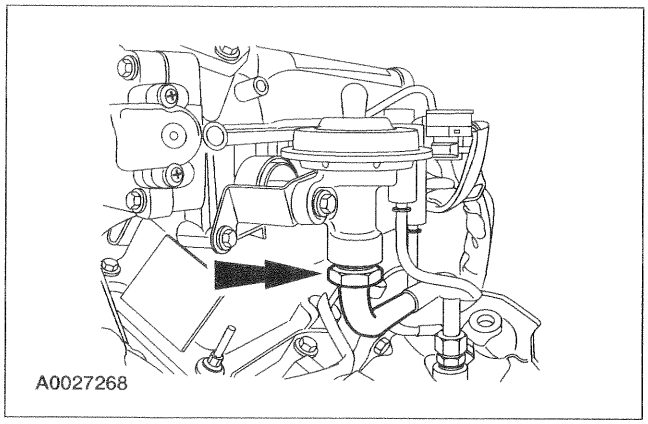


10. Disconnect the positive crankcase ventilation (PCV) tube from the upper intake manifold.

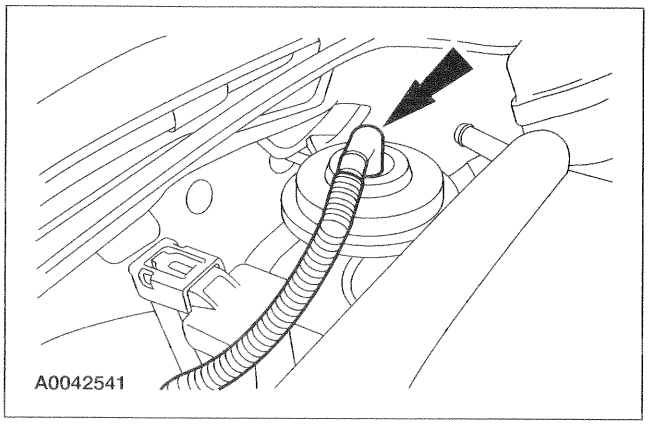


IN-VEHICLE REPAIR (Continued)

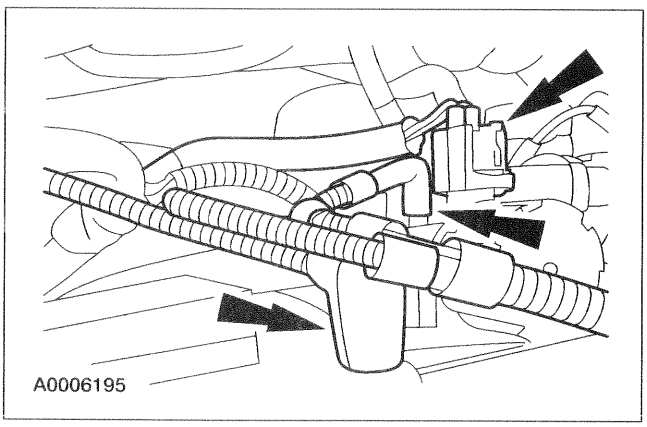
11. Loosen the nut and disconnect the exhaust gas recirculation (EGR) tube from the EGR valve.



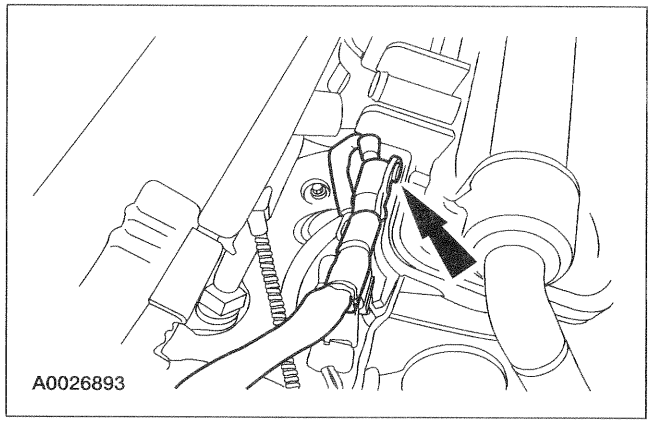
12. Disconnect the vacuum hose from the EGR valve.



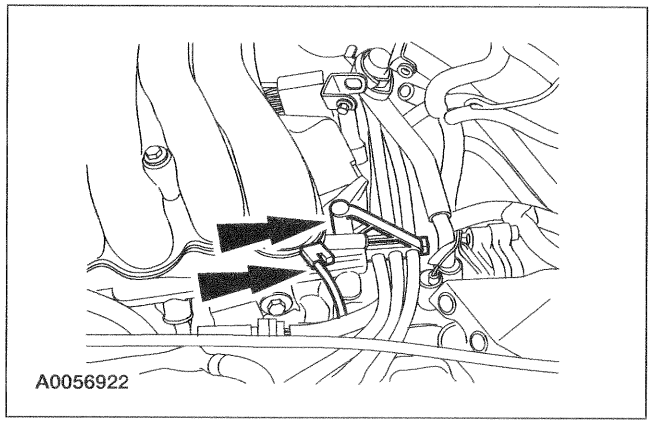
13. Disconnect the vacuum regulator solenoid vacuum and electrical connections. Disconnect the vacuum hose from the upper intake manifold.



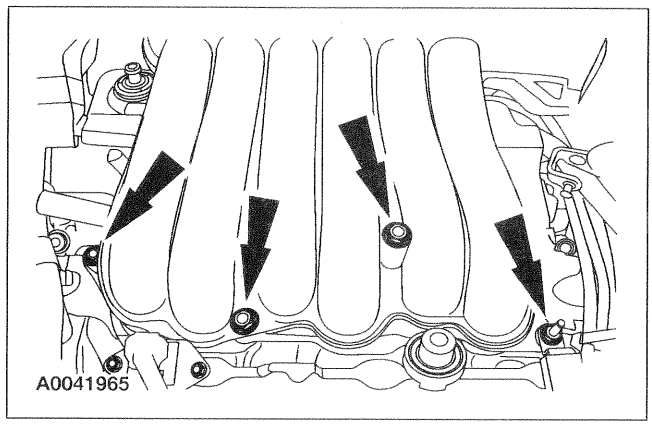
14. Disconnect the wire harness retaining clip.



15. Disconnect the spark plug holder and the radio interference capacitor electrical connector.



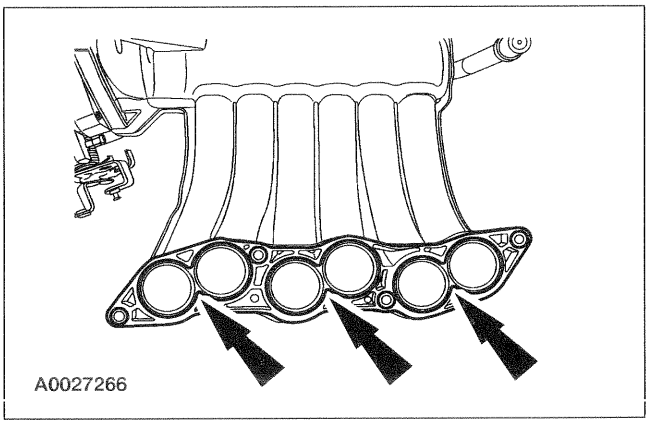
16. Remove the bolts and the upper intake manifold.



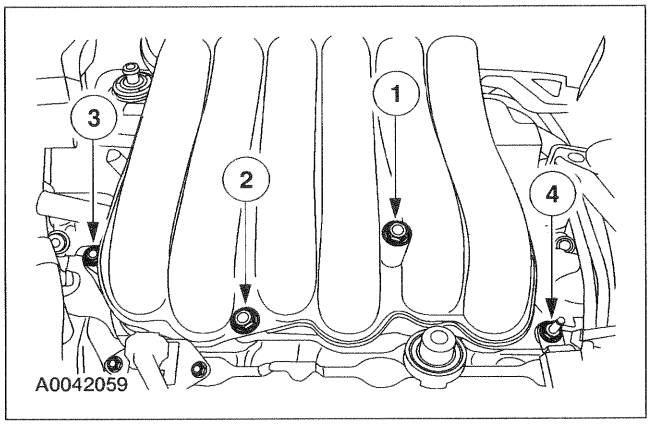
IN-VEHICLE REPAIR (Continued)

Installation

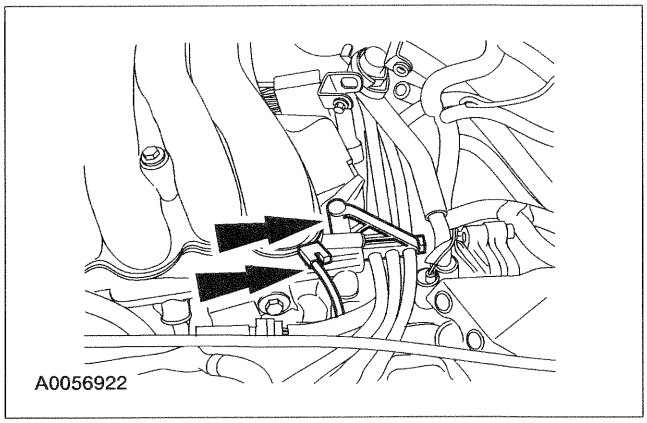
1. Clean all the sealing surfaces.
2. Inspect the upper intake manifold gaskets. Install new gasket as necessary.



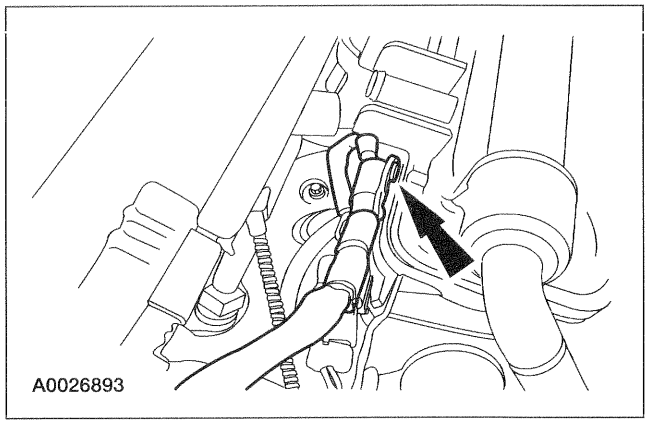
3. Install the upper intake manifold. Tighten bolts in two stages in the sequence shown.
   1 Stage 1: Tighten the bolts hand tight.
   2 Stage 2: Tighten the bolts to 10 Nm (89 lb-in).



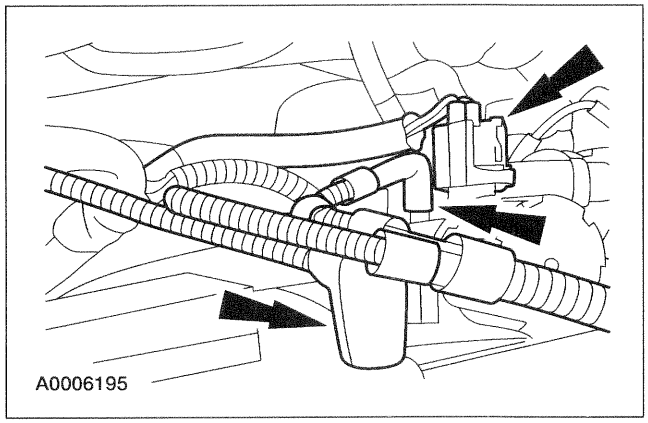
4. Connect the spark plug holder and the radio interference capacitor electrical connector.



5. Connect the wire harness retaining clip.

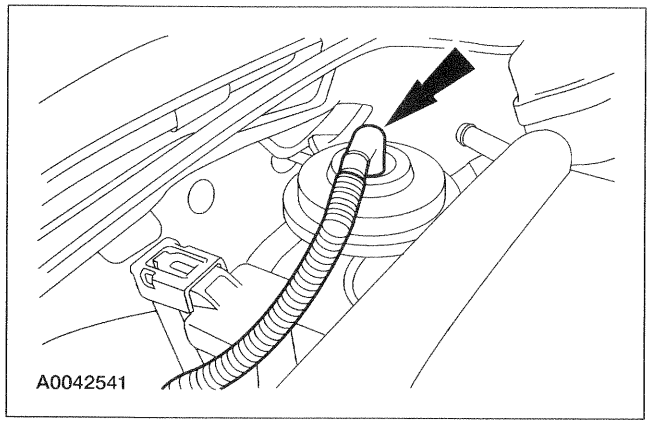


6. Connect the vacuum regulator solenoid vacuum and electrical connections. Connect the vacuum hose to the upper intake manifold.

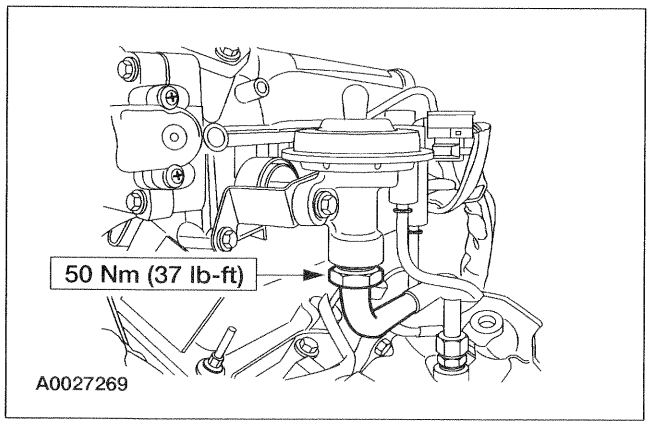


IN-VEHICLE REPAIR (Continued)

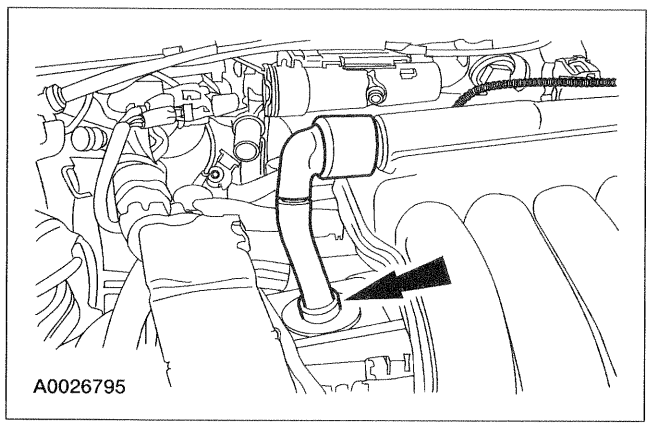
7. Connect the vacuum hose to the EGR valve.



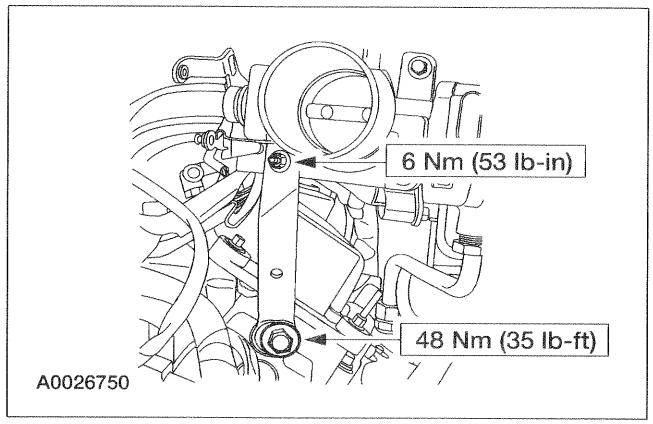
8. Connect the EGR tube to the EGR valve.



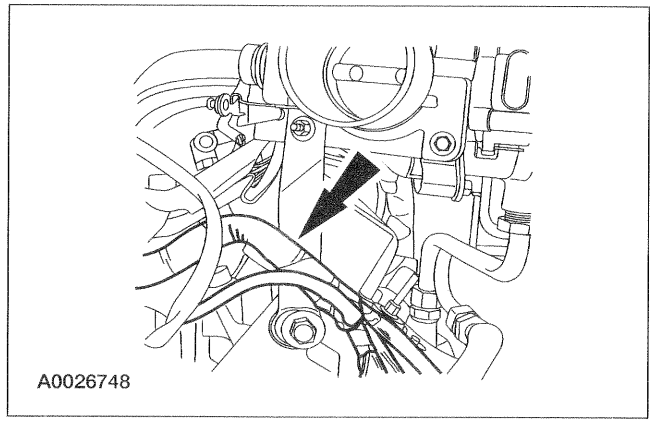
9. Connect the PCV tube to the upper intake manifold.



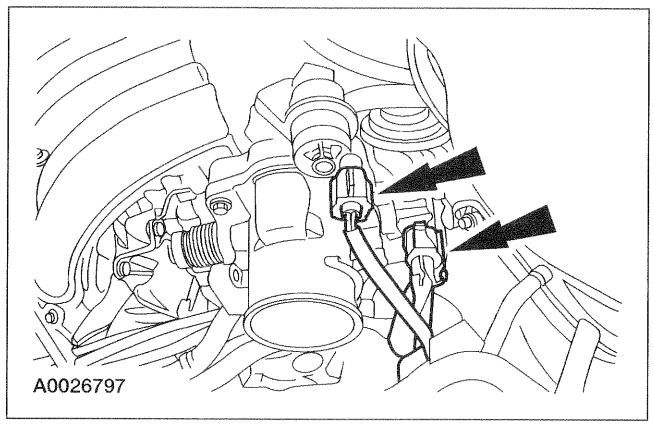
10. Install the upper intake manifold support bracket.



11. Connect the engine wiring harness to the intake manifold support bracket.

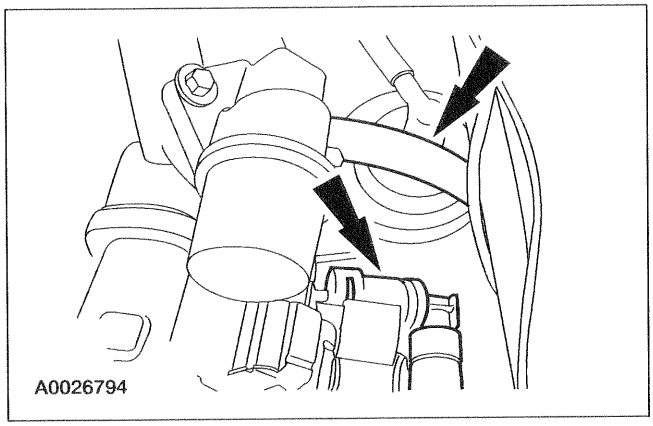


12. Connect the IAC and TP sensor electrical connectors.

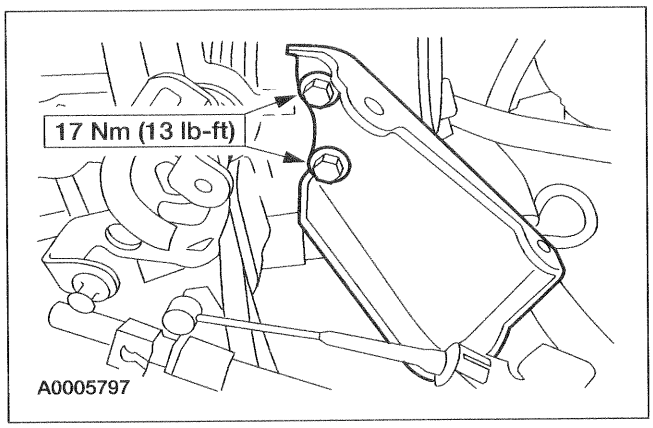


IN-VEHICLE REPAIR (Continued)

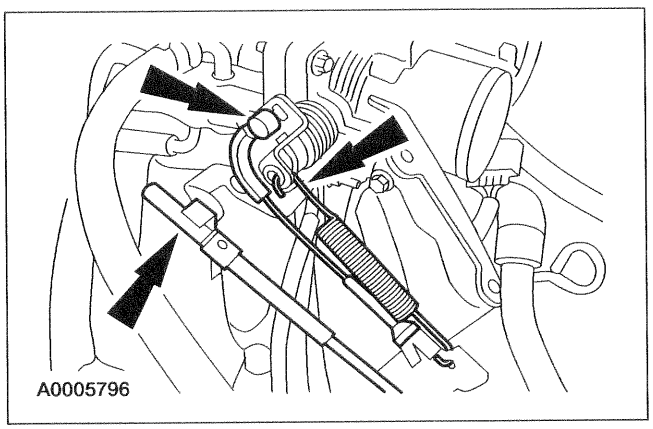
13. Connect the evaporative emissions return tube and the vacuum hose.



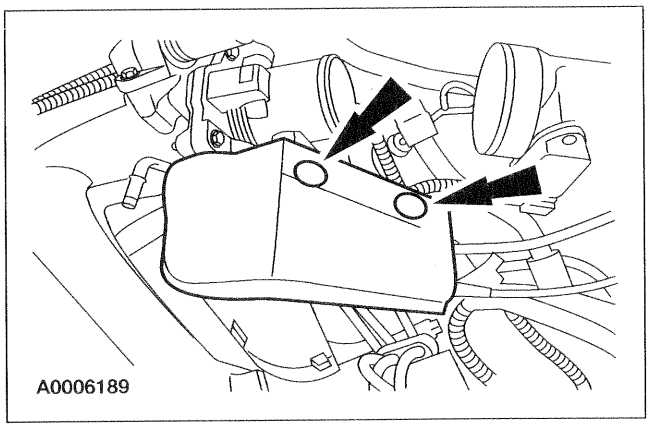
14. Position the accelerator cable bracket and install the bolts.



15. Connect the accelerator control cable, speed control cable and the throttle return spring.



16. Install the snow shield.



17. Install the air cleaner assembly and the air cleaner outlet tube. For additional information, refer to Section 303-12.

18. Connect the battery ground cable. For additional information, refer to Section 414-01.

Lower Intake Manifold

Material

Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

Removal

1. Drain the engine cooling system. For additional information, refer to Section 303-03.

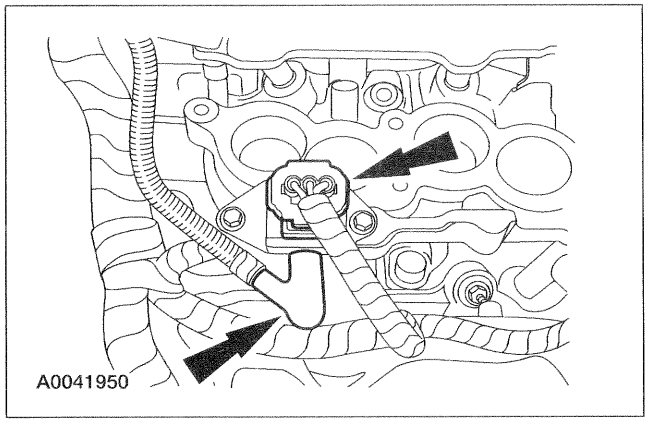
2. Disconnect the fuel tube spring lock coupling. For additional information, refer to section Section 310-00.

3. Remove the upper intake manifold. For additional information, refer to Upper Intake Manifold in this section.

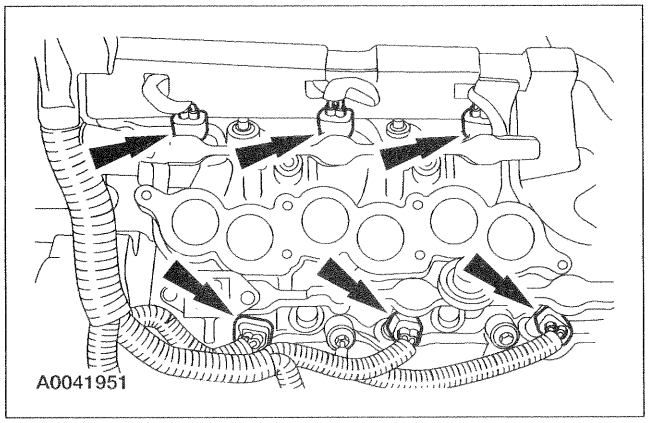
4. Remove the LH and the RH valve covers. For additional information, refer to Valve Cover LH and Valve Cover RH in this section.

IN-VEHICLE REPAIR (Continued)

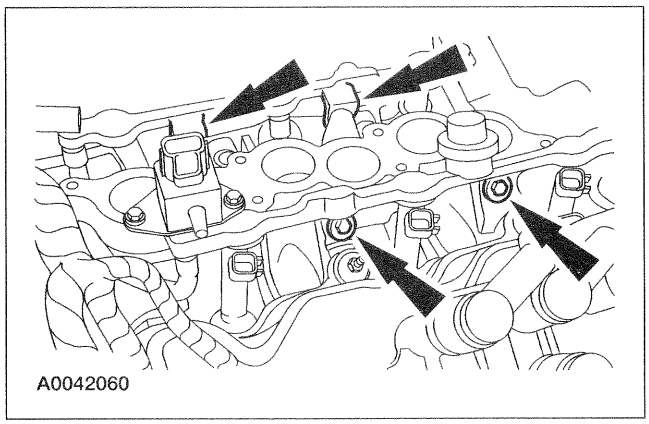
5. Disconnect the fuel rail pressure (FRP) sensor electrical and vacuum connections.



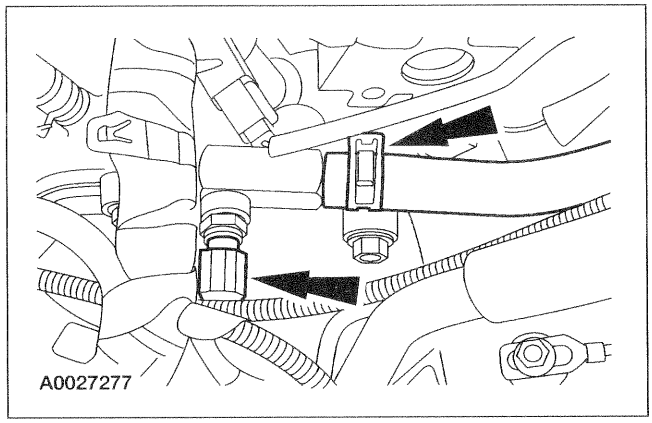
6. Disconnect the fuel injector electrical connectors.



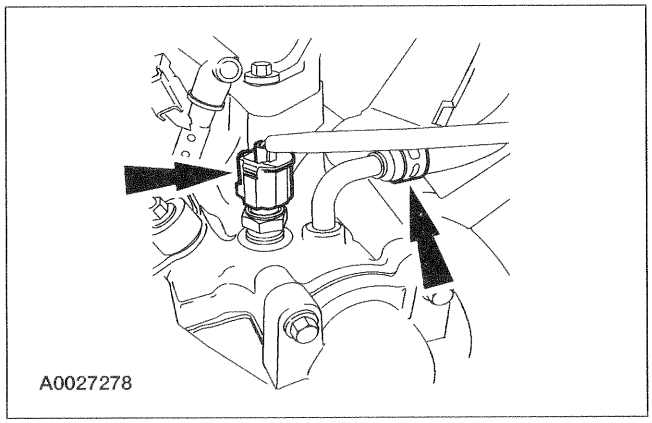
7. Remove the fuel injection supply manifold and fuel injectors as an assembly.



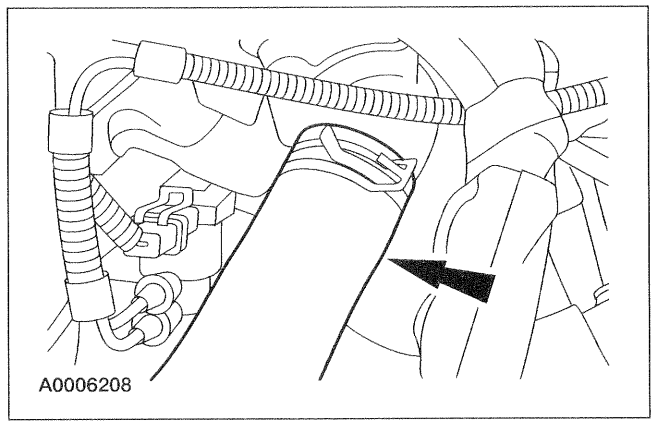
8. Disconnect the heater hose and engine coolant temperature (ECT) sender electrical connector.



9. Disconnect the ECT sensor electrical connector and the degas bottle hose.



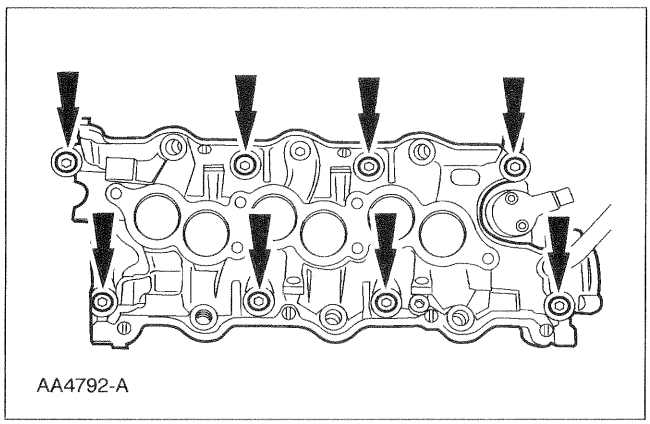
10. Disconnect the upper radiator hose from the thermostat housing.



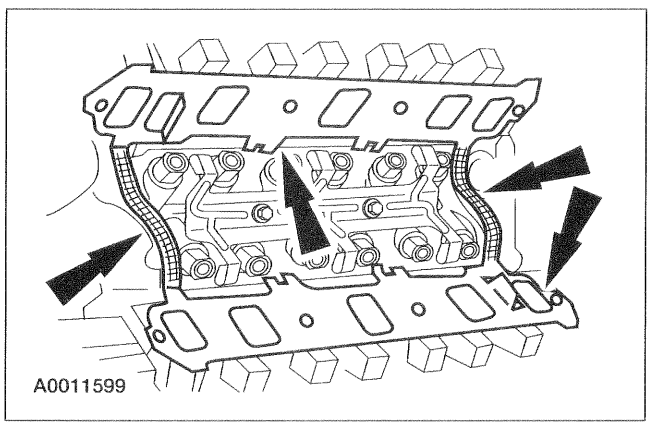
11. Remove the camshaft position (CMP) sensor. For additional information, refer to Section 303-14.

IN-VEHICLE REPAIR (Continued)

12. Remove the bolts and the lower intake manifold.

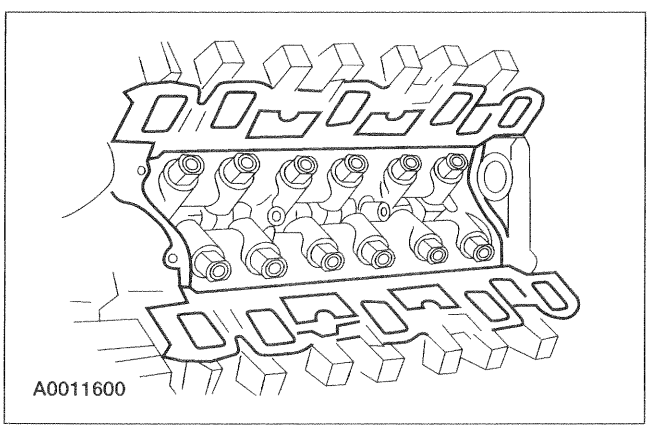


13. Remove the intake manifold gaskets and the end seals.



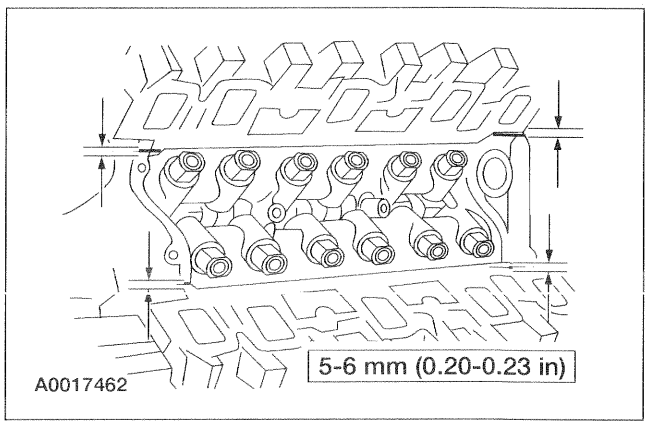
Installation

1. Using metal surface cleaner, clean all the sealing surfaces.

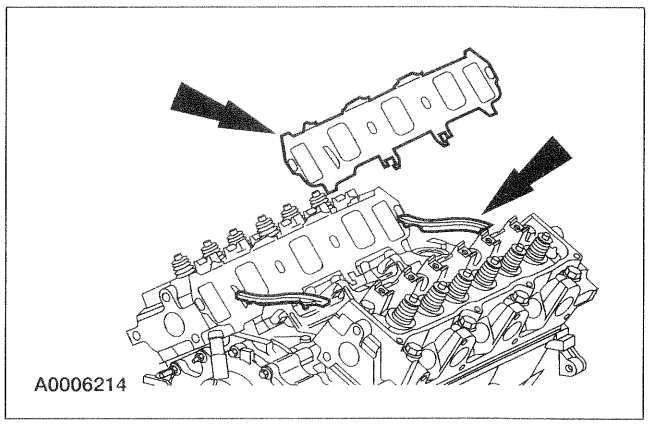


2. **NOTE:** If the lower intake manifold is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

   Apply silicone gasket and sealant at the four cylinder block-to-cylinder head seams.

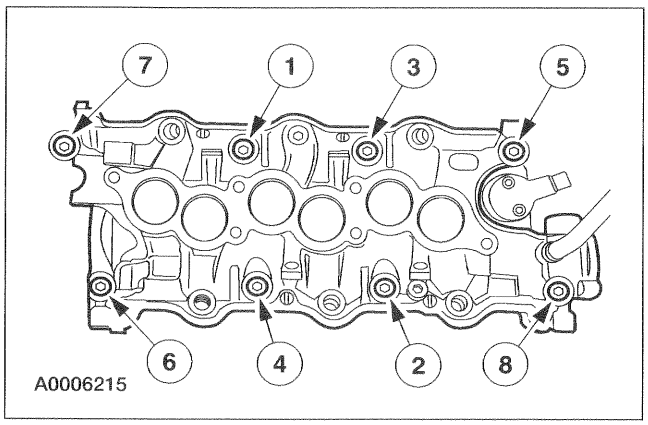


3. Install the lower intake manifold gaskets and end seals.
   - Position the intake manifold gaskets.
   - Position the intake manifold end seals.



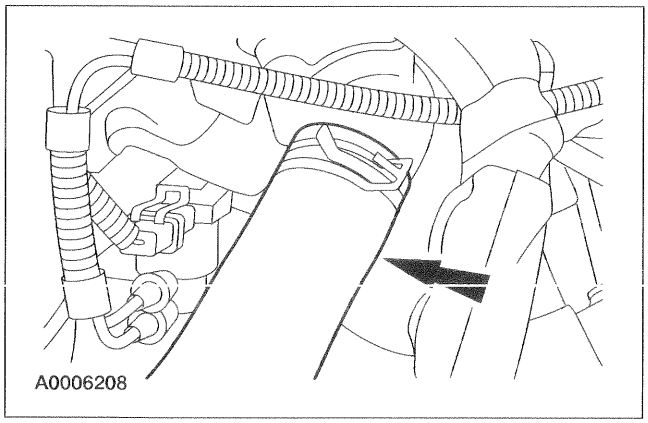
IN-VEHICLE REPAIR (Continued)

4. Install the intake manifold. Tighten the bolts in two stages in the sequence shown.
   - Stage 1: Tighten to 15 Nm (11 lb-ft).
   - Stage 2: Tighten to 32 Nm (24 lb-ft).

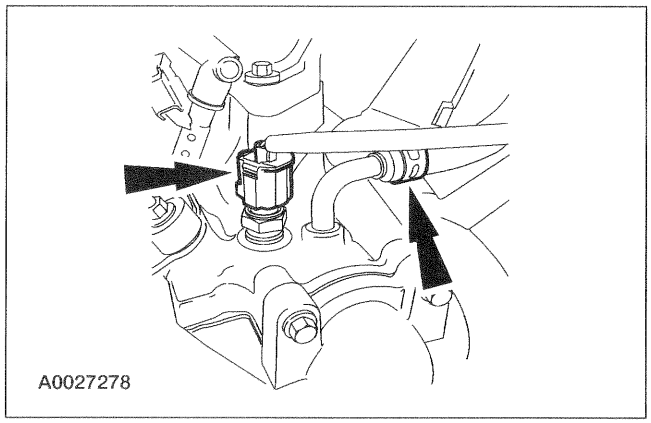


5. Install the camshaft position (CMP) sensor. For additional information, refer to Section 303-14.

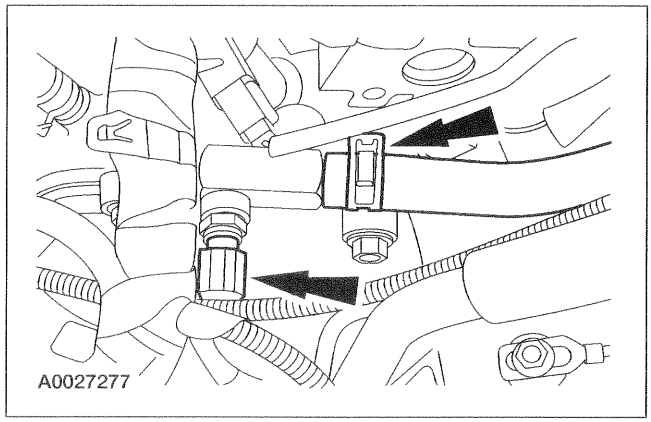
6. Connect the upper radiator hose to the thermostat housing.



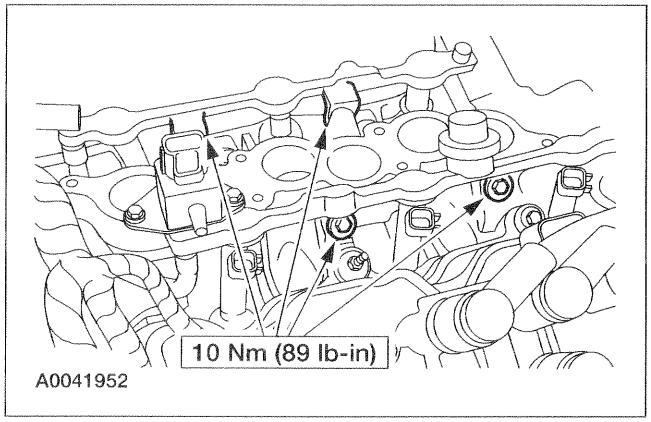
7. Connect the engine coolant temperature (ECT) sensor electrical connector and the degas bottle hose.



8. Connect the heater hose and the ECT sender electrical connector.

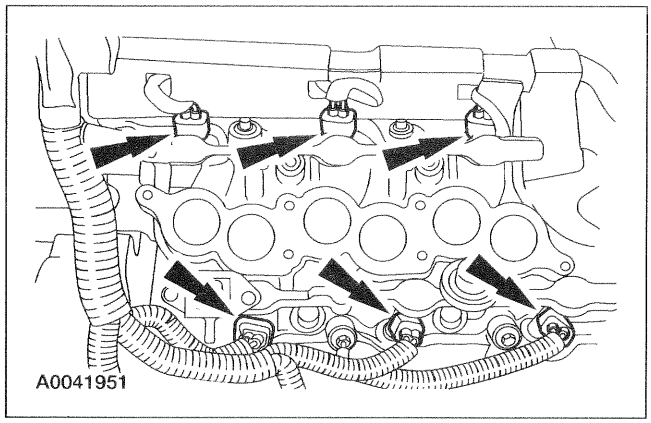


9. Install the fuel injection supply manifold and fuel injectors as an assembly.

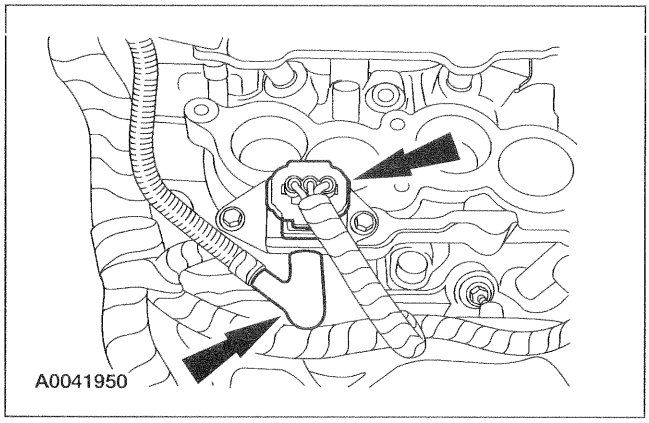


IN-VEHICLE REPAIR (Continued)

10. Connect the fuel injector electrical connectors.



11. Connect the fuel rail pressure (FRP) sensor electrical and vacuum connections.



12. Install both valve covers. For additional information, refer to Valve Cover LH and Valve Cover RH in this section.

13. Install the upper intake manifold. For additional information, refer to Upper Intake Manifold in this section.

14. Connect the fuel tube spring lock coupling. For additional information, refer to Section 310-01.

15. Fill and bleed the engine cooling system. For additional information, refer to Section 303-03.

Valve Cover RH

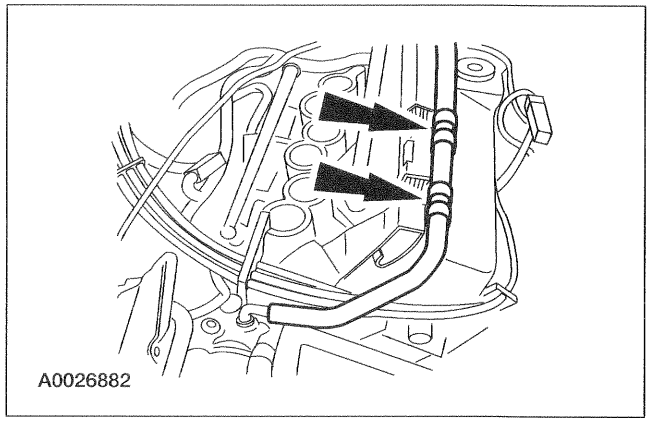
Material

Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

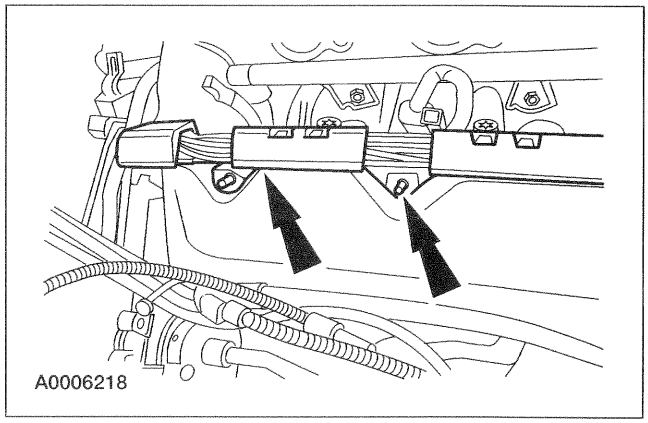
Removal

1. Remove the upper intake manifold. For additional information, refer to Upper Intake Manifold in this section.

2. Lift the degas bottle hose off the valve cover studs and position the hose aside.

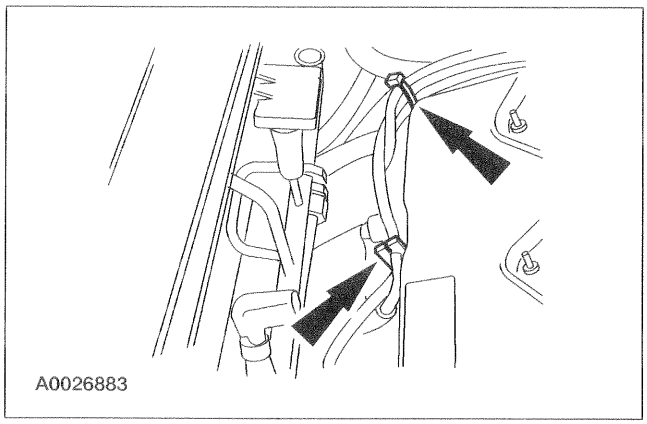


3. Lift the fuel charging wiring harness off the valve cover studs and position the wiring harness aside.

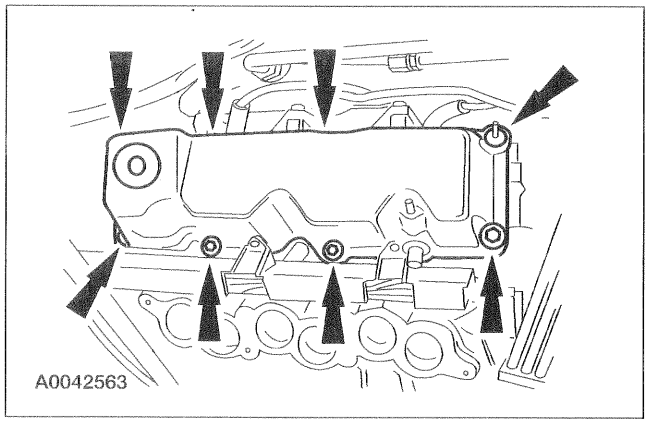


IN-VEHICLE REPAIR (Continued)

4. Position the spark plug wires aside.



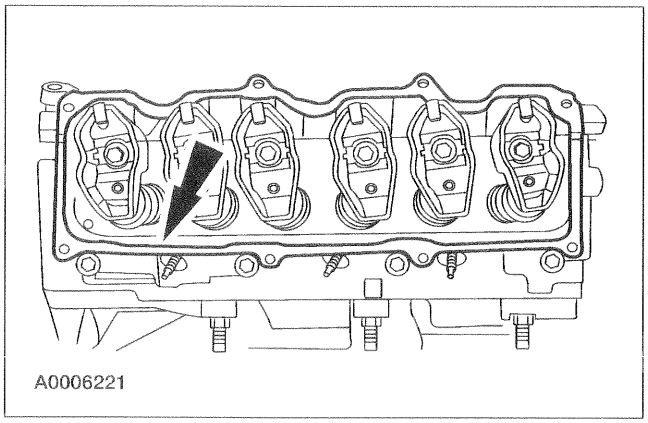
5. Remove the RH valve cover.



Installation

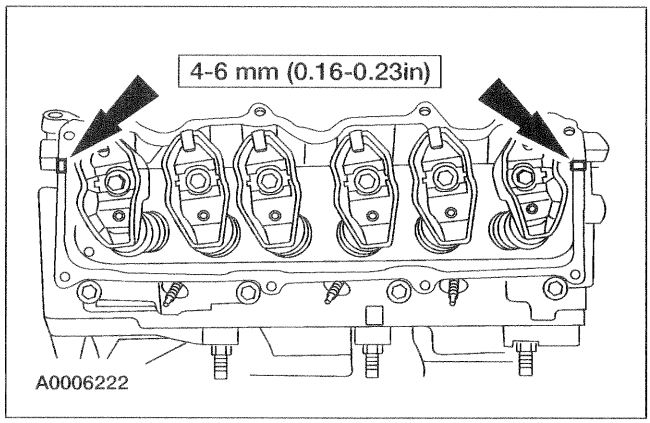
1. **NOTE:** Do not clean the valve cover gasket with solvent. Damage to the valve cover gasket may occur.

   Using metal surface cleaner, clean the cylinder head mating surfaces.

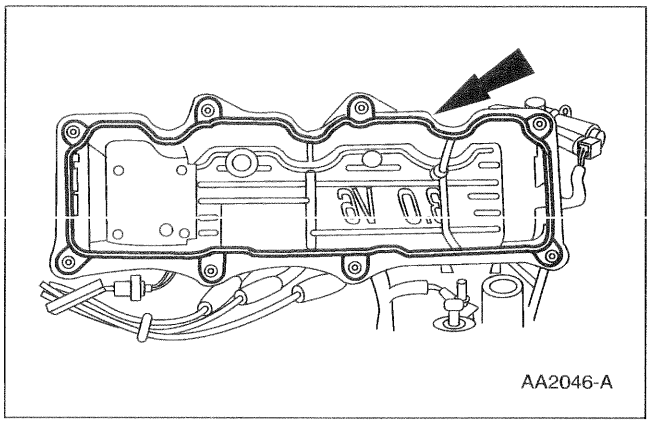


2. **NOTE:** If the RH valve cover is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

   Apply a bead of silicone gasket and sealant in two places where the cylinder head and intake manifold meet.

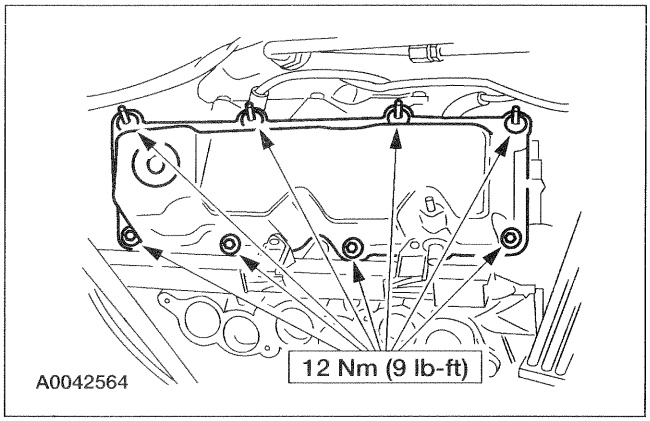


3. Install the valve cover gasket, if removed.

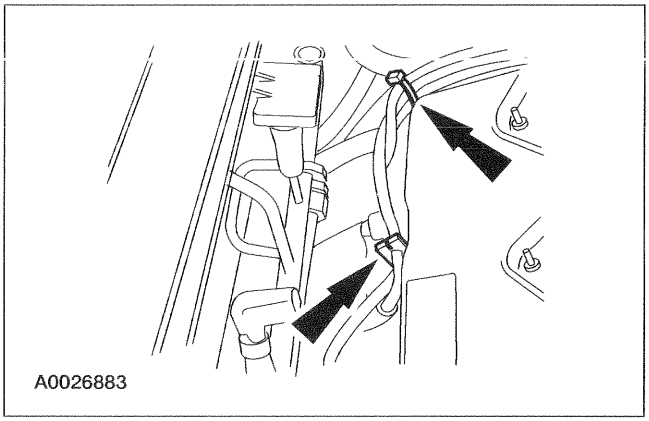


IN-VEHICLE REPAIR (Continued)

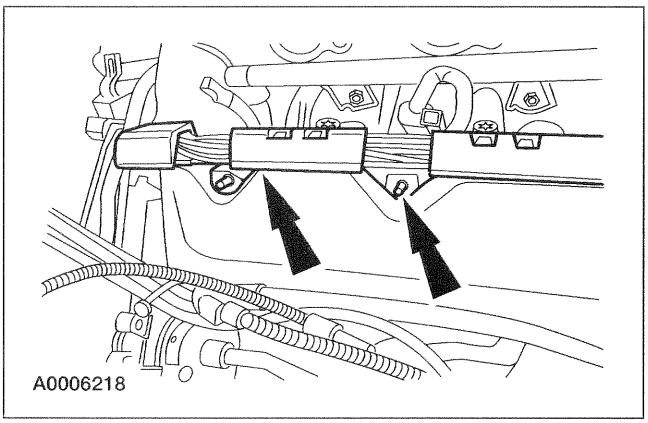
4. Install the RH valve cover.



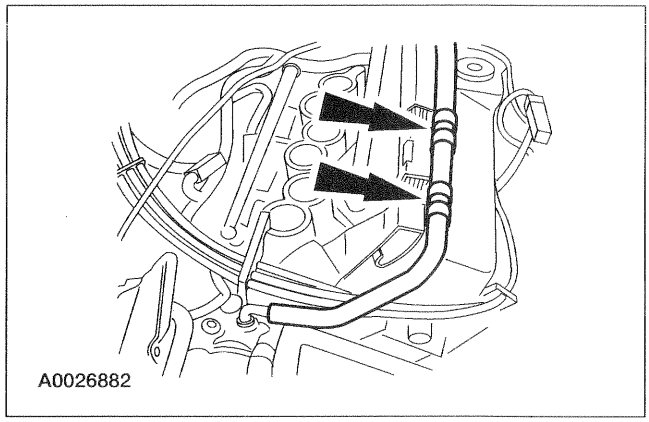
5. Route the spark plug wires.



6. Install the fuel charging wiring harness.



7. Install the degas bottle hose.



8. Install the upper intake manifold. For additional information, refer to Upper Intake Manifold in this section.

Valve Cover LH

Material

Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

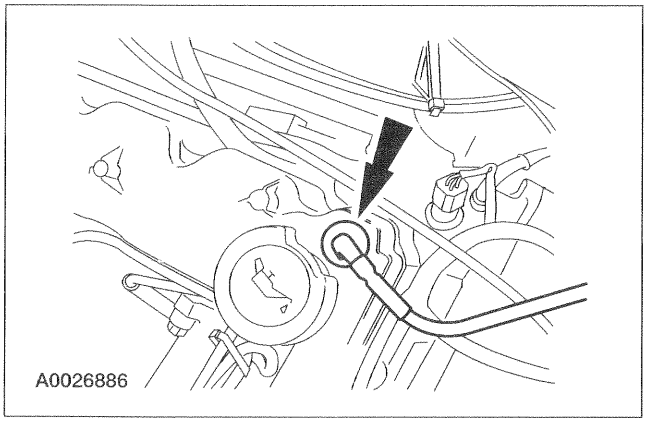
Removal

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

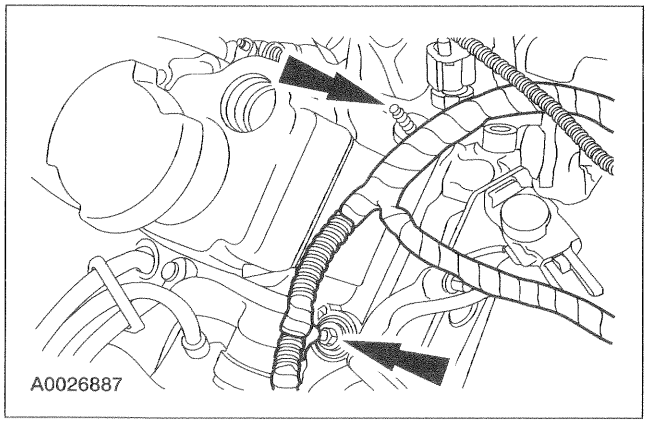
2. Remove the ignition coil. For additional information, refer to section Section 303-07A.

IN-VEHICLE REPAIR (Continued)

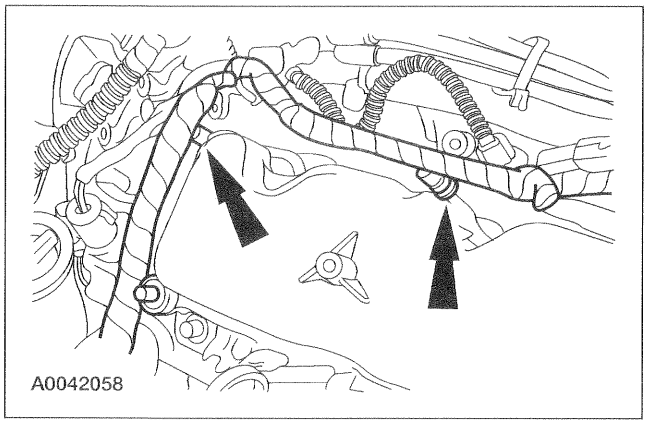
3. Disconnect the crankcase ventilation hose.



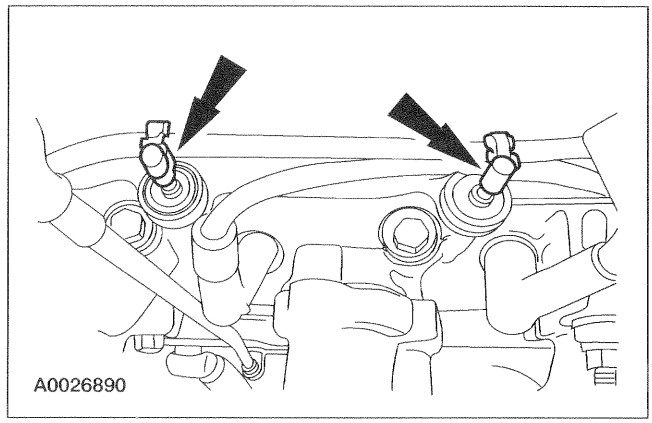
4. Release the wiring harness from the valve cover studs and position aside.



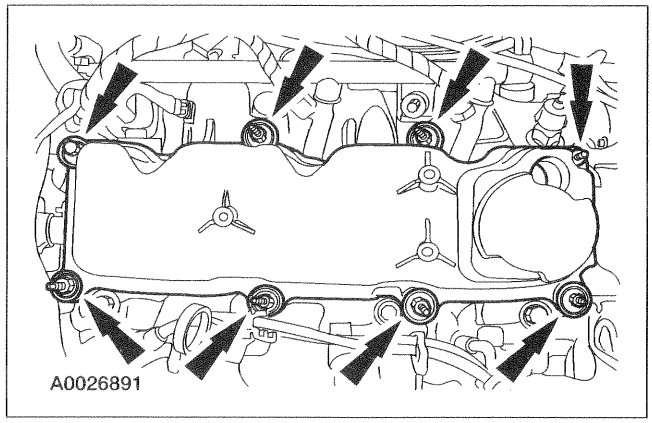
5. Release the wiring harness from the valve cover studs and position aside.



6. Position the spark plug wires aside.



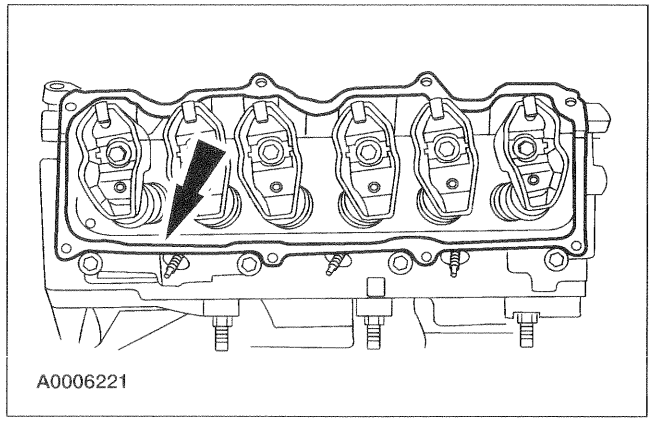
7. Remove the LH valve cover.



Installation

1. **NOTE:** Do not clean the valve cover gasket with solvent. Damage to the valve cover gasket may occur.

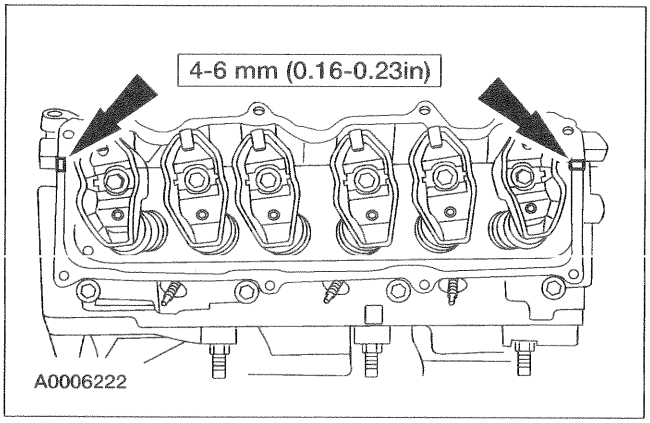
   Using metal surface cleaner, clean the cylinder head mating surfaces.



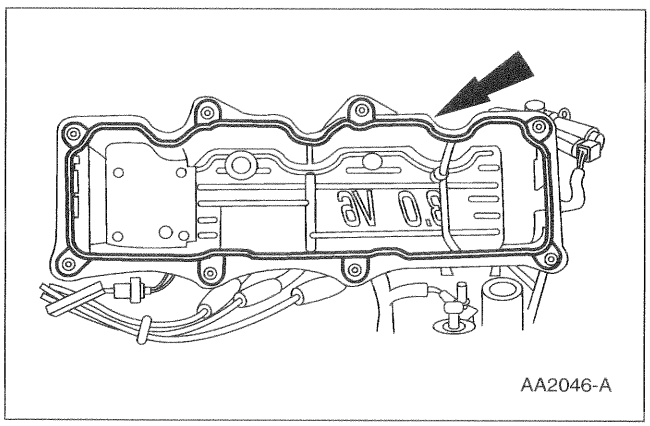
IN-VEHICLE REPAIR (Continued)

2. **NOTE:** If the LH valve cover is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

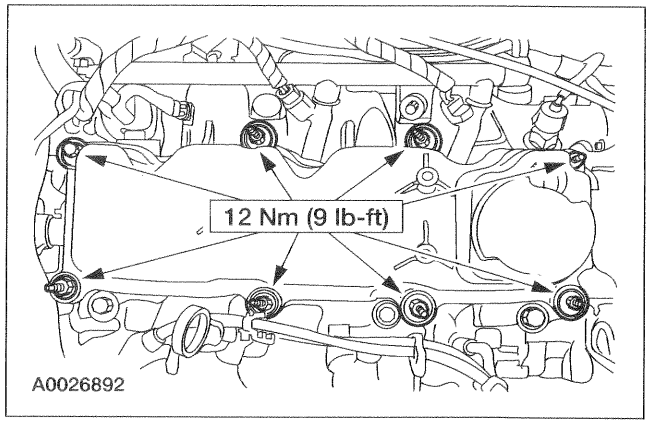
   Apply a bead of silicone gasket and sealant in two places where the cylinder head and intake manifold meet.



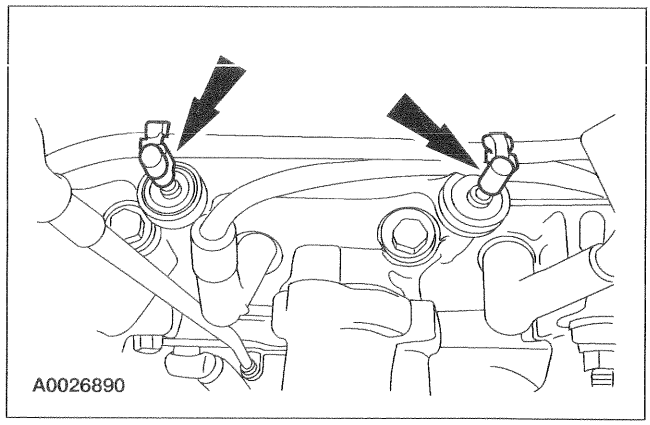
3. Install the valve cover gasket, if removed.



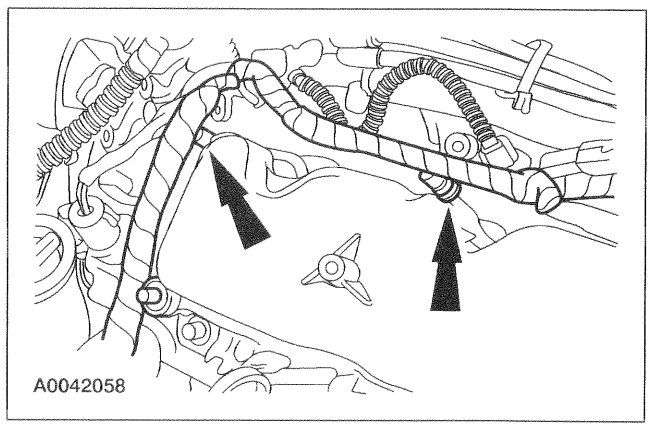
4. Install the valve cover.



5. Route the spark plug wires.

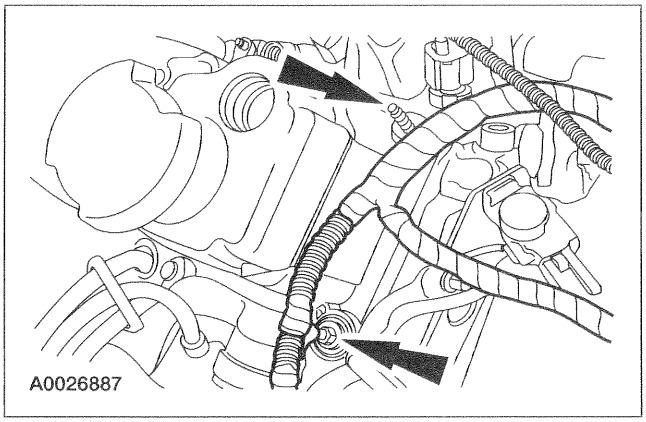


6. Install the engine wiring harness.

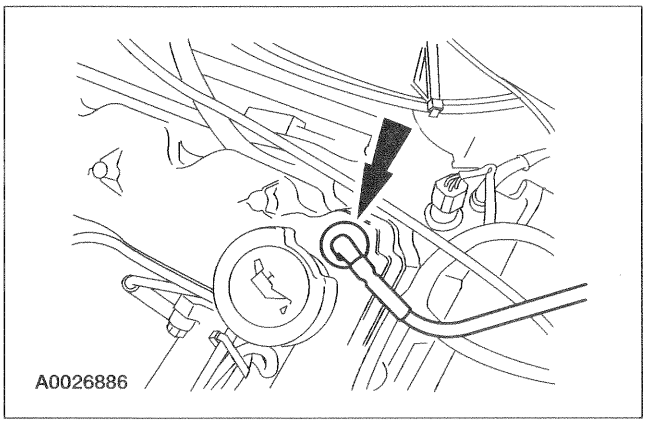


IN-VEHICLE REPAIR (Continued)

7. Install the engine wiring harness.



8. Connect the crankcase vent tube.

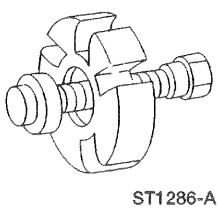


9. Install the ignition coil. For additional information, refer to section Section 303-07A.

10. Connect the battery ground cable. For additional information, refer to Section 414-01.

Crankshaft Pulley

Special Tool(s)

 ST1286-A	Remover, Crankshaft Vibration Damper 303-009 (T58P-6316-D)

Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

Removal

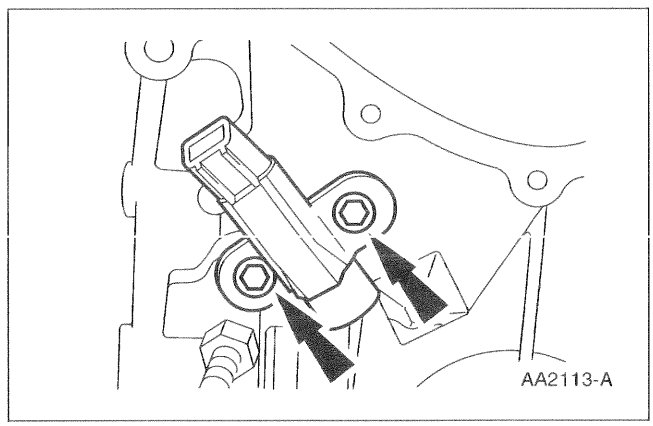
1. Remove the accessory drive belt. For additional information, refer to Section 303-05.

2. Raise and support the vehicle. For additional information, refer to Section 100-02.

3. Remove the RH front wheel.

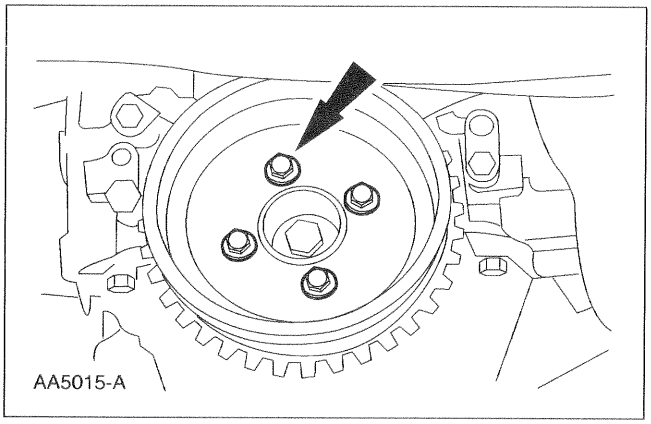
4. Remove the splash shield. For additional information, refer to sectionSection 501-02.

5. Disconnect and remove the crankshaft position (CKP) sensor.

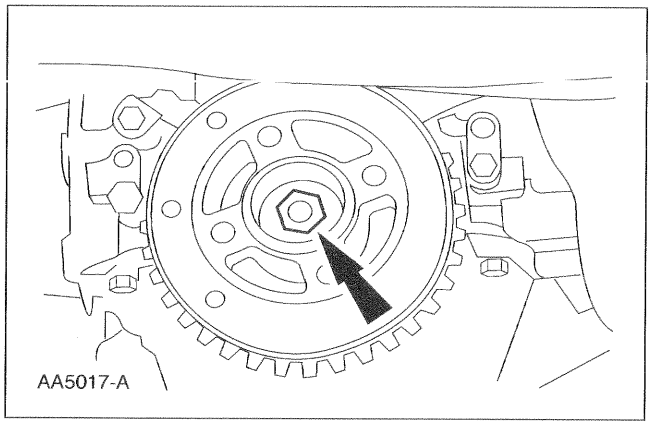


IN-VEHICLE REPAIR (Continued)

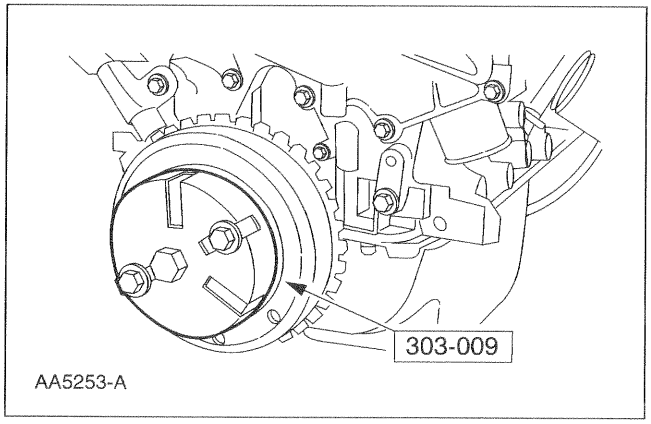
6. Remove the bolts and the crankshaft pulley.



7. Remove the crankshaft damper bolt and washer.



8. Using the special tool, remove the crankshaft damper.

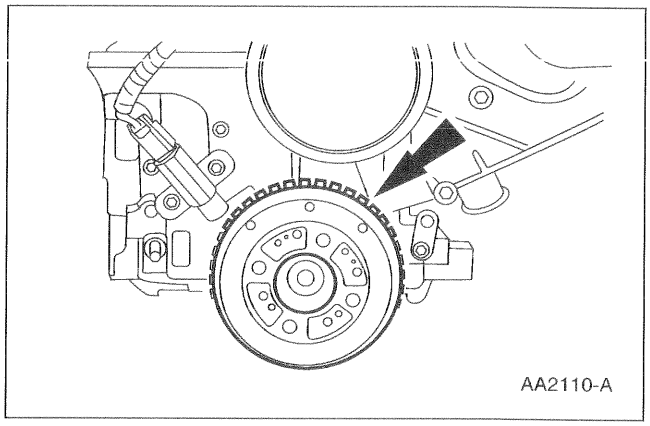


Installation

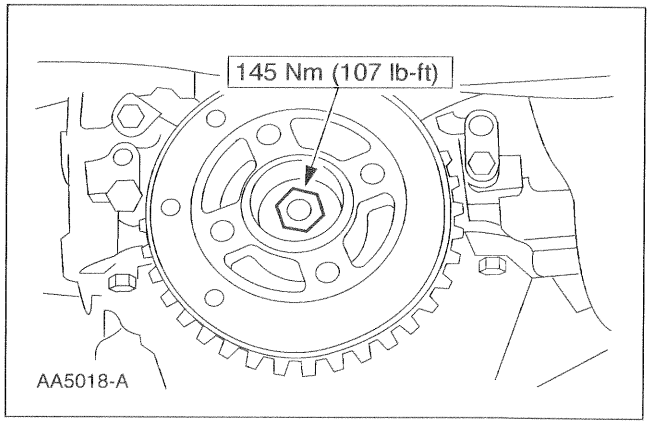
1. **NOTE:** If the crankshaft damper is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

   Install the crankshaft damper.

   - Coat the sealing surfaces of the crankshaft damper with clean engine oil.
   - Coat the crankshaft damper keyway with silicone gasket and sealant.
   - Install the crankshaft damper.

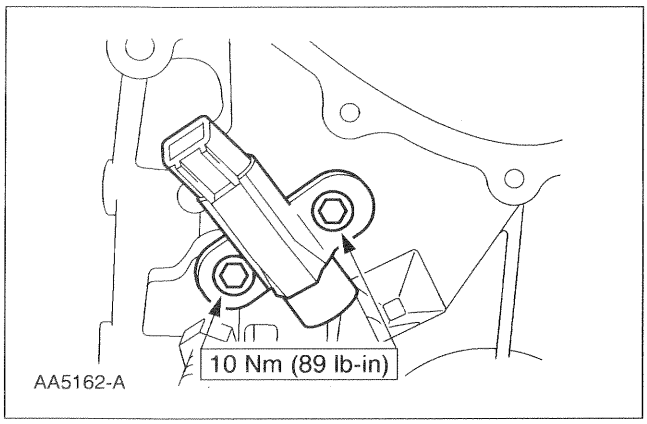


2. Install the crankshaft damper bolt and the washer.

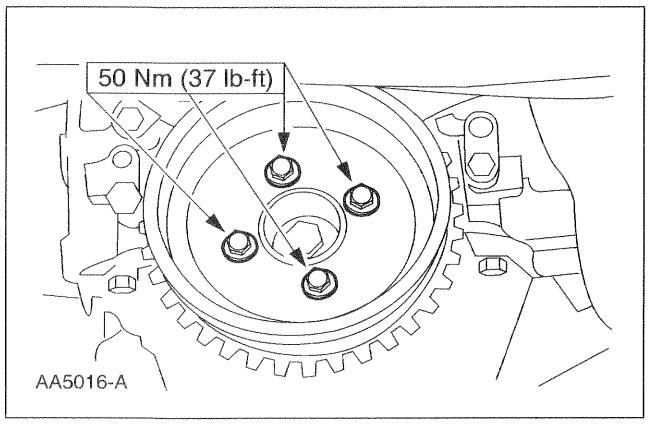


IN-VEHICLE REPAIR (Continued)

3. Install and connect the crankshaft position (CKP) sensor.



4. Install the crankshaft pulley.



5. Install the splash shield. For additional information, refer to sectionSection 501-02.

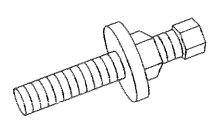
6. Install the RH front wheel.

7. Lower the vehicle.

8. Install the accessory drive belt. For additional information, refer to Section 303-05.

Crankshaft Front Seal

Special Tool(s)

 ST1387-A	Replacer, Vibration Damper 303-175 (T82L-6316-A)

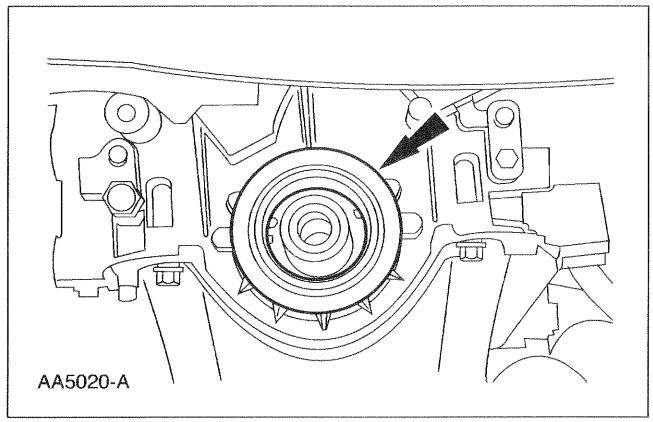
Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

Removal

1. Remove the crankshaft pulley. For additional information, refer to Crankshaft Pulley in this section.

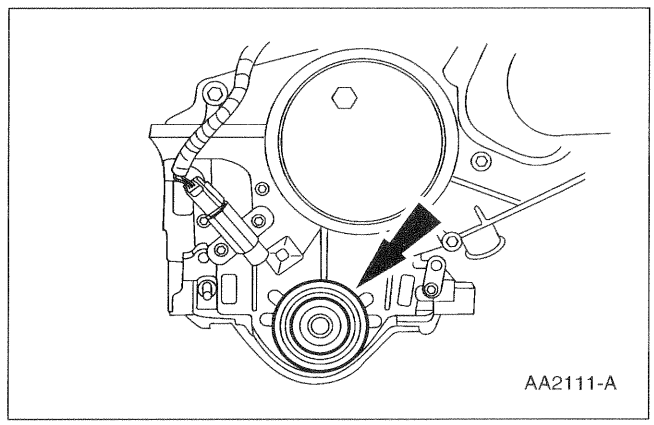
2. Remove the crankshaft oil seal.



Installation

1. **NOTE:** Lubricate the seal lip with clean engine oil.

   Using crankshaft vibration damper replacer, install the crankshaft oil seal.



2. Install the crankshaft pulley. For additional information, refer to Crankshaft Pulley in this section.

IN-VEHICLE REPAIR (Continued)

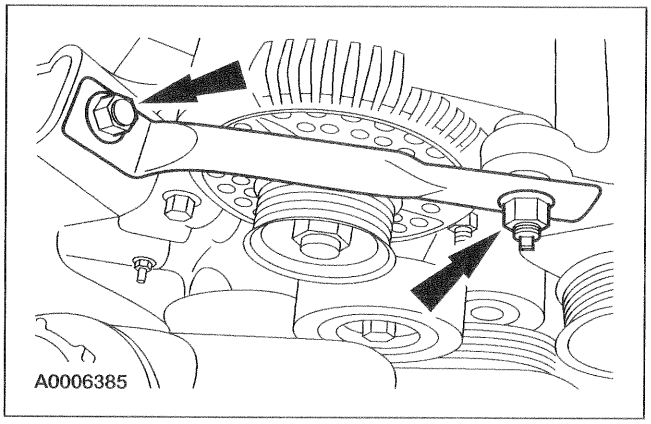
Engine Front Cover

Material

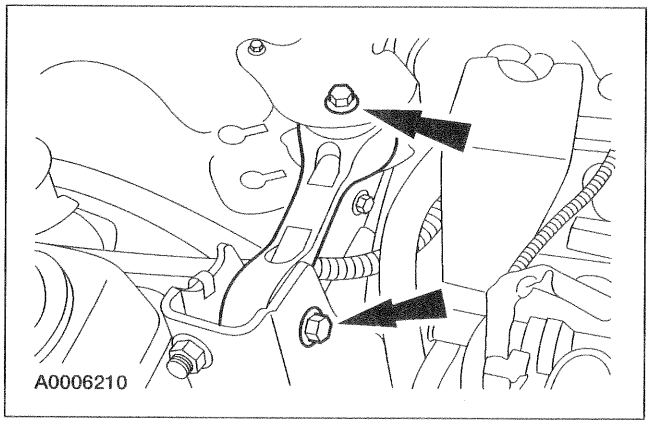
Item	Specification
Pipe Sealant with Teflon® D8AZ-19554-A or equivalent	WSK-M2G350-A2

Removal

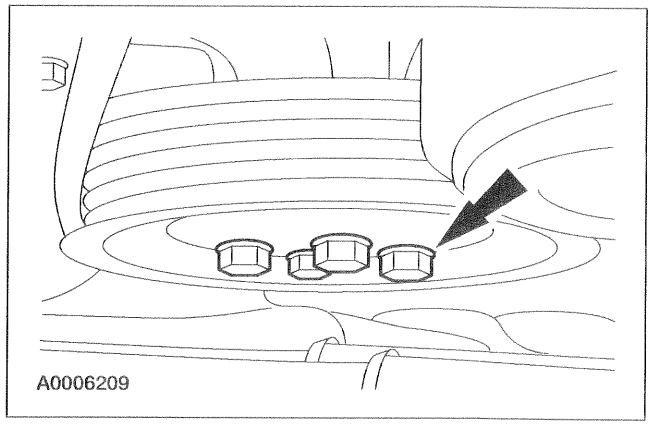
1. Drain the engine coolant. For additional information, refer to Section 303-03.
2. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.
3. Remove the engine anti-roll strut brace.
   - Remove the nuts.
   - Remove the brace.



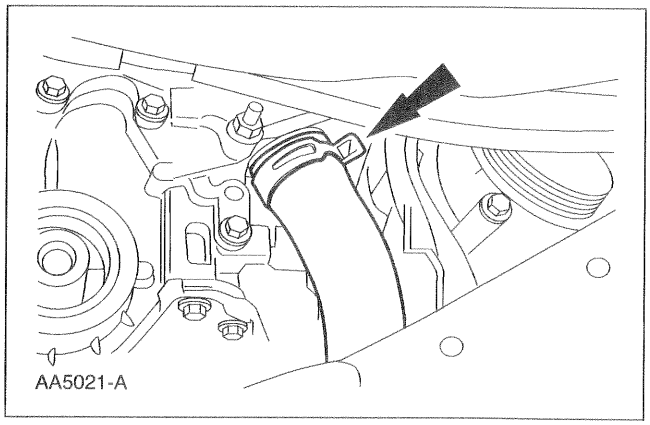
4. Remove the engine anti-roll strut.
   - Remove the bolts.



5. Remove the coolant expansion tank (8A080). For additional information, refer to Section 303-03.
6. Loosen the four water pump pulley bolts.

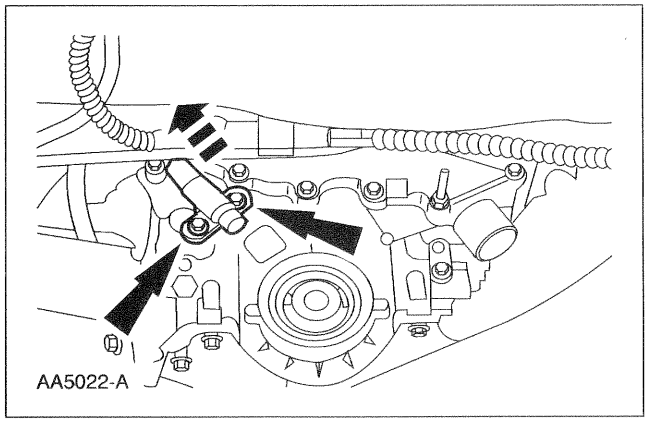


7. Remove the crankshaft damper (6316). For additional information, refer to Crankshaft Pulley in this section.
8. Disconnect the lower radiator hose.
   - Reposition the clamp.
   - Disconnect the hose.



IN-VEHICLE REPAIR (Continued)

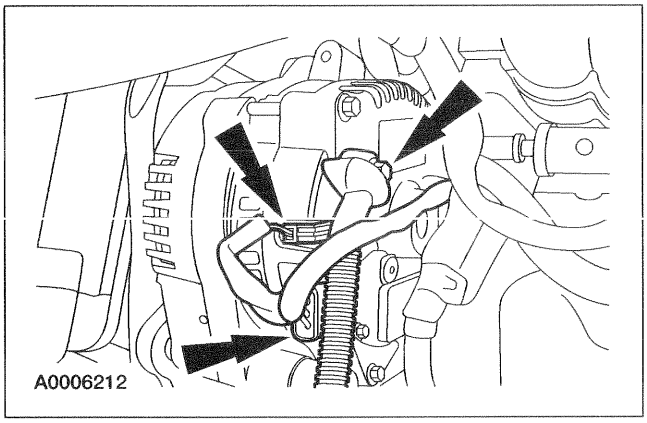
9. Remove the crankshaft position (CKP) sensor (6C315).
   - Disconnect the sensor.
   - Remove the bolts.
   - Remove the sensor.



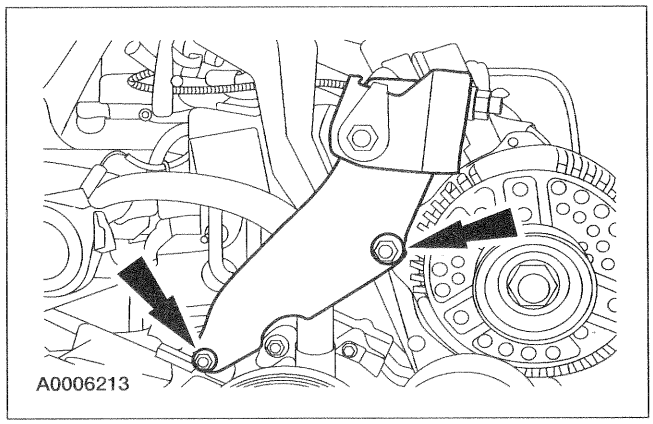
10. Remove the oil pan. For additional information, refer to Oil Pan in this section.

11. Lower the vehicle.

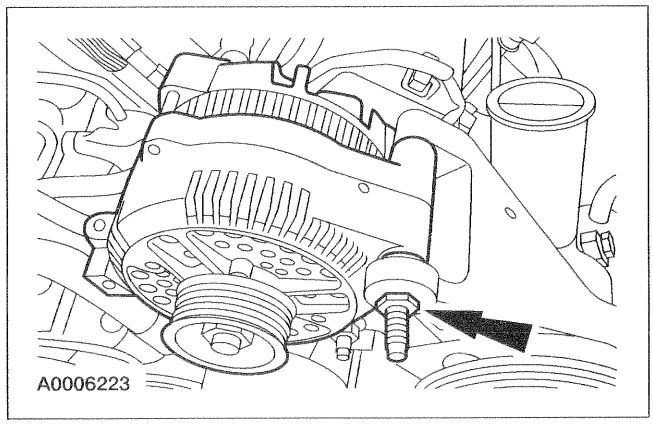
12. Disconnect the generator (10346).



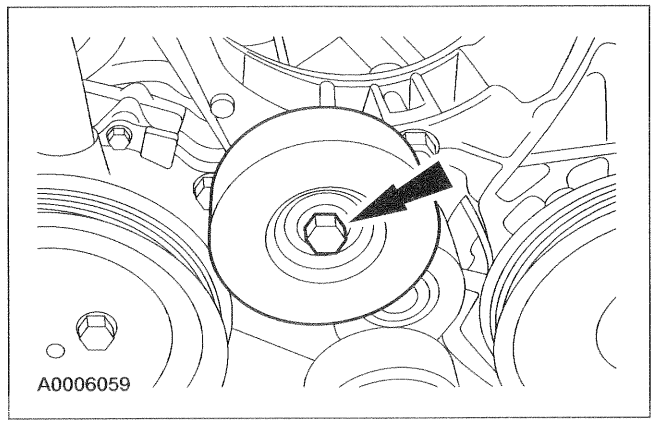
13. Remove the generator support bracket.
    - Remove the nut.
    - Remove the bolt.



14. Remove the generator.
    - Remove the stud bolt.

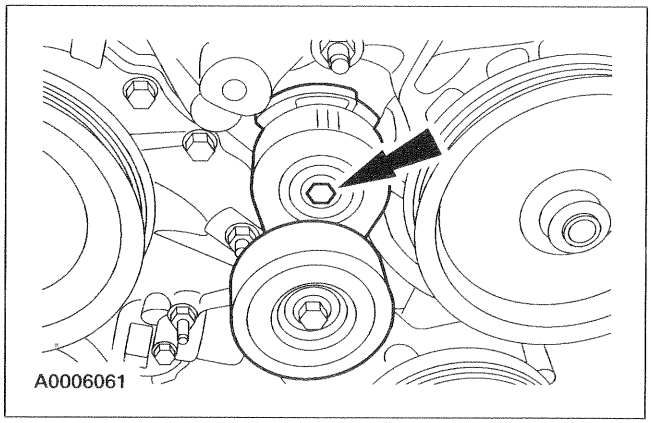


15. Remove the accessory drive belt idler pulley.
    - Remove the bolt.

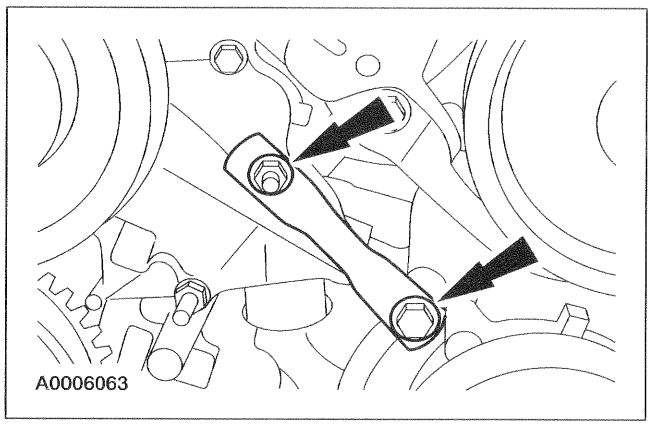


IN-VEHICLE REPAIR (Continued)

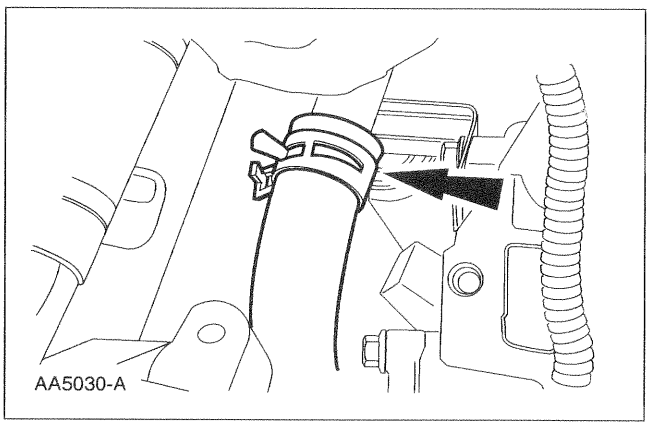
16. Remove the accessory drive belt tensioner (6B209).
    - Remove the bolt.



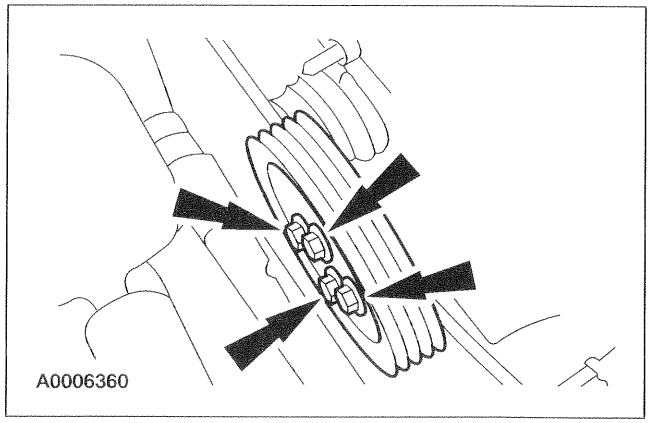
17. Remove the A/C compressor bracket.
    - Remove the nut.
    - Remove the bolt.



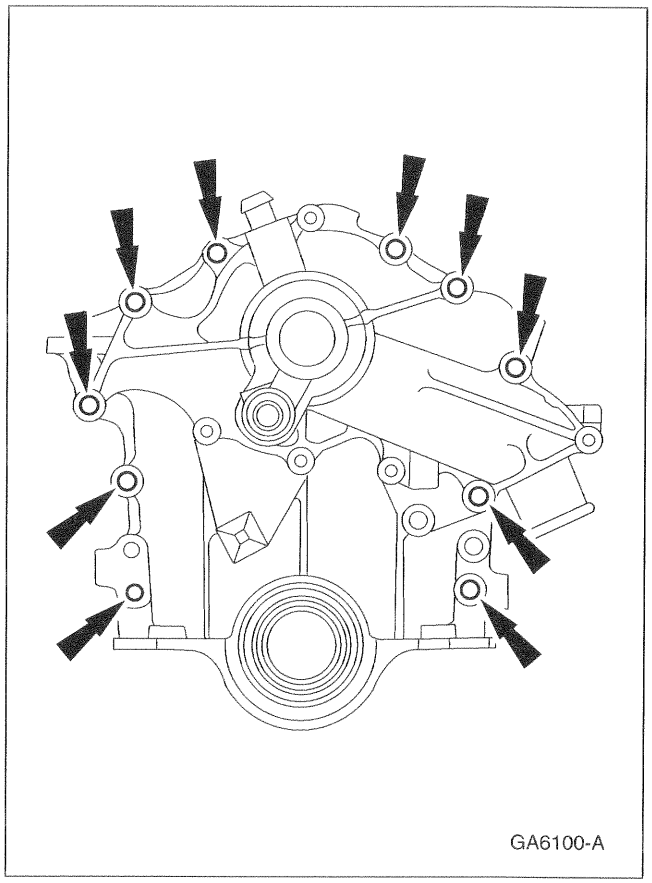
18. Disconnect the heater hose (18472).
    - Reposition the clamp.
    - Disconnect the hose.



19. Remove the water pump pulley (8509).
    - Remove the bolts.
    - Remove the pulley.

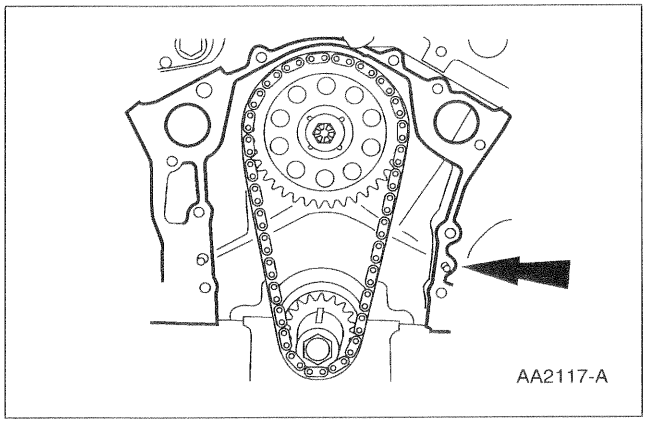


20. Remove the engine front cover (6059) and water pump (8501) as an assembly.
    - Remove the bolts.
    - Remove the front cover.



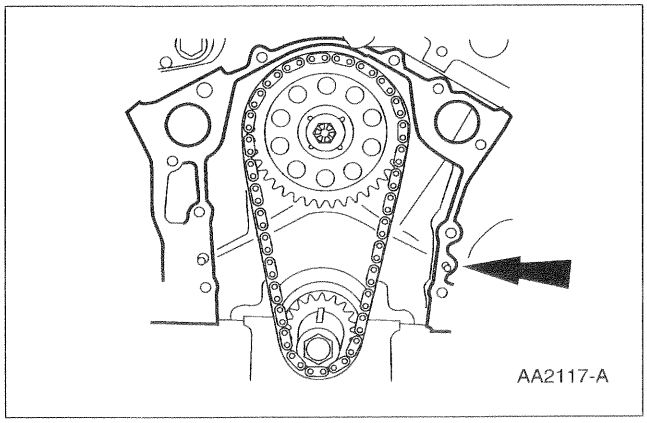
IN-VEHICLE REPAIR (Continued)

21. Remove and discard the front cover gasket (6020).

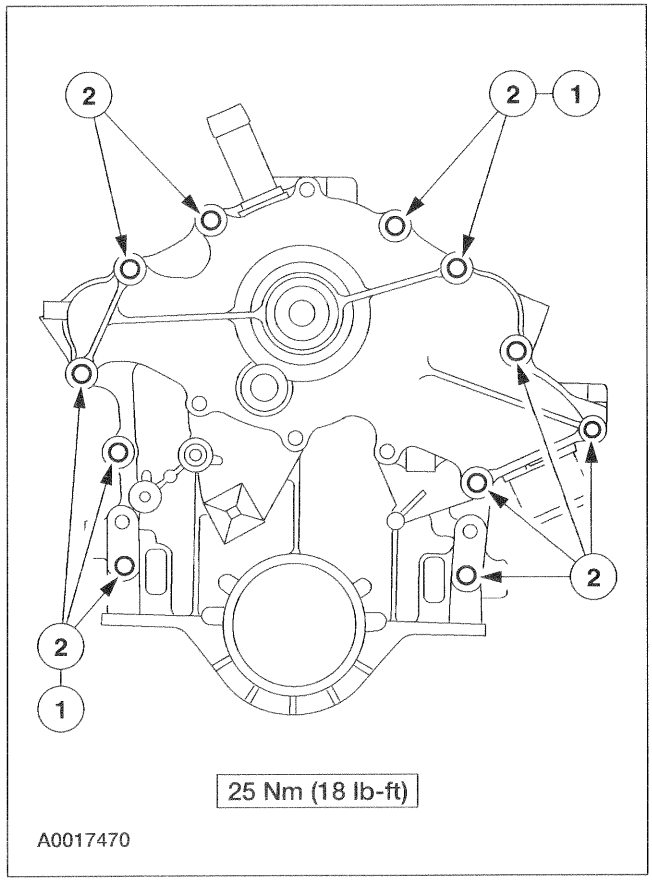


Installation

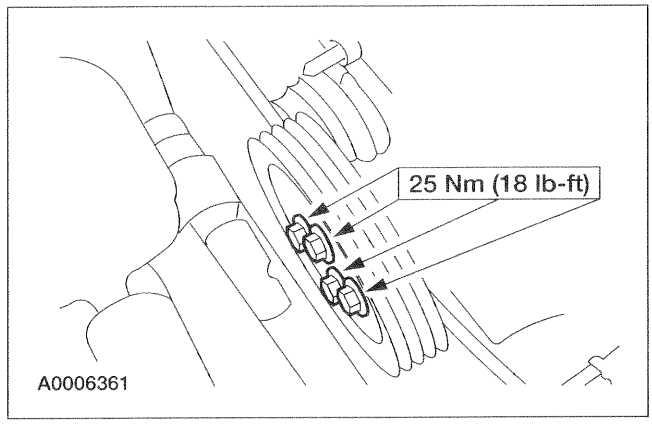
1. Clean all sealing surfaces and position a new front cover gasket.



2. Install the engine front cover and water pump assembly.
   1 Apply Pipe Sealant with Teflon® to the bolts indicated.
   2 Install the bolts.

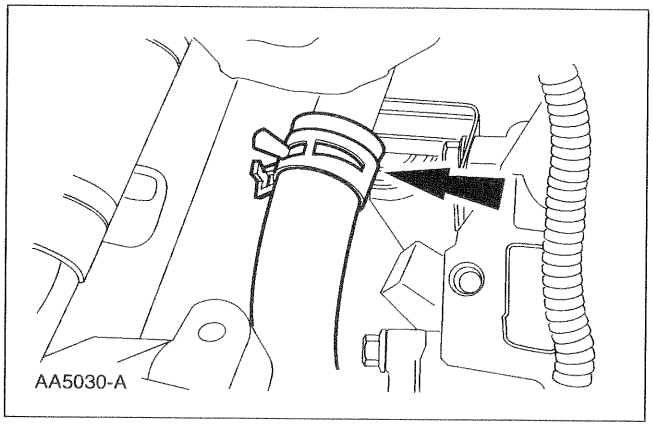


3. Install the water pump pulley.

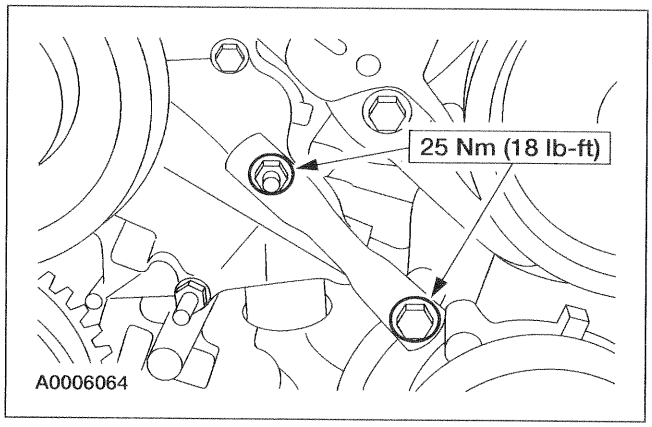


IN-VEHICLE REPAIR (Continued)

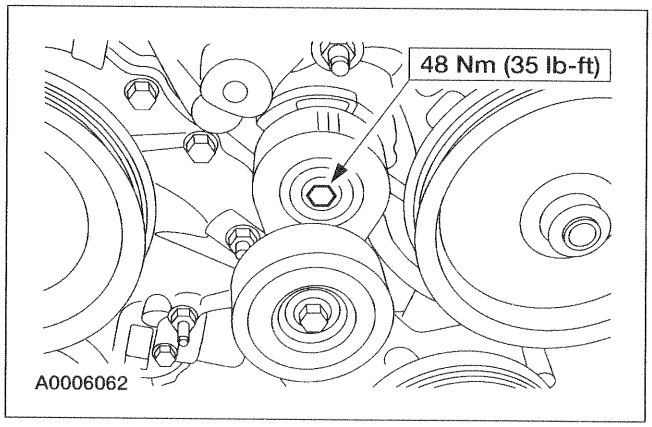
4. Connect the heater hose.
   - Connect the hose.
   - Position the clamp.



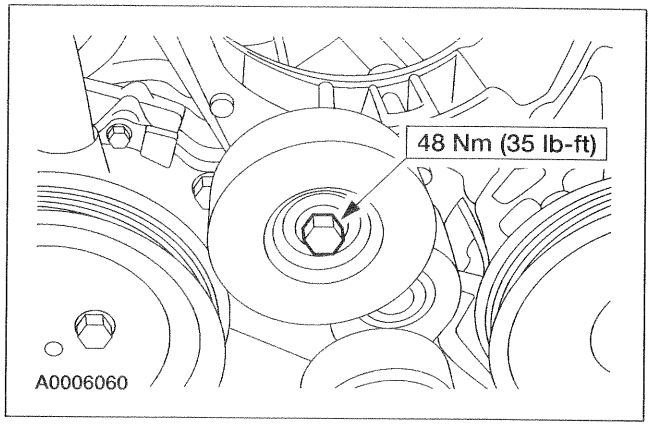
5. Install the A/C compressor bracket.
   - Position the bracket.
   - Install the bolt.
   - Install the nut.



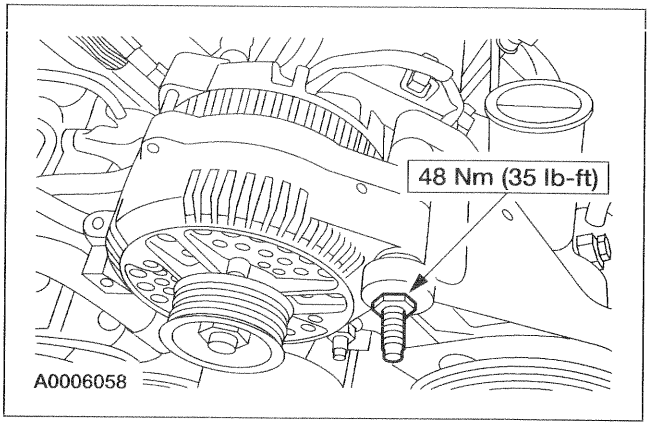
6. Install the accessory drive belt tensioner.



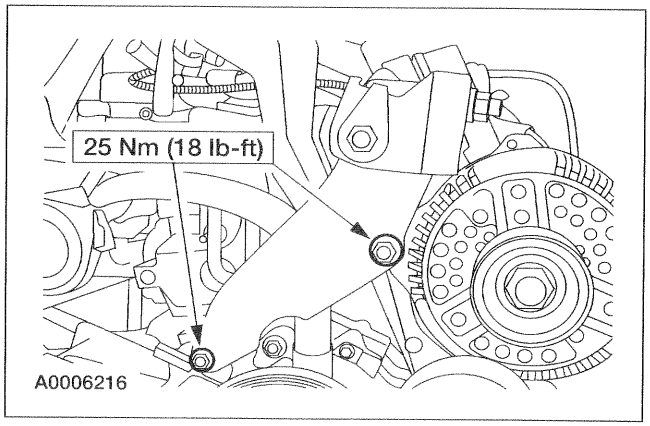
7. Install the accessory drive belt idler pulley.



8. Install the generator.
   - Install the stud bolt.

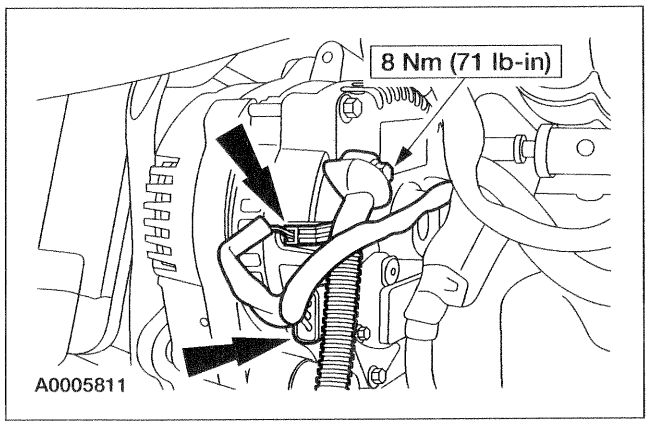


9. Install the generator support bracket.
   - Position the bracket.
   - Install the bolt.
   - Install the nut.



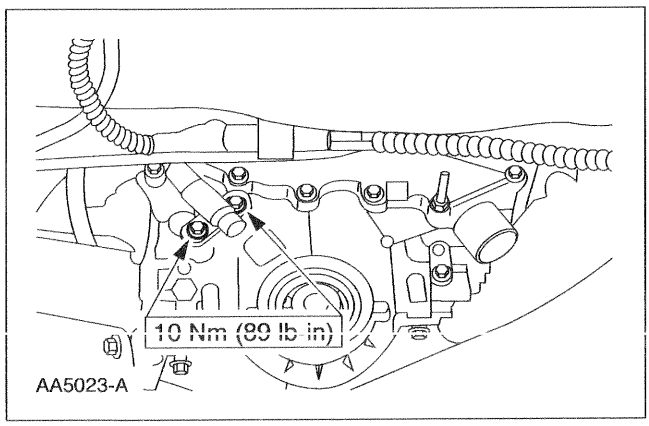
IN-VEHICLE REPAIR (Continued)

10. Connect the generator.

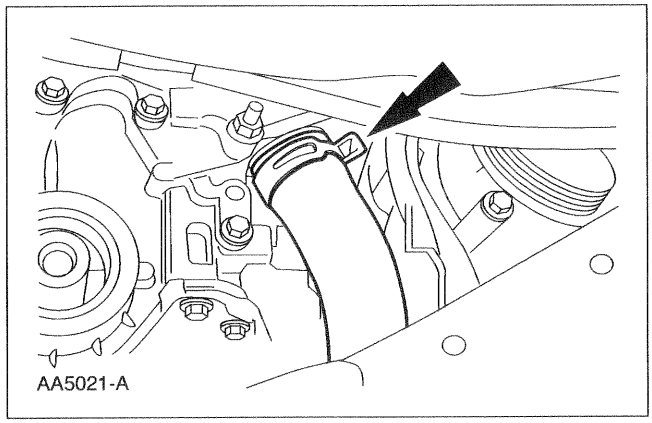


11. Raise the vehicle on a hoist. For additional information, refer to Section 100-02.

12. Install the crankshaft position (CKP) sensor.
    - Position the sensor.
    - Install the bolts.
    - Connect the connector.



13. Connect the lower radiator hose.
    - Connect the hose.
    - Reposition the clamp.

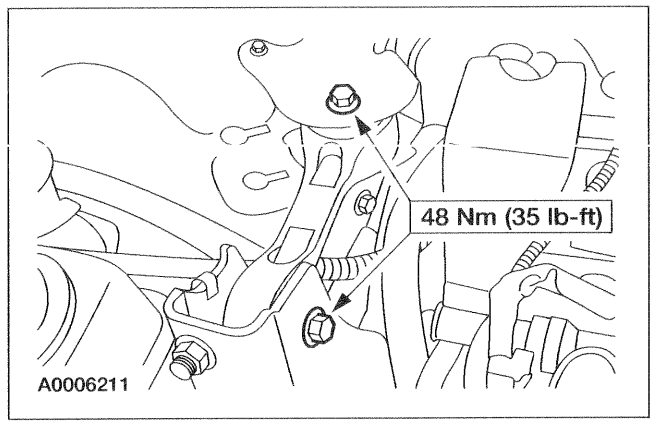


14. Install the oil pan. For additional information, refer to Oil Pan in this section.

15. Install the crankshaft damper. For additional information, refer to Crankshaft Pulley in this section.

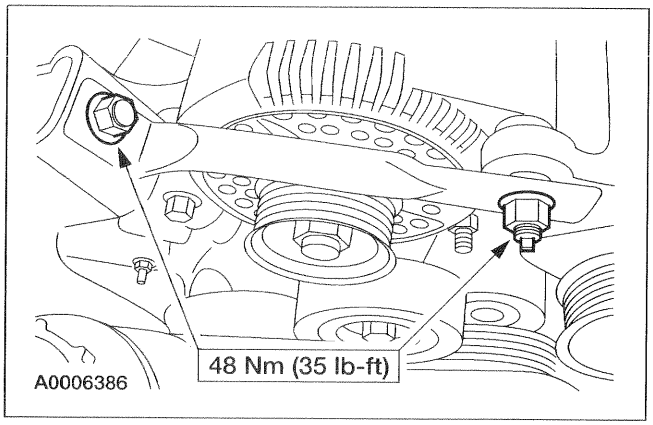
16. Install the coolant expansion tank. For additional information, refer to Section 303-03.

17. Install the engine anti-roll strut.



IN-VEHICLE REPAIR (Continued)

18. Install the engine anti-roll strut brace.



19. Connect the battery.

20. Fill and bleed the cooling system. For additional information, refer to Section 303-03.

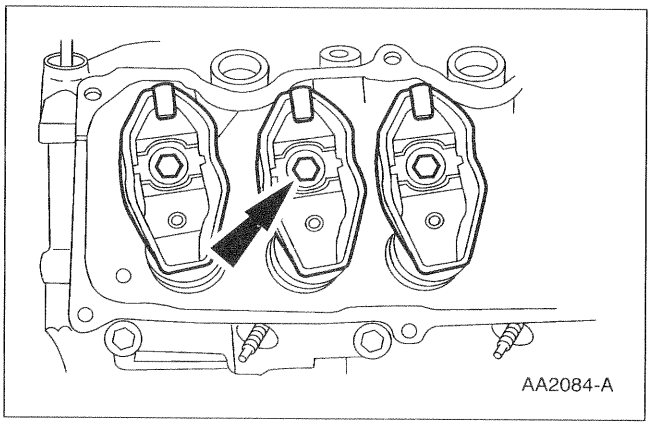
Rocker Arm

Removal and Installation

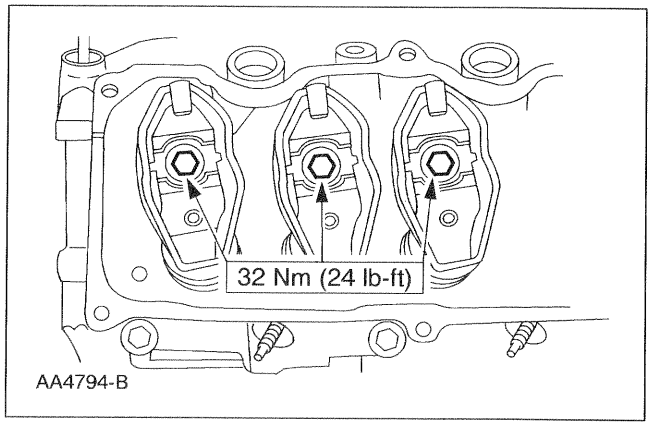
1. Remove the LH and the RH valve covers. For additional information, refer to Valve Cover LH and Valve Cover RH in this section.

2. **NOTE:** Identify the location of each rocker arm. Each rocker arm must be installed in the original location.

   Remove the bolts and the rocker arms.



3. To install, reverse the removal procedure. Tighten the rocker arm bolts in two stages.
   - Stage 1: Tighten to 10 Nm (89 lb-in).
   - Stage 2: Tighten to 32 Nm (24 lb-in).



Push Rod

Removal and Installation

1. Remove the rocker arms. For additional information, refer to Rocker Arm in this section.

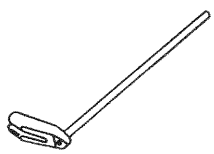
2. **NOTE:** Identify the location of each push rod. Each push rod must be installed in the original location.

   Remove the push rods.

3. To install, reverse the removal procedure.

Valve Seals

Special Tool(s)

 ST1383-A	Compressor, Valve Spring 303-163 (T81P-6513-A)

Removal and Installation

1. Remove the rocker arms. For additional information, refer to Rocker Arm in this section.

IN-VEHICLE REPAIR (Continued)

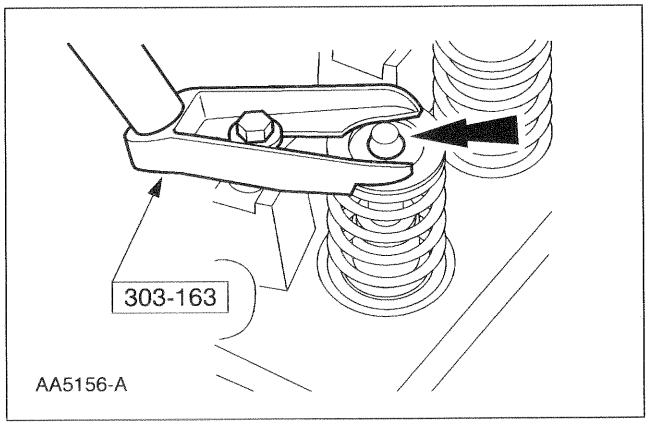
2. Rotate the crankshaft until the piston for the valve being worked on is at the top of its stroke with both the intake valve and the exhaust valve closed.

3. ⚠ **CAUTION: If the components are to be reinstalled, they must be installed in the same position. Mark the components for location.**

   Hold the valve in the cylinder head.

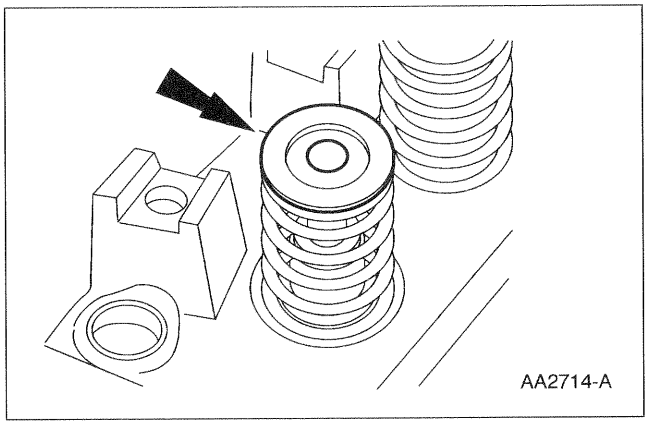
   - Remove the spark plug. For additional information, refer to Section 303-07A.
   - Apply a minimum of 689 kPa (100 psi) of compressed air to the cylinder.

4. Using the special tool, remove the valve spring retainer keys.



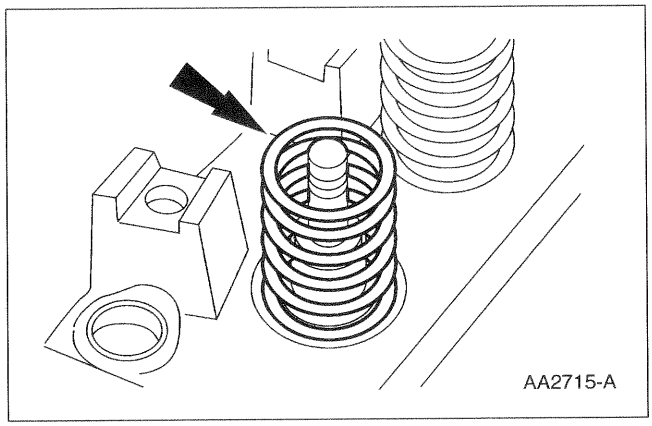
5. **NOTE:** Refer to Section 303-00 for valve spring retainer inspection

   Remove the valve spring retainer.

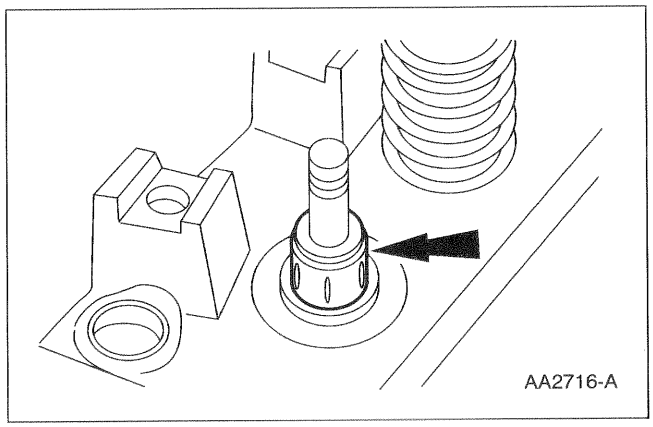


6. **NOTE:** Refer to Section 303-00 for valve spring inspection.

   Remove the valve spring.



7. Remove the valve stem seal.



8. To install, reverse the removal procedure.

Hydraulic Lash Adjuster

Material

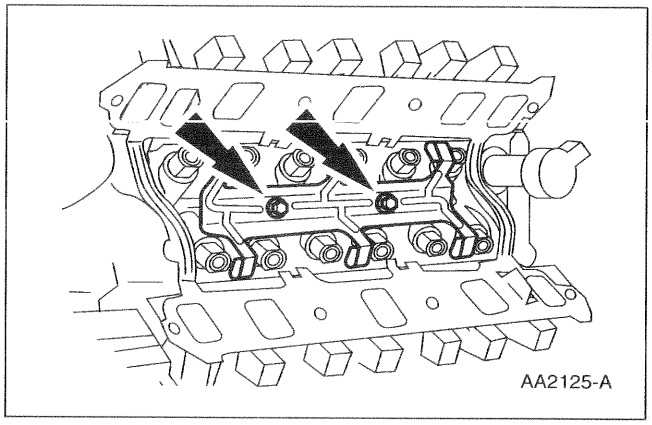
Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

IN-VEHICLE REPAIR (Continued)

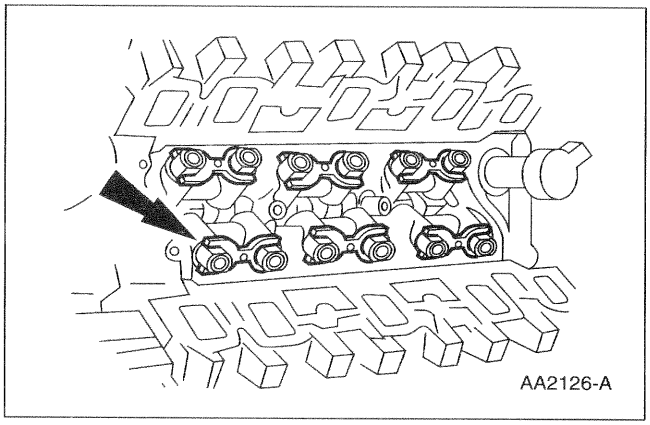
Removal

NOTE: For a valve train noise concern, inspect the valve-to-rocker arm clearance, rocker arms and push rods for wear. For additional information, refer to Section 303-00.

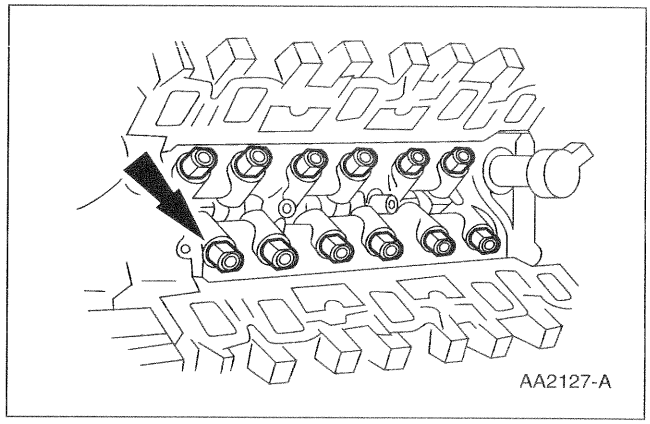
1. Remove the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.
2. Remove the pushrods. For additional information, refer to Push Rod in this section.
3. Remove the tappet guide plate retainer.



4. Remove the valve tappet guide plates.

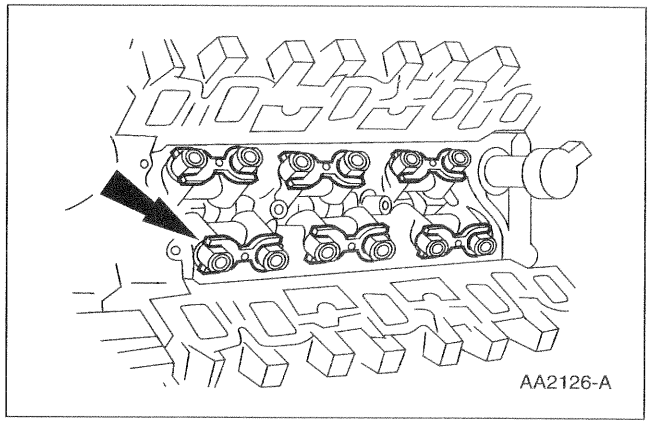


5. Remove the valve tappets.

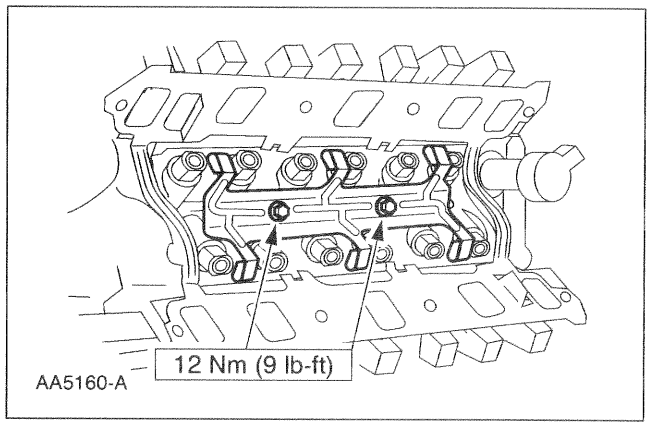


Installation

1. **NOTE:** Lubricate the valve tappets and the valve tappet bores with clean engine oil.
   Install the valve tappets.
2. Install the valve tappet guide plates.



3. Install the tappet guide plate retainer.



IN-VEHICLE REPAIR (Continued)

4. Install the pushrods. For additional information, refer to Push Rod in this section.

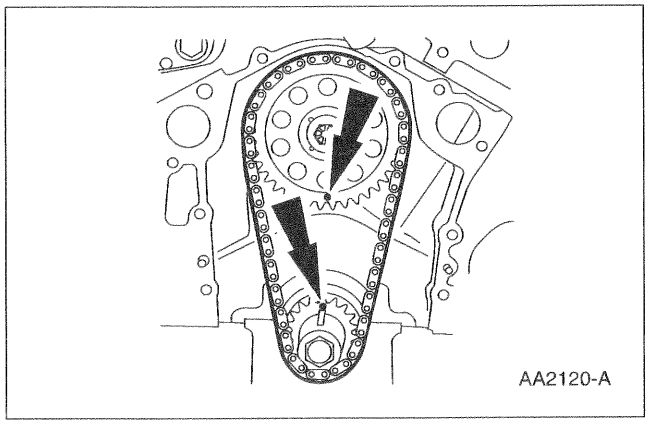
5. Install the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.

Timing Chain

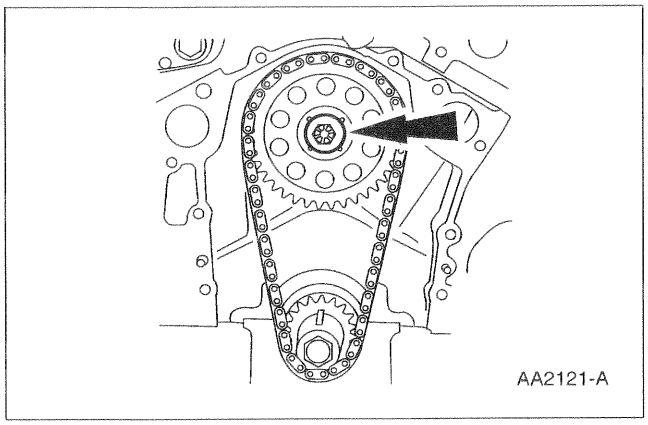
Removal

1. Remove the engine front cover. For additional information, refer to Engine Front Cover in this section.

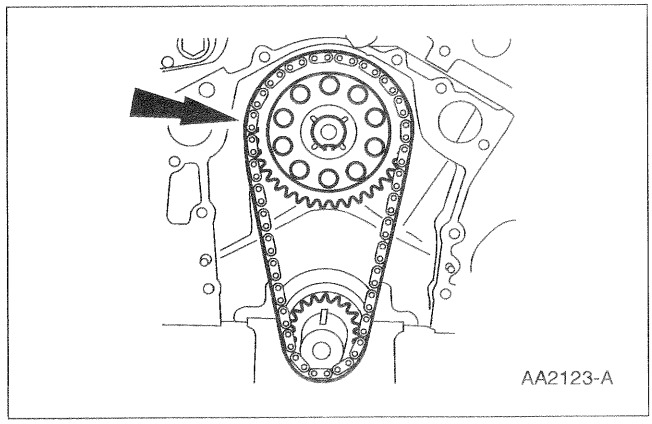
2. Rotate the crankshaft and align the timing marks.



3. Remove the camshaft sprocket bolt.

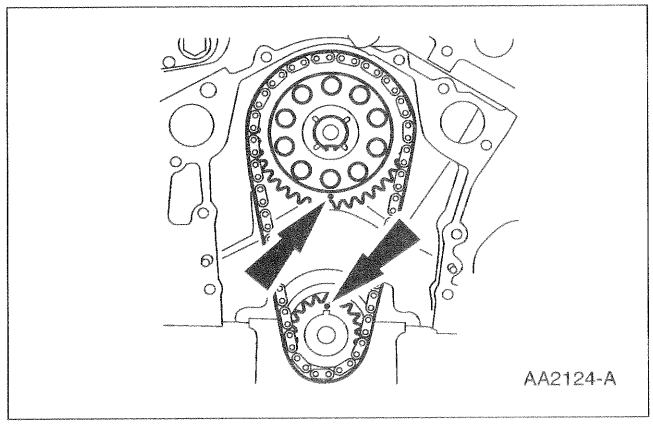


4. Remove the timing chain, the camshaft sprocket and the crankshaft sprocket as an assembly.

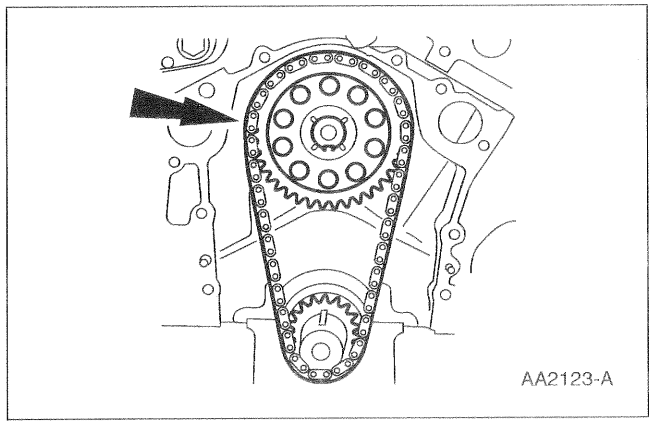


Installation

1. Align the timing marks.

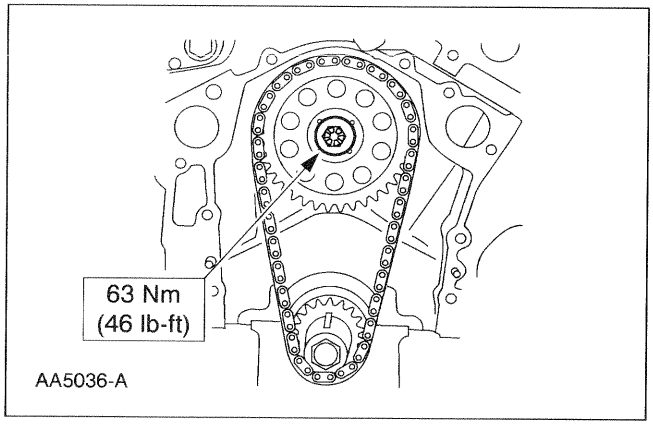


2. Install the timing chain, the camshaft sprocket and the crankshaft sprocket as an assembly.



IN-VEHICLE REPAIR (Continued)

3. Install the camshaft sprocket bolt.



4. Install the engine front cover. For additional information, refer to Engine Front Cover in this section.

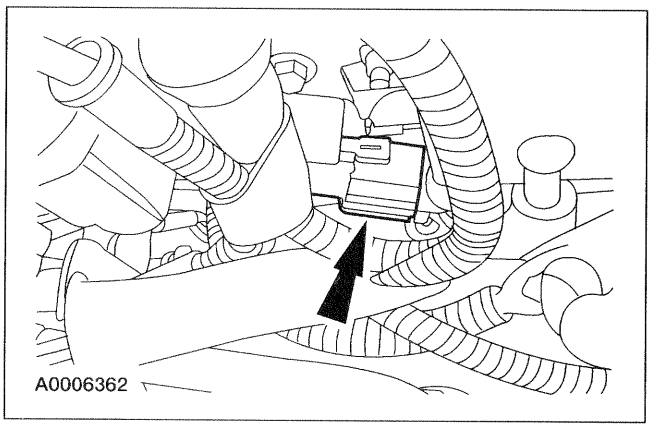
Exhaust Manifold — RH

Removal

1. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.

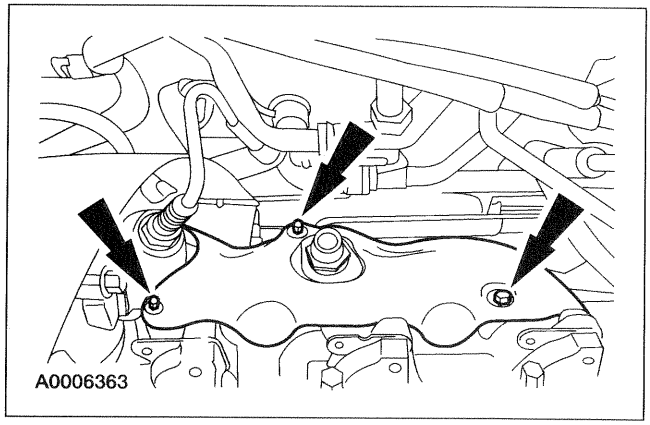
2. Remove the cowl vent screen and cowl extension. For additional information, refer to Section 501-02.

3. Disconnect the oxygen sensor (HO2S) (9F472) electrical connector.

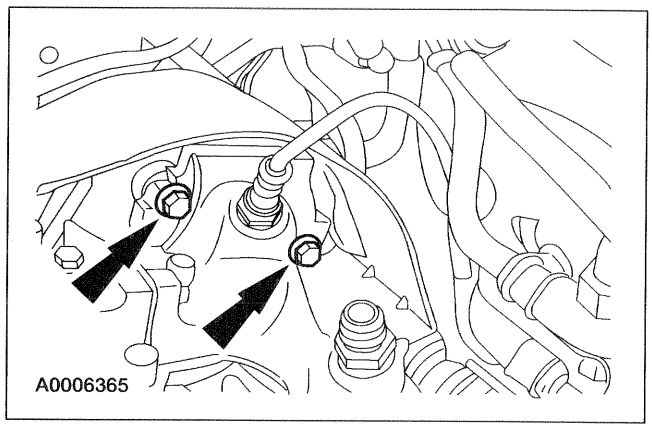


4. Remove the exhaust manifold to exhaust gas recirculation (EGR) valve tube. For additional information, refer to Section 303-08.

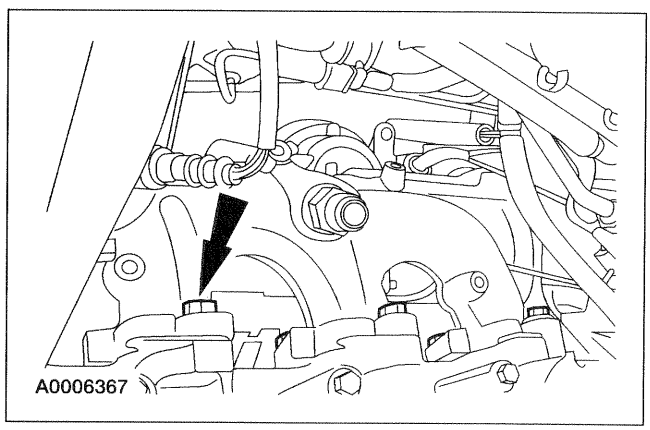
5. Remove the exhaust manifold heat shield.
   - Remove the bolts.
   - Remove the heat shield.



6. Disconnect the catalytic converter from the exhaust manifold.
   - Remove the bolts.

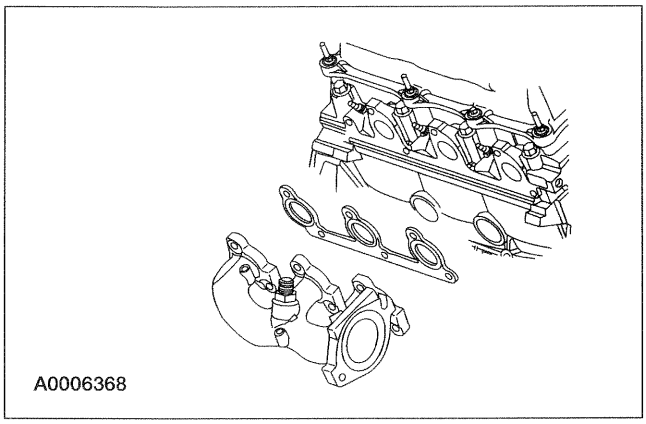


7. Remove the six bolts and the exhaust manifold.
   - Remove the six bolts.



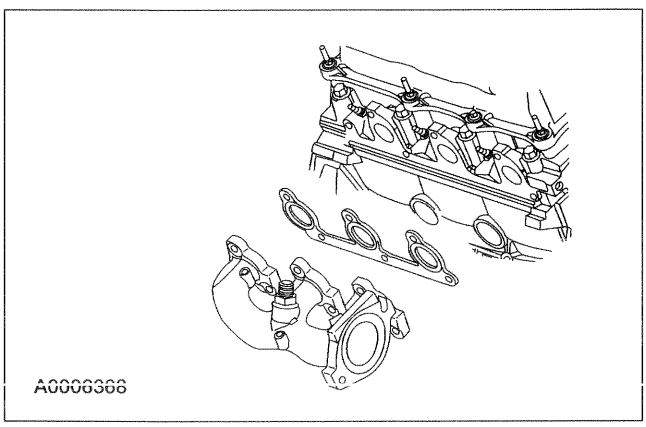
IN-VEHICLE REPAIR (Continued)

8. Remove the RH exhaust manifold (9430) and the exhaust manifold gasket (9448).
   - Discard the exhaust manifold gasket.

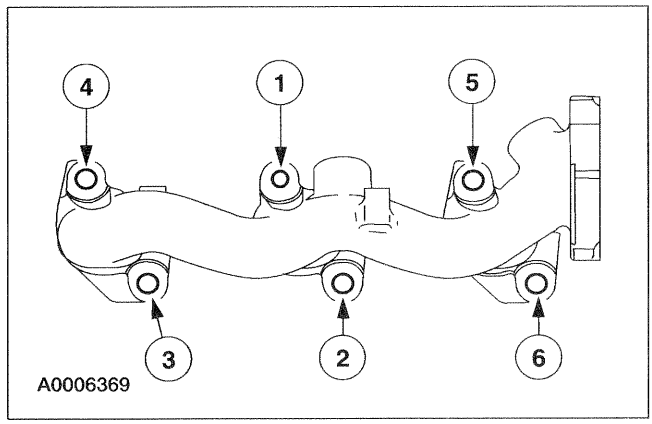


Installation

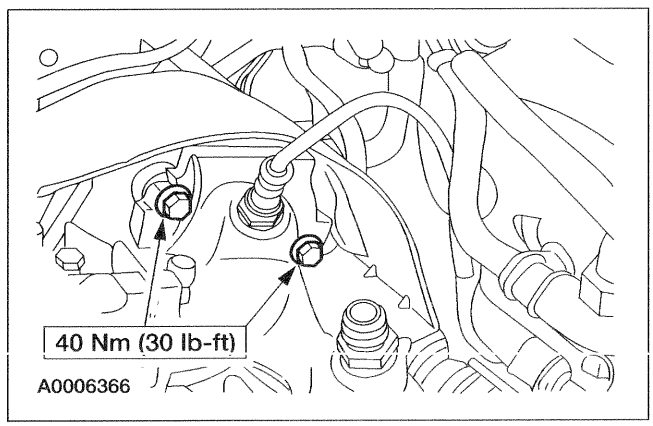
1. Position a new exhaust manifold gasket and install the exhaust manifold.



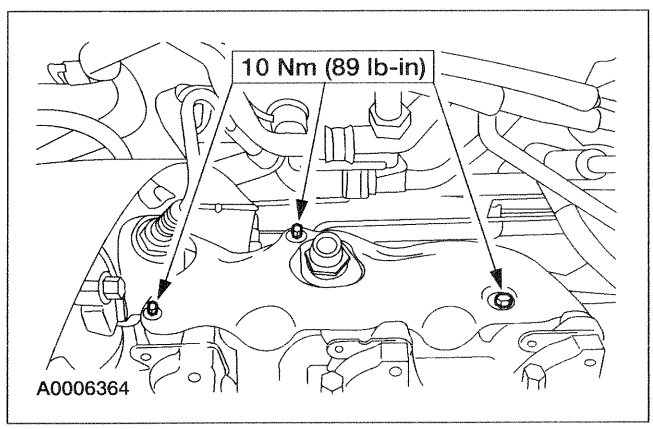
2. Install the bolts.
   - Tighten in the sequence shown, in two stages:
   1 Stage 1: Tighten to 10 Nm (89 lb-in).
   2 Stage 2: Tighten to 22 Nm (16 lb-ft).



3. Connect the catalytic converter.
   - Install the bolts.



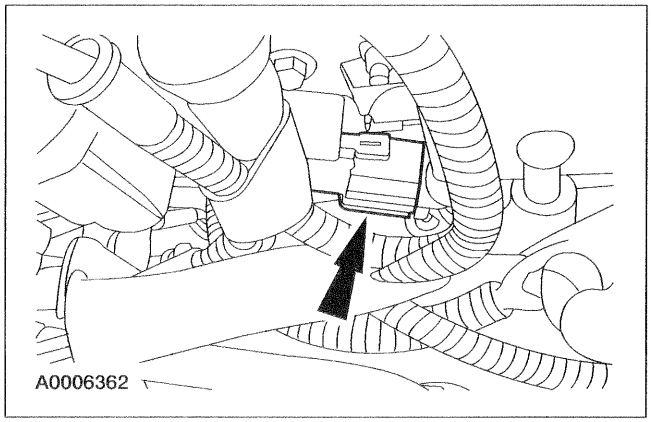
4. Install the exhaust manifold heat shield.
   - Install the bolts.



IN-VEHICLE REPAIR (Continued)

5. Install the exhaust manifold to exhaust gas recirculation (EGR) valve tube. For additional information, refer to Section 303-08.

6. Connect the HO2S electrical connector.

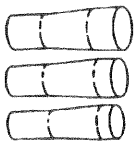


7. Install the cowl vent screen and cowl extension. For additional information, refer to Section 501-02.

8. Connect the battery ground cable.

Exhaust Manifold LH

Special Tool(s)

 ST1444-A	Teflon®Seal Replacer Set 211-D027 (D90P-3517-A) or equivalent

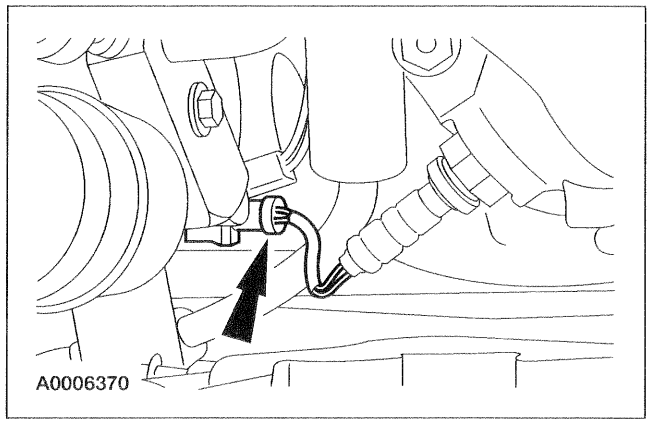
Material

Item	Specification
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

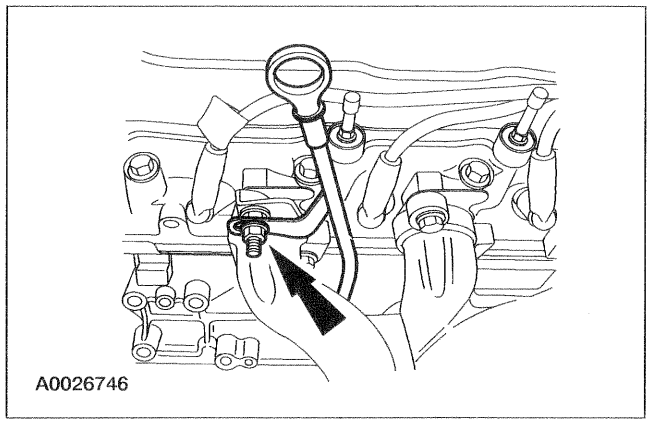
Removal

1. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.

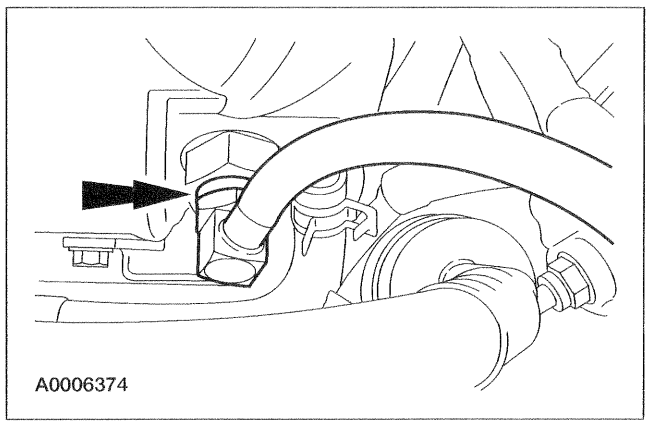
2. Disconnect the heated oxygen sensor (HO2S) (9F472) electrical connector.



3. Remove the oil level indicator tube (6754).
   - Remove the nut.
   - Remove the tube.

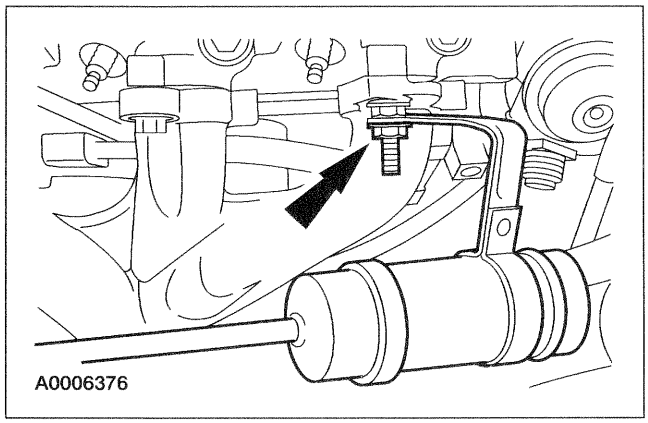


4. Disconnect the power steering pressure line (3A714) from the power steering pump.
   - Loosen the compression nut.

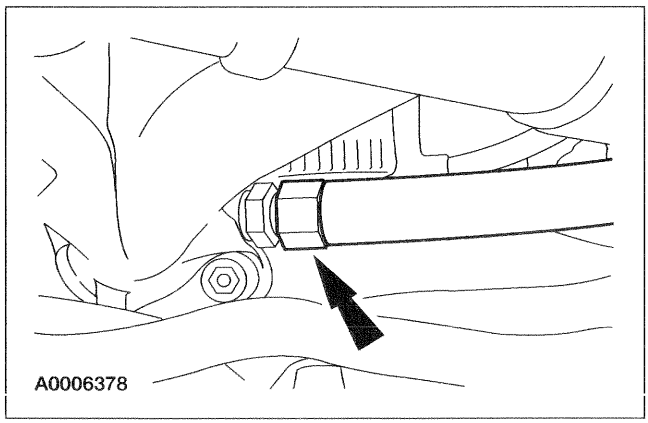


IN-VEHICLE REPAIR (Continued)

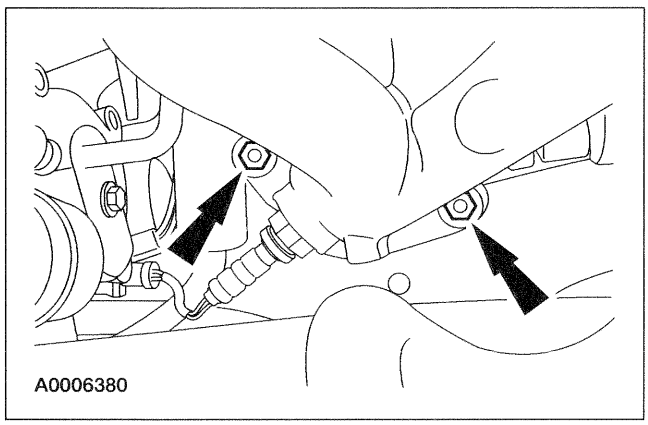
5. Position the power steering pressure line aside.
   - Remove the nut.



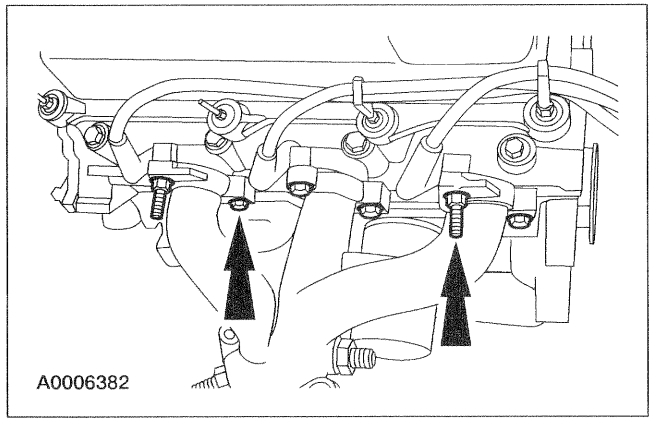
6. If equipped, disconnect the secondary air injection tube from the exhaust manifold (9431).
   - Loosen the compression nut.



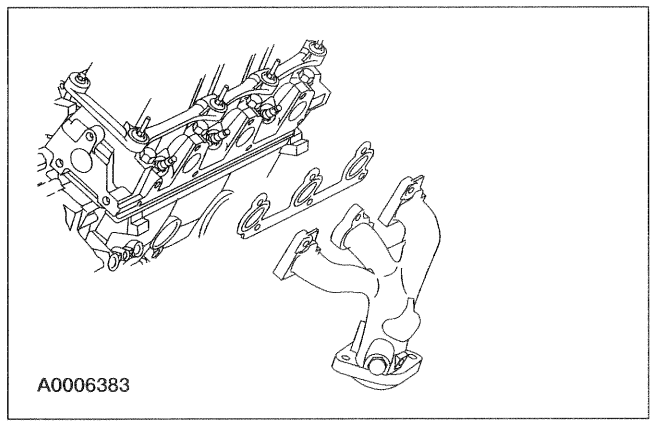
7. Separate the dual converter Y-pipe from the exhaust manifold.
   - Remove the nuts.



8. Remove the four exhaust manifold bolts and two stud bolts.

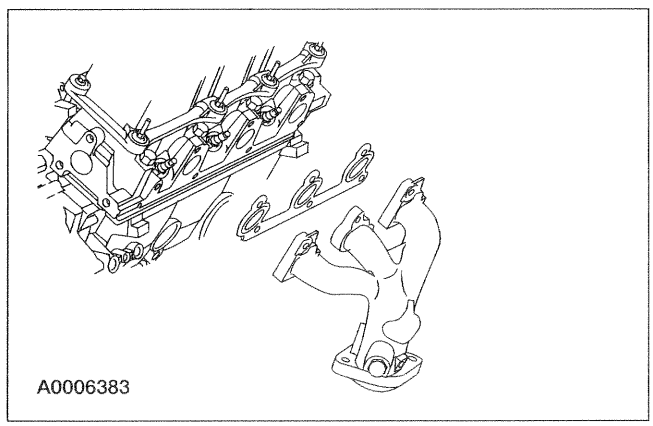


9. Remove the exhaust manifold and the exhaust manifold gasket (9448).
   - Discard the exhaust manifold gasket.



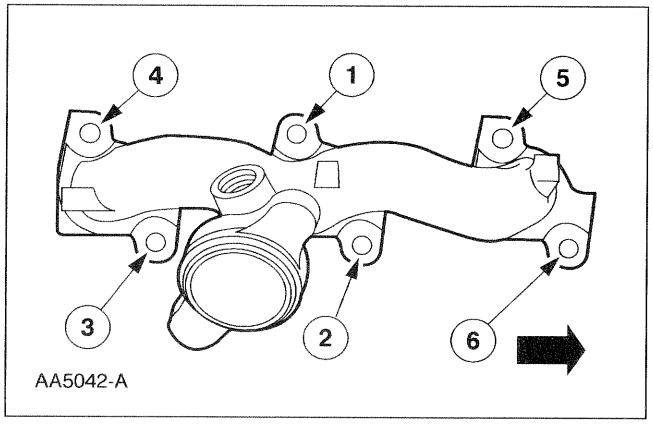
Installation

1. Position a new exhaust manifold gasket (9448) and install the exhaust manifold.

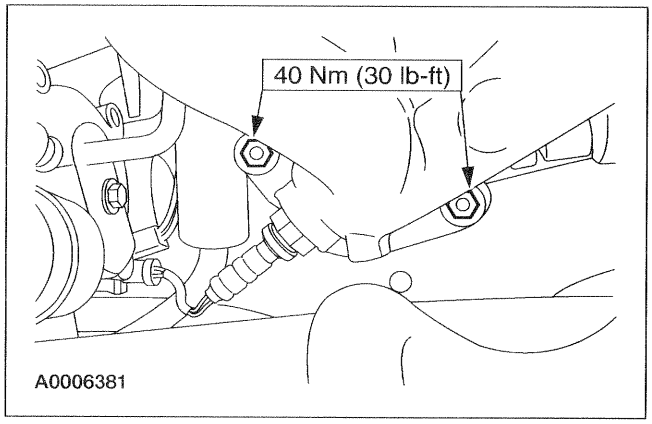


IN-VEHICLE REPAIR (Continued)

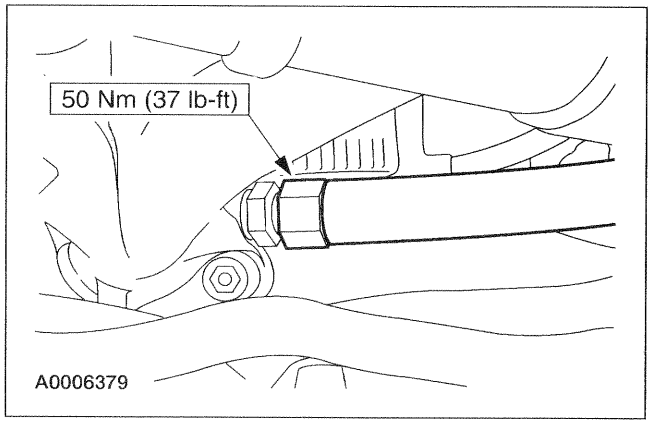
2. Install the bolts.
   - Tighten the bolts in sequence in two stages:
   1 Tighten to 10 Nm (8 lb-ft).
   2 Tighten to 22 Nm (16 lb-ft).



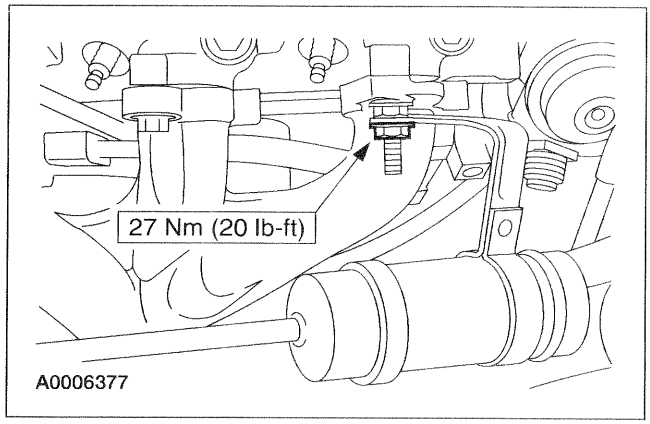
3. Connect the dual converter Y-pipe to the exhaust manifold.
   - Install the nuts.



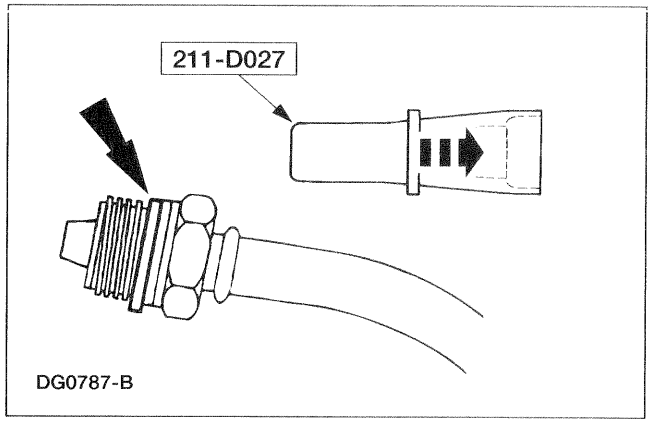
4. If equipped, connect the secondary air injection tube to the exhaust manifold.



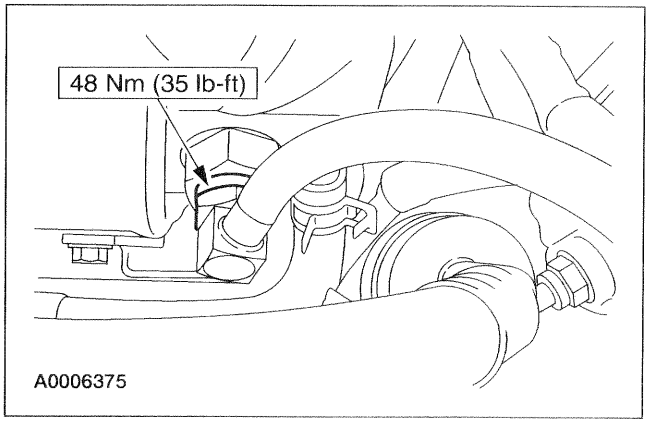
5. Reposition the power steering pressure line and install the nut.



6. Using the special tool, install a new seal on the power steering pressure line.

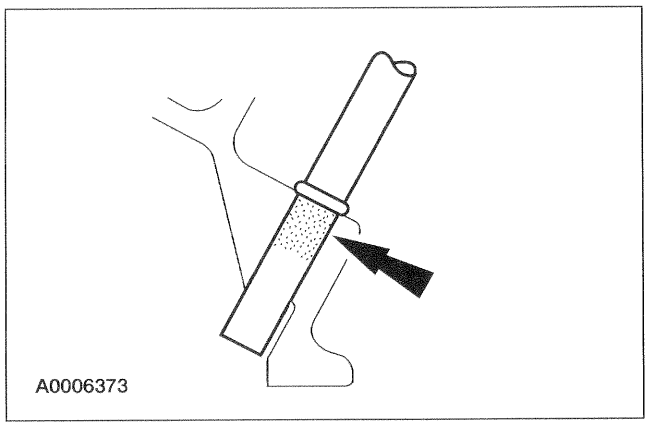


7. Connect the power steering pressure line to the power steering pump.

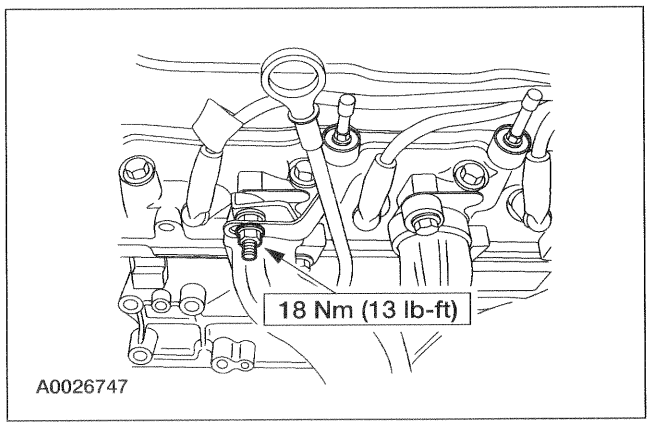


IN-VEHICLE REPAIR (Continued)

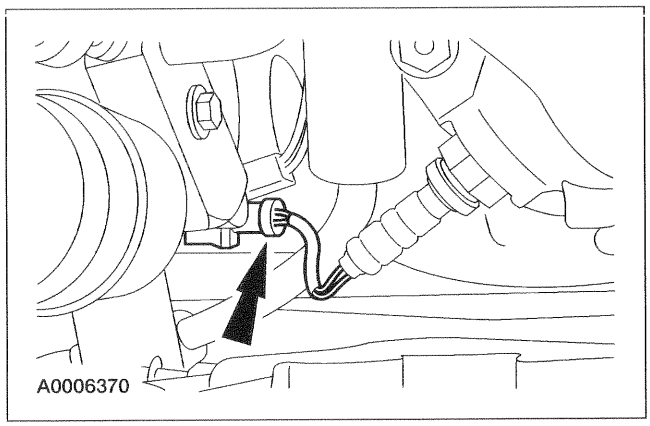
8. Coat the sealing surface of the oil level indicator tube with silicone gasket and sealant.



9. Install the oil level indicator tube.



10. Connect the HO2S electrical connector.



11. Connect the battery.

Cylinder Head RH

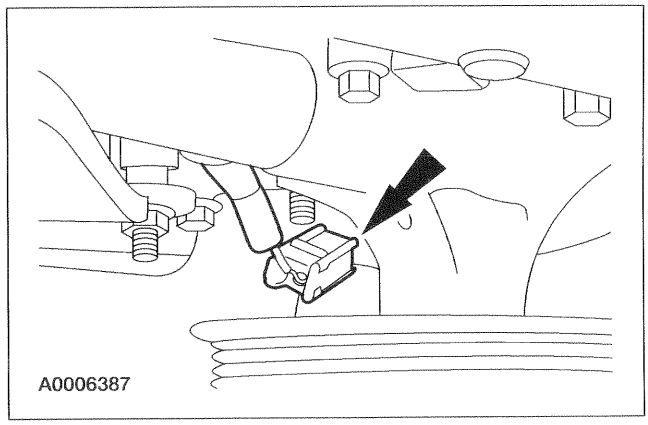
Material

Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A

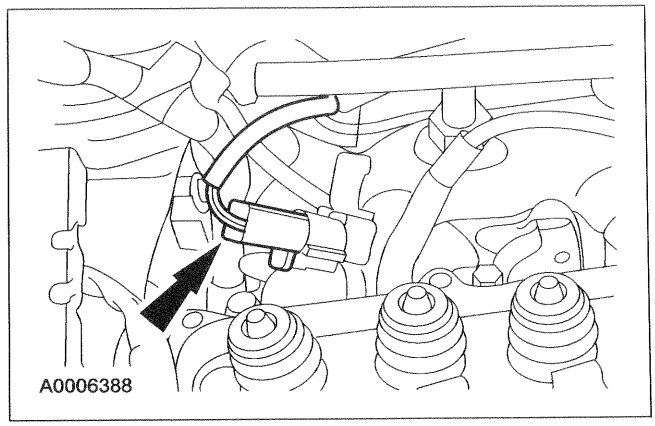
Removal

1. Remove the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.

2. Disconnect the crankshaft position (CKP) sensor electrical connector.

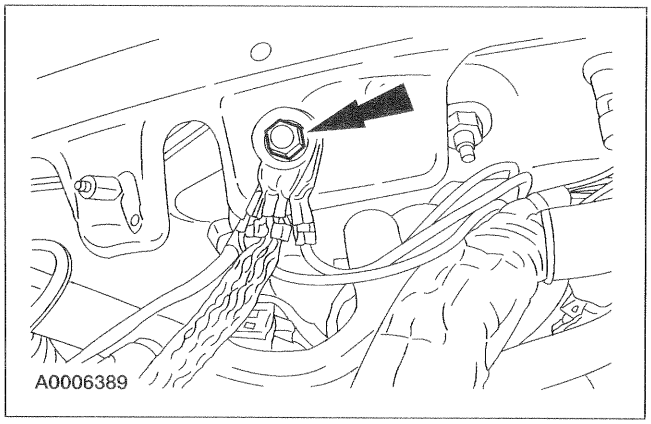


3. Disconnect the oxygen sensor (HO2S) electrical connector.

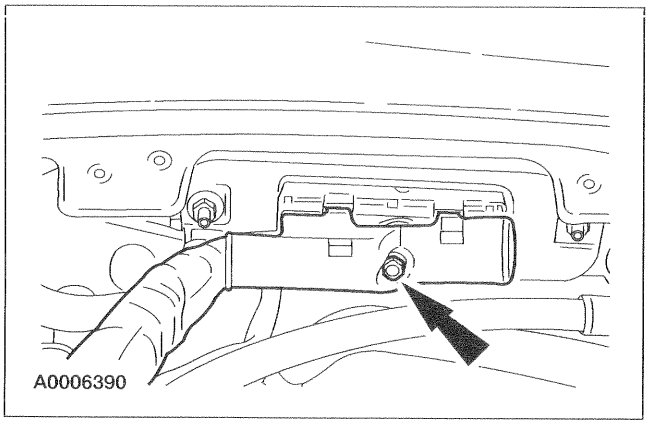


IN-VEHICLE REPAIR (Continued)

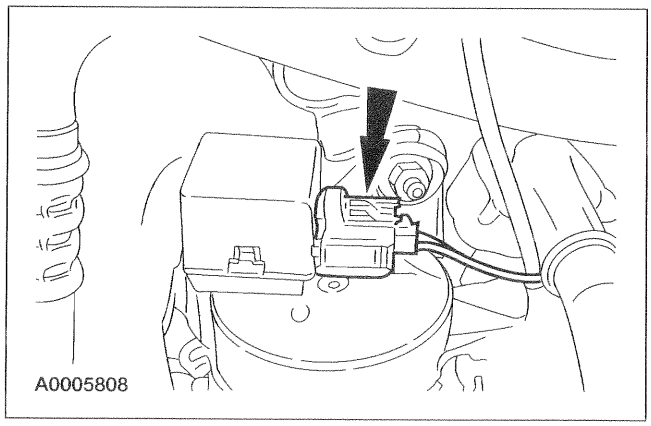
4. Remove the nut and disconnect the wiring harness ground connections.



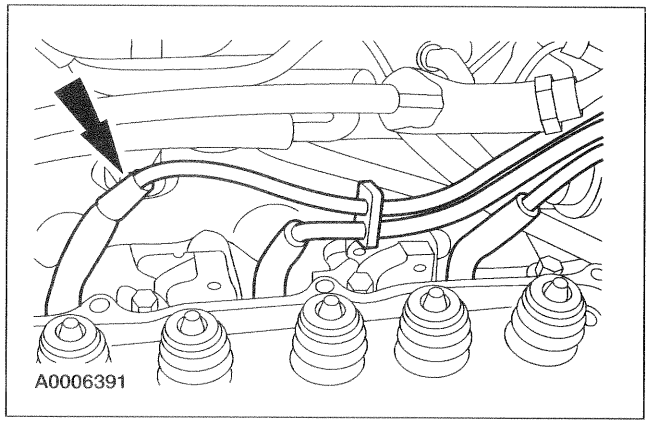
5. Loosen the bolt and disconnect the powertrain control module (PCM) electrical connector.



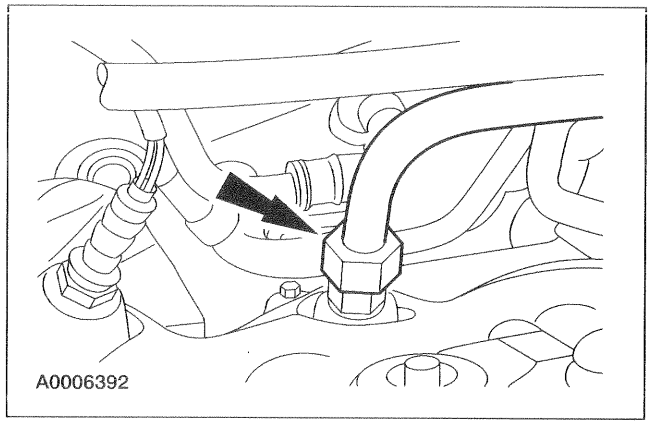
6. Disconnect the evaporative emissions (EVAP) canister purge valve electrical connector.



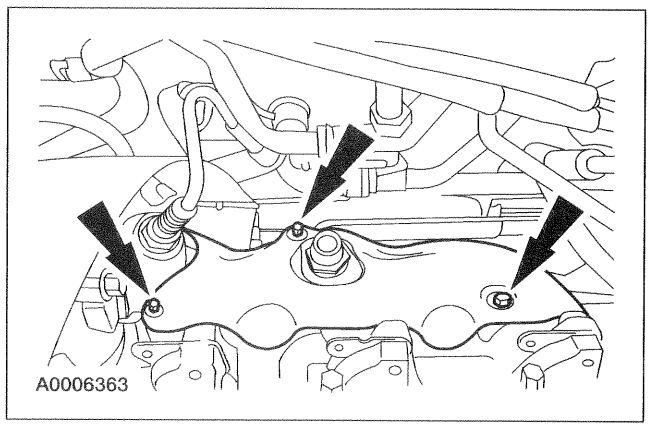
7. Disconnect the spark plug wires and position the wires aside.



8. Loosen the nut and disconnect the exhaust gas recirculation (EGR) tube.

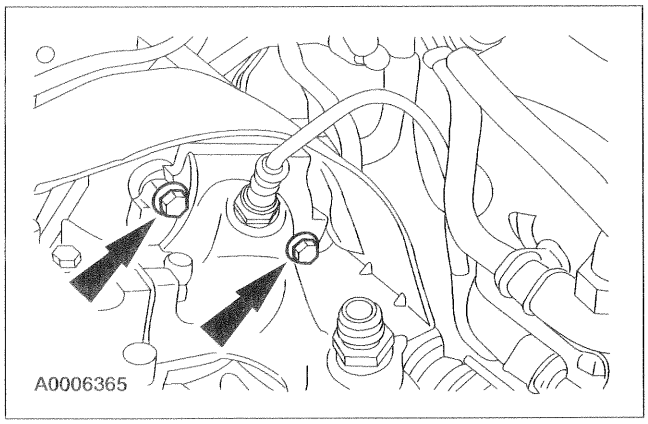


9. Remove the three bolts and the exhaust manifold heat shield.

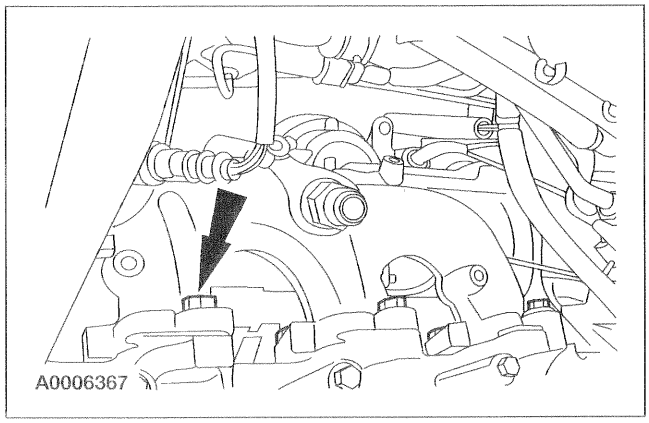


IN-VEHICLE REPAIR (Continued)

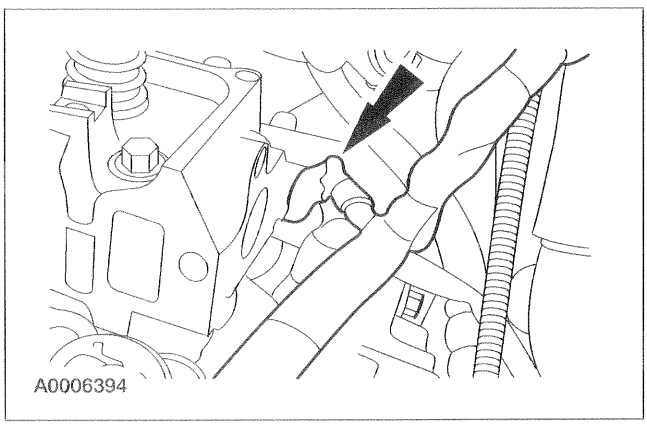
10. Loosen the exhaust manifold-to-catalytic converter bolts.



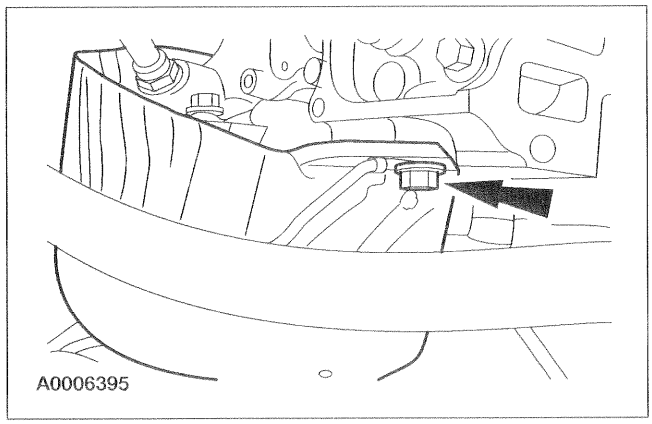
11. Remove the six exhaust manifold-to-cylinder head bolts.



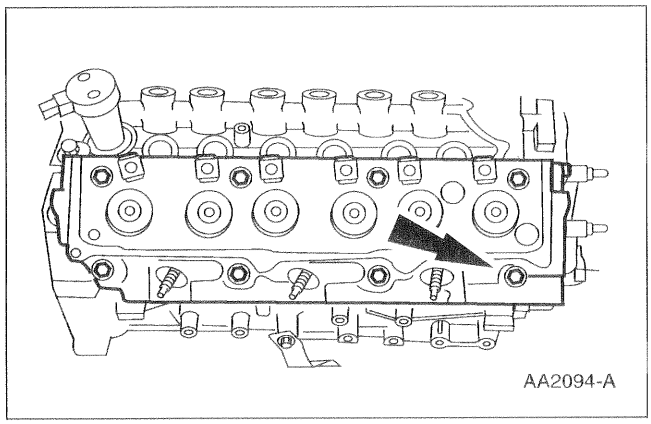
12. Disconnect the engine wire harness locator.



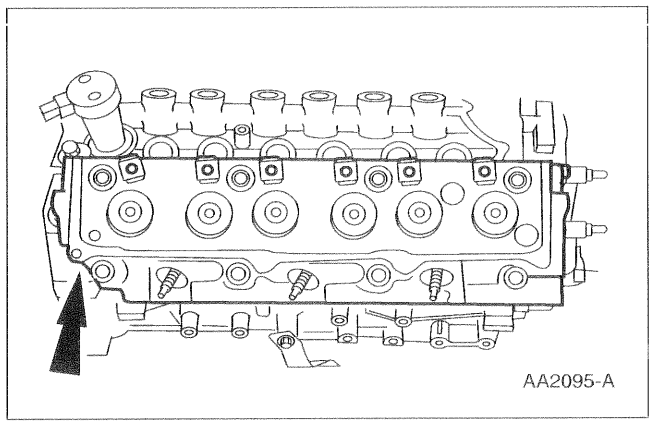
13. Remove the bolt and separate the catalytic converter heat shield from the cylinder head.



14. Remove the eight cylinder head bolts.

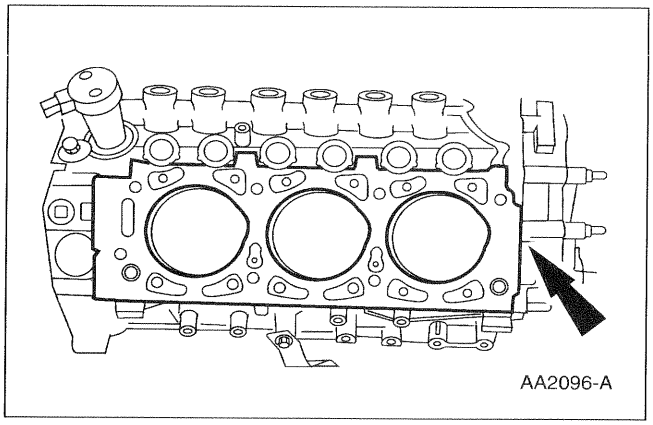


15. Remove the cylinder head.



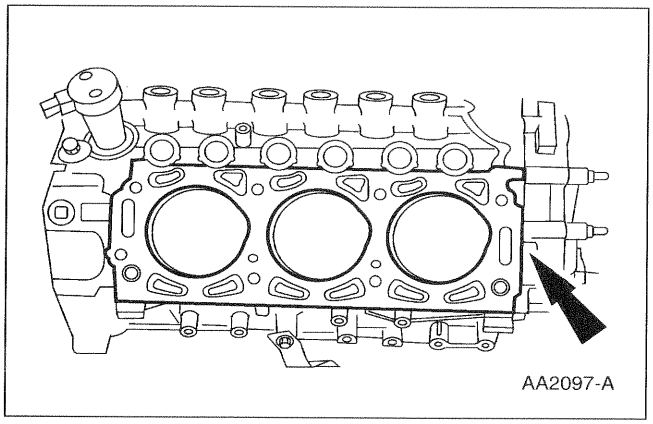
IN-VEHICLE REPAIR (Continued)

16. Remove and discard the head gasket.



Installation

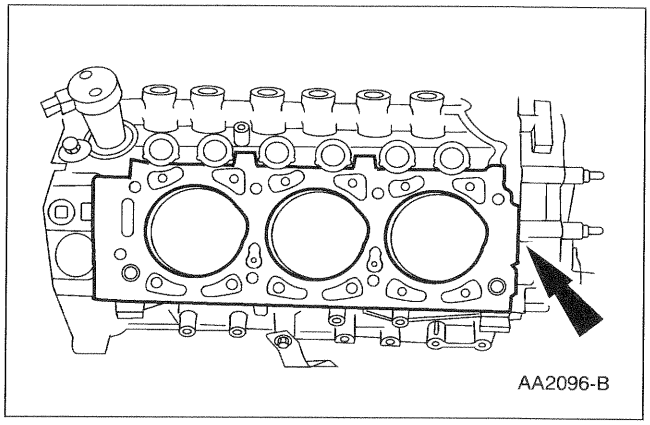
1. Using metal surface cleaner, clean the cylinder head sealing surfaces.



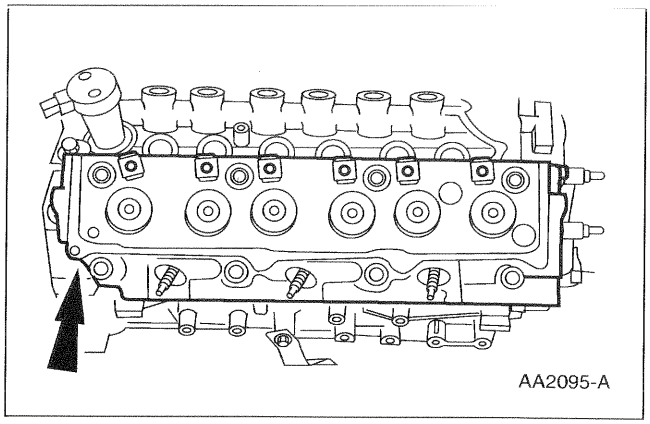
2. Check the cylinder head and cylinder block for flatness. For additional information, refer to Section 303-00.

3. **NOTE:** The "V" notch in the cylinder head gasket faces the front of the engine.

   Position a new cylinder head gasket.

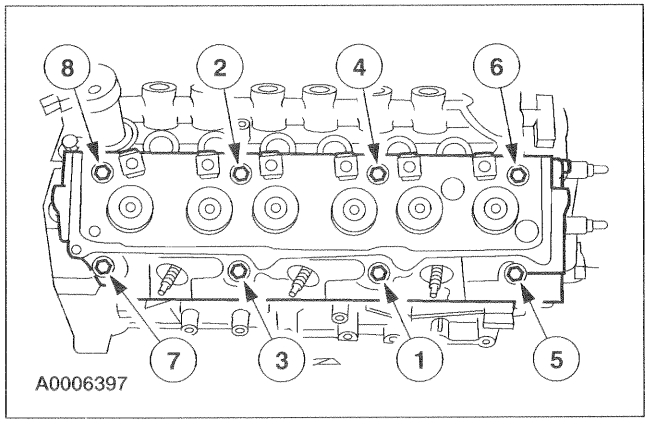


4. Position the cylinder head.

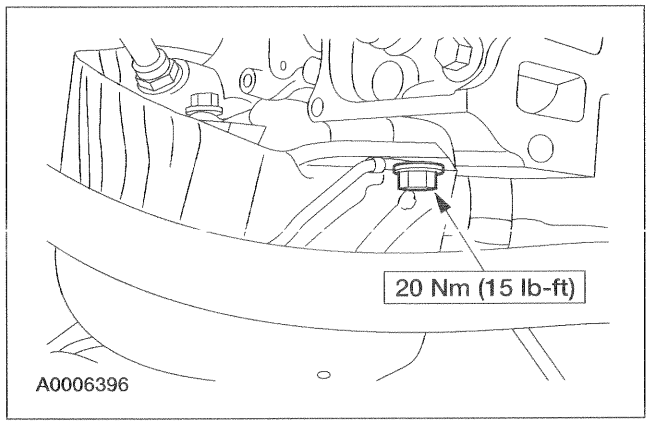


IN-VEHICLE REPAIR (Continued)

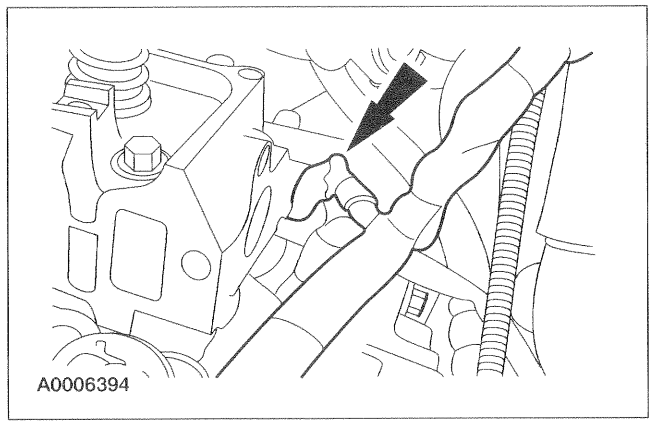
5. Install the bolts. Tighten the bolts in five stages in the sequence shown.
   - Stage 1: Tighten to 50 Nm (37 lb-ft).
   - Stage 2: Loosen the bolts one full turn.
   - Stage 3: Tighten to 30 Nm (22 lb-ft).
   - Stage 4: Rotate each bolt 90 degrees.
   - Stage 5: Rotate each bolt an additional 90 degrees.



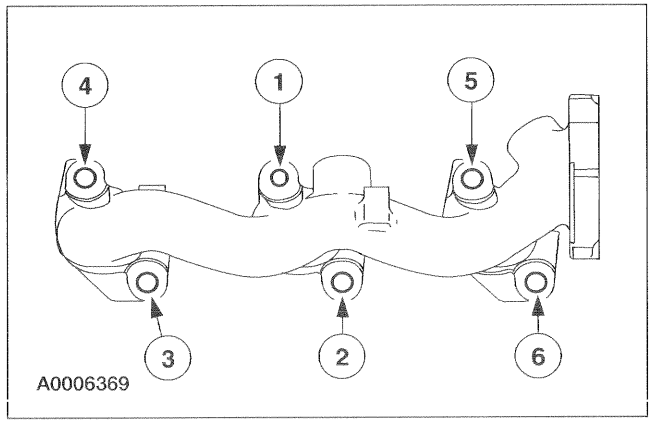
6. Install the catalytic converter heat shield and wire harness ground connection.



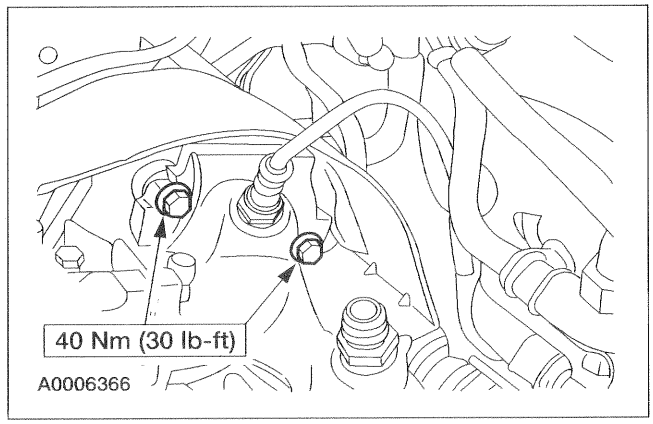
7. Position the wiring harness and install the harness locator.



8. Install the exhaust manifold. Tighten the bolts in two stages in the sequence shown.
   - Stage 1: Tighten to 10 Nm (89 lb-in).
   - Stage 2: Tighten to 22 Nm (16 lb-ft).

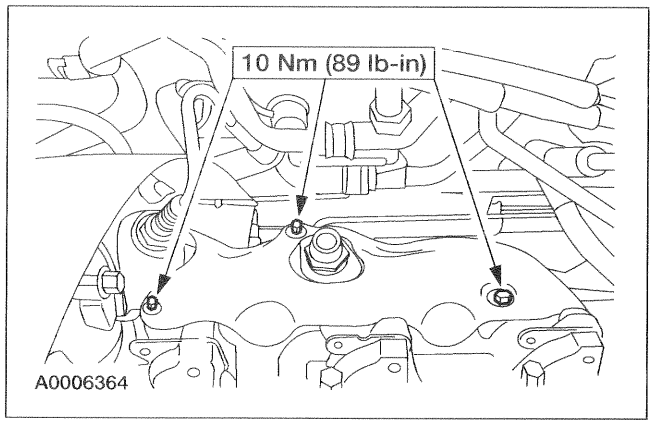


9. Tighten the exhaust manifold-to-catalytic converter bolts.

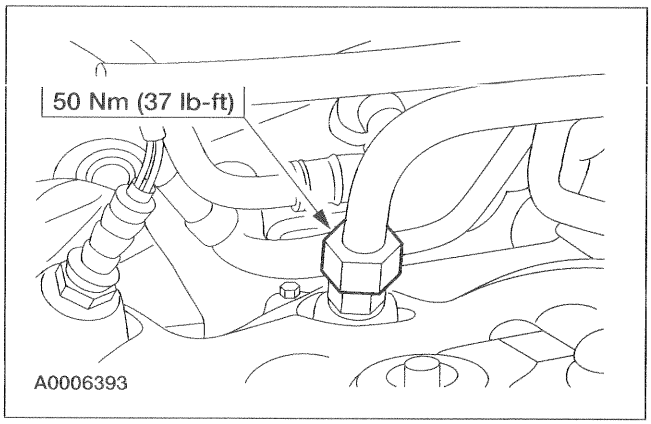


IN-VEHICLE REPAIR (Continued)

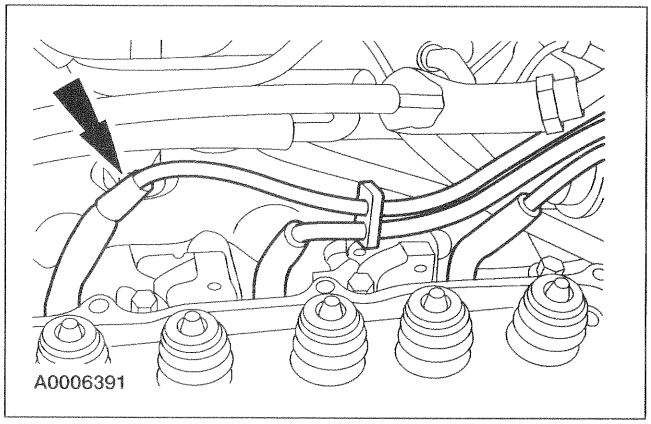
10. Install the exhaust manifold heat shield.



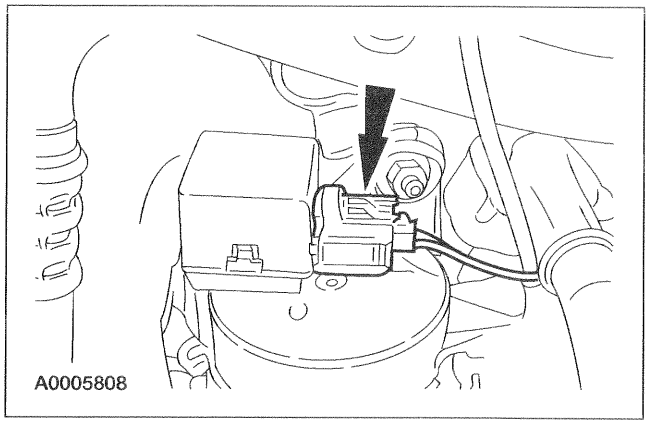
11. Install the EGR tube.



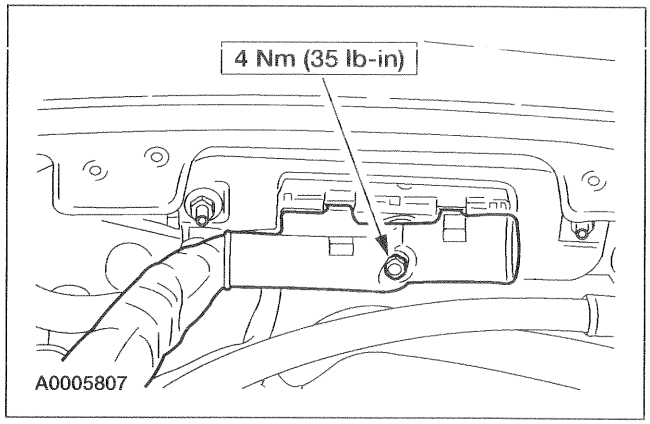
12. Reposition and connect the spark plug wires.



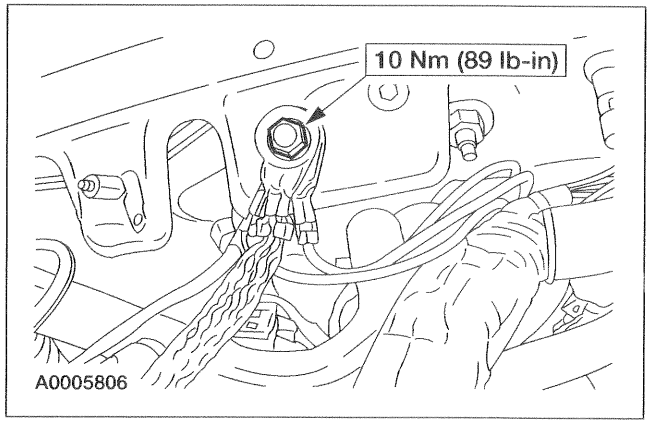
13. Connect the EVAP canister purge valve electrical connector.



14. Connect the PCM electrical connector.

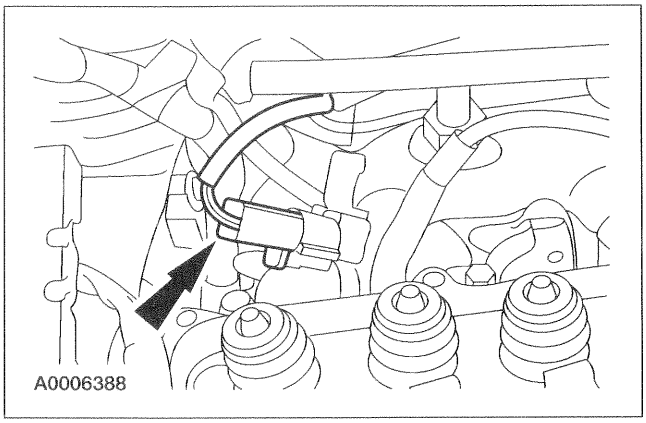


15. Connect the wire harness ground connections.

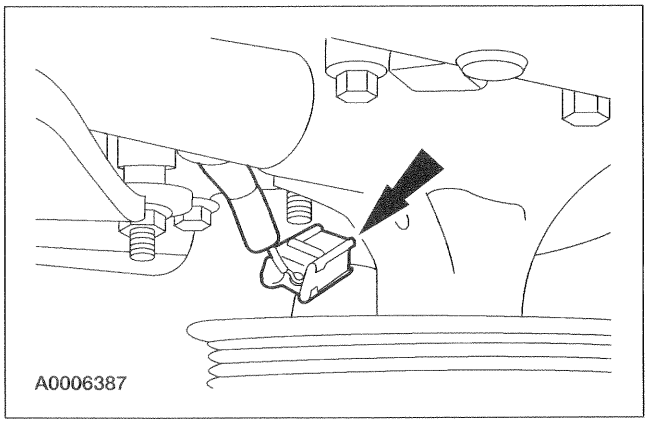


IN-VEHICLE REPAIR (Continued)

16. Connect the HO2S electrical connector.



17. Connect the CKP electrical connector.



18. Install the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.

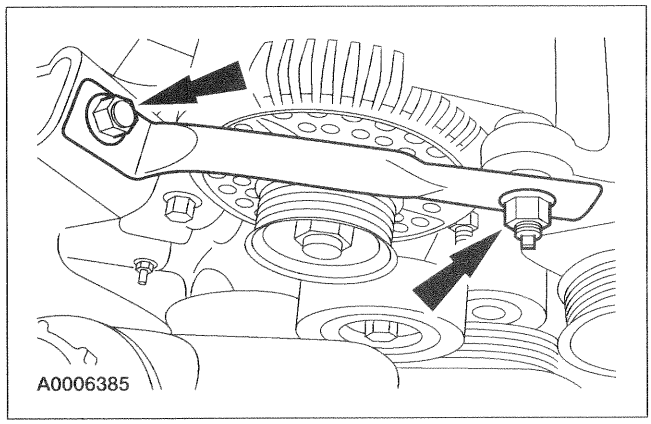
Cylinder Head LH

Material

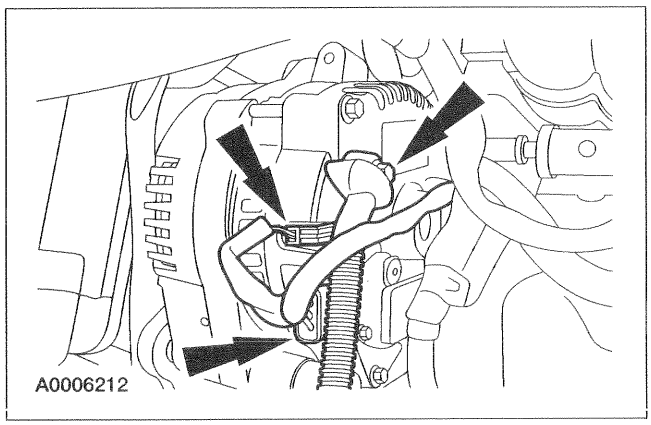
Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A

Removal

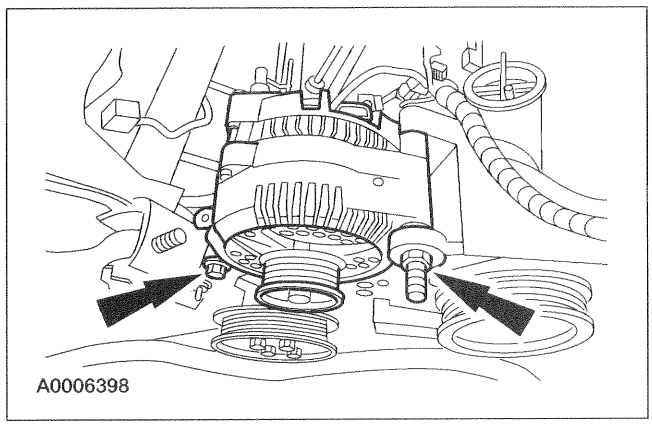
1. Remove the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.
2. Remove the accessory drive belt. For additional information, refer toSection 303-05.
3. Remove the retainers and the engine anti-roll strut brace.



4. Disconnect the generator electrical connections.

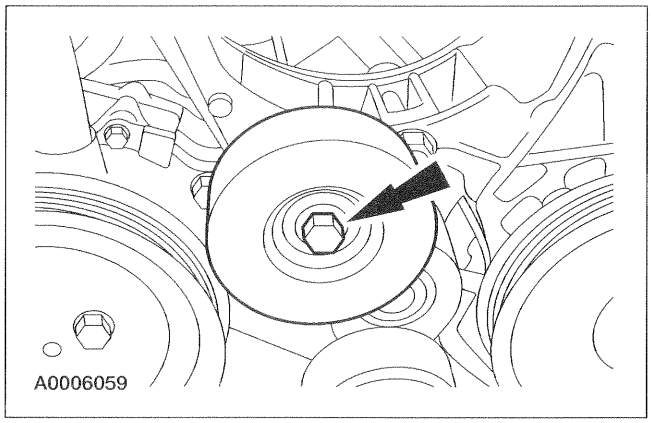


5. Remove the retainers and the generator.

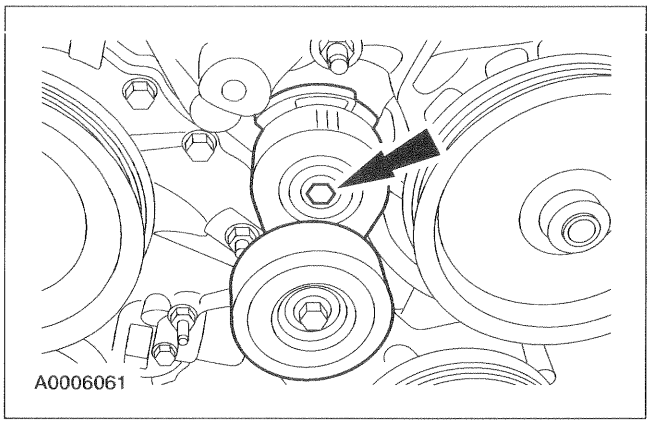


IN-VEHICLE REPAIR (Continued)

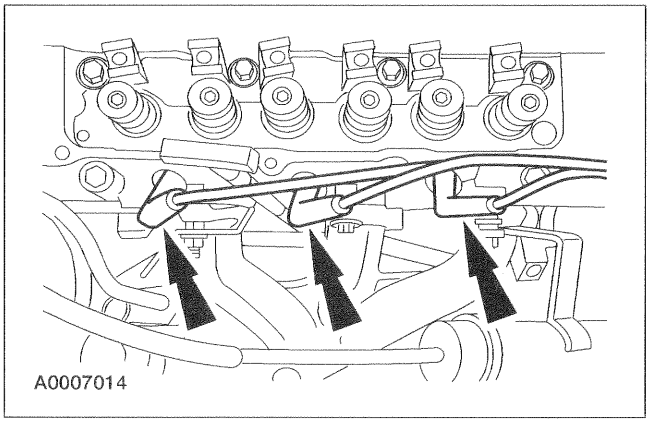
6. Remove the bolt and the drive belt idler pulley.



7. Remove the bolt and the drive belt tensioner pulley.

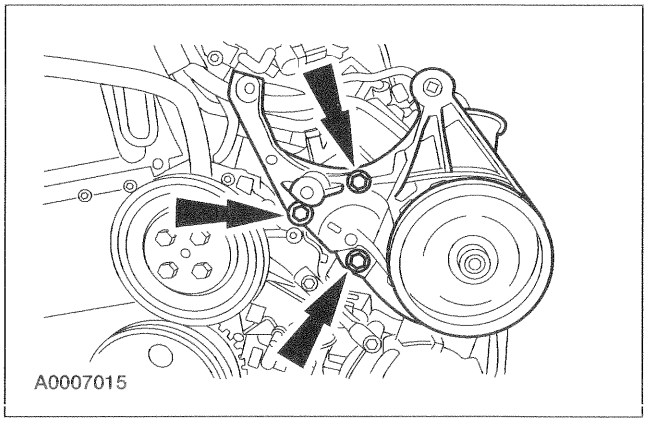


8. Remove the spark plug wires.

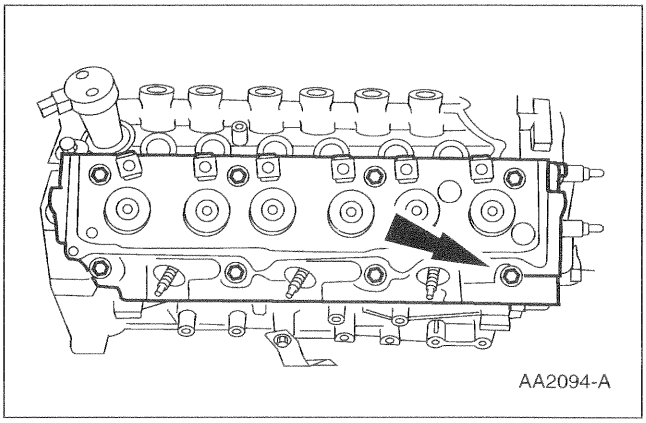


9. Remove the LH exhaust manifold. For additional information, refer to Exhaust Manifold LH in this section.

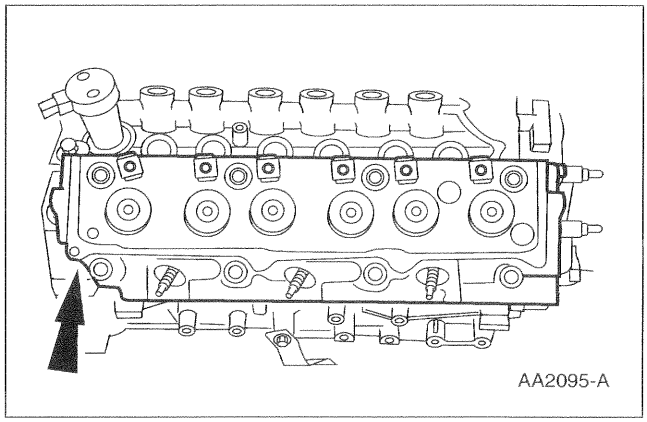
10. Remove the power steering pump and bracket assembly.
    - Disconnect the power steering return hose.
    - Remove the bolt.
    - Remove the two nuts.



11. Remove the eight cylinder head bolts.

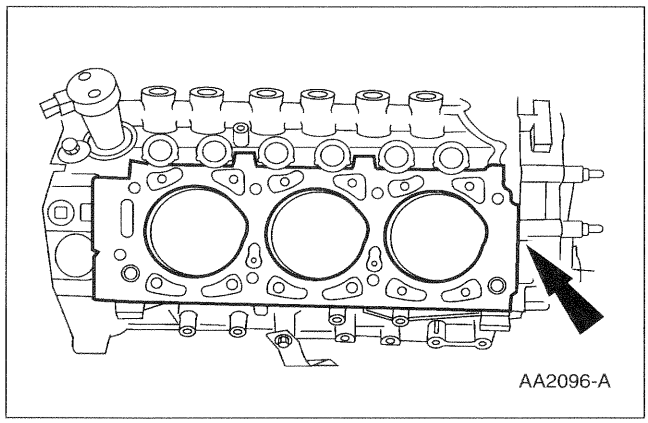


12. Remove the cylinder heads.



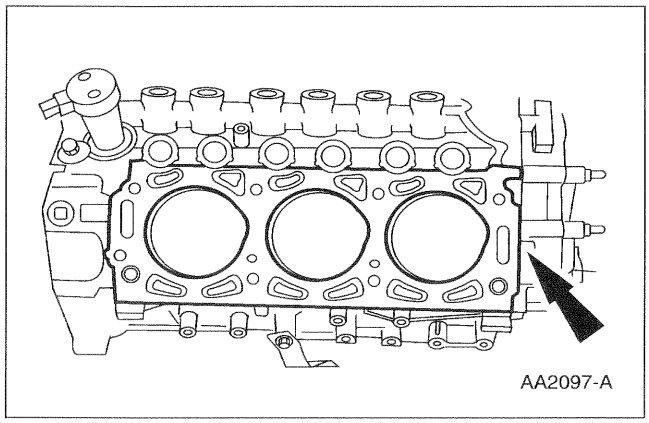
IN-VEHICLE REPAIR (Continued)

13. Remove and discard the head gasket.



Installation

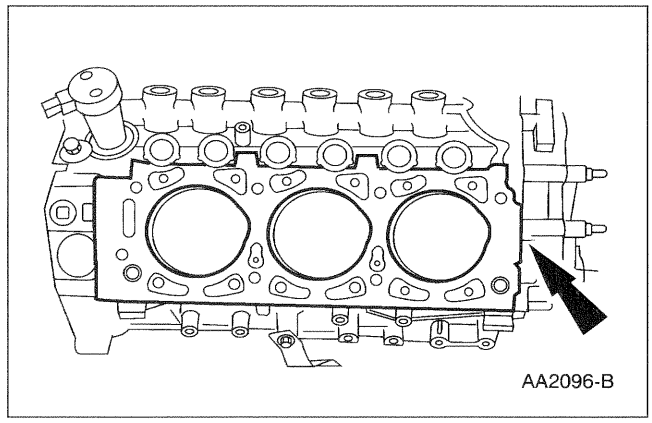
1. Using metal surface cleaner, clean the cylinder head sealing surfaces.



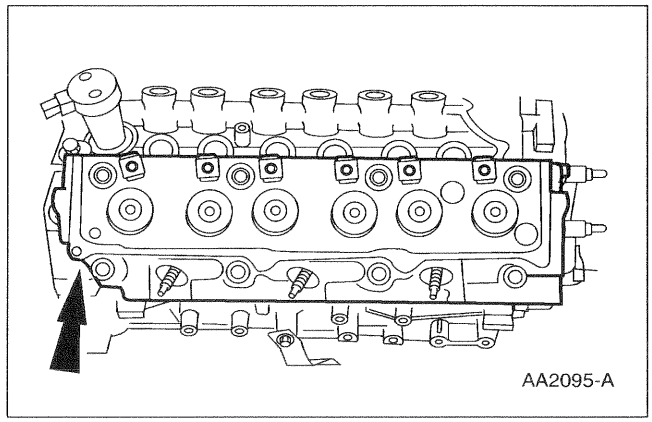
2. Check the cylinder head and the cylinder block for flatness. For additional information, refer to Section 303-00.

3. **NOTE:** The "V" notch in the cylinder head gasket faces the front of the engine.

   Position a new cylinder head gasket.

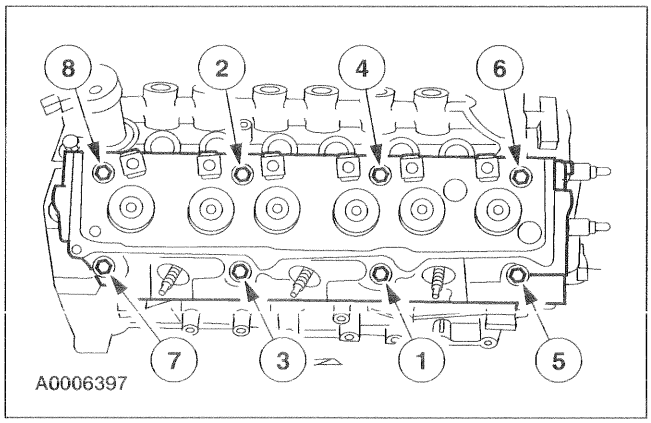


4. Position the cylinder head.

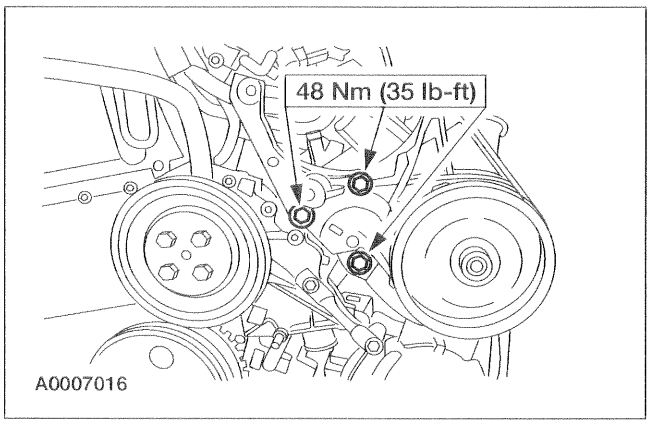


IN-VEHICLE REPAIR (Continued)

5. Install the bolts. Tighten the bolts in five stages in the sequence shown.
   - Stage 1: Tighten to 50 Nm (37 lb-ft).
   - Stage 2: Loosen the bolts one full turn.
   - Stage 3: Tighten to 30 Nm (22 lb-ft).
   - Stage 4: Rotate an additional 90 degrees.
   - Stage 5: Rotate an additional 90 degrees.

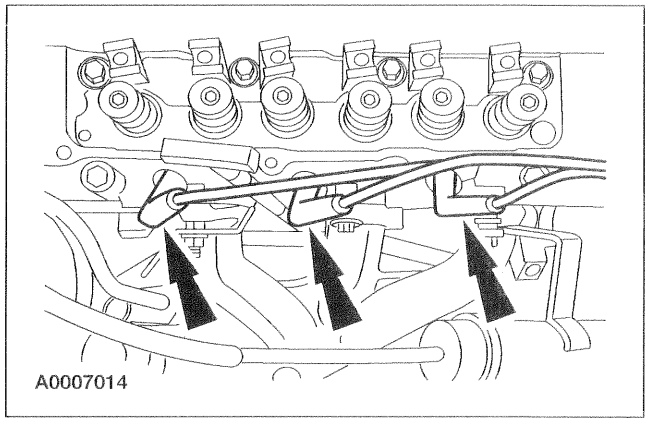


6. Install the power steering pump and bracket assembly.
   - Install the bolt.
   - Install the two nuts.
   - Connect the power steering return hose.

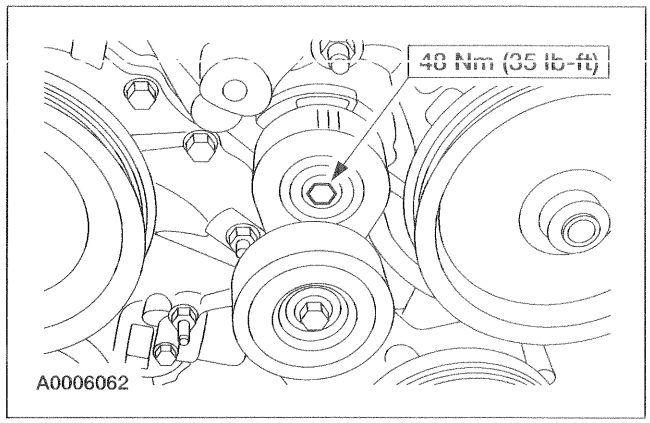


7. Install the LH exhaust manifold. For additional information, refer to Exhaust Manifold LH in this section.

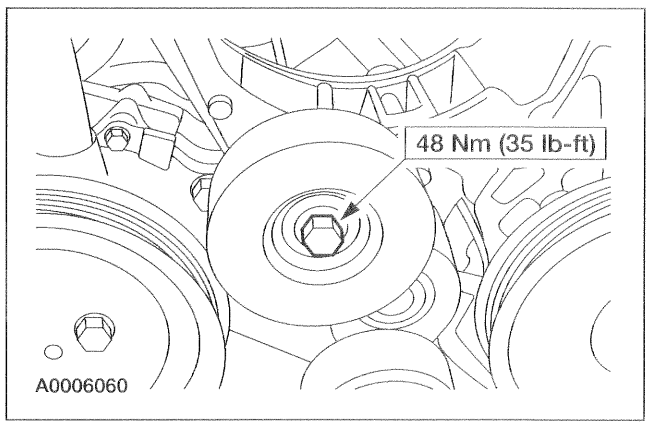
8. Install the spark plug wires.



9. Install the drive belt tensioner and bolt.

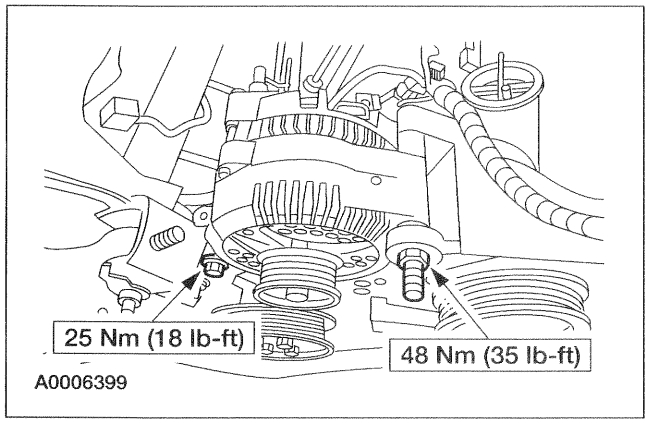


10. Install the drive belt idler pulley and bolt.

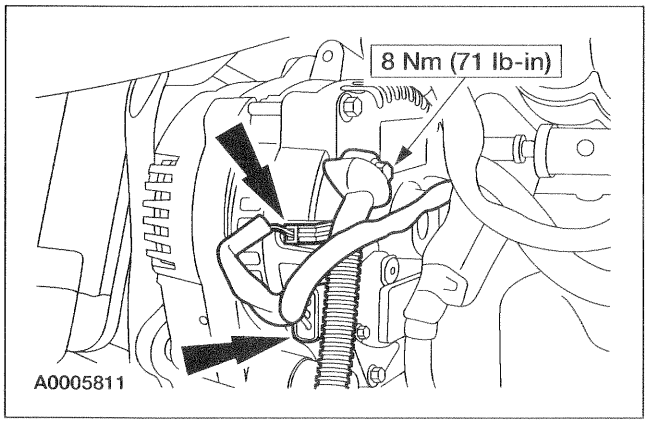


IN-VEHICLE REPAIR (Continued)

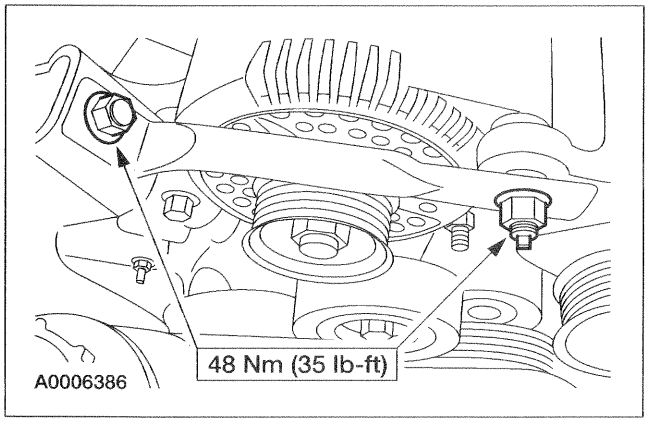
11. Install the generator and the retainers.



12. Connect the generator electrical connections.



13. Install the engine anti-roll strut brace and the retainers.



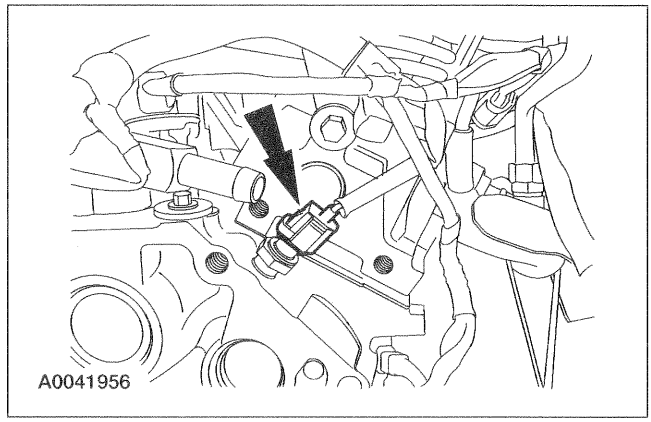
14. Install the accessory drive belt. For additional information, refer to Section 303-05.

15. Install the lower intake manifold. For additional information, refer to Lower Intake Manifold in this section.

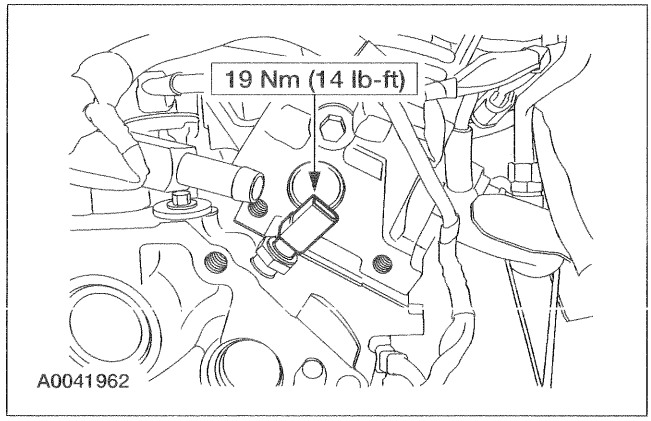
Oil Pressure Switch

Removal and Installation

1. **NOTE:** Engine removed for clarity.
   Disconnect the oil pressure switch electrical connector.



2. Remove the oil pressure switch.



3. To install, reverse the removal procedure.

Oil Level Indicator and Tube

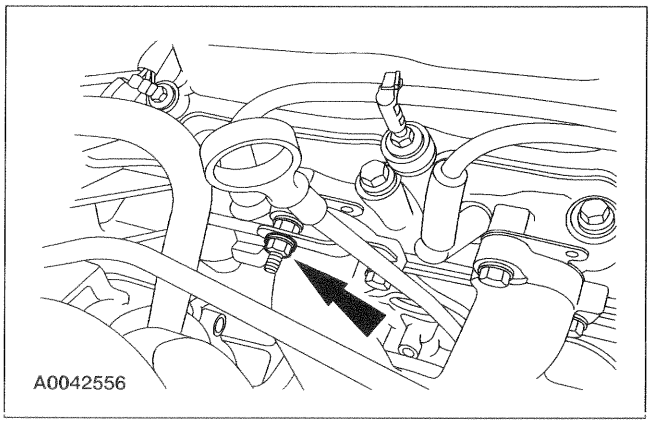
Material

Item	Specification
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

IN-VEHICLE REPAIR (Continued)

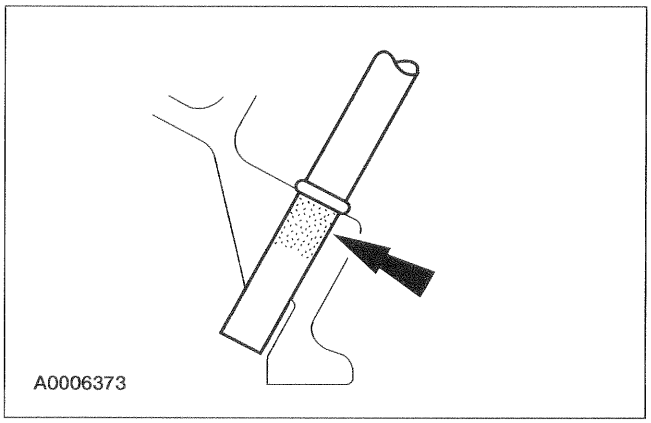
Removal

1. Remove the oil level indicator and tube (6754).
   - Remove the nut.
   - Remove the tube.

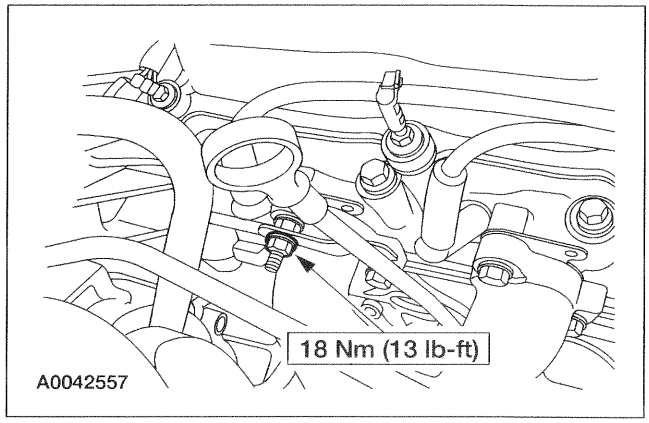


Installation

1. Coat the sealing surface of the oil level indicator tube with silicone gasket and sealant.



2. Install the oil level indicator tube.
   - Install the tube.
   - Install the nut.



Oil Pan

Material

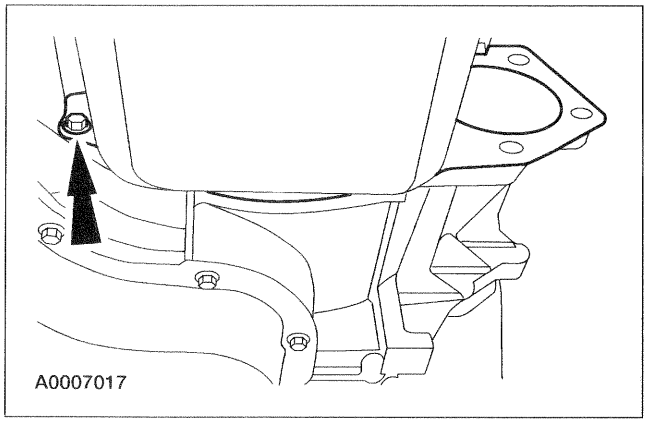
Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

Removal

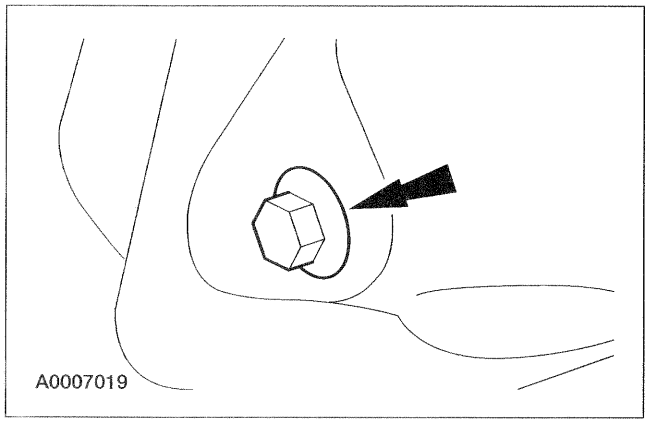
1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Raise and support the vehicle. For additional information, refer to Section 100-02.
3. Remove the dual converter Y-pipe. For additional information, refer to Section 309-00.
4. Remove the starter motor. For additional information, refer to Section 303-06.

IN-VEHICLE REPAIR (Continued)

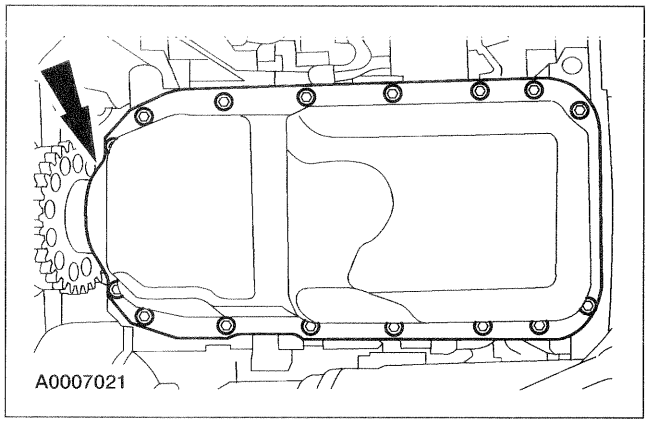
5. Remove the bolt and the engine rear plate.



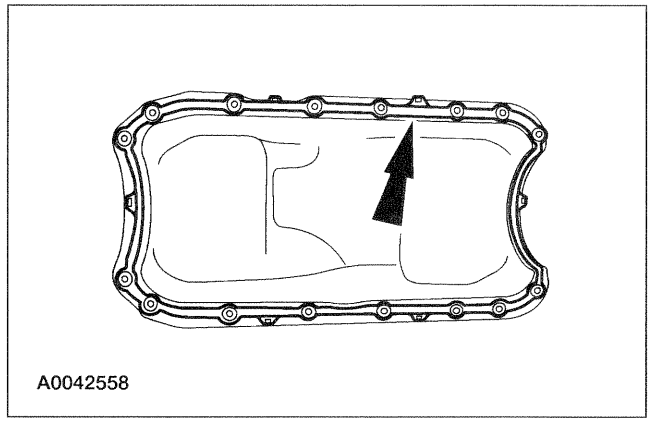
6. Drain the engine oil.



7. Remove the 16 bolts and the oil pan.



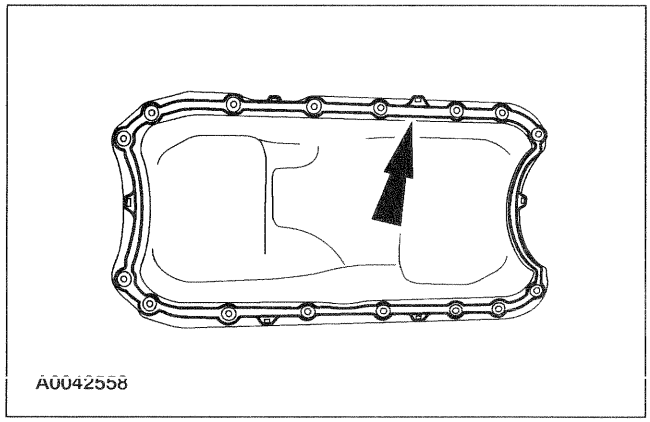
8. Remove the oil pan gasket from the oil pan.



9. Using metal surface cleaner, clean the oil pan sealing surfaces.

Installation

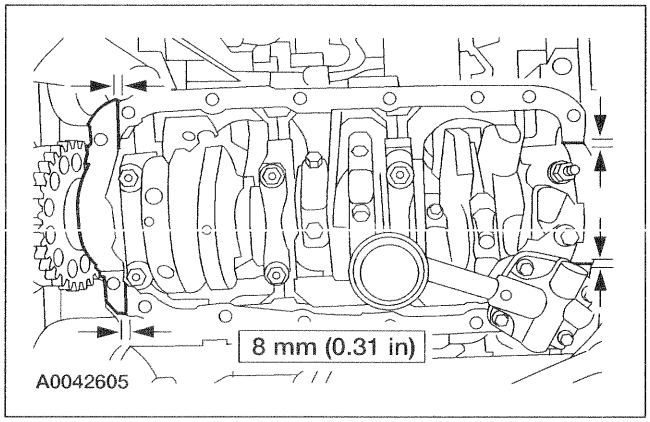
1. Install the oil pan gasket onto the oil pan.



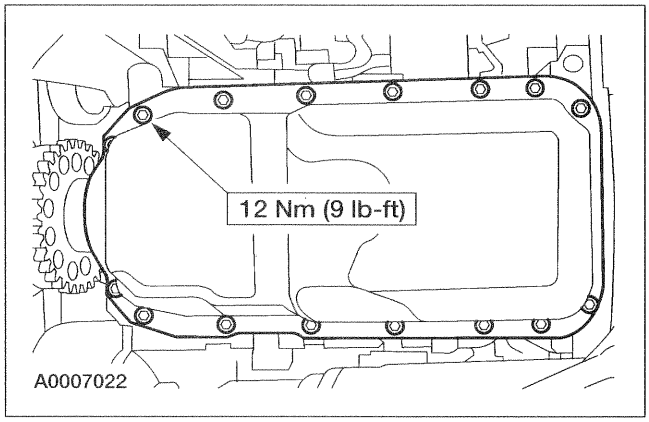
IN-VEHICLE REPAIR (Continued)

2. **NOTE:** If the oil pan is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

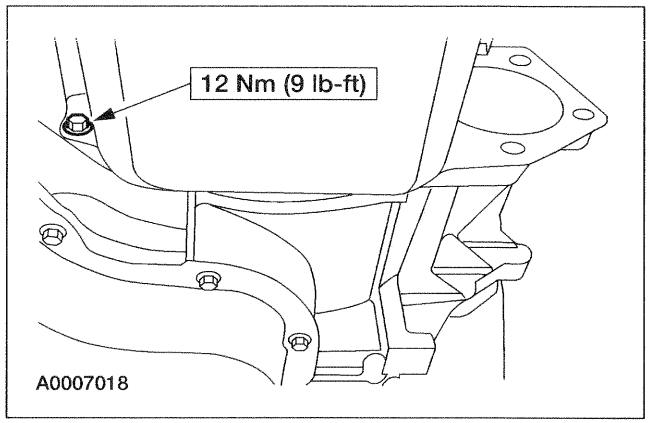
   Apply a bead of silicone gasket and sealant in two places where the cylinder block meets the front cover and in two places where the rear main bearing cap meets the cylinder block.



3. Install the oil pan and the 16 bolts. Tighten the bolts in three stages:
   - Stage 1: Tighten the four corner bolts to 12 Nm (9 lb-ft).
   - Stage 2: Tighten the remaining bolts from back to front to 12 Nm (9 lb-ft).
   - Stage 3: Check all bolts for correct tightness.



4. Install the engine rear plate and the bolt.



5. Install the starter motor. For additional information, refer to Section 303-06.
6. Install the dual converter Y-pipe. For additional information, refer to Section 309-00.
7. Lower the vehicle.
8. Connect the battery ground cable. For additional information, refer to Section 414-01.
9. Fill the engine with clean engine oil.
10. **NOTE:** The cooling fan should cycle at least one time. Start the engine and allow it to reach normal operating temperature.

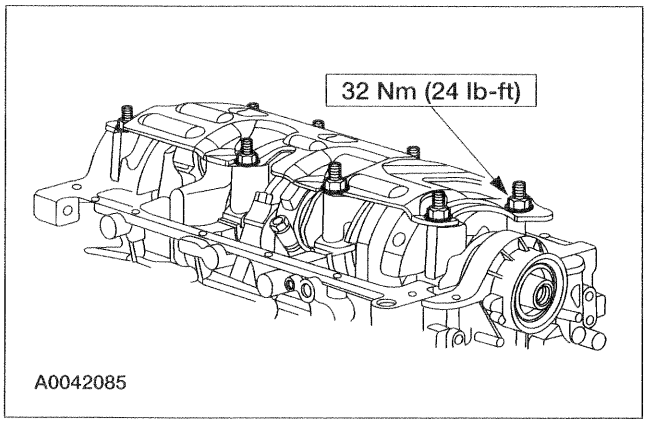
    Stop the engine.
11. Raise and support the vehicle.
12. Retighten the oil pan bolts from the back to front to 12 Nm (9 lb-ft).
13. Inspect the oil pan gasket for correct alignment.
14. Lower the vehicle.

Oil Pan Baffle

1. Remove the oil pan. For additional information, refer to Oil Pan in this section.

IN-VEHICLE REPAIR (Continued)

2. Remove the seven nuts and remove the oil pan baffle.



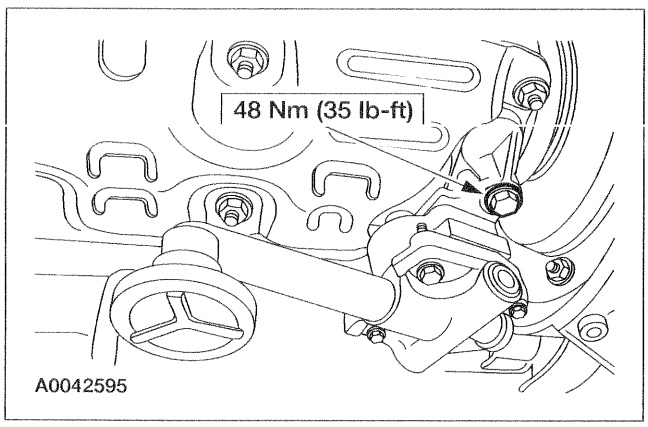
3. To install, reverse the removal procedure.

Oil Pump

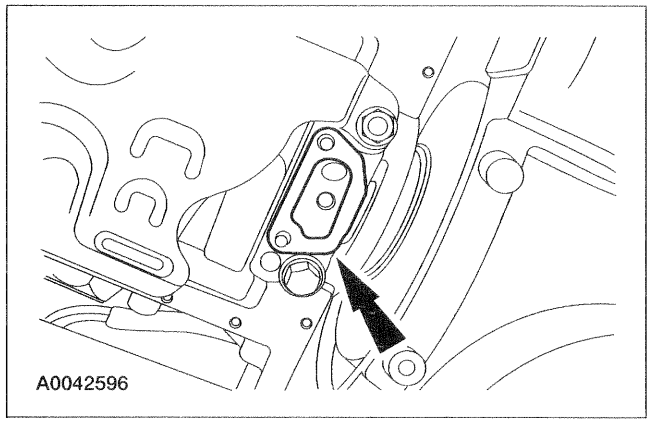
Removal and Installation

1. Remove the oil pan (6675). For additional information, refer to Oil Pan in this section.

2. Remove the oil pump (6600).
   - Remove the bolt.



3. Clean all the sealing surfaces.



4. If an internal inspection is required, remove the oil pump cover. Refer to Section 303-00 for component testing.

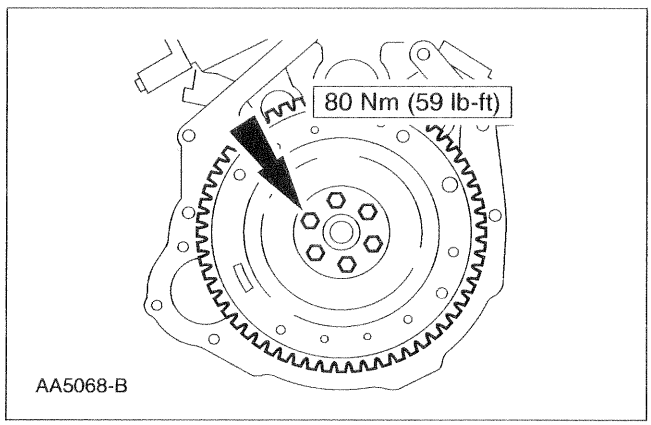
5. To install, reverse the removal procedure.

Flexplate

Removal and Installation

1. Remove the transaxle. For additional information, refer to Section 307-01A (AX4S) or Section 307-01B (AX4N).

2. Remove the flexplate.
   - Remove the bolts.

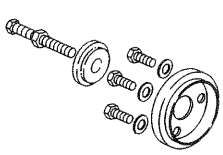
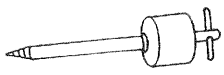


3. To install, reverse the removal procedure.

IN-VEHICLE REPAIR (Continued)

Crankshaft Rear Seal

Special Tool(s)

 ST2627-A	Installer, Crankshaft Rear Main Oil Seal 303-323 (T88L-6701-A)
 ST1807-A	Remover, Jet Plug 310-005 (T77L-9533-B)

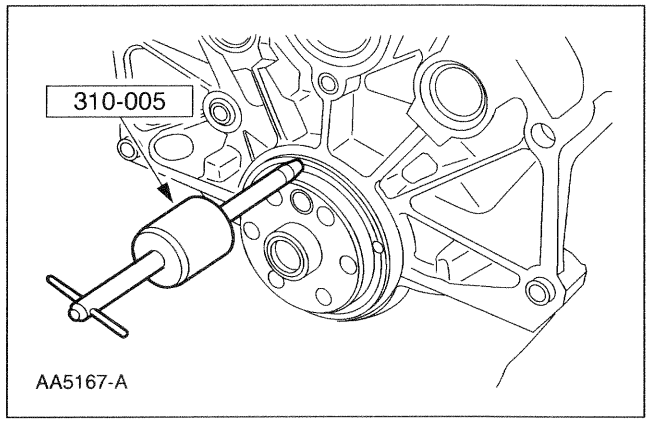
Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

Removal

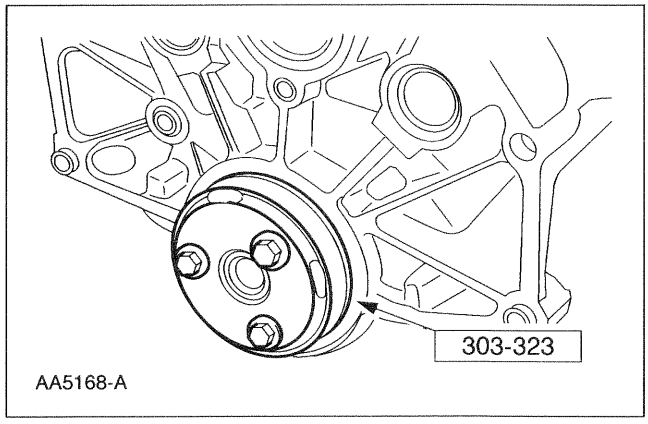
1. Remove the flexplate. For additional information, refer to Flexplate in this section.
2. **⚠ CAUTION: Use care to avoid scratching or damaging the oil seal surface or leakage may occur.**

   Using a sharp awl, punch one hole into the crankshaft rear seal metal surface between the seal lip and the cylinder block.
3. Screw the threaded end of the special tool into the rear seal. Use the special tool to remove the crankshaft rear seal.



Installation

1. Lubricate the outer lips and the inner seal on the crankshaft rear seal with clean engine oil.
2. Using the special tool, install the crankshaft rear seal. Alternate bolt tightening to correctly seat the crankshaft rear seal.



3. Install the flexplate. For additional information, refer to Flexplate in this section.

IN-VEHICLE REPAIR (Continued)

Crankshaft Main Bearings

Special Tool(s)

	Remover/Installer, Upper Main Bearing 303-002 (TOOL-6331)

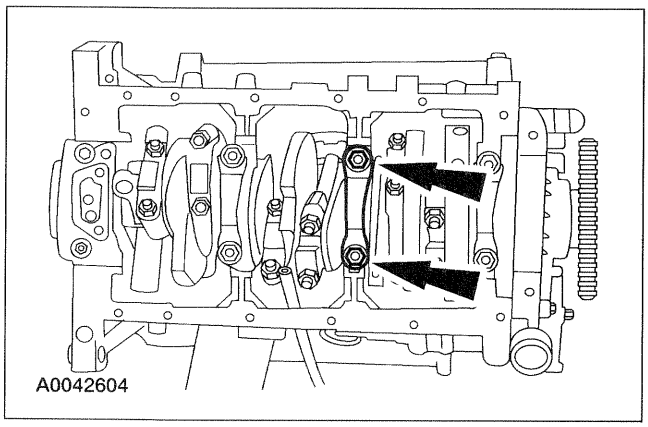
Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

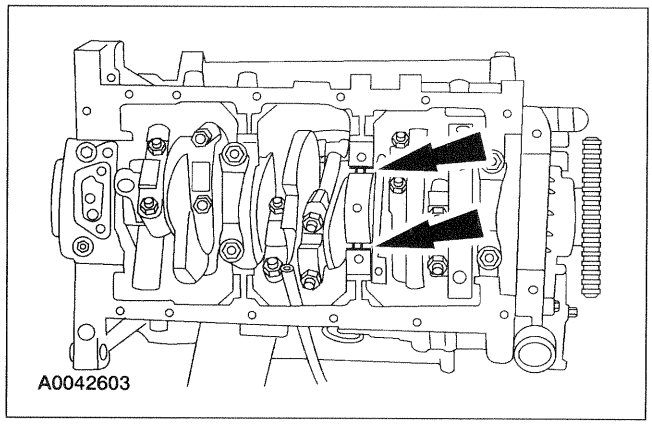
Removal

1. Remove the oil pan. For additional information, refer to Oil Pan in this section.
2. If necessary, remove the oil pump. For additional information, refer to Oil Pump in this section.
3. **⚠ CAUTION: The crankshaft main bearings must be inspected and replaced or new bearings installed one set at a time or engine damage may occur.**

   Remove one crankshaft main bearing cap.



4. Remove the crankshaft main bearing.

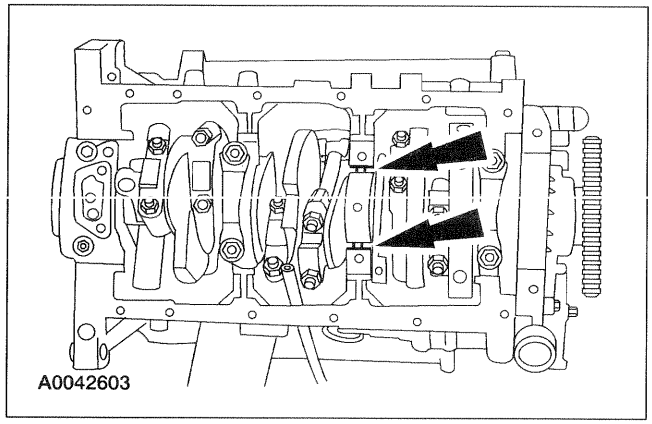


Installation

1. **⚠ CAUTION: The crankshaft main bearings are precision fit. For additional information, refer to Section 303-00 for checking clearances or bearing selection.**

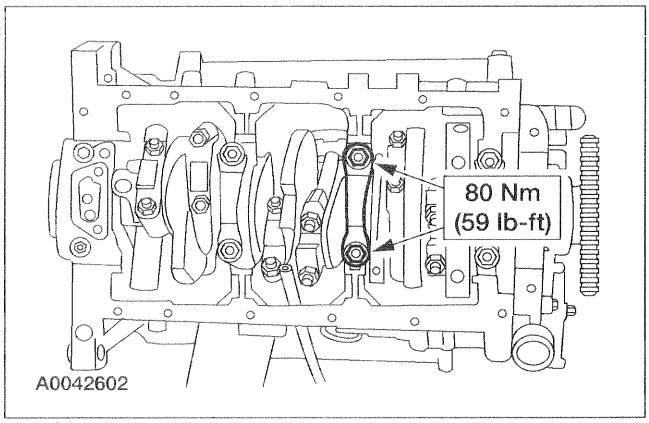
   ⚠ CAUTION: The crankshaft main bearings must be lubricated with clean engine oil.

   Install the crankshaft main bearing.



IN-VEHICLE REPAIR (Continued)

2. Install the crankshaft main bearing cap.



3. Repeat the procedure until all the crankshaft main bearings are inspected and replaced or new bearings are installed.

4. If removed, install the oil pump. For additional information, refer to Oil Pump in this section.

5. Install the oil pan. For additional information, refer to Oil Pan in this section.

Connecting Rod Bearings

Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

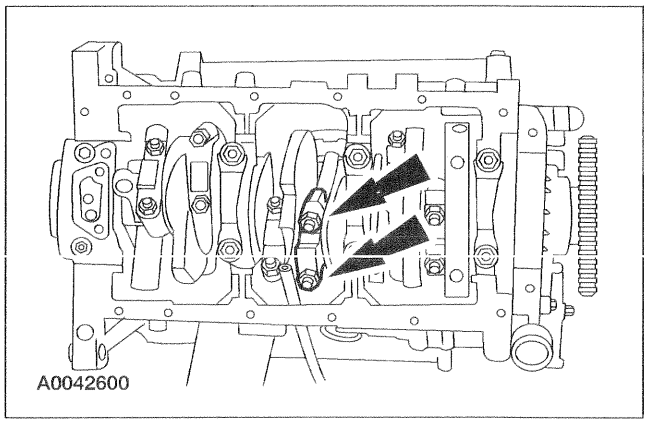
Removal

1. Remove the oil pan. For additional information, refer to Oil Pan in this section.

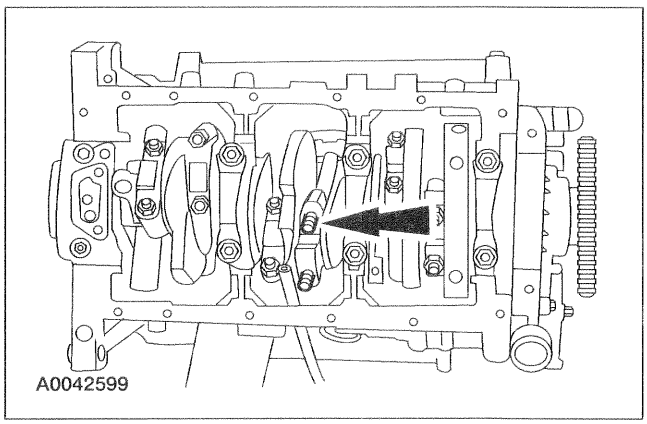
2. If necessary, remove the oil pump. For additional information, refer to Oil Pump in this section.

3. **CAUTION: The connecting rod bearing caps and the connecting rods are a matched set. Installing the incorrect connecting rod bearing cap on a connecting rod may result in engine damage.**

   Remove the connecting rod bearing cap.



4. Remove the connecting rod bearings.



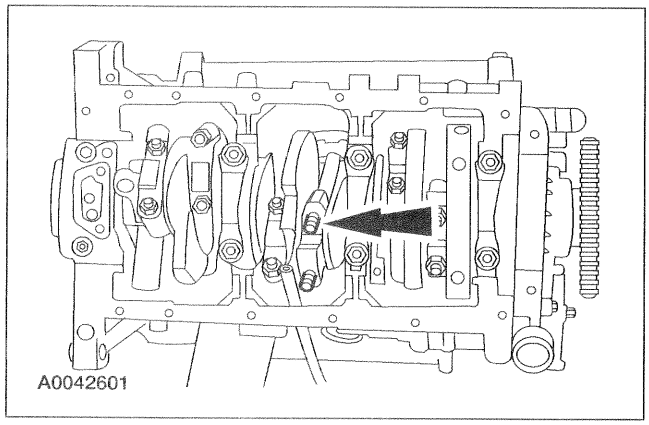
IN-VEHICLE REPAIR (Continued)

Installation

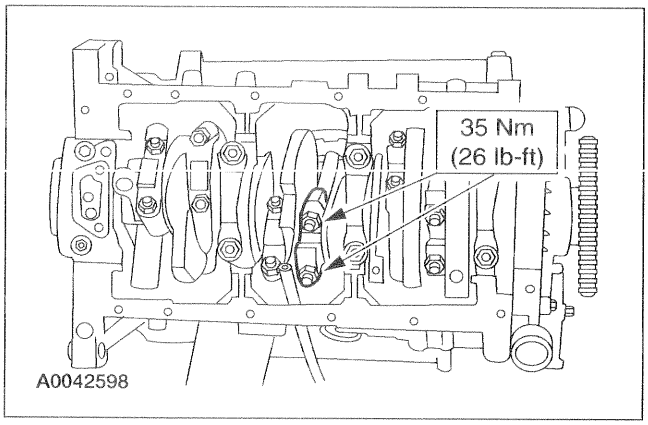
1. **⚠ CAUTION: The connecting rod bearings are precision fit. For additional information, refer to Section 303-00 for checking clearances or bearing selection.**

   ⚠ CAUTION: The connecting rod bearings must be lubricated with clean engine oil prior to installation or damage to the connecting rod bearing may occur.

   Install the connecting rod bearings.



2. Install the connecting rod bearing cap.



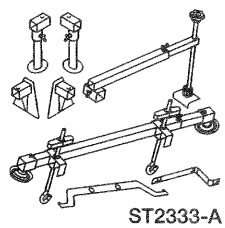
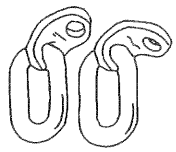
3. Repeat the procedure until all the connecting rod bearings are replaced.

4. If removed, install the oil pump. For additional information, refer to Oil Pump in this section.

5. Install the oil pan. For additional information, refer to Oil Pan in this section.

Engine Support Insulator

Special Tool(s)

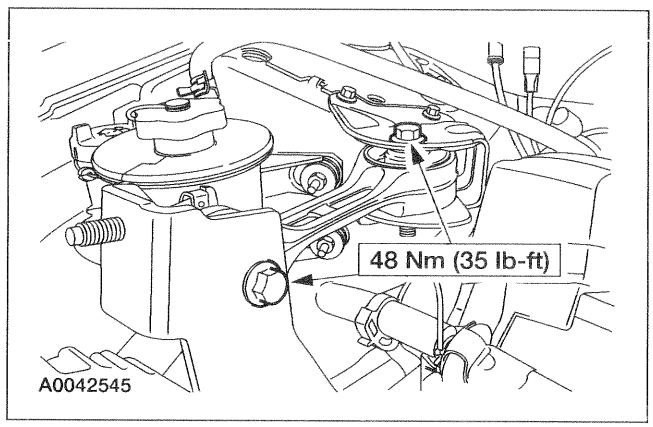
 ST2333-A	3 Bar Engine Support Kit 303-F072
 ST1831-A	Lifting Eyes 303-D030 (D81L-6001-D) or equivalent

Removal and Installation

1. Remove the air cleaner and the air cleaner outlet tube. For additional information, refer to sectionSection 303-12.

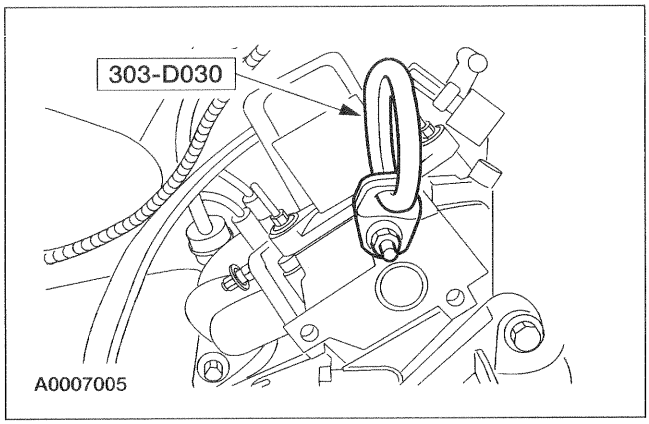
2. Remove the cowl vent screen and cowl extension. For additional information, refer to Section 501-02.

3. Remove the engine anti-roll strut.
   - Remove the two bolts.



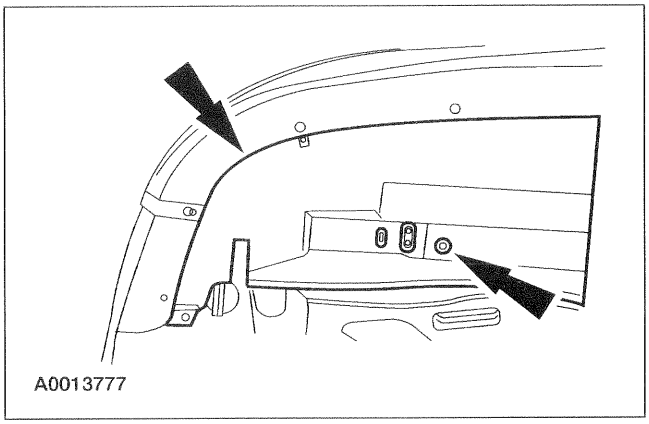
IN-VEHICLE REPAIR (Continued)

4. Install the engine lift bracket.

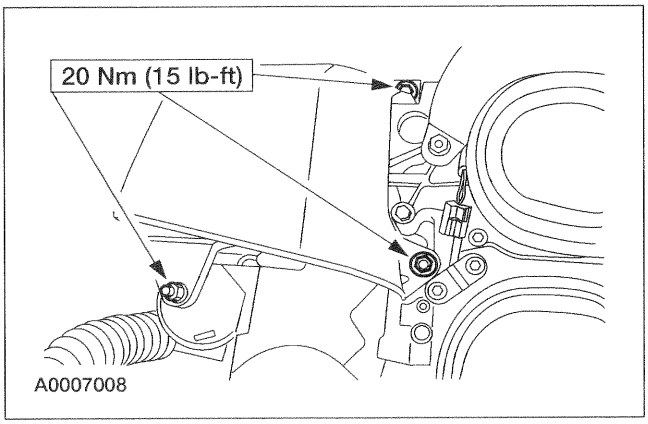


5. Remove the catalytic converters. For additional information, refer to Section 309-00.

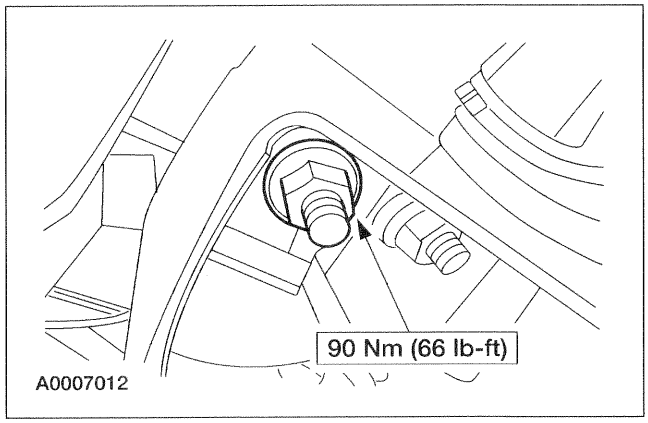
6. Remove the valance panel.
   - Remove three screws.
   - Remove nine pin-type retainers.



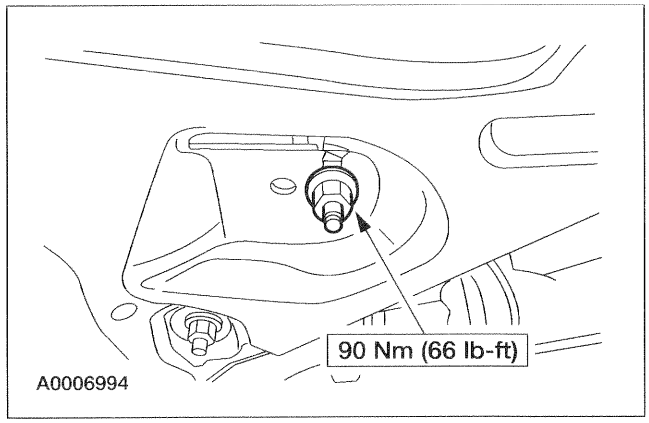
7. Remove the RH catalytic converter heat shield.
   - Remove the bolt.
   - Remove the two nuts.



8. Remove the RH engine support insulator-to-subframe nut.

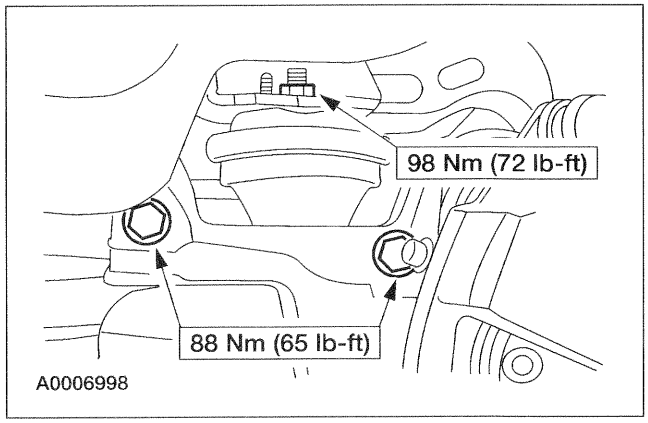


9. Remove the LH engine support insulator-to-subframe nut.



10. Remove the LH front wheel assembly.

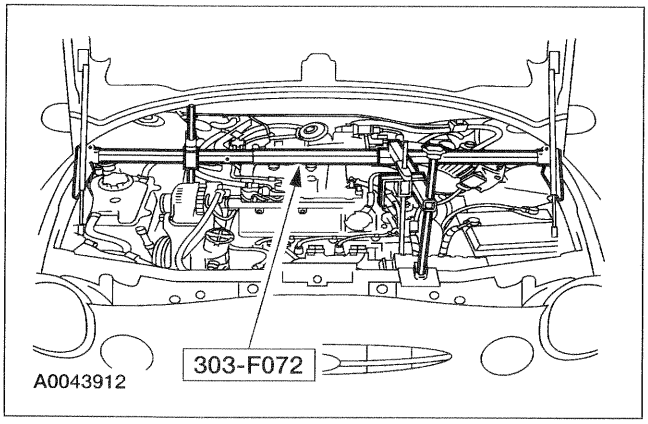
11. Remove the nut and two bolts retaining the rear engine support insulator.



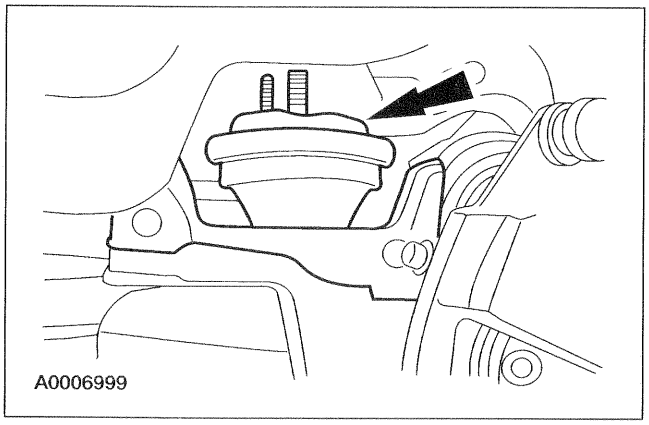
12. Partially lower the vehicle.

IN-VEHICLE REPAIR (Continued)

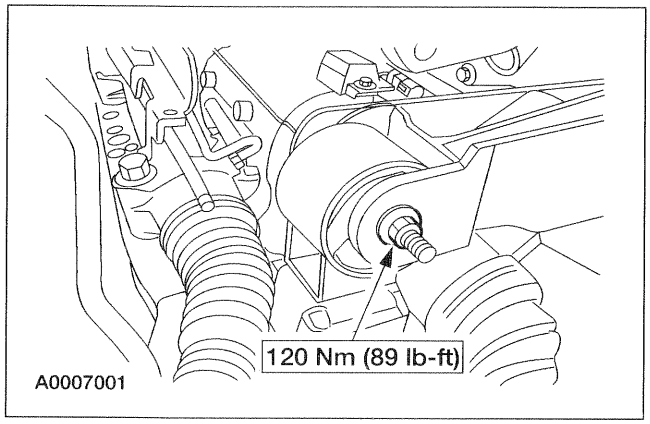
13. Using the special tool, lift the engine 5.08 cm (2.0 in).



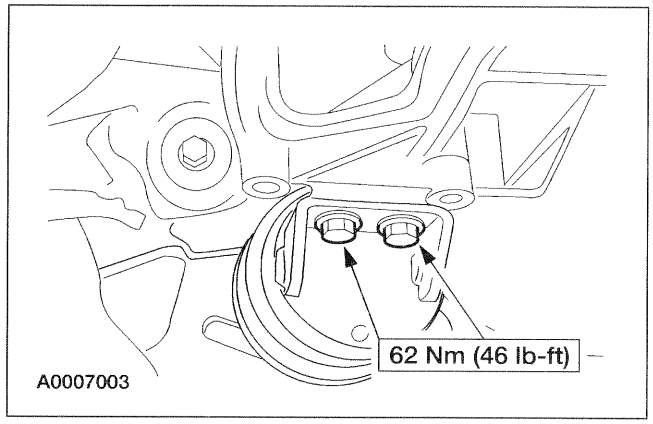
14. Remove the rear engine support insulator.



15. Remove the RH engine support insulator.
    - Remove the through bolt.



16. Remove the LH engine support insulator.
    - Remove the bolts.

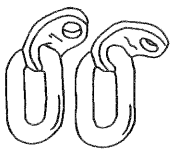
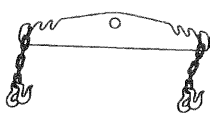
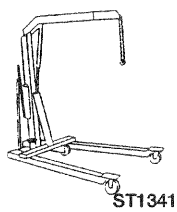
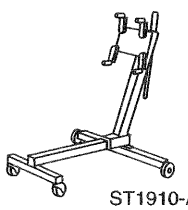


17. To install, reverse the removal procedure.

REMOVAL

Engine

Special Tool(s)

 ST1682-A	Powertrain Lift With Tilting Plate 014-00765 or equivalent
 ST1831-A	Lifting Eyes 303-D030 (D81L-6001-D) or equivalent
 ST1602-A	Spreader Bar 303-D089 (D93P-6001-A3) or equivalent
 ST1341-A	Heavy Duty Floor Crane 014-00072 or equivalent
 ST1910-A	Engine Stand 014-00232 or equivalent

Removal

1. Disconnect the battery ground cable (14301). For additional information, refer to Section 414-01.

2. Drain the engine cooling system. For additional information, refer to Section 303-03.

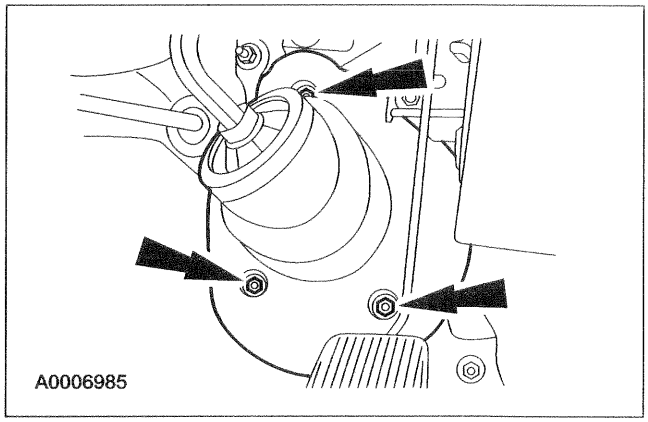
3. Remove the cowl vent screen and cowl extension. For additional information, refer to Section 501-02.

4. Remove the engine air cleaner (ACL) (9600) and the air cleaner outlet tube (9B659). For additional information, refer to Section 303-12.

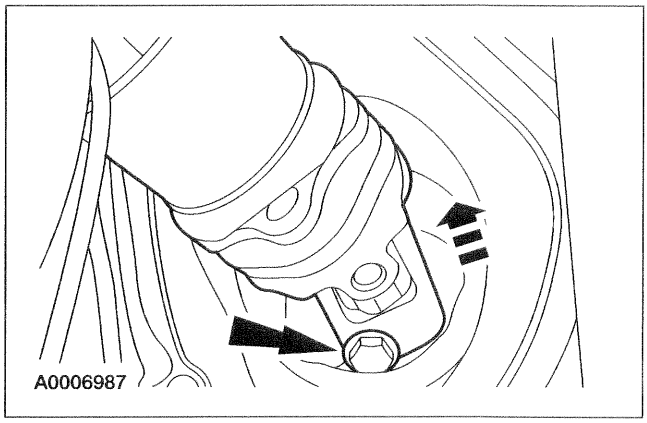
5. Recover the refrigerant from the A/C system. For additional information, refer to Section 412-00.

6. Relieve the fuel system pressure. For additional information, refer to Section 310-00.

7. Position the steering column input shaft coupling boot aside.
   - Remove the three nuts.

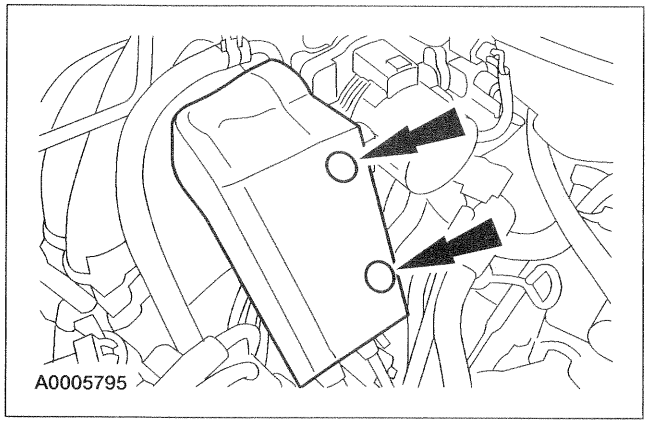


8. Separate the steering column from the steering gear.
   - Loosen the pinch bolt and slide the coupling off the steering gear input shaft.

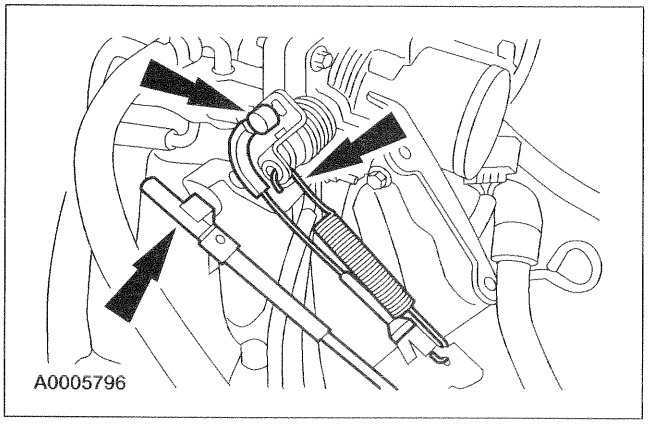


REMOVAL (Continued)

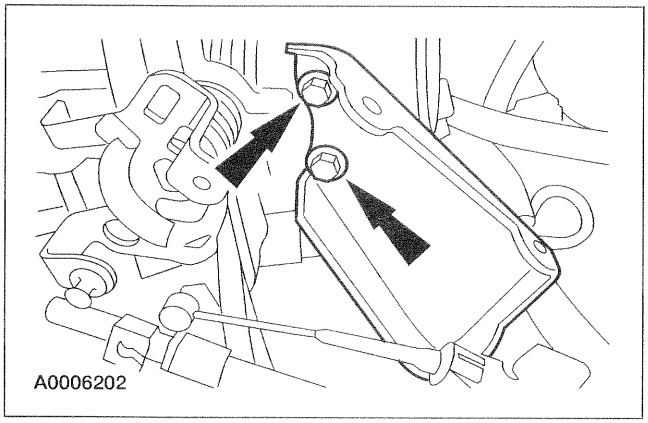
9. Remove the snow shield.
   - Remove the pin-type retainers.



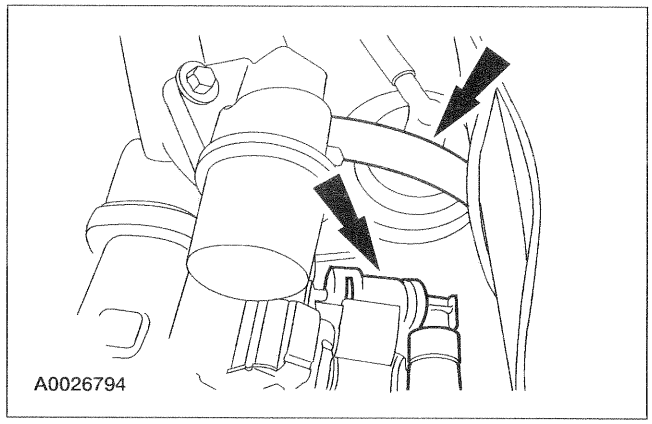
10. Disconnect the accelerator cable (9A758), speed control actuator cable (9A825) and the throttle return spring from the throttle body.



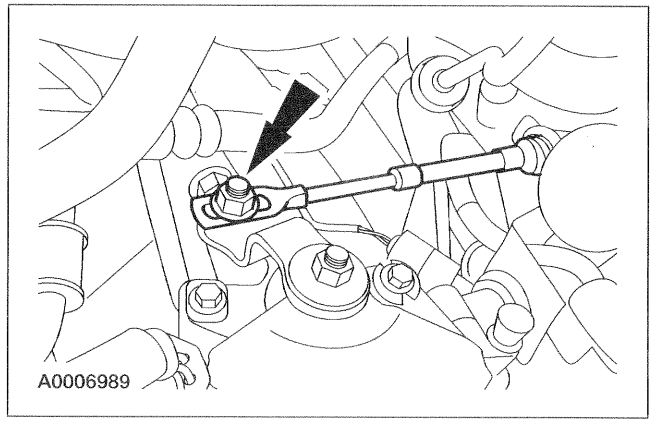
11. Position the accelerator cable bracket aside.
    - Remove the bolts.



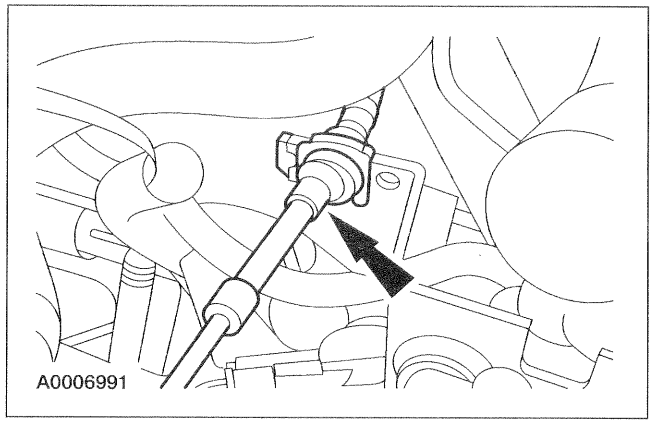
12. Disconnect the chassis vacuum hose.



13. Disconnect the manual control lever cable.
    - Remove the nut.

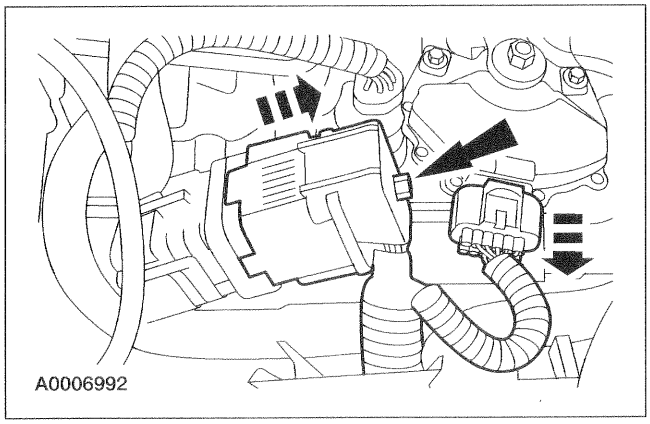


14. Disconnect the manual control lever cable from the bracket and position aside.

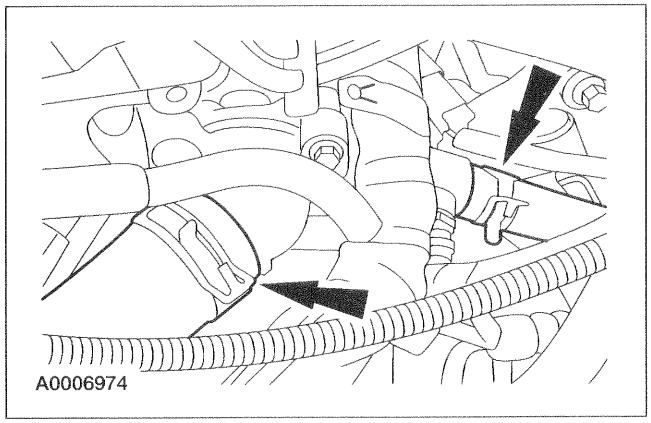


REMOVAL (Continued)

15. Loosen the bolt and disconnect the 42-pin and transmission range (TR) sensor electrical connectors.

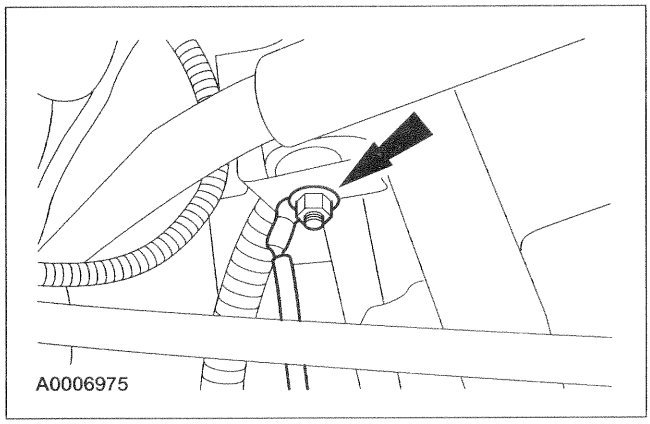


16. Disconnect the upper radiator hose and the heater water hose from the thermostat housing.

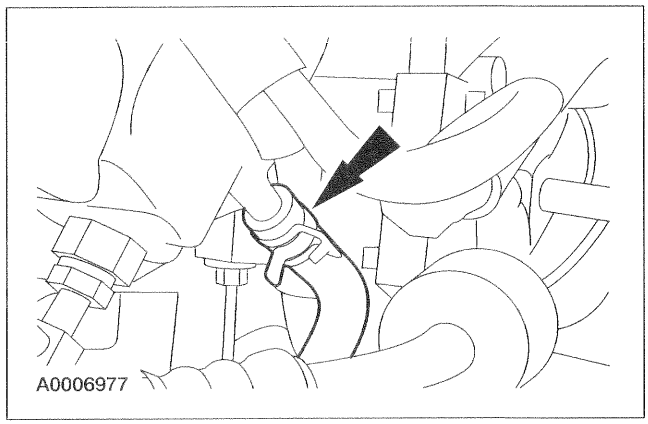


17. Remove the battery. For additional information, refer to Section 414-01.

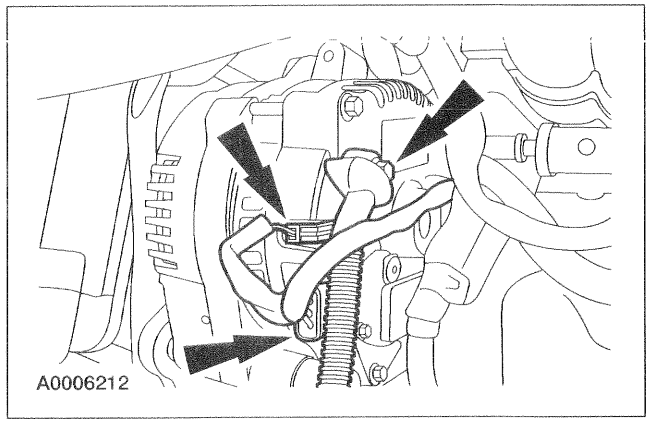
18. Disconnect the ground strap electrical connector.
    - Remove the nut.



19. Disconnect the power steering return hose.



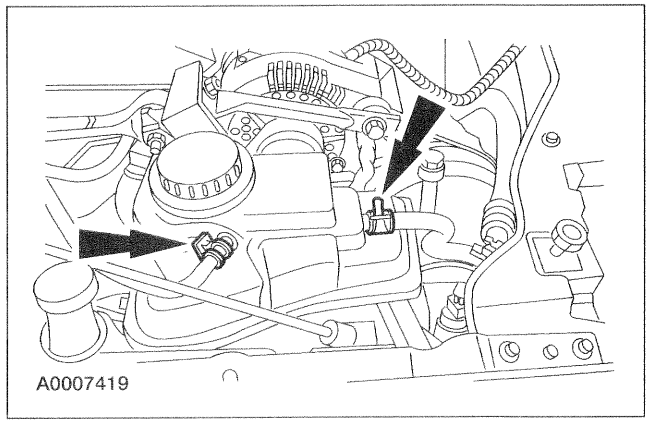
20. Disconnect the generator electrical connectors and position the wire harness aside.



21. Disconnect the A/C suction tube from the accumulator drier. For additional information, refer to Section 412-00.

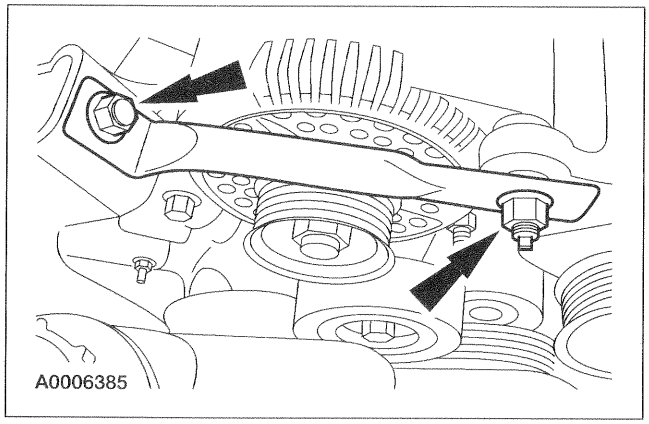
22. Disconnect the fuel supply hose. For additional information, refer to Section 310-00.

23. Disconnect the degas bottle hoses.

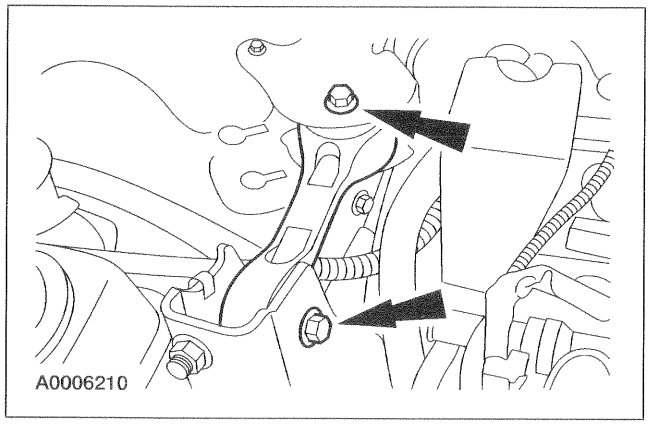


REMOVAL (Continued)

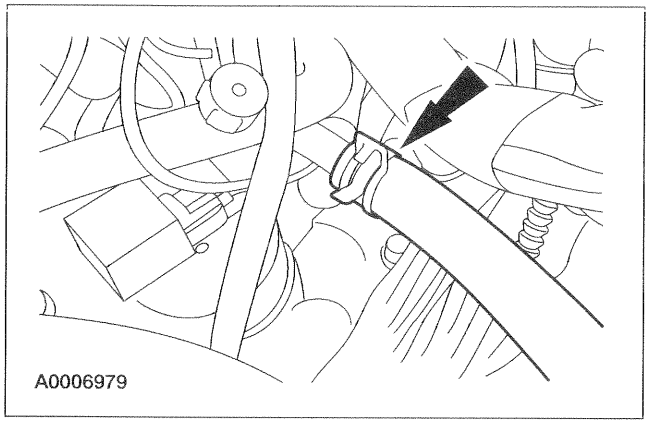
24. Remove the nut, the bolt, and the engine roll restrictor brace.



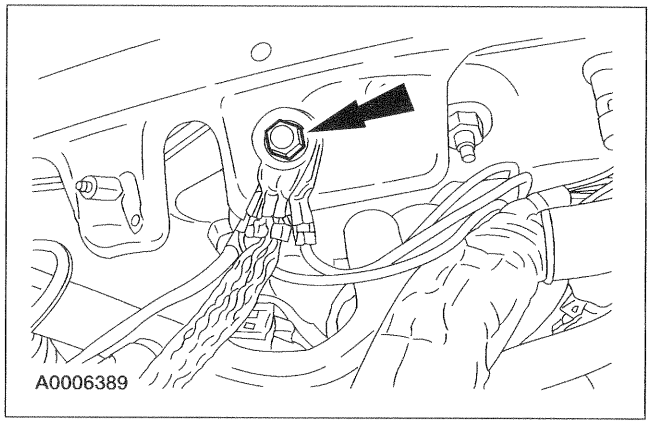
25. Remove the bolts and the engine roll restrictor.



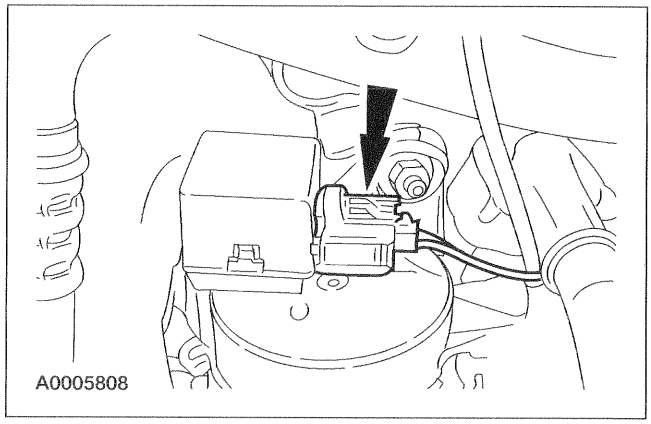
26. Disconnect the heater water hose.



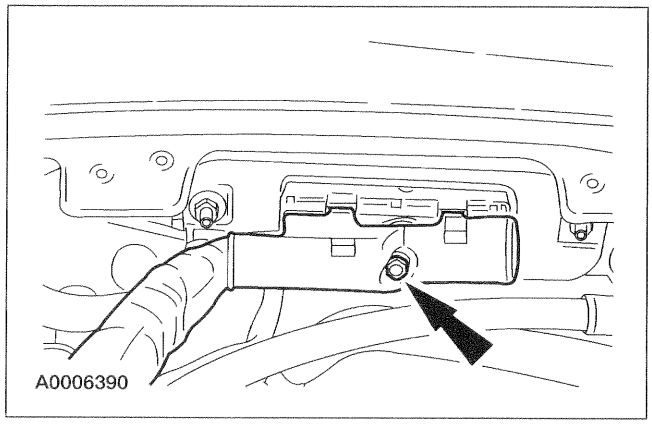
27. Disconnect the ground electrical connectors.
    - Remove the bolt.



28. Disconnect the evaporative emissions (EVAP) canister purge valve electrical connector.



29. Disconnect the powertrain control module (PCM) electrical connector.
    - Loosen the bolt.



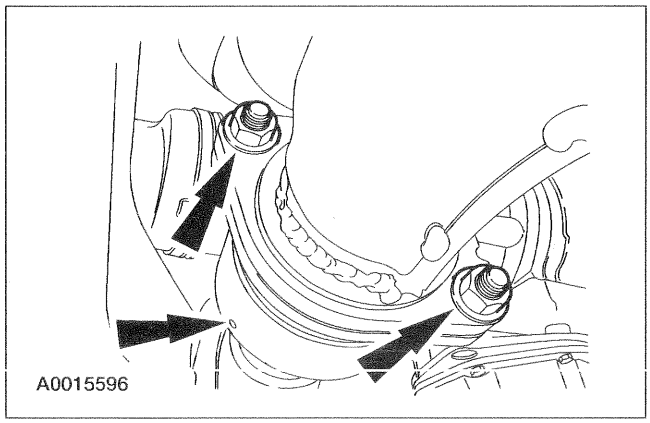
30. Raise the vehicle on a hoist. For additional information, refer to Section 100-02.

REMOVAL (Continued)

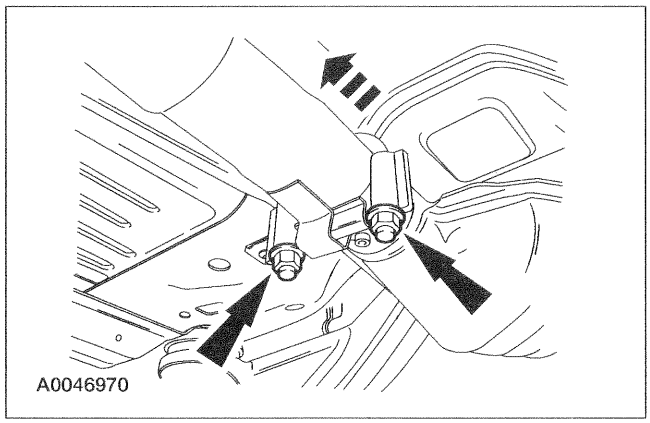
31. Remove the front wheels.

32. **NOTE:** Support the exhaust with mechanic's wire.

    Remove the nuts and disconnect the three-way catalytic converter from the dual converter Y-pipe.

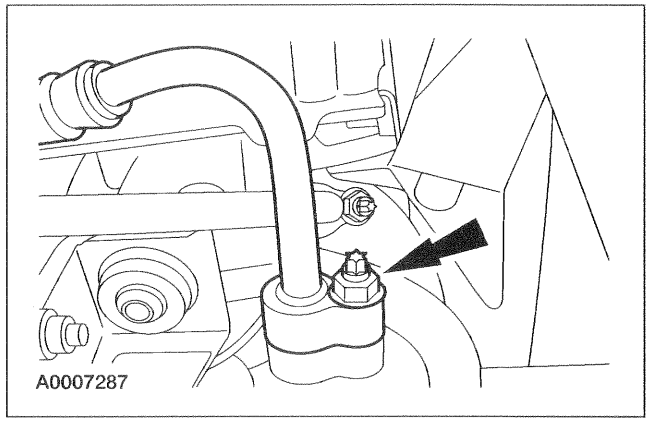


33. Remove the nuts and the muffler clamp.

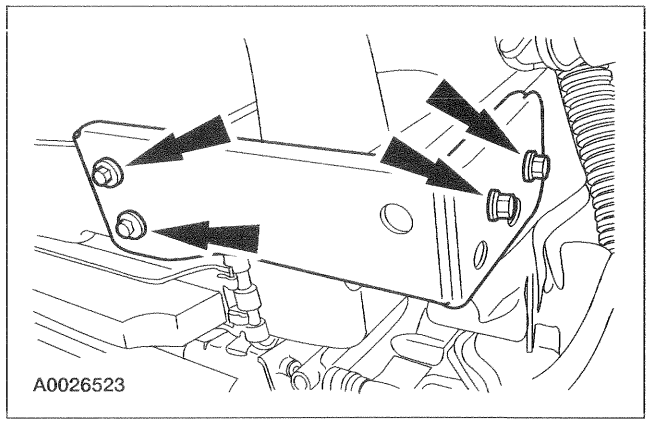


34. Separate and remove the three-way catalytic converter from the muffler pipe.

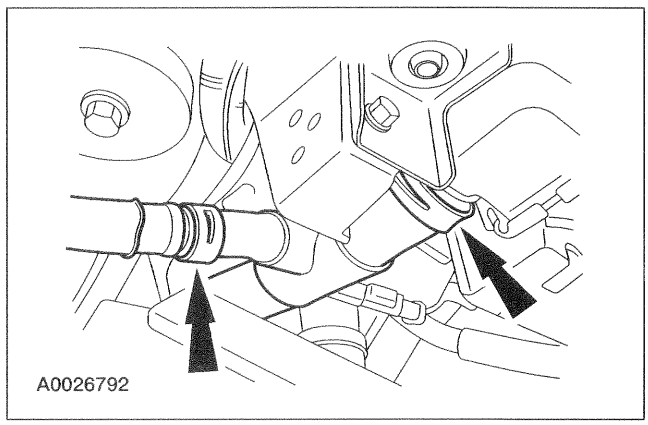
35. Disconnect the A/C discharge tube.
    - Remove the nut.



36. Remove the radiator support bracket.

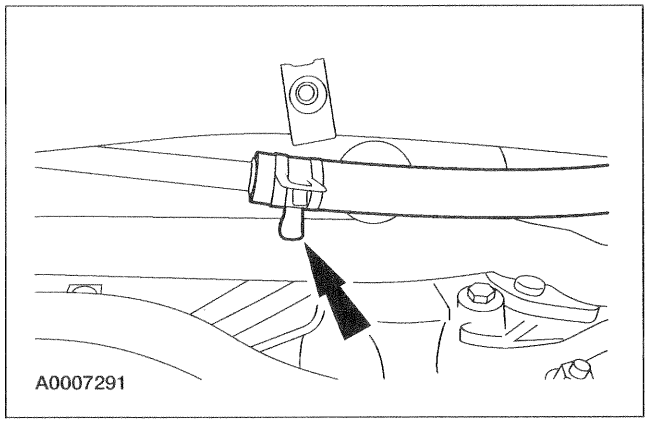


37. Disconnect the lower radiator hose from the radiator and degas bottle supply hose.

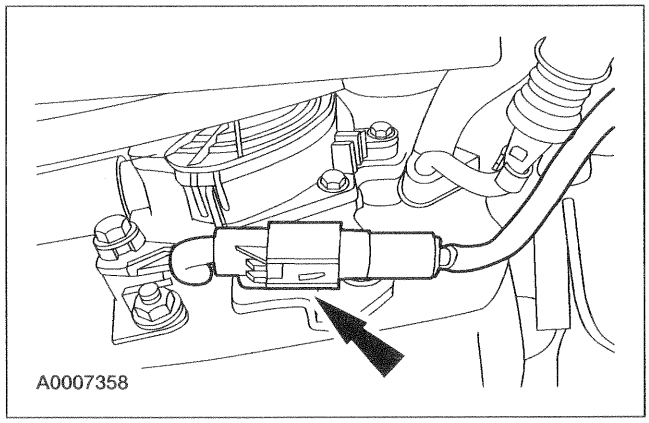


REMOVAL (Continued)

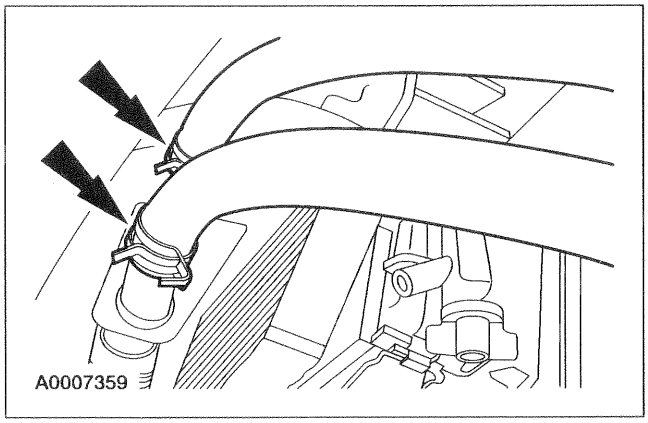
38. Disconnect the transmission oil cooler hose.



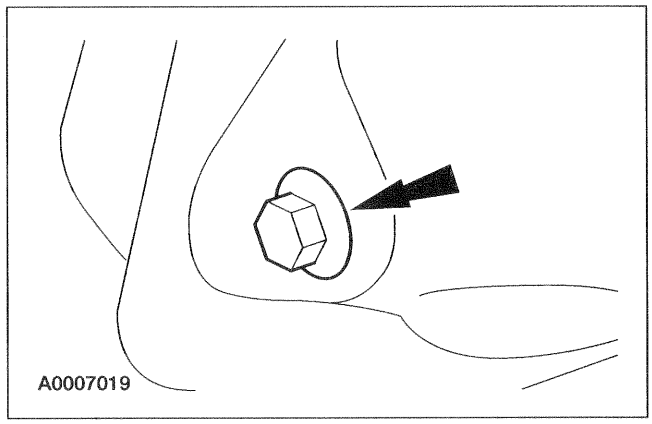
39. Disconnect the wire harness electrical connector, if equipped.



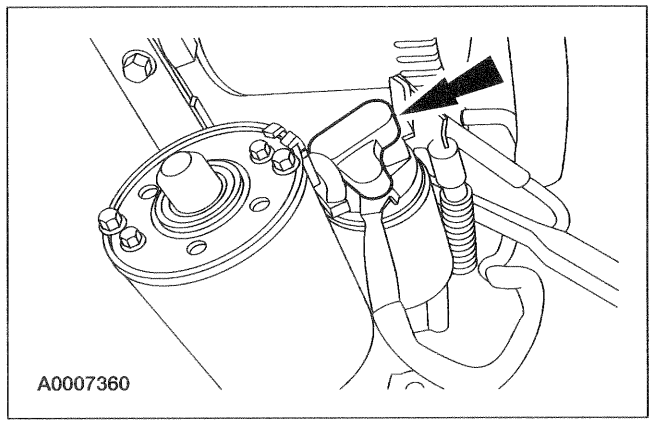
40. Disconnect the auxiliary oil cooler assembly.
    - Disconnect the transmission oil cooler hose, if equipped.
    - Disconnect the power steering return hose.



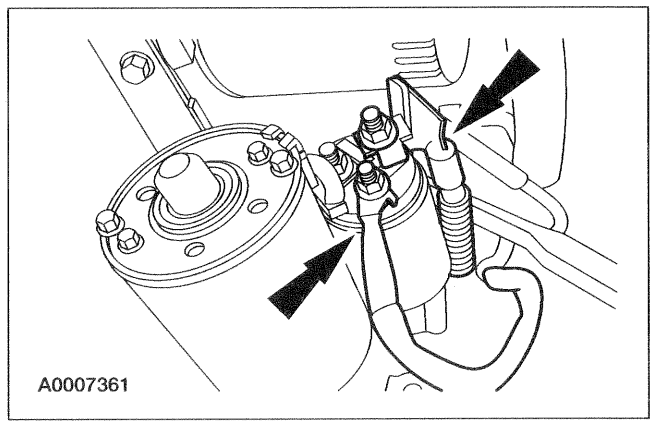
41. Remove the oil pan drain plug and drain the engine oil.
    - Install the drain plug when finished.



42. Remove the starter motor electrical connector cover.

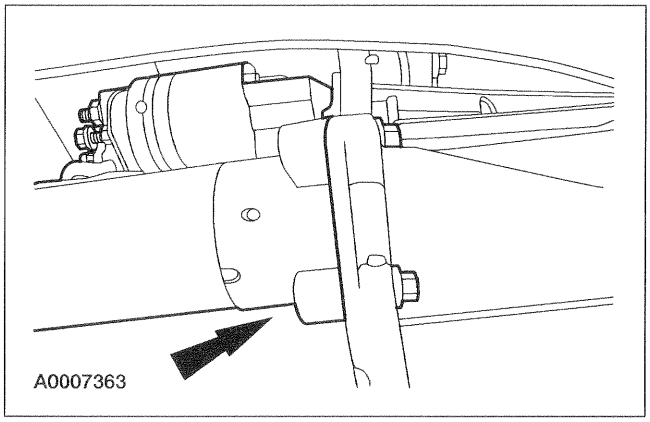


43. Disconnect the starter motor electrical connectors.
    - Remove the two nuts.

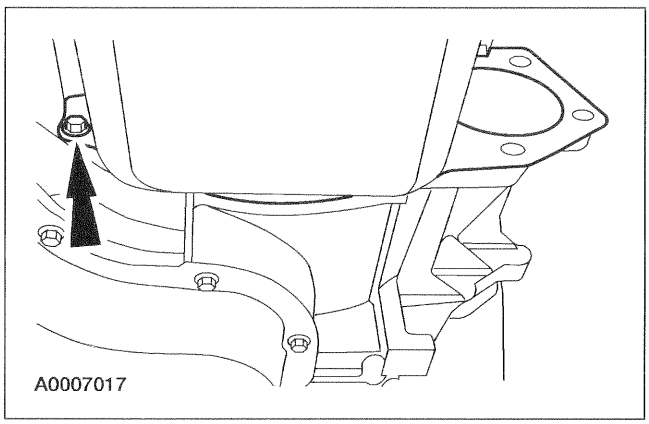


REMOVAL (Continued)

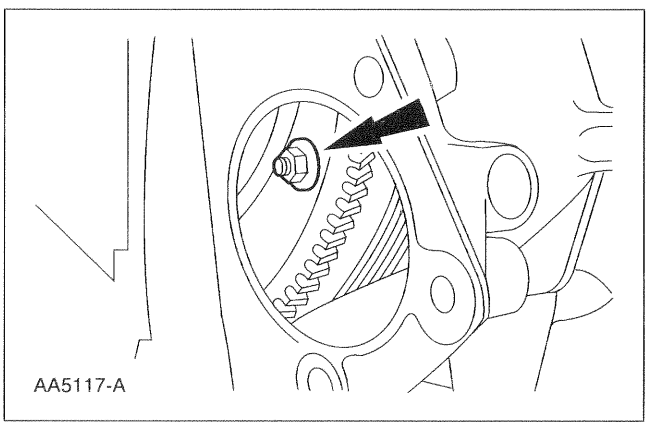
44. Remove the starter motor.
    - Remove the two bolts.



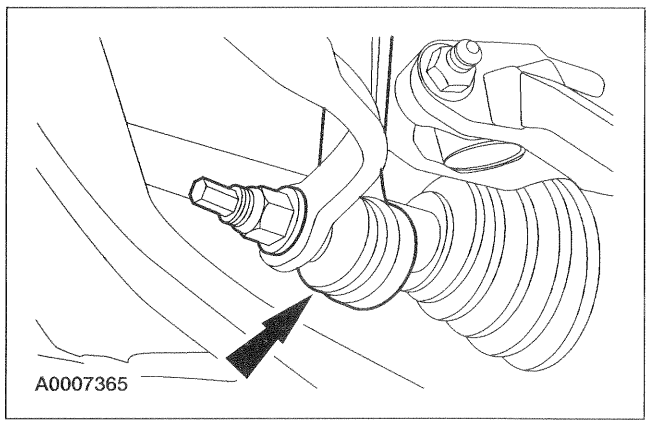
45. Remove the engine rear plate.
    - Remove the bolt.



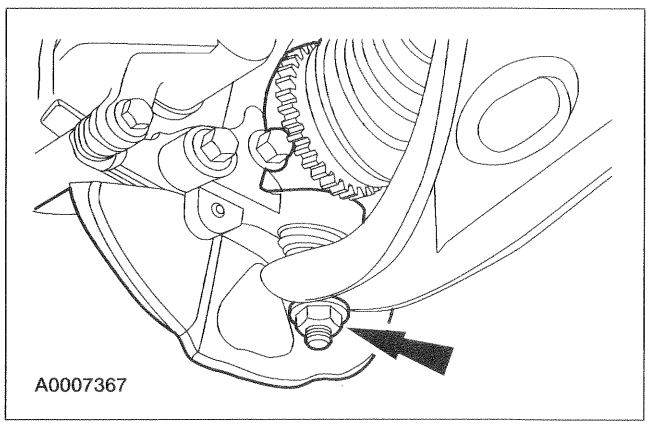
46. Remove the four torque converter nuts.



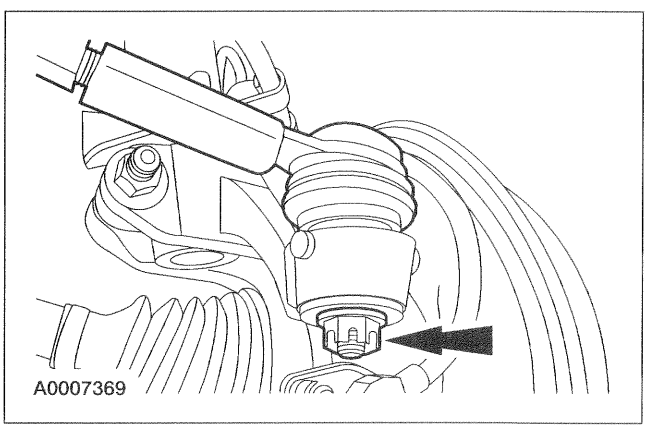
47. Disconnect the LH and RH stabilizer links from the stabilizer bar.
    - Remove the nuts.



48. Separate the LH and RH lower control arms from the steering knuckles.
    - Remove the nuts.

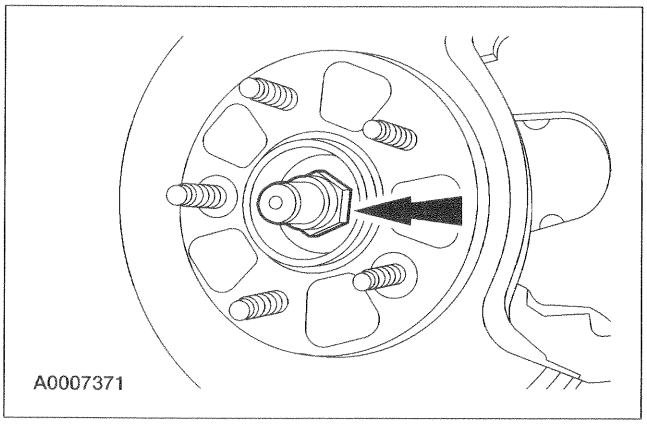


49. Separate the LH and RH tie rod ends from the steering knuckles.
    - Remove the nuts.

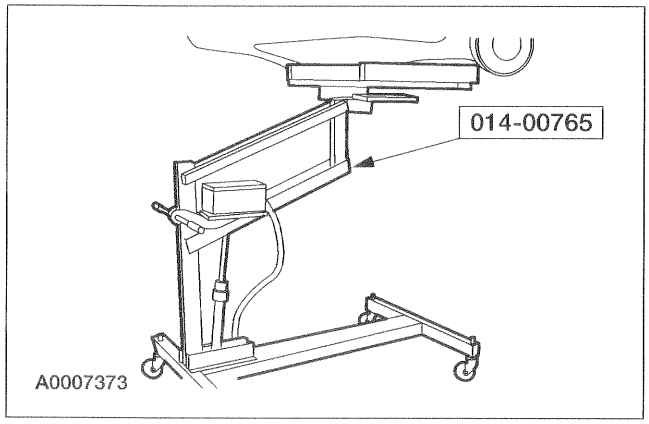


REMOVAL (Continued)

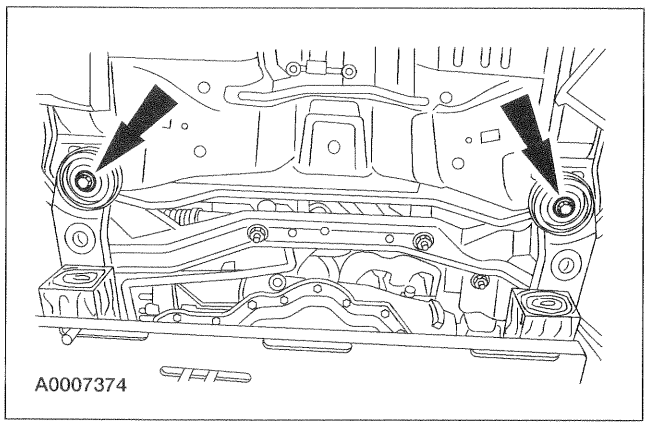
50. Separate the LH and RH half shafts from the steering knuckles.
    - Remove the nuts.



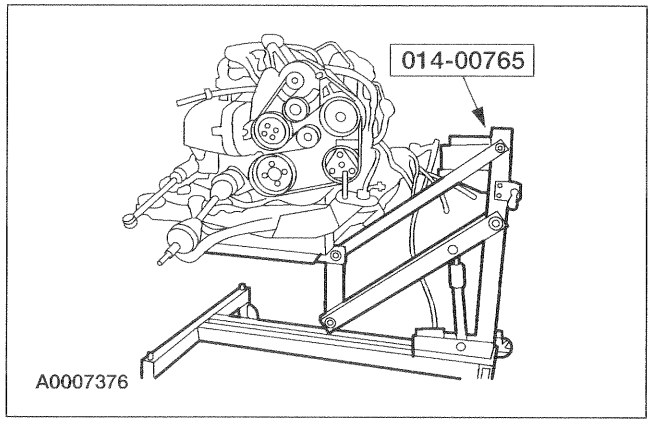
51. Position the special tool.



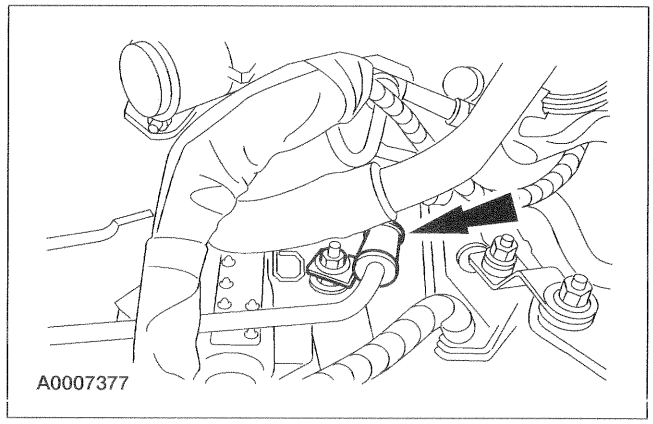
52. Remove the four front subframe-to-body bolts.



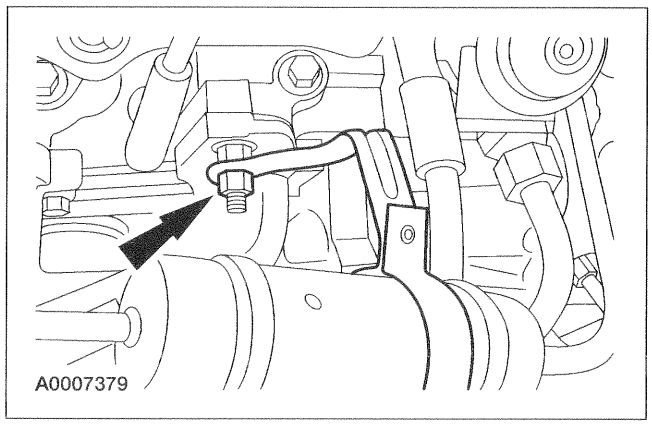
53. Using the special tool, lower the engine, transmission and subframe assembly out of the vehicle.



54. Remove the power steering pressure line bracket.
    - Remove the nut.

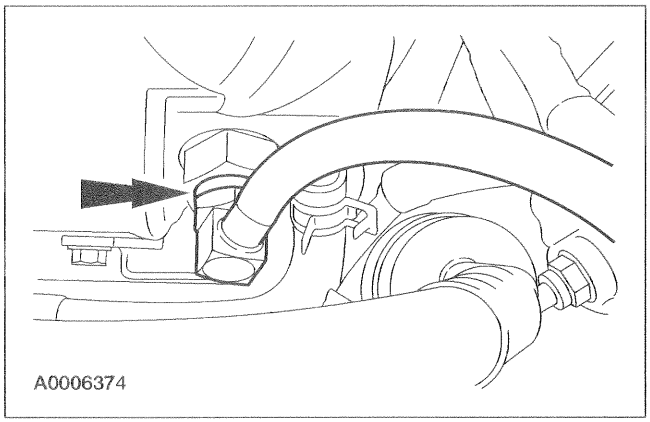


55. Remove the power steering pressure line bracket.
    - Remove the nut.

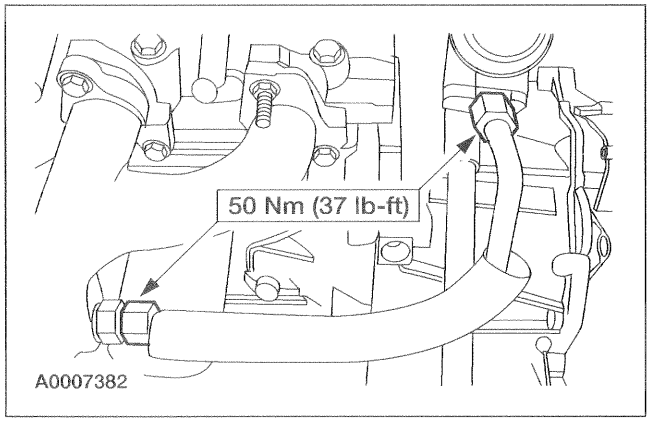


REMOVAL (Continued)

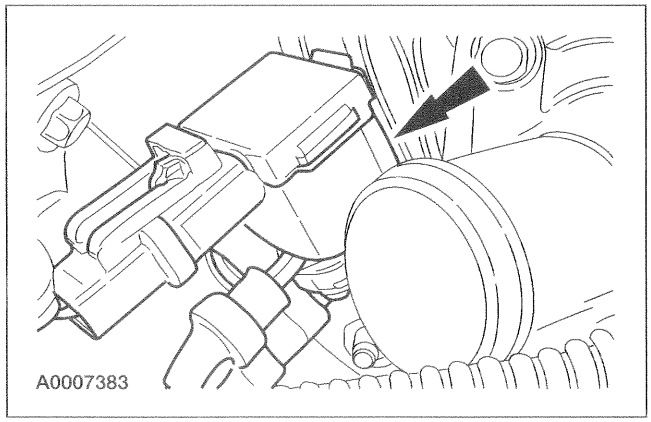
56. Disconnect the power steering pressure line from the power steering pump.



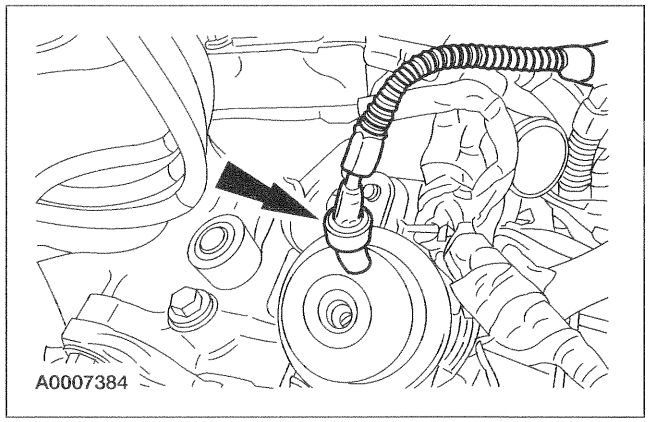
57. Remove the LH secondary air injection tube, if equipped.
    - Loosen the compression nuts.



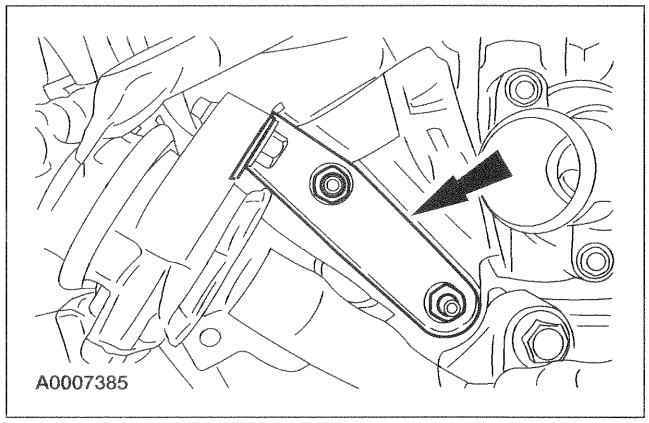
58. Separate the control valve solenoid from the bracket and position aside, if equipped.



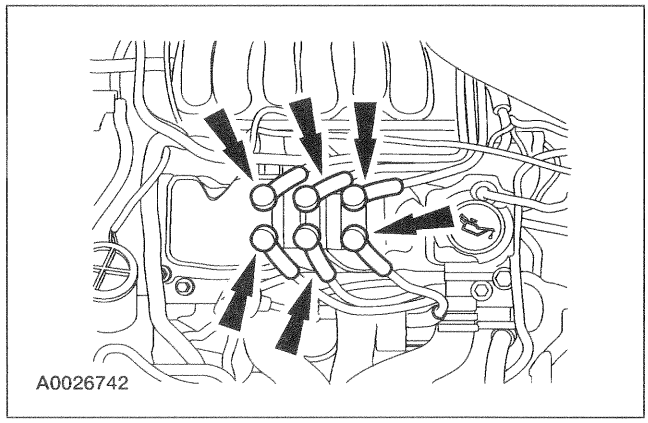
59. Disconnect the secondary air injection valve vacuum tube, if equipped.



60. Remove the secondary air injection valve and bracket, if equipped.
    - Remove the two nuts.

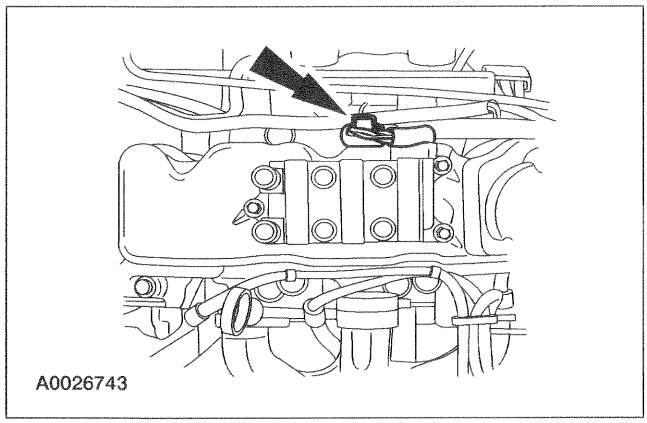


61. Disconnect the ignition coil.
    - Disconnect the spark plug wires.

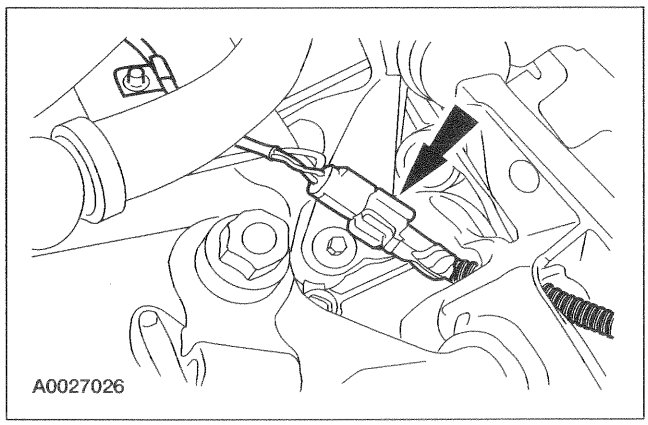


REMOVAL (Continued)

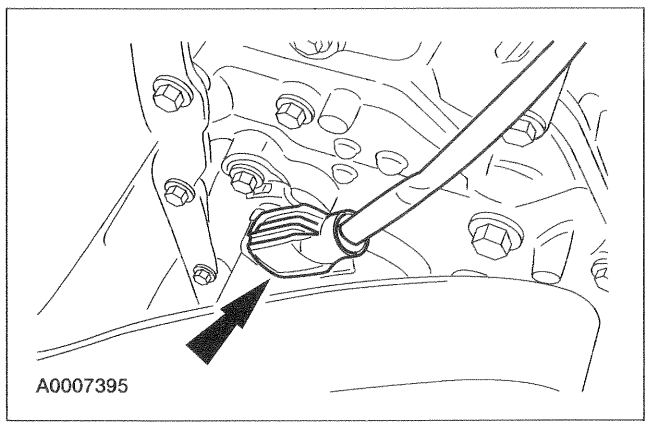
62. Disconnect the ignition coil electrical connector.



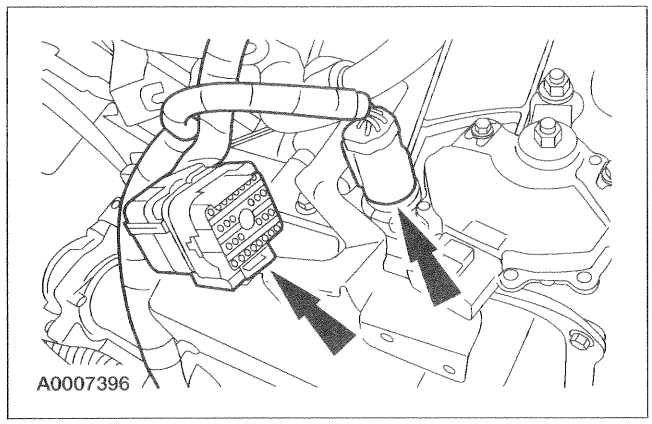
63. Disconnect the output speed sensor (OSS) and position the wire harness aside.



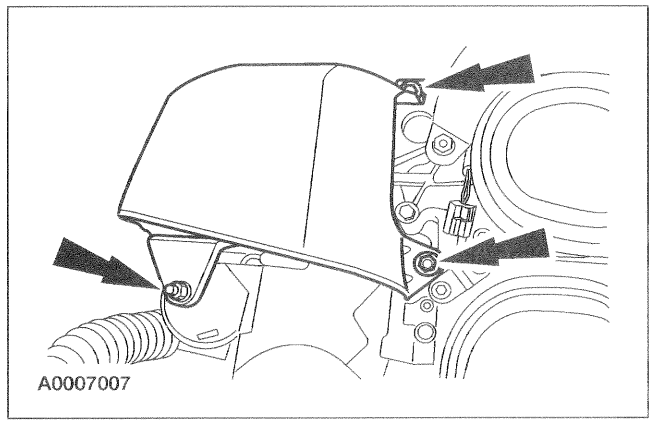
64. Disconnect the turbine shaft speed (TSS) sensor electrical connector.



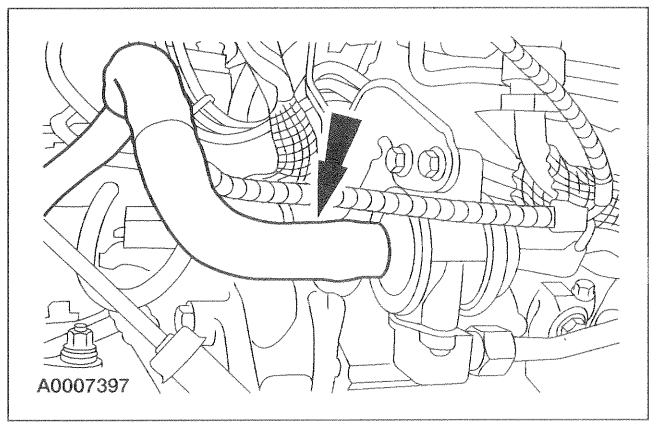
65. Disconnect the transaxle harness electrical connector and position the wire harness aside.



66. Remove the RH catalytic converter heat shield.
    - Remove one bolt.
    - Remove two nuts.

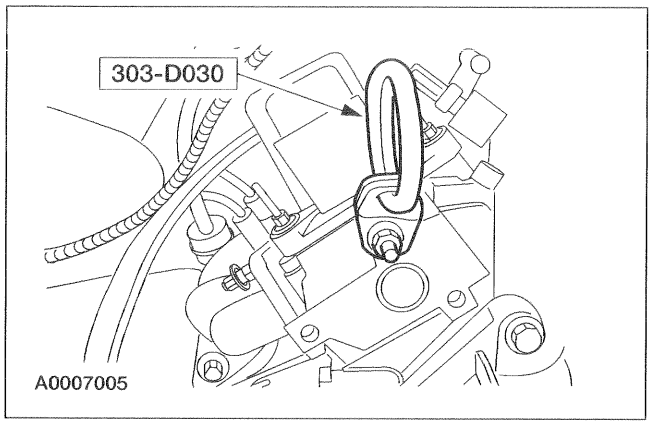


67. Remove the secondary air injection hose, if equipped.

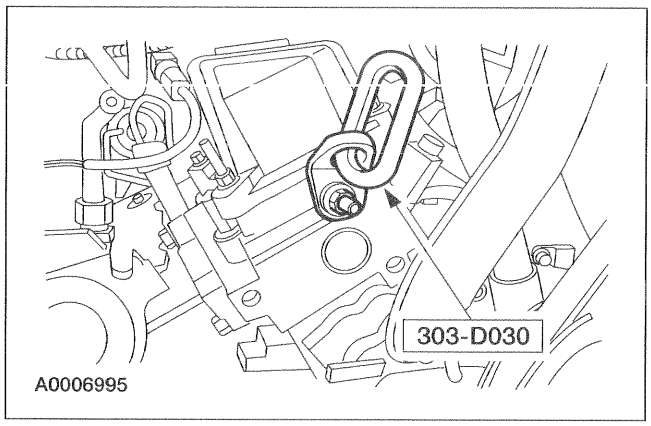


REMOVAL (Continued)

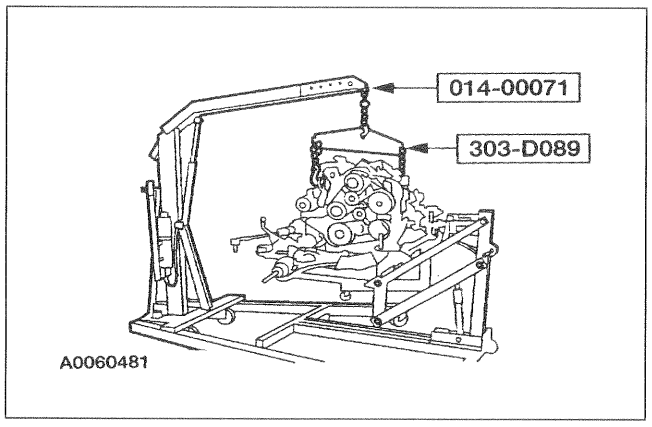
68. Install the LH engine lifting eye.



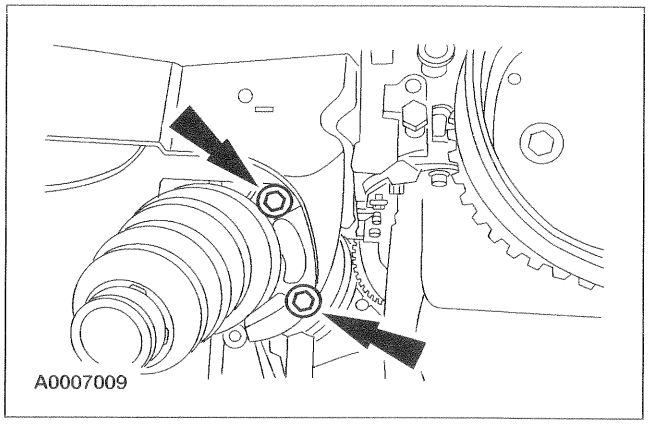
69. Install the RH engine lifting eye.



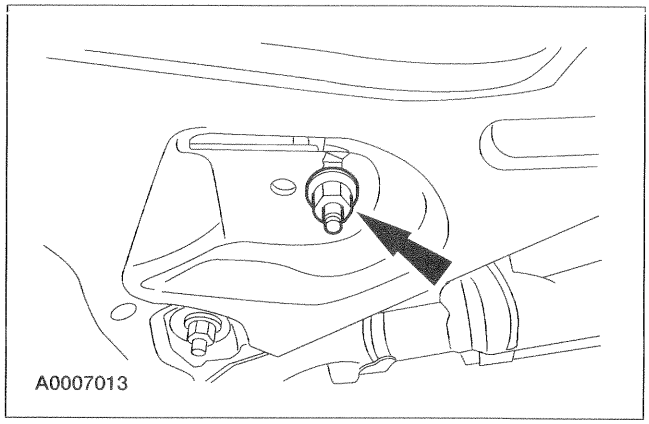
70. Using the special tools, support the engine.



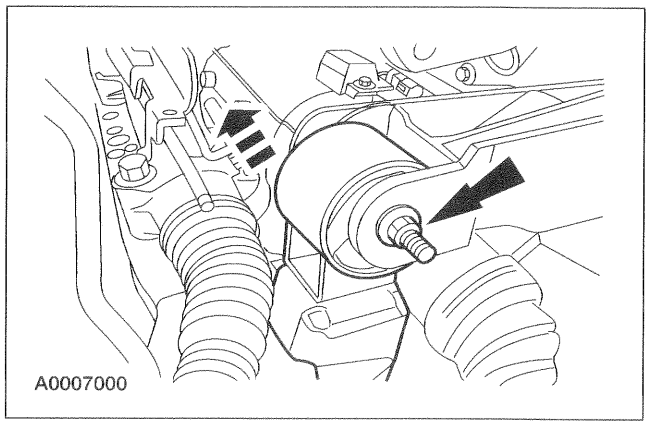
71. Remove the two RH engine support insulator-to-transmission bolts.



72. Remove the LH engine support insulator-to-subframe nut.

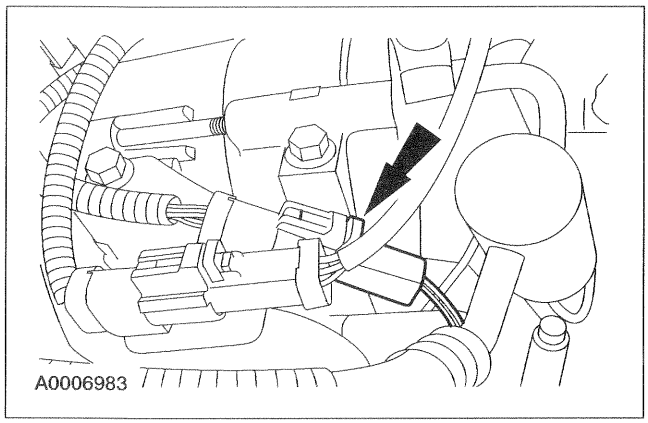


73. Remove the RH engine support insulator through bolt.

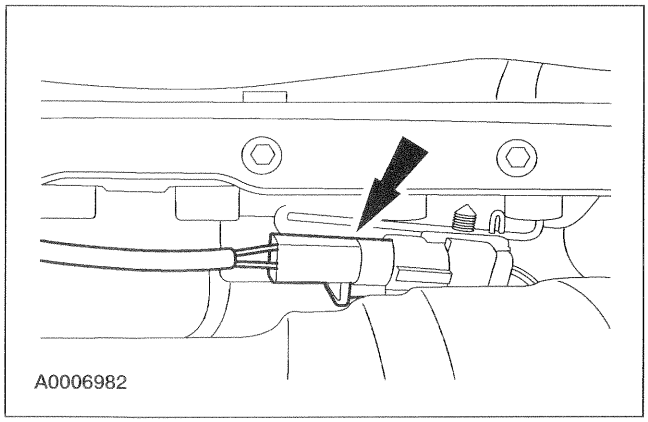


REMOVAL (Continued)

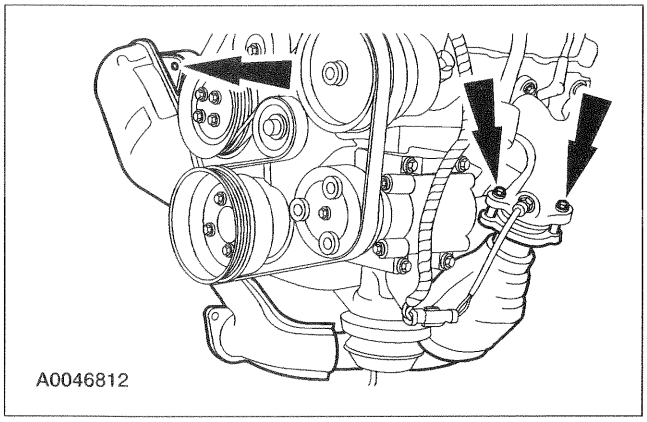
74. Disconnect the catalyst monitor sensor electrical connector.



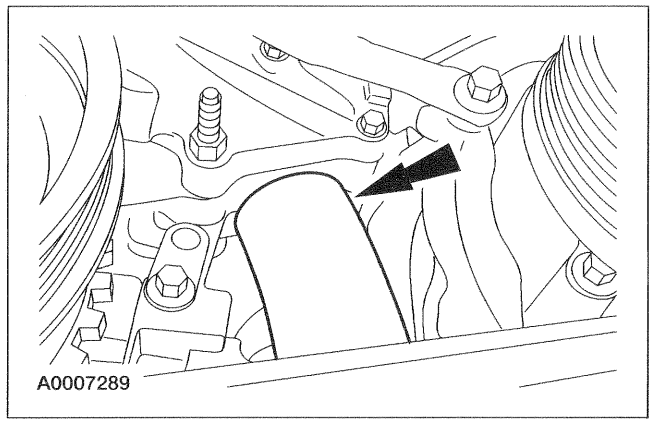
75. Disconnect the catalyst monitor sensor electrical connector.



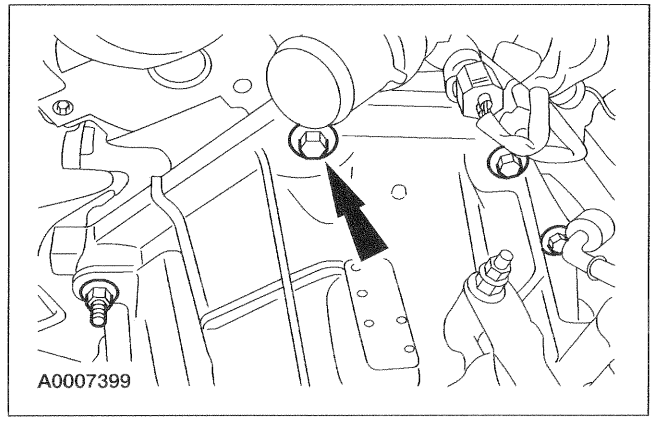
76. Remove the bolts and the y-pipe.



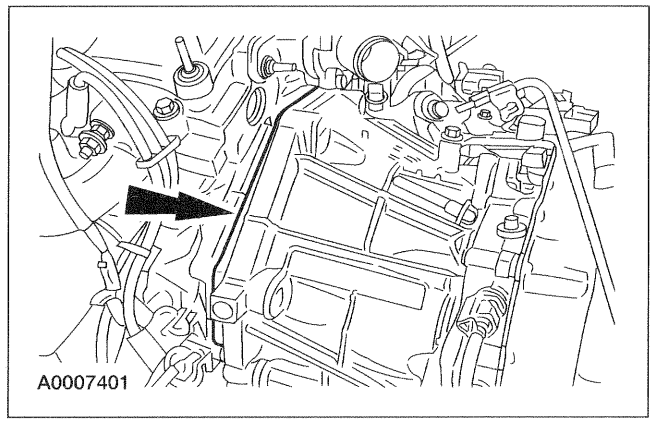
77. Disconnect the lower radiator hose from the water pump.



78. Remove the transmission to engine bolts.
    - Remove five bolts.
    - Remove one stud bolt.

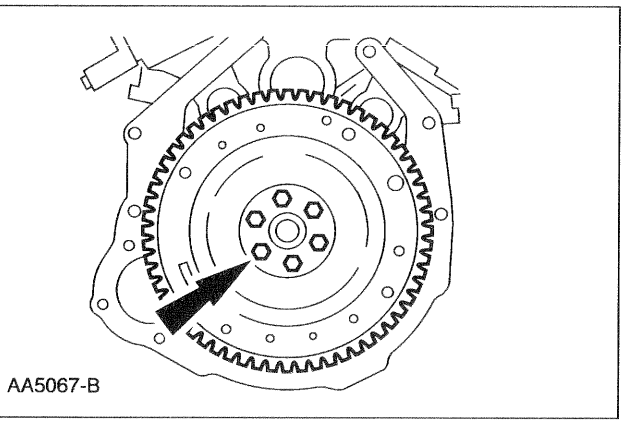


79. Separate the engine (6007) from the transmission.



REMOVAL (Continued)

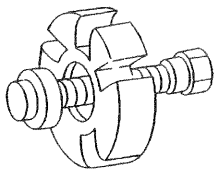
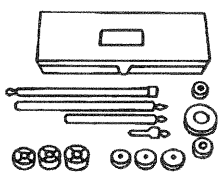
80. Remove the bolts and the flexplate.



DISASSEMBLY

Engine

Special Tool(s)

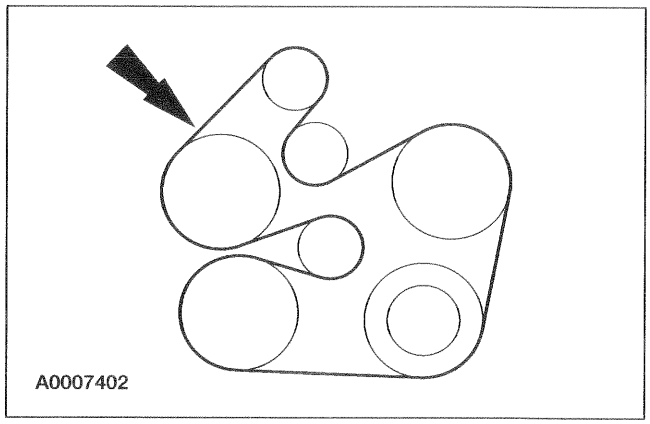
 ST1286-A	Crankshaft Damper Remover 303-009 (T58P-6316-D)
 ST1381-A	Camshaft Bearing Set 303-017 (T65L-6250-A)

Material

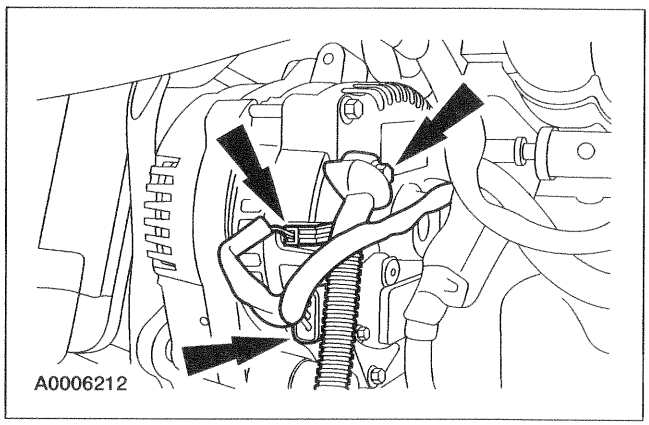
Item	Specification
Metal Surface Cleaner F4AZ-19A536-RA or equivalent	WSE-M5B392-A

Disassembly

1. Remove the drive belt.

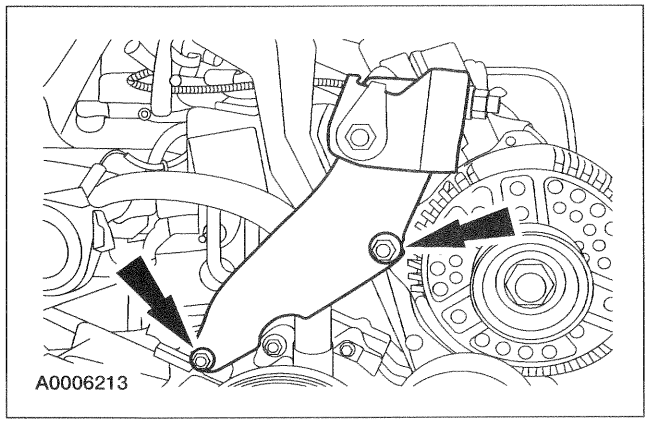


2. Disconnect the generator electrical connections.

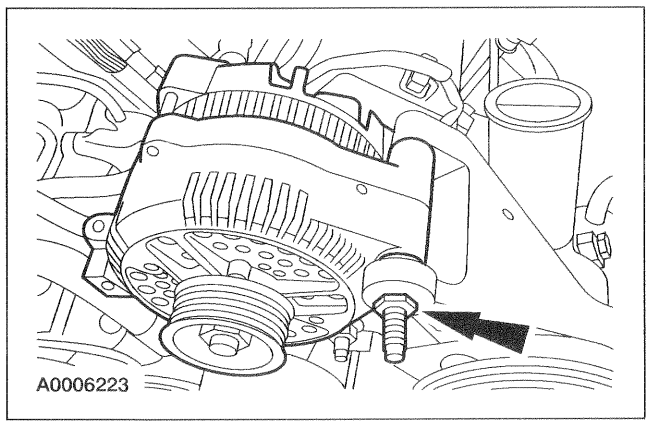


DISASSEMBLY (Continued)

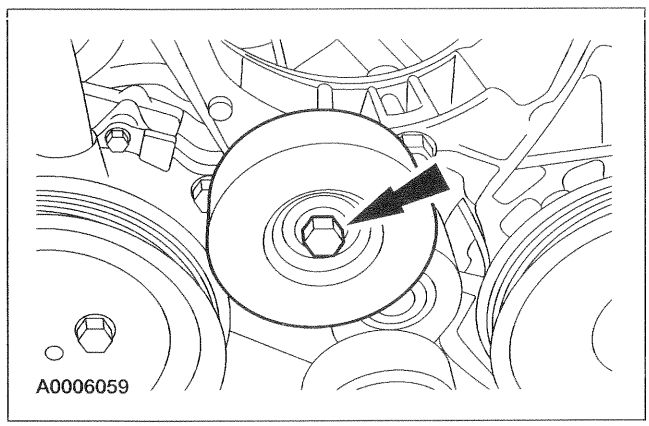
3. Remove the retainers and the generator support bracket.



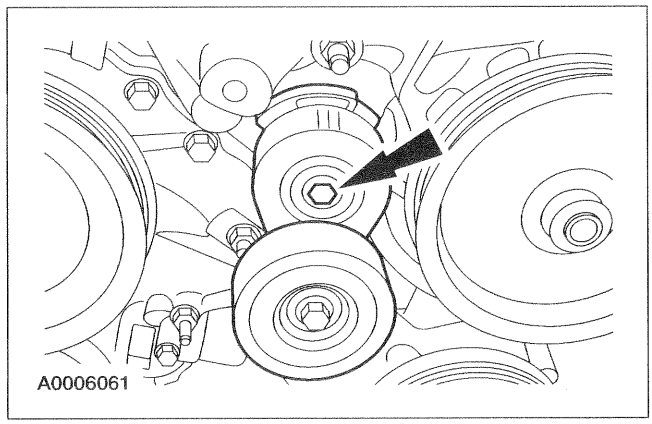
4. Remove the stud bolt and the generator.



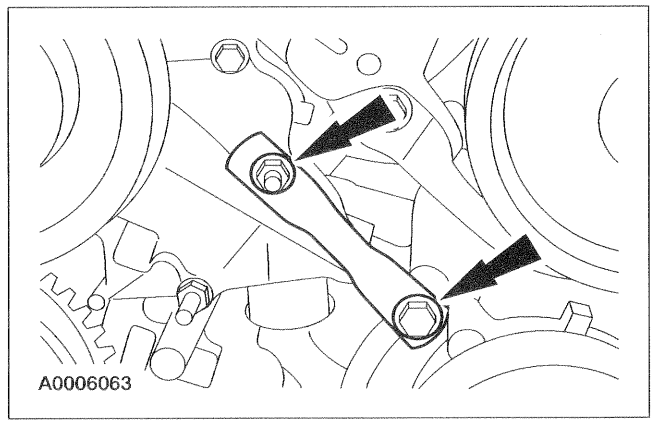
5. Remove the bolt and the drive belt idler pulley.



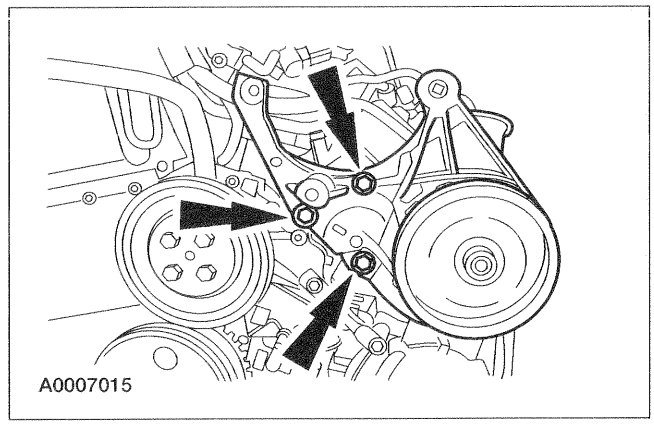
6. Remove the bolt and the drive belt tensioner.



7. Remove the retainers and the support bracket.

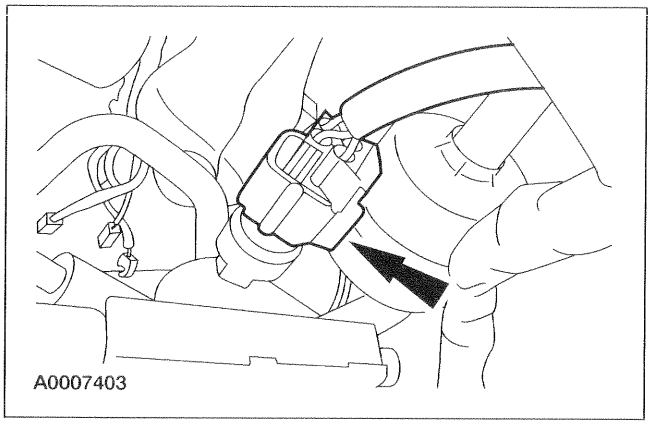


8. Remove the retainers and the power steering pump and bracket assembly.

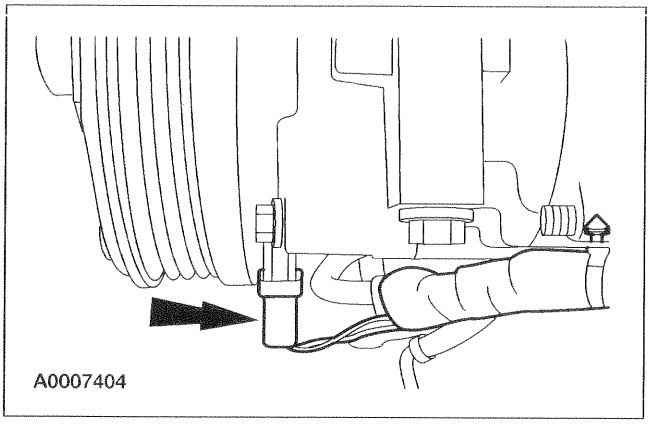


DISASSEMBLY (Continued)

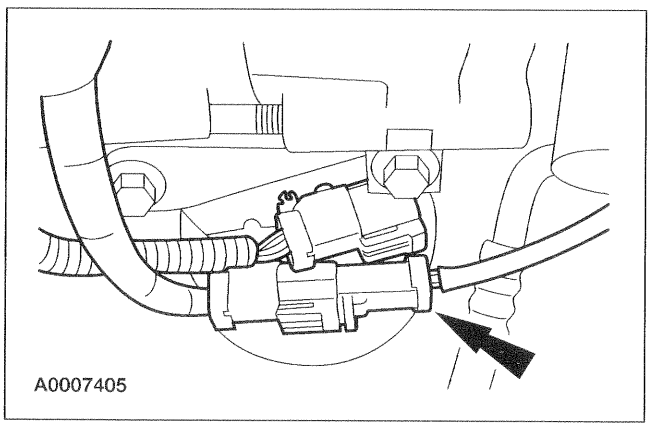
9. Disconnect the A/C high pressure cutoff switch electrical connector.



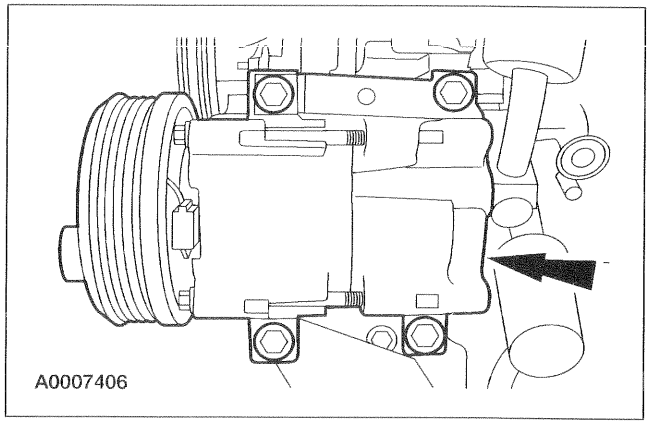
10. Disconnect the A/C compressor clutch coil electrical connector.



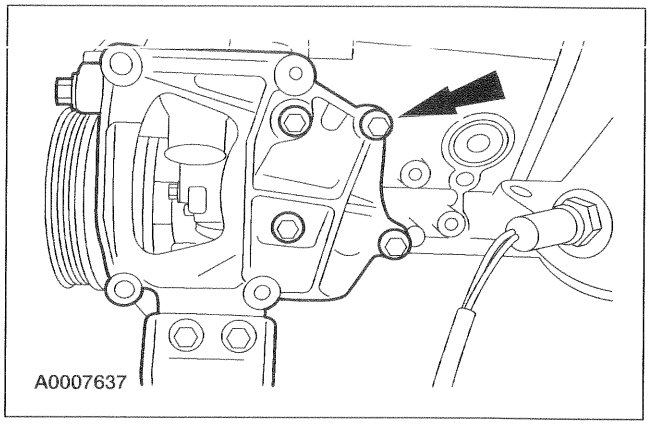
11. Disconnect the oxygen sensor electrical connector and separate the connector ends from the bracket.



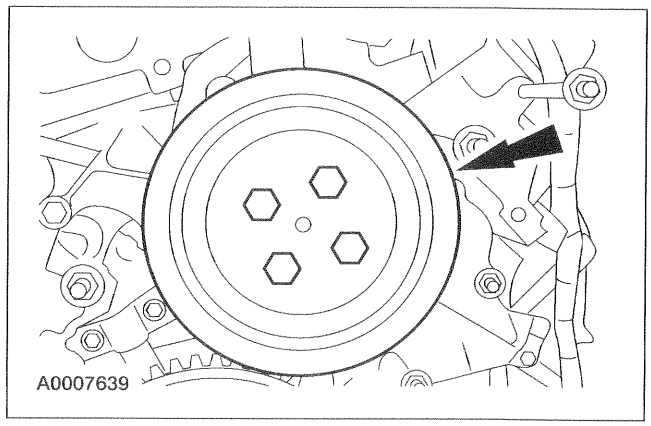
12. Remove the four bolts and the A/C compressor.



13. Remove the four bolts and the A/C compressor mounting bracket.

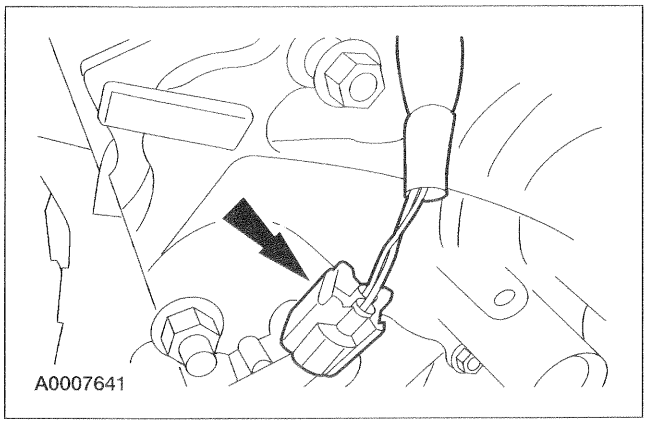


14. Remove the four bolts and the water pump pulley.

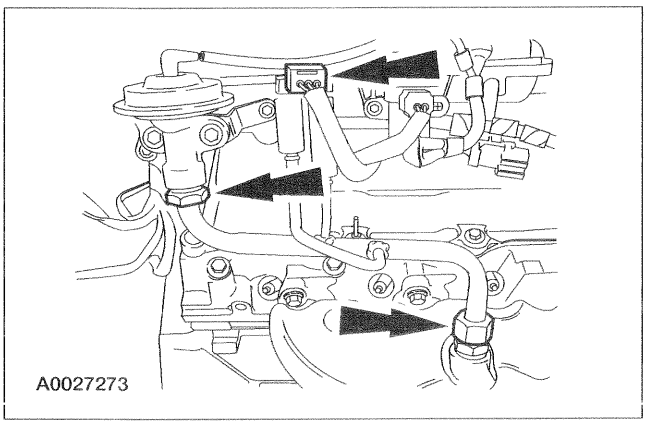


DISASSEMBLY (Continued)

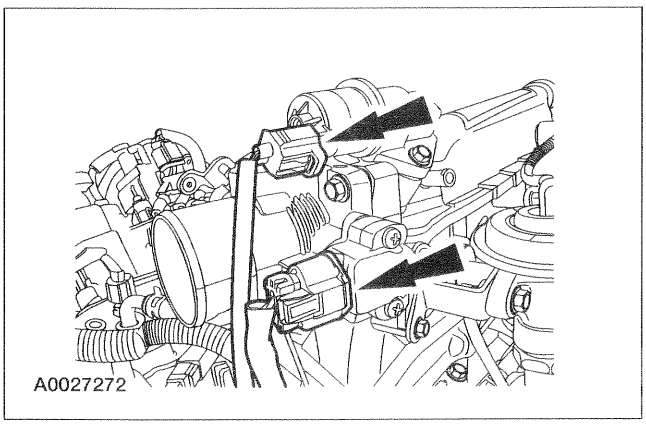
15. Disconnect the crankshaft position sensor (CKP) electrical connector.



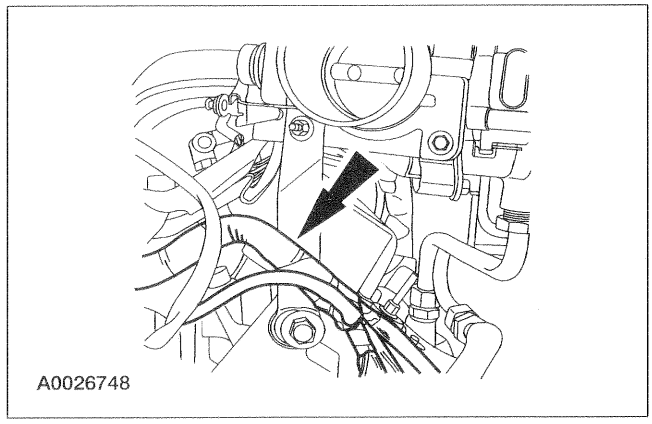
16. Remove the exhaust gas recirculation (EGR) tube.
    - Disconnect the electrical connector.
    - Loosen the two compression nuts.



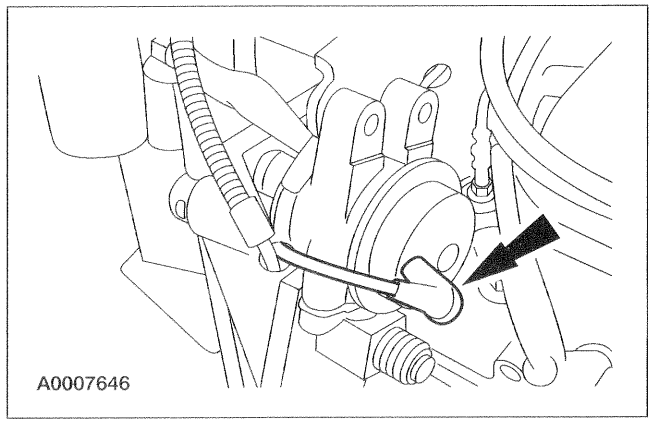
17. Disconnect the idle air control (IAC) valve and throttle position (TP) sensor electrical connectors.



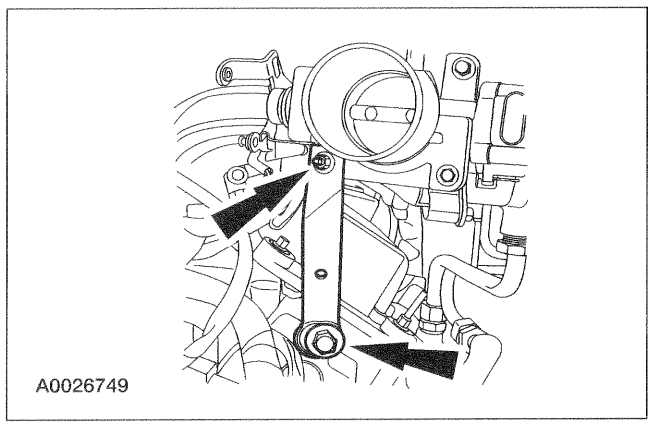
18. Remove the pin-type retainer and position the wire harness aside.



19. Disconnect the vacuum tube from the secondary air injection valve.

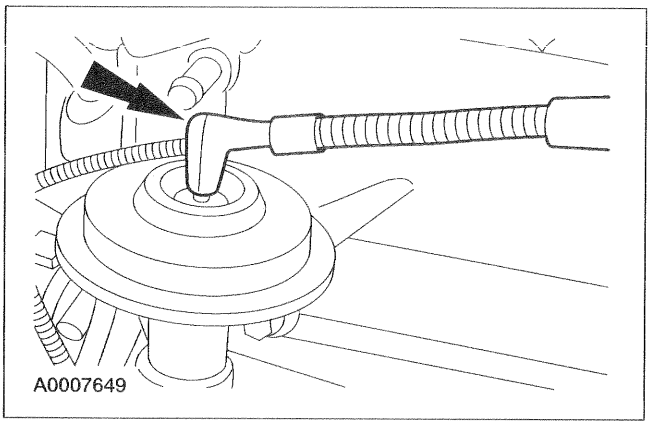


20. Remove the retainers and the upper intake manifold support bracket.

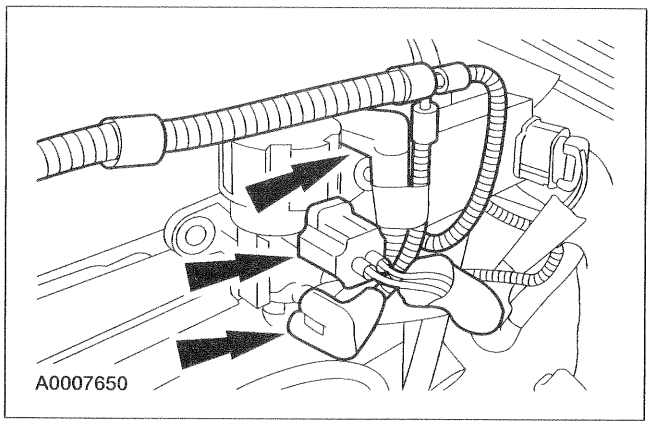


DISASSEMBLY (Continued)

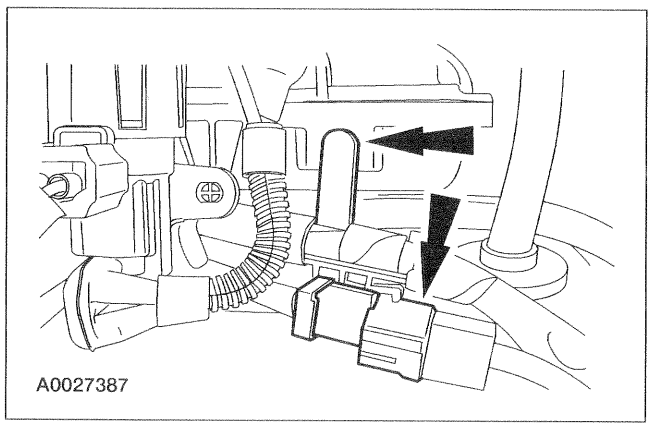
21. Disconnect the EGR valve vacuum tube.



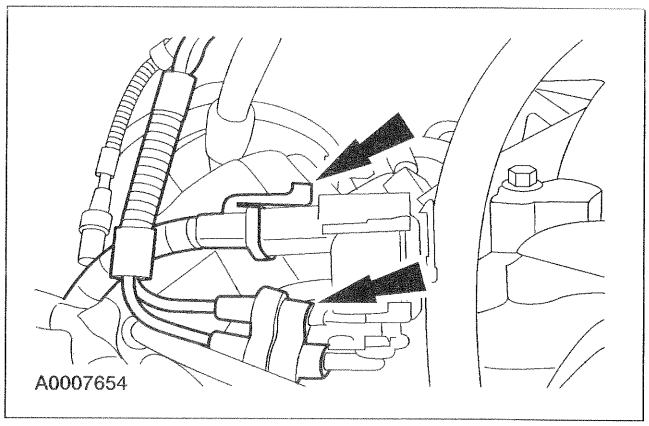
22. Disconnect the following:
    - Disconnect the EGR vacuum regulator solenoid electrical and vacuum connections.
    - Disconnect the vacuum harness connection to the upper intake manifold.



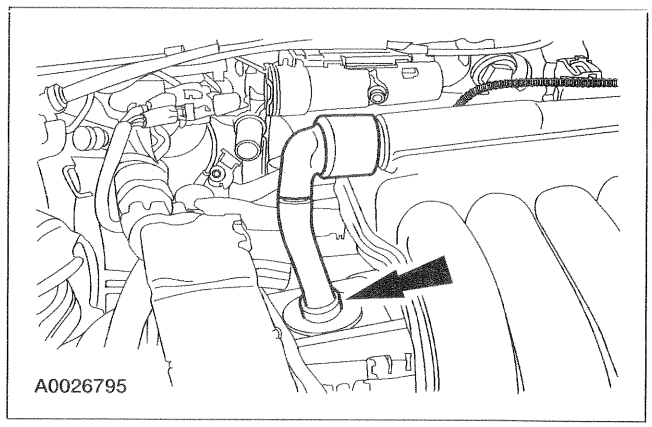
23. Disconnect the oxygen sensor electrical connector and separate it from the bracket.



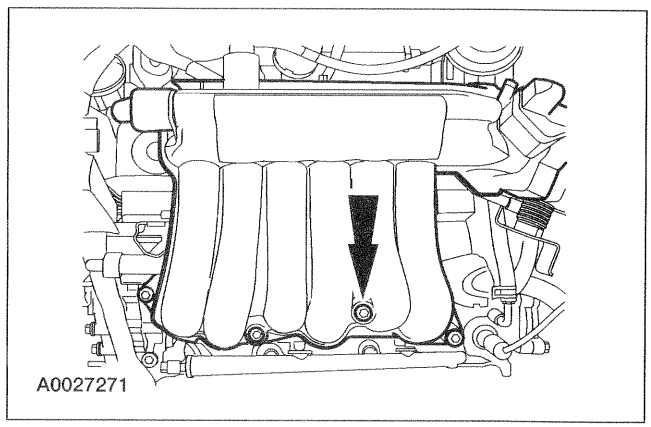
24. Disconnect the secondary air injection control solenoid electrical and vacuum connections.



25. Disconnect the positive crankcase ventilation (PCV) valve.

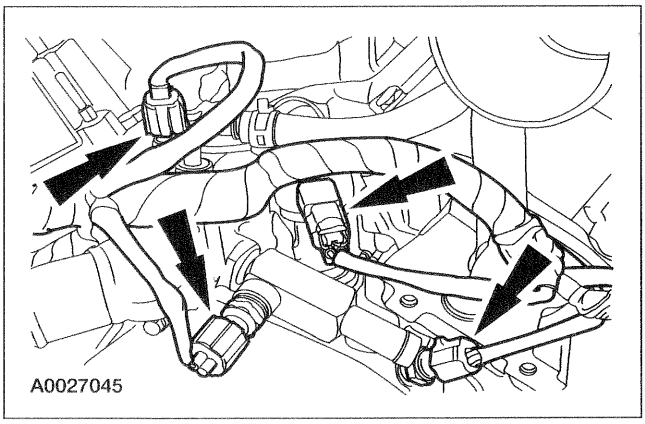


26. Remove the four bolts and the upper intake manifold.

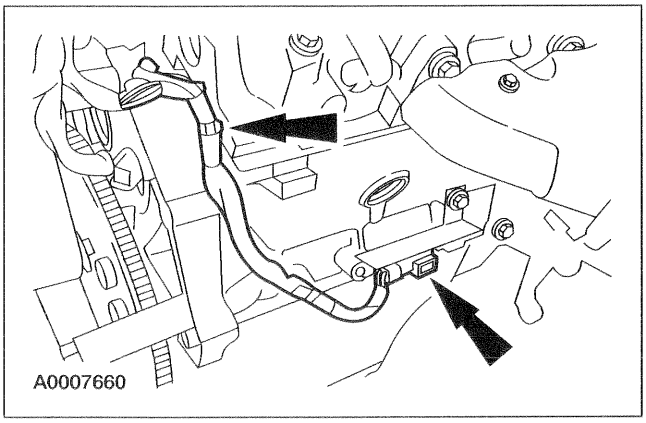


DISASSEMBLY (Continued)

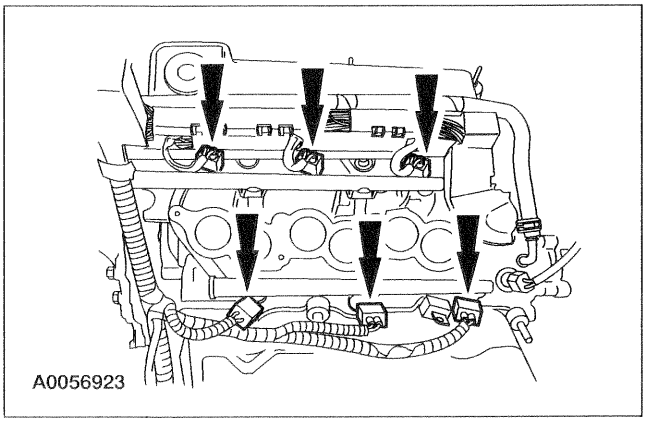
27. Disconnect the camshaft position (CMP) sensor, engine coolant temperature (ECT) sensor, ECT sender and the oil pressure switch electrical connectors.



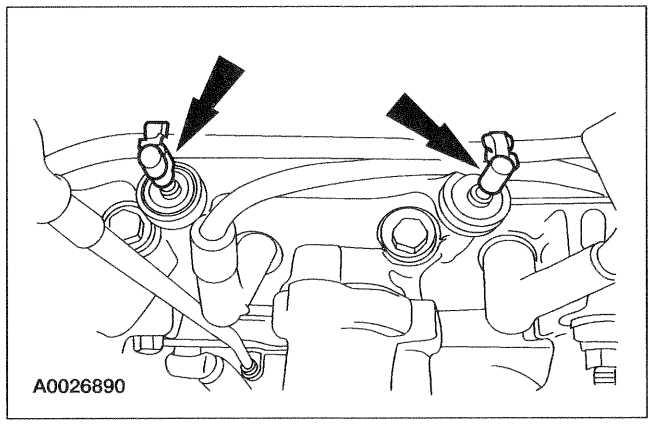
28. Remove the pin-type retainers and separate the wire harness from the engine.



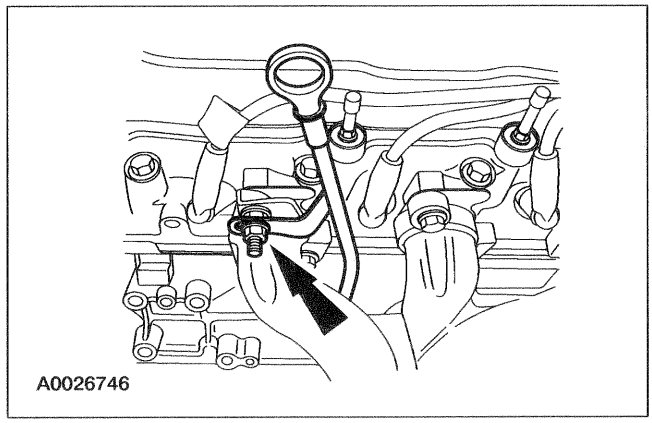
29. Disconnect the fuel injectors and remove the engine control sensor wiring harness.



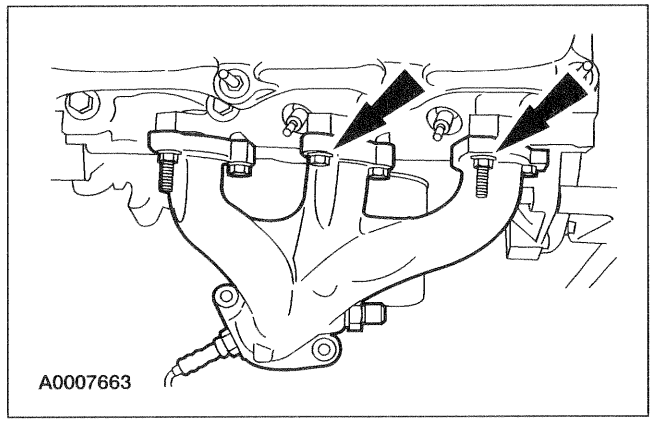
30. Disconnect and remove the LH spark plug wires.



31. Remove the nut and the oil level indicator and tube assembly.

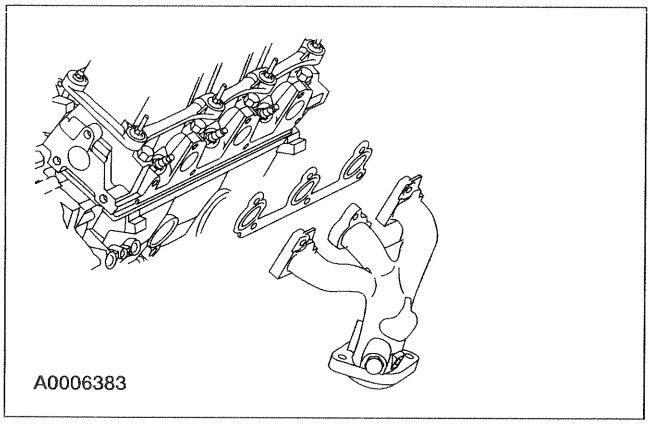


32. Remove the six bolts and the LH exhaust manifold.

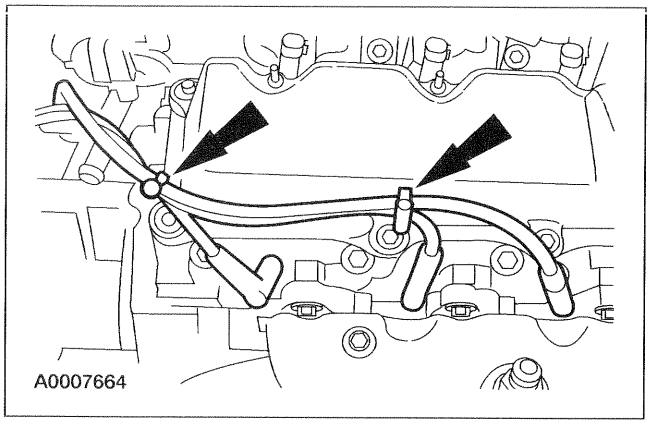


DISASSEMBLY (Continued)

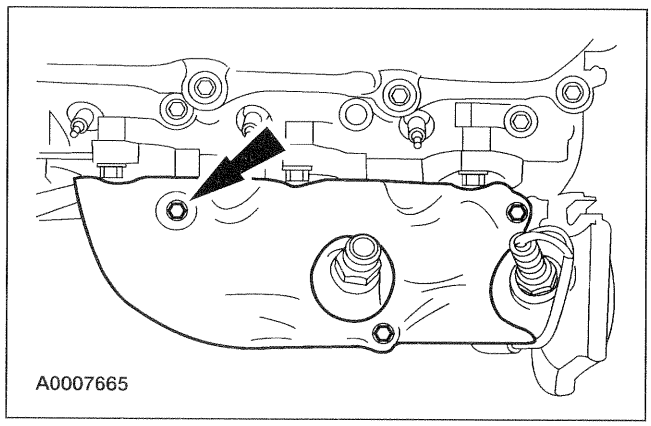
33. Remove and discard the LH exhaust manifold gasket.



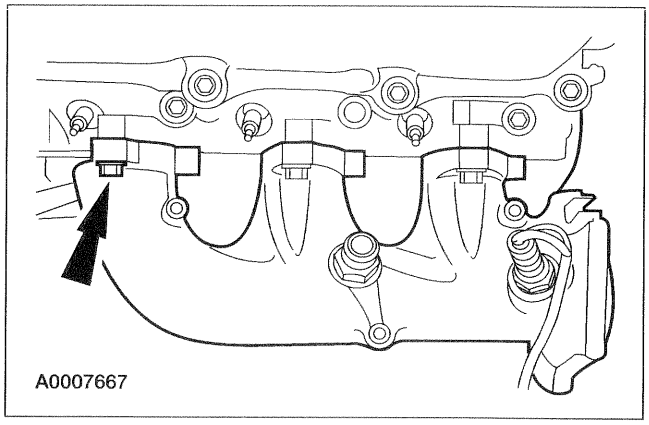
34. Disconnect and remove the RH spark plug wires.



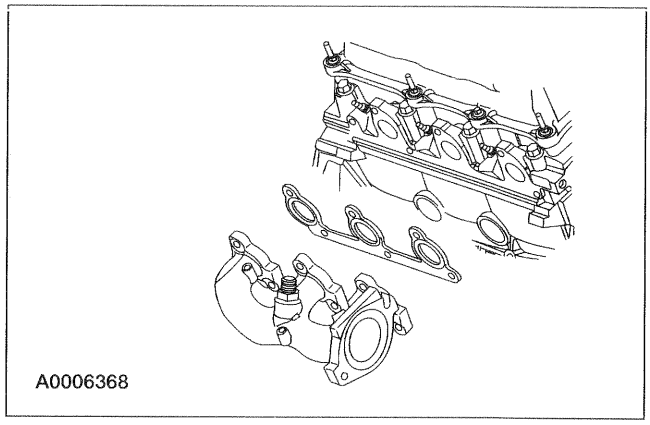
35. Remove the three bolts and the RH exhaust manifold heat shield.



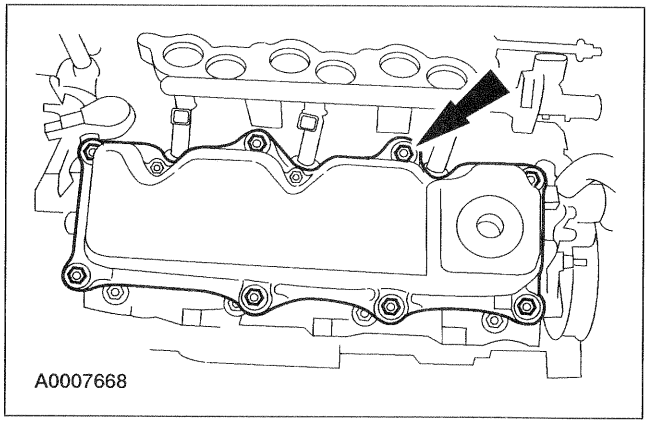
36. Remove the six bolts and the RH exhaust manifold.



37. Remove and discard the RH exhaust manifold gasket.

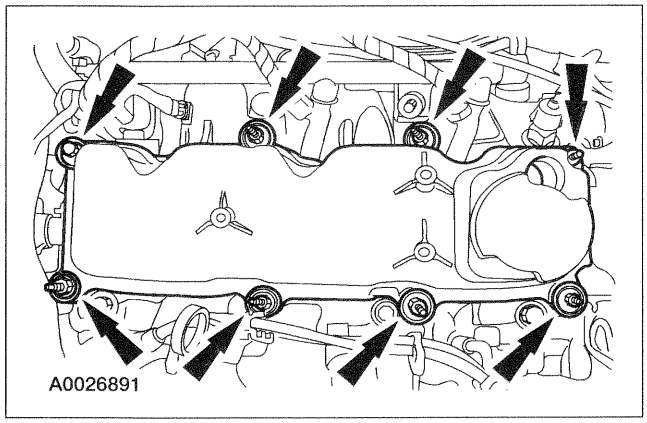


38. Remove the retainers and the RH valve cover.

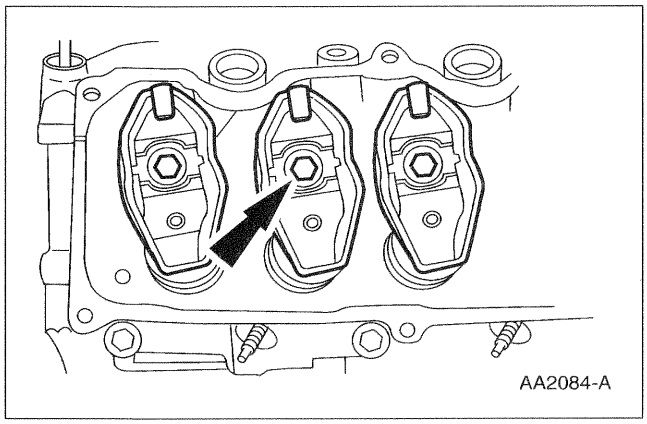


DISASSEMBLY (Continued)

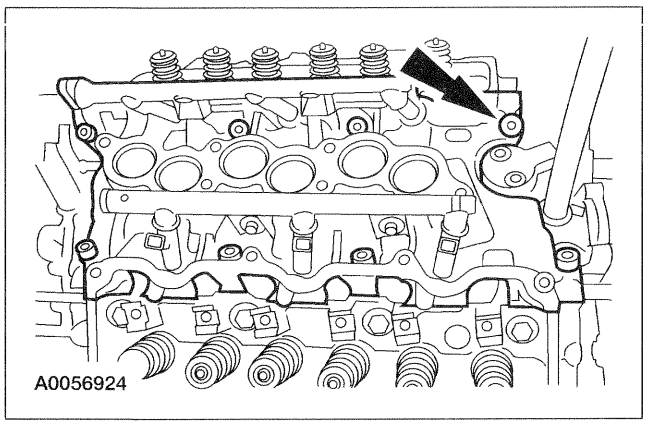
39. Remove the retainers and the LH valve cover.



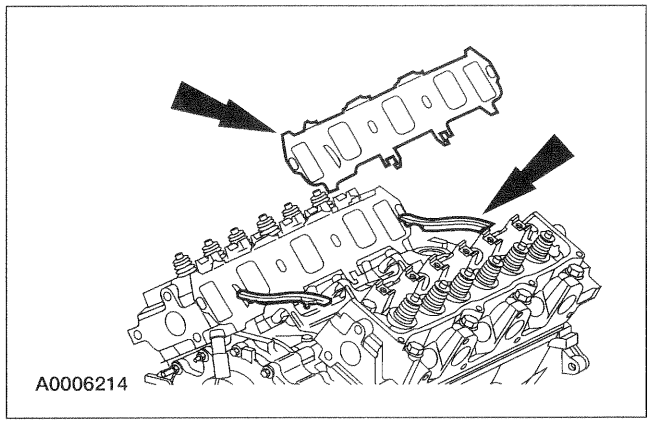
40. Remove the rocker arms and push rods.



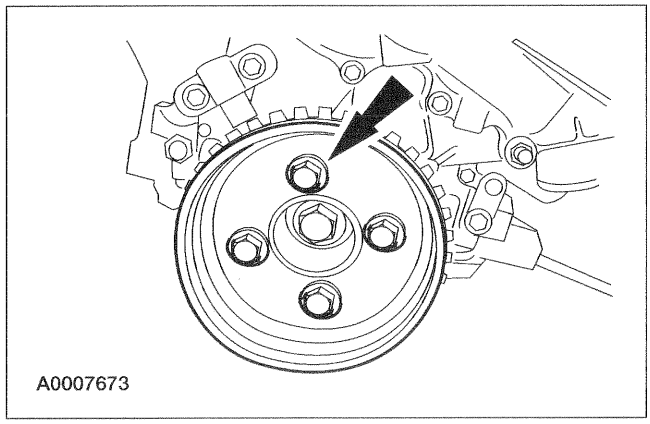
41. Remove the eight bolts and the lower intake manifold.



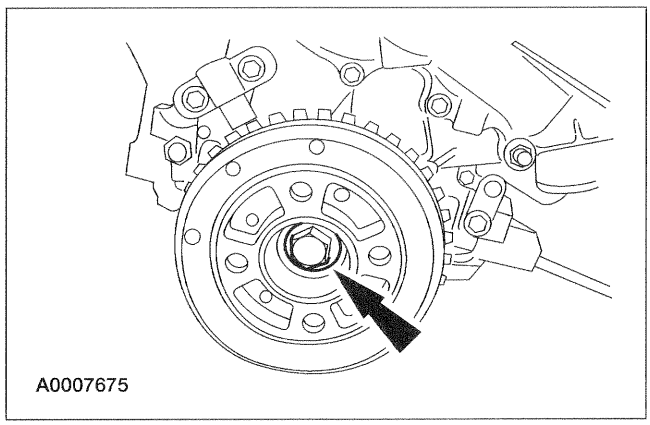
42. Remove and discard the lower intake manifold gaskets.



43. Remove the four bolts and the crankshaft pulley.

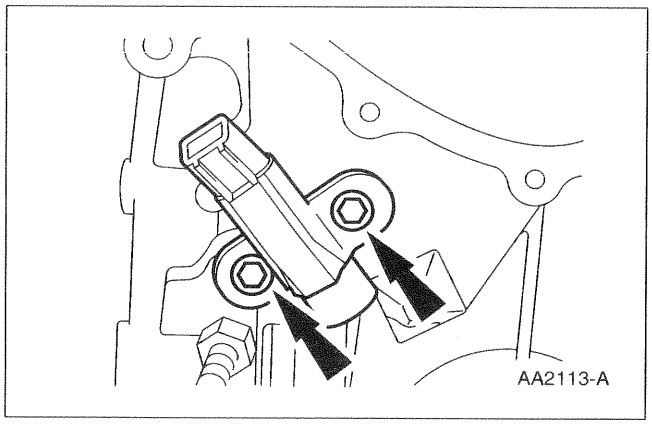


44. Remove the crankshaft damper bolt.

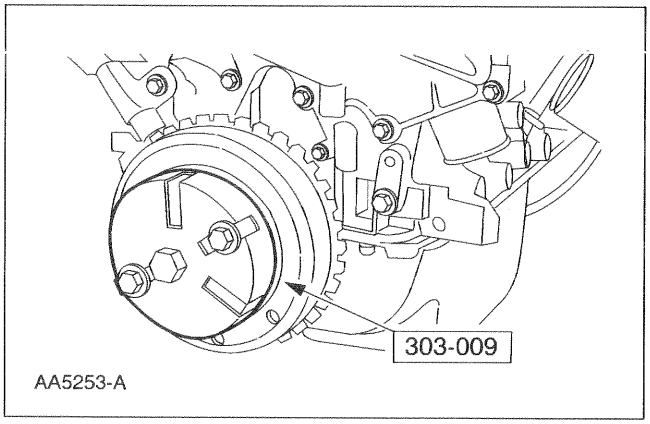


DISASSEMBLY (Continued)

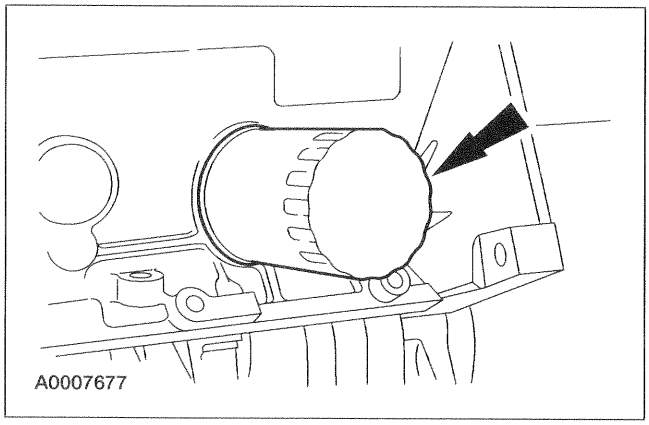
45. Remove the crankshaft position (CKP) sensor.



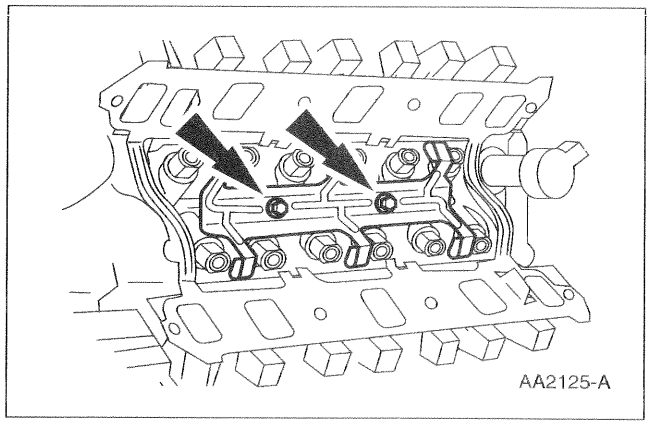
46. Using the special tool, remove the crankshaft damper.



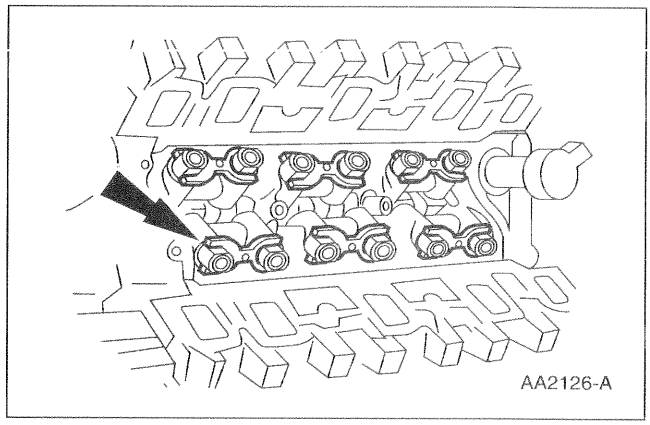
47. Remove the oil filter.



48. Remove the two bolts and the valve tappet guide plate retainer.

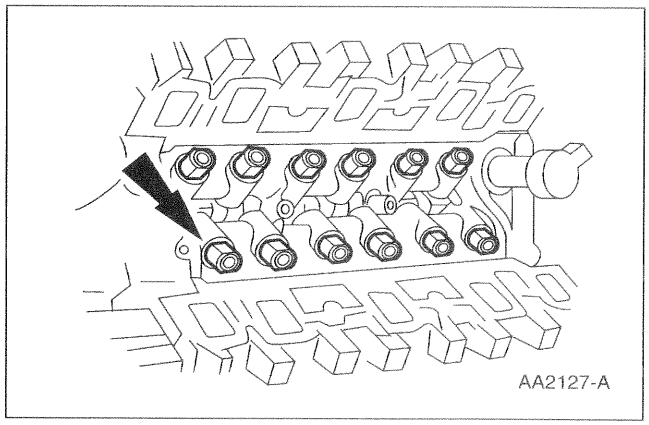


49. Remove the valve tappet guide plates.



50. **NOTE:** The valve tappets are positional. Identify each valve tappet for installation in the original position.

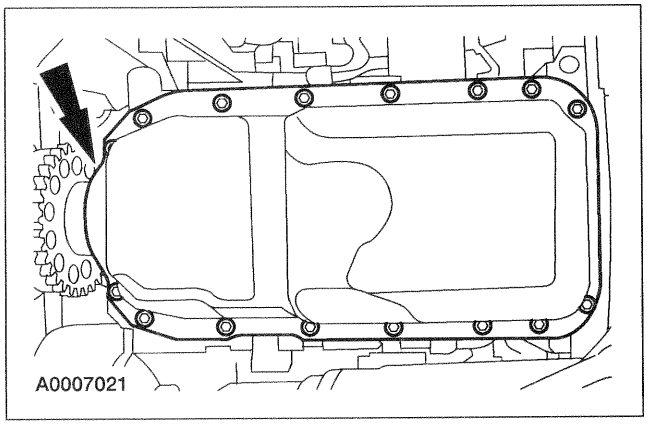
    Remove the valve tappets.



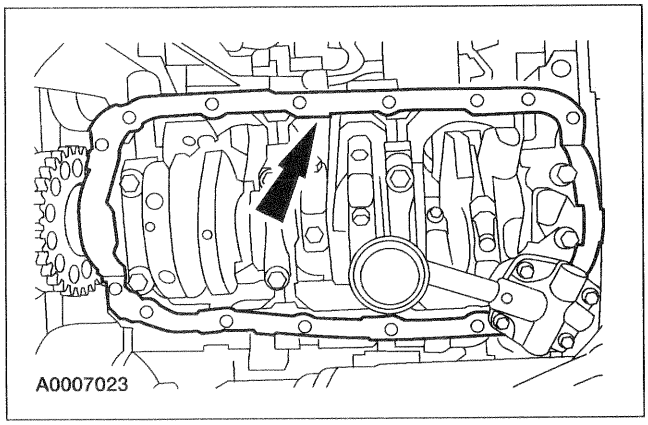
51. Remove the camshaft synchronizer. For additional information, refer to Section 303-14.

DISASSEMBLY (Continued)

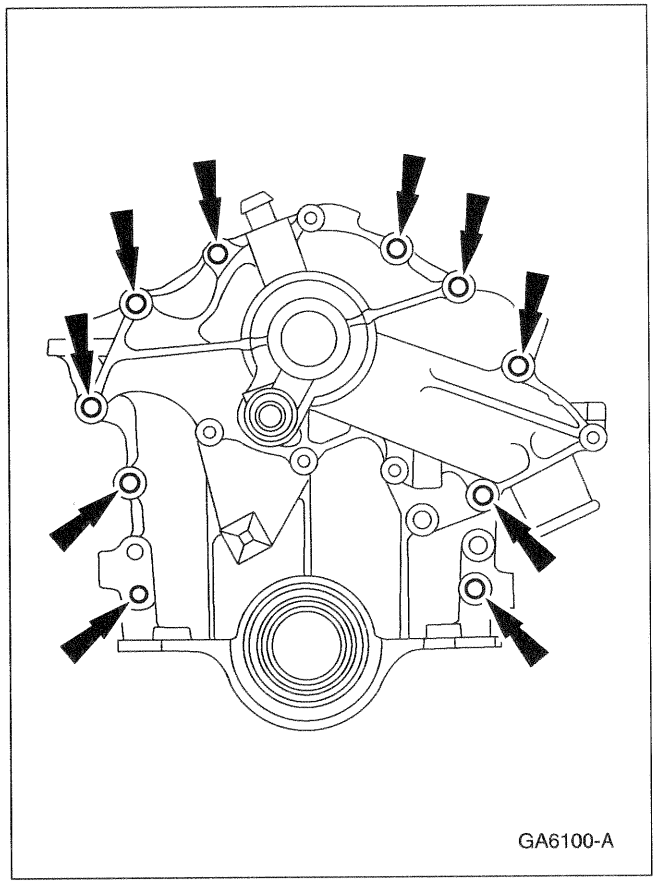
52. Remove the 16 bolts and the oil pan.



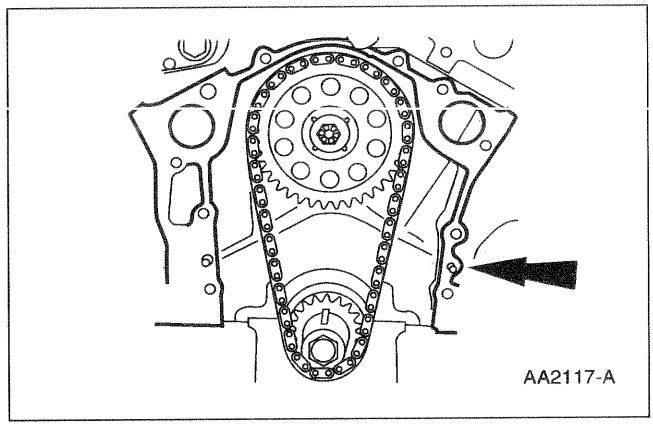
53. Remove and discard the oil pan gasket.



54. Remove the bolts and the engine front cover.

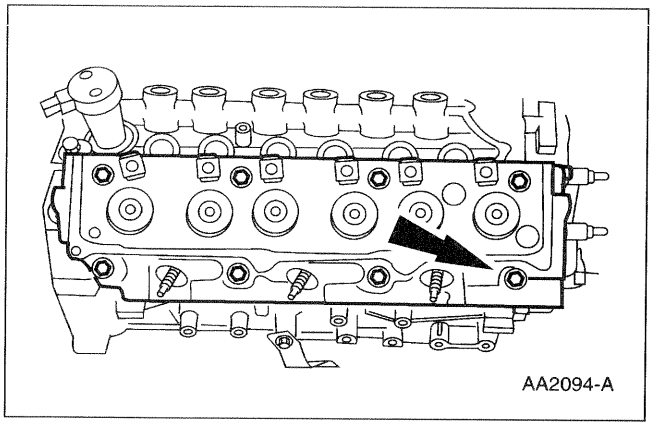


55. Remove the engine front cover gasket.

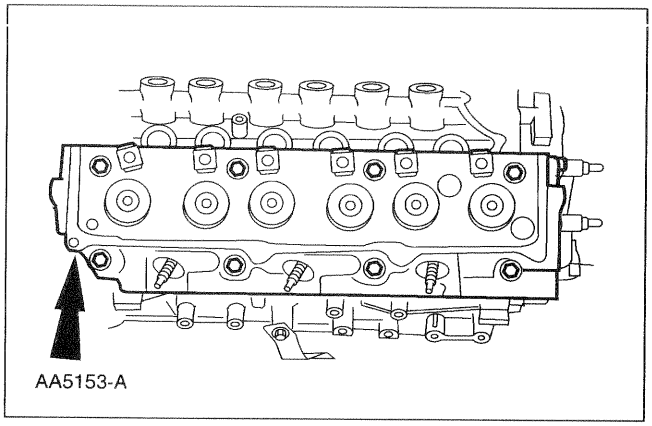


DISASSEMBLY (Continued)

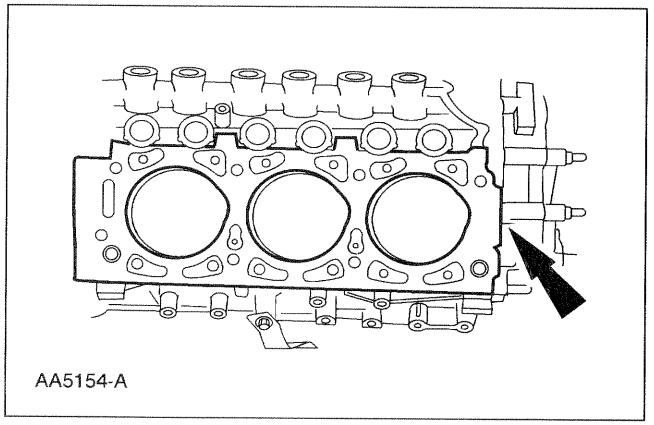
56. Remove the eight bolts and the RH cylinder head.



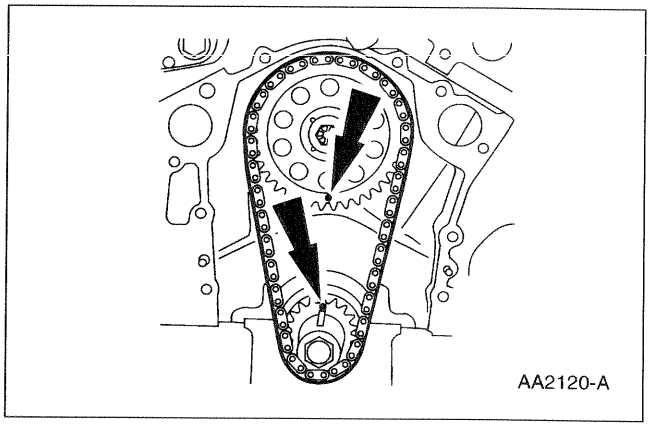
57. Remove the eight bolts and the LH cylinder head.



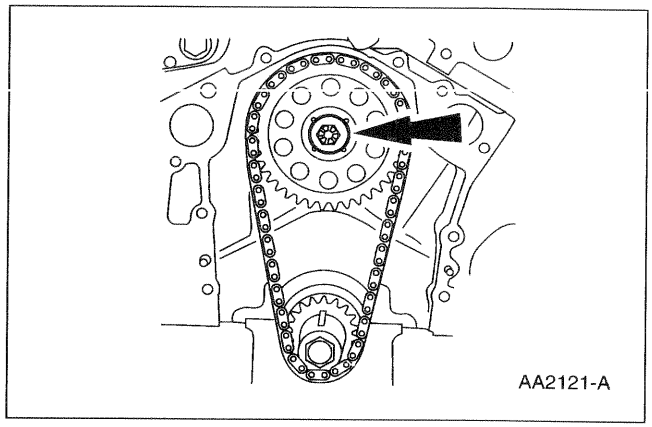
58. Remove and discard both cylinder head gaskets.



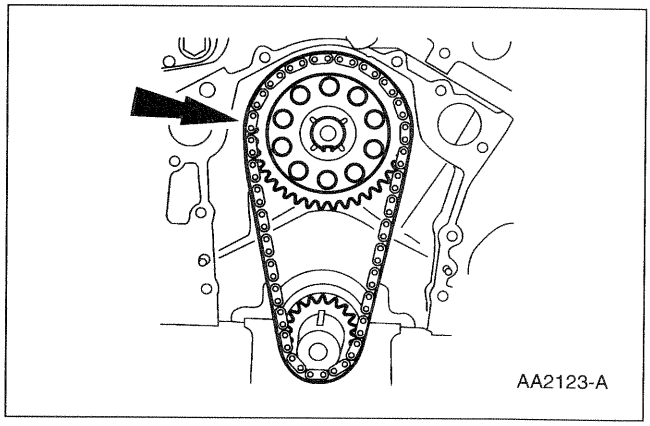
59. Align the timing marks.



60. Remove the camshaft sprocket bolt.

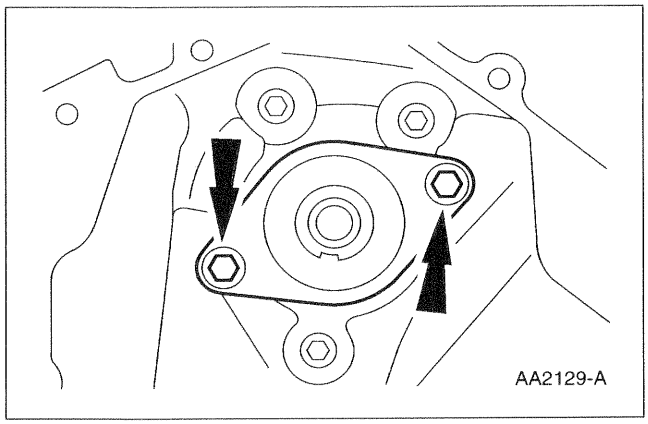


61. Remove the timing sprockets and the timing chain as an assembly.

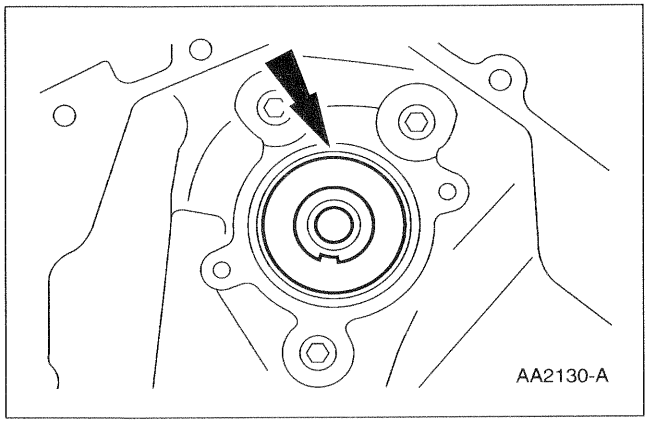


DISASSEMBLY (Continued)

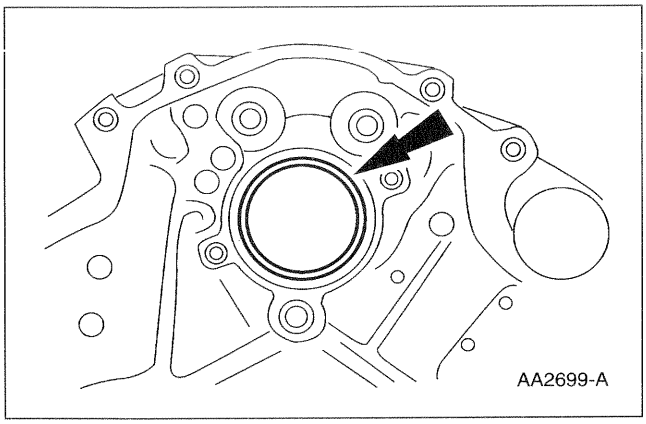
62. Remove the bolts and the camshaft thrust plate.



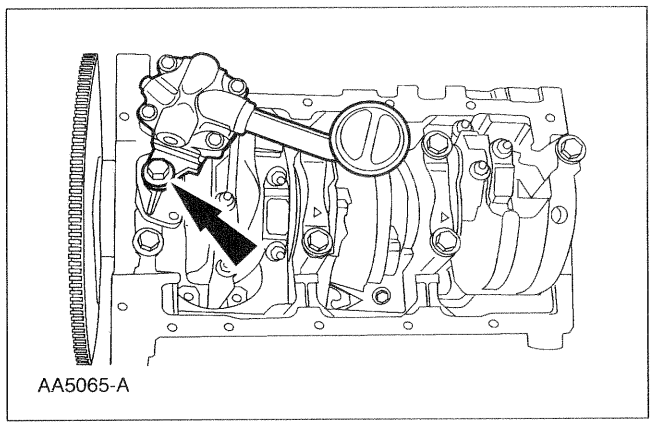
63. Remove the camshaft.



64. If required, remove the camshaft bearings.



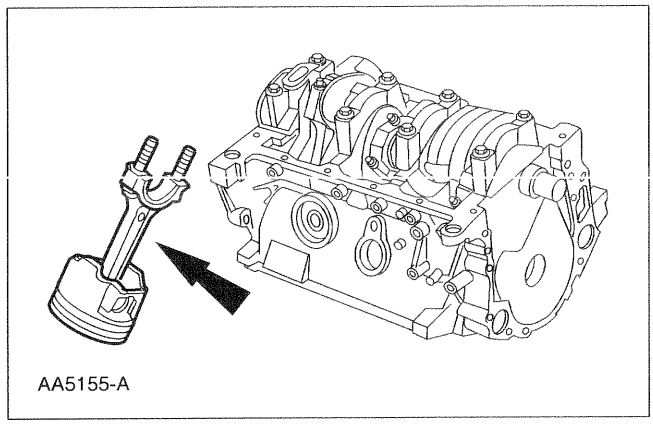
65. Remove the bolt and the oil pump.



66. **NOTE:** Before removing the piston and connecting rod assemblies, inspect the top of the cylinder bores. If required, remove the cylinder ridge. For additional information, refer to Section 303-00.

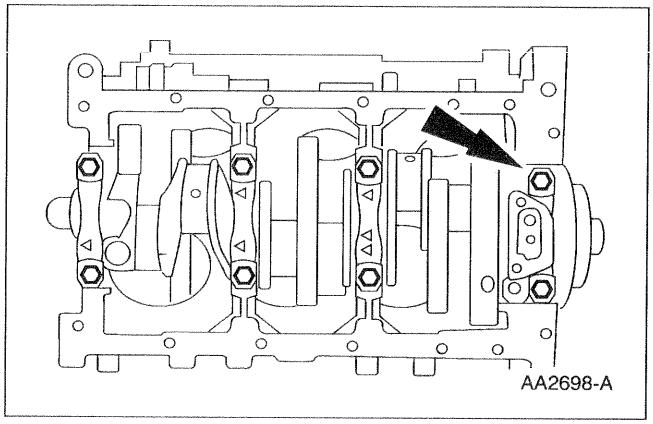
    Remove the piston and connecting rod assemblies one at a time.

    - Remove the connecting rod nuts in pairs.
    - Remove the connecting rod cap.
    - Remove the piston and connecting rod assembly.

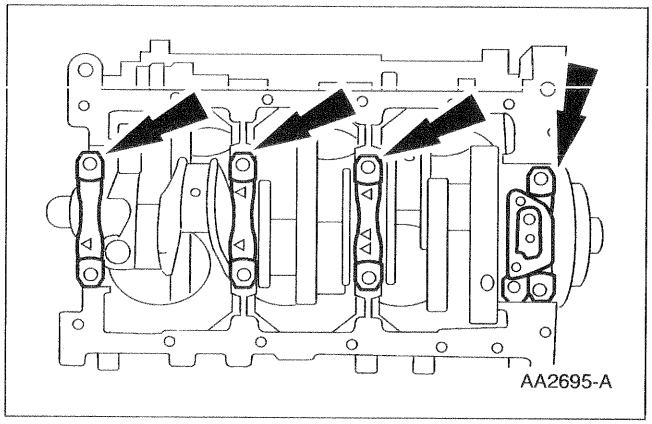


DISASSEMBLY (Continued)

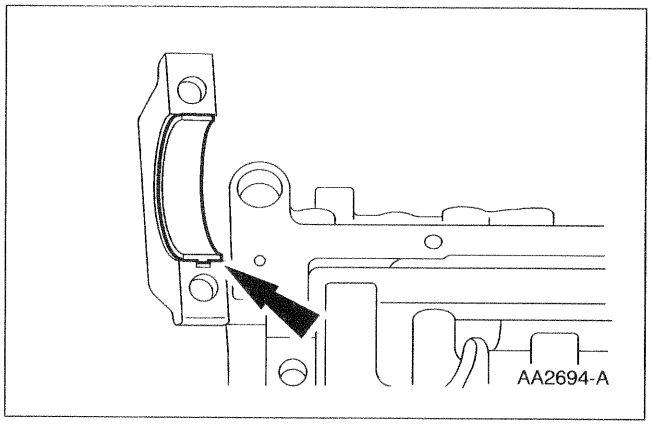
67. Remove the eight main bearing cap bolts.



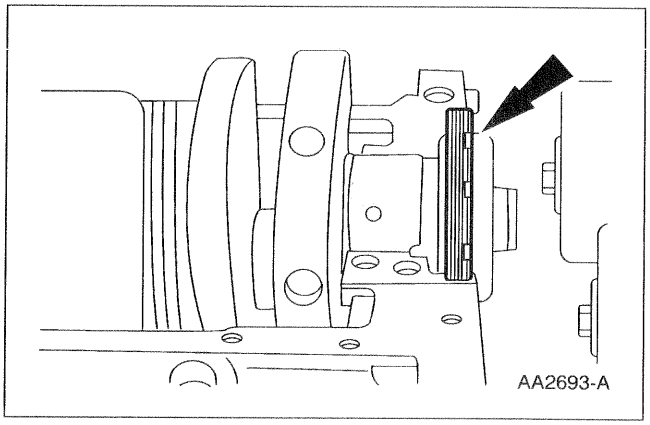
68. Remove the main bearing caps.



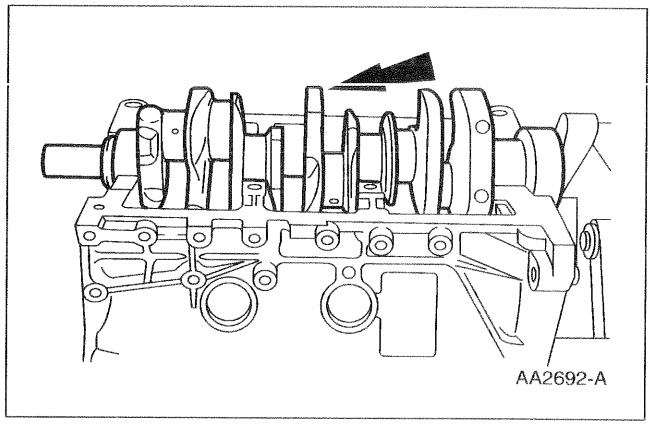
69. Remove the lower crankshaft main bearings.



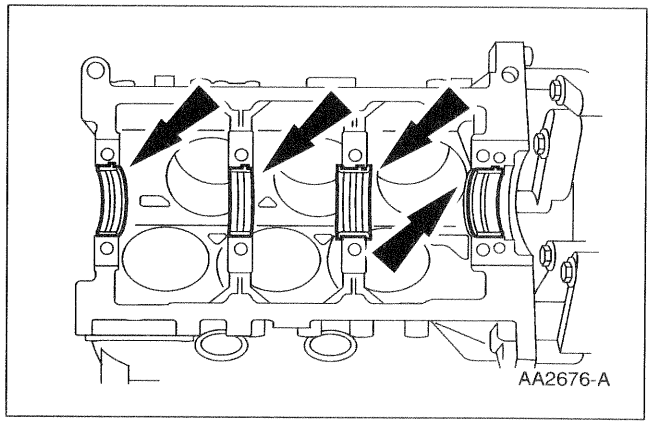
70. Remove the crankshaft rear seal.



71. Remove the crankshaft.



72. Remove the upper crankshaft main bearings.

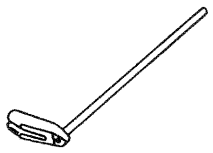


73. Using metal surface cleaner, clean all mating and sealing surfaces.

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

Cylinder Head

Special Tool(s)

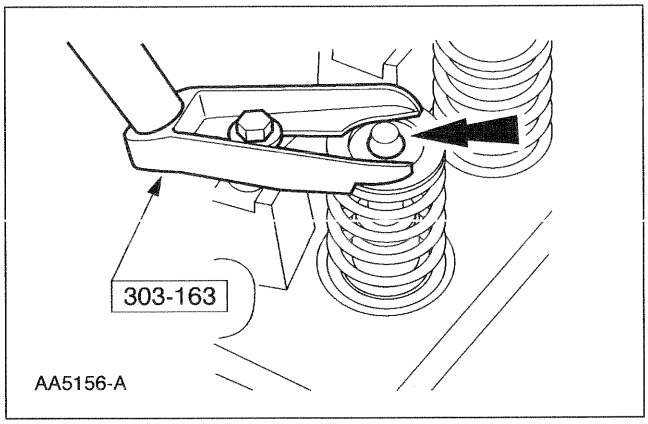
 ST1383-A	Compressor, Valve Spring 303-163 (T81P-6513-A)

Material

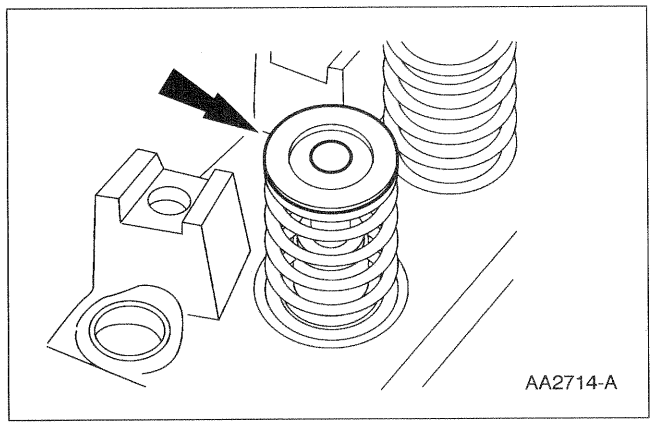
Item	Specification
Super Premium SAE 5W-20 Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

Disassembly and Assembly

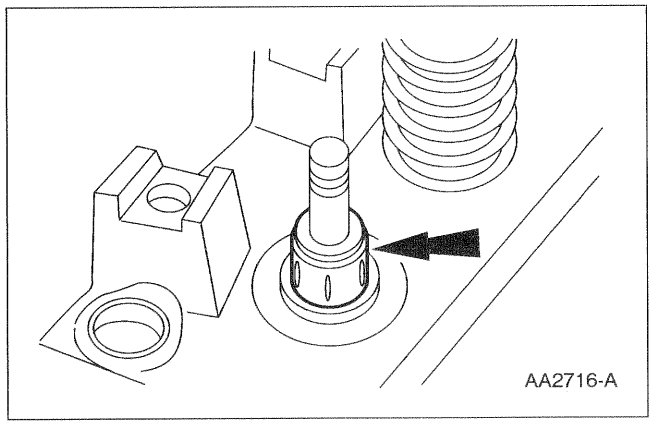
1. Using the special tool, compress the valve spring (6513) and remove the valve spring retainers (6518).



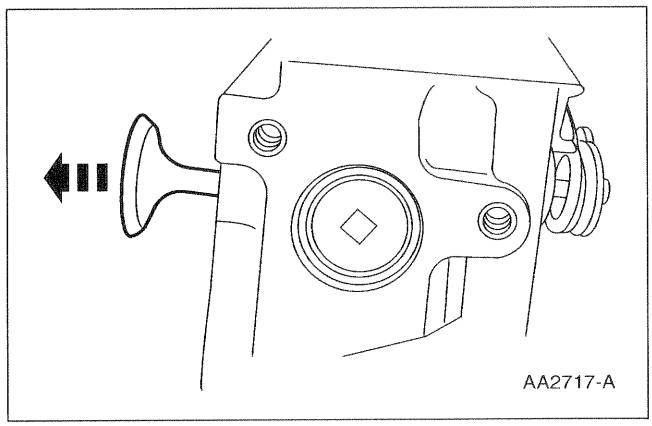
2. Remove the valve springs (6513).
   - For component tests, refer to Section 303-00.



3. Remove the valve seal (6A517).



4. Remove the valve (6507/6505).
   - For component tests, refer to Section 303-00.

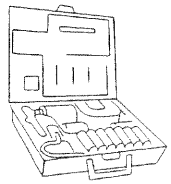


DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)

5. To assemble, reverse the disassembly procedure.
   - Lubricate the valve stem and the valve seal with clean engine oil.

Piston — Pin Connecting Rod, Press Fit

Special Tool(s)

 ST1336-A	Service Set, Piston Pin 303-S024 (T68P-6135-A)

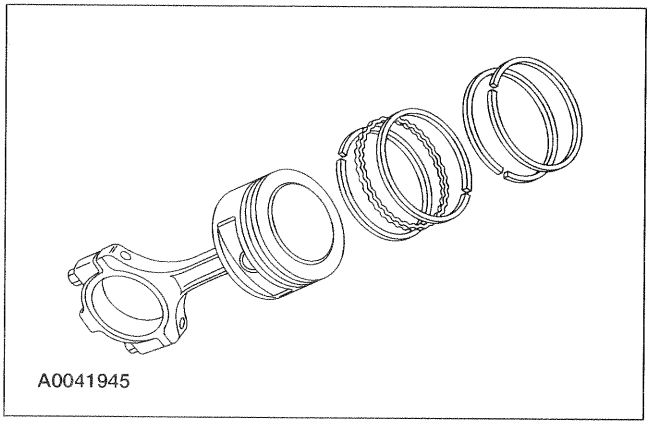
Material

Item	Specification
Super Premium SAE 5W-20 Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

Disassembly

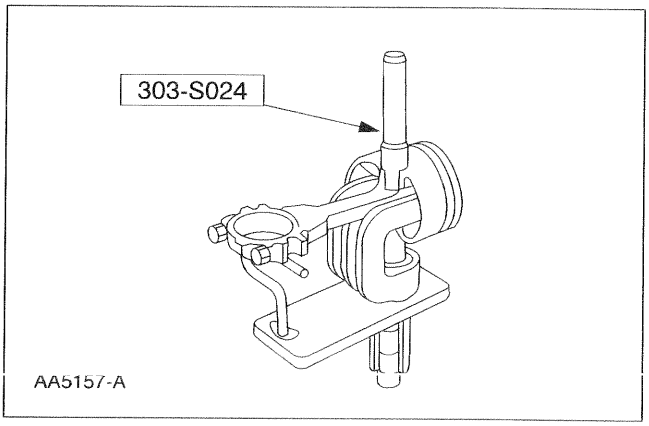
1. **NOTE:** Use a suitable ring expander to remove piston rings to prevent damage.

   Remove the piston rings one at a time starting with the top compression ring and finishing with the lower oil control ring.

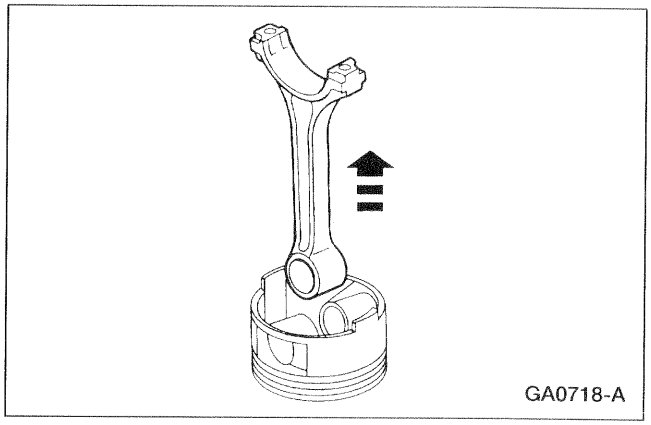


2. **NOTE:** Take note of piston connecting rod assembly and mark the piston (6110) and the connecting rod (6205) to make sure of correct orientation during reassembly.

   Using the special tool, press the piston pin (6135) out of the piston and connecting rod assembly.



3. Remove the connecting rod (6205) from the piston (6110).

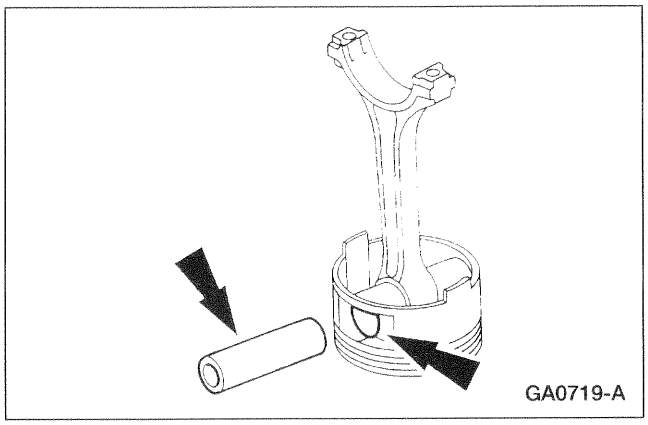


4. Clean and inspect the piston and the connecting rod. For additional information, refer to Section 303-00.

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)

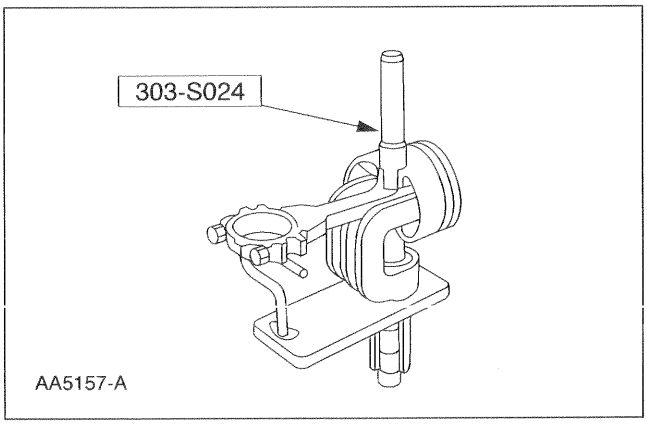
Assembly

1. Lubricate the piston pin and piston pin bore with clean engine oil.



2. **NOTE:** During assembly the small end of the connecting rod must be heated to 232°-316°C (450°-600°F).

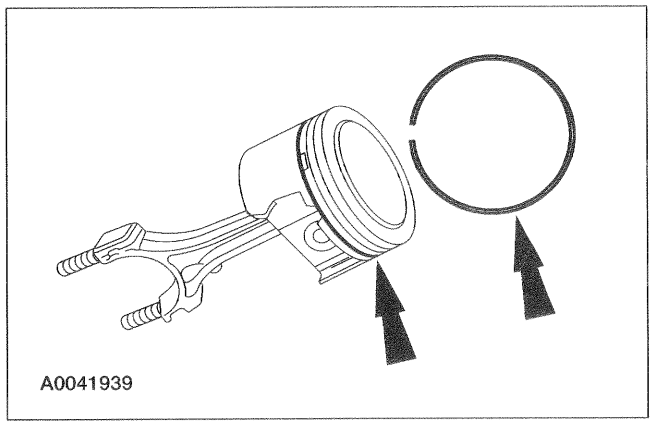
   Using the special tool, press the piston pin into the piston and the connecting rod.



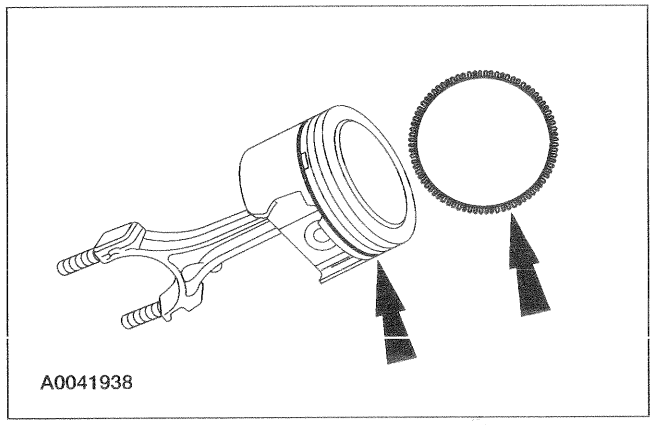
3. **NOTE:** Lubricate the piston and the piston rings with clean engine oil.

   NOTE: Use a suitable ring expander to install the piston rings. Make sure ring end gaps are equally spaced around the circumference of the piston for all piston rings.

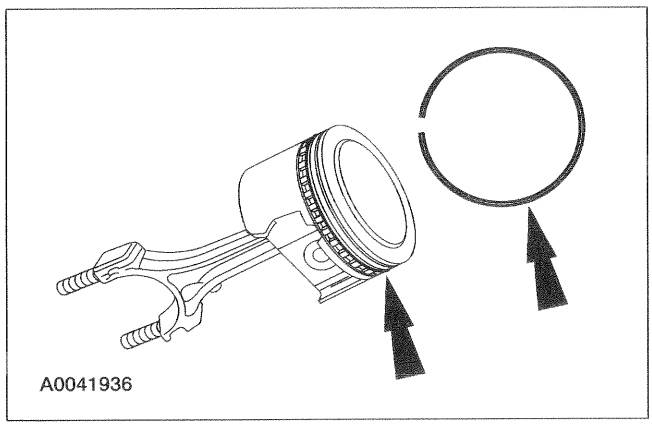
   Install the second oil control ring.



4. Install the oil control spacer ring.

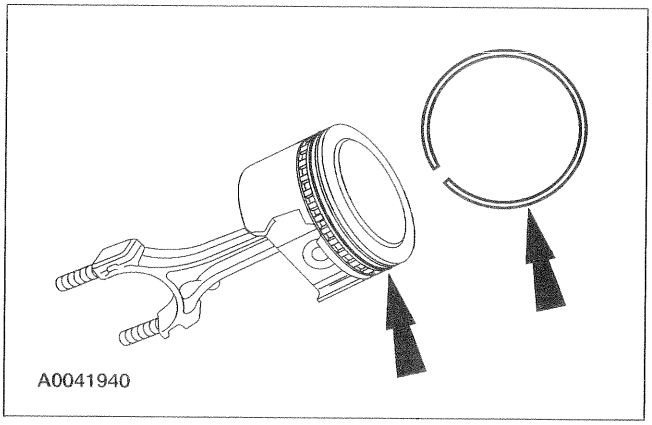


5. Install the first oil control ring.

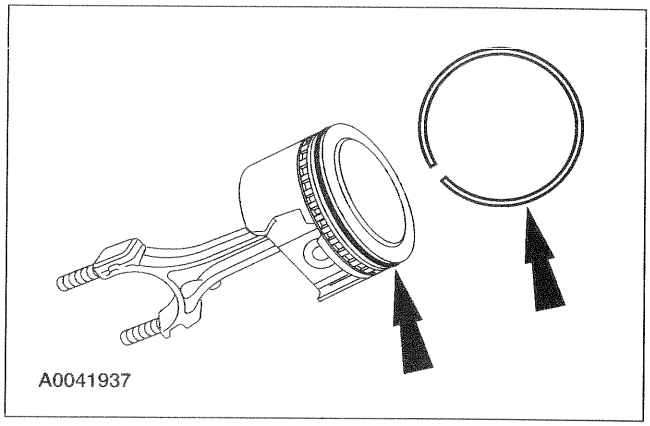


DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)

6. Install the second compression ring.



7. Install the top compression ring.

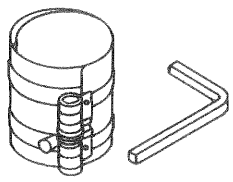
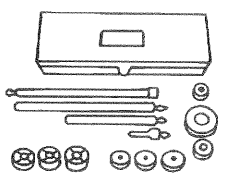


8. Check the piston ring end gap and ring-to-groove side clearance. For additional information, refer to Section 303-00.

ASSEMBLY

Engine

Special Tool(s)

	Piston Ring Compressor 303-D032 (D81L-6002-C)
 ST1381-A	Camshaft Bearing Set 303-017 (T65L-6250-A)

Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H
Gasket Maker F8AZ-19B508-AB or equivalent	WSK-M2G348-A5

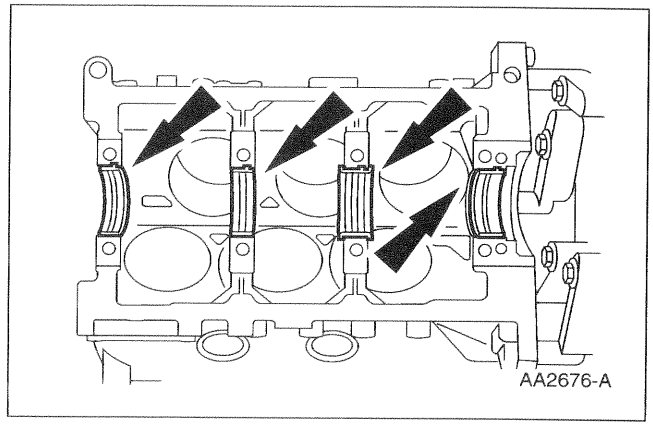
(Continued)

Material

Item	Specification
Pipe Sealant with Teflon® D8AZ-19554-A or equivalent	WSK-M2G350-A2
Silicone Gasket and Sealant F7AZ-19554-EA or equivalent	WSE-M4G323-A4

1. ⚠ **CAUTION: The crankshaft main bearings are precision fit. For additional information, refer to Section 303-00 for checking clearances.**

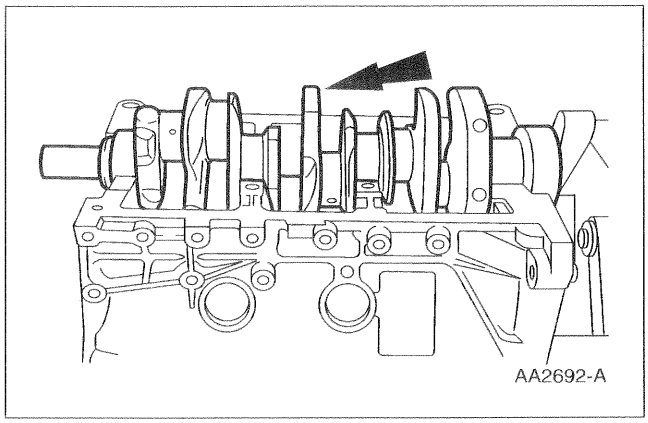
   Install the crankshaft upper main bearings.



ASSEMBLY (Continued)

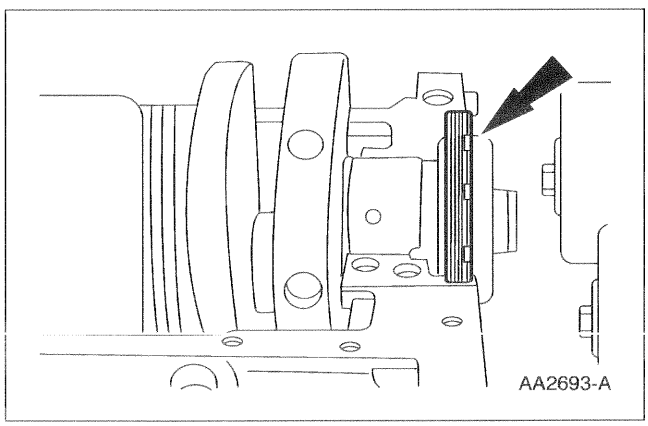
2. **NOTE:** Lubricate the crankshaft journals and the crankshaft main bearings with clean engine oil.

   Position the crankshaft.

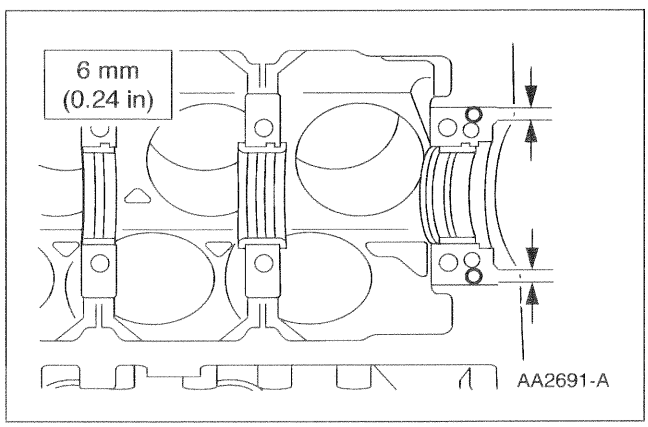


3. **NOTE:** Lubricate the inner and outer sealing surfaces of the crankshaft rear seal with clean engine oil.

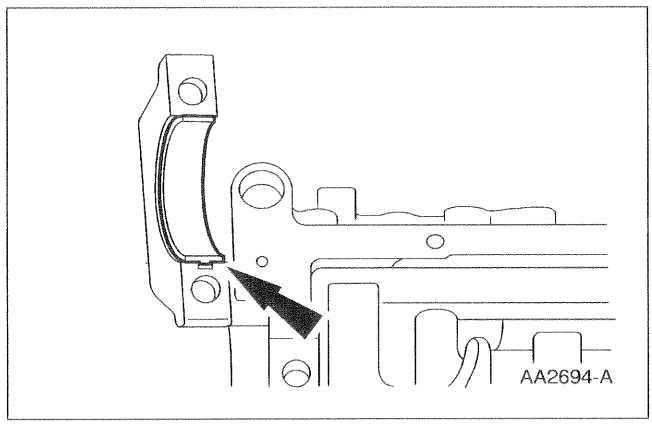
   Install the crankshaft rear seal.



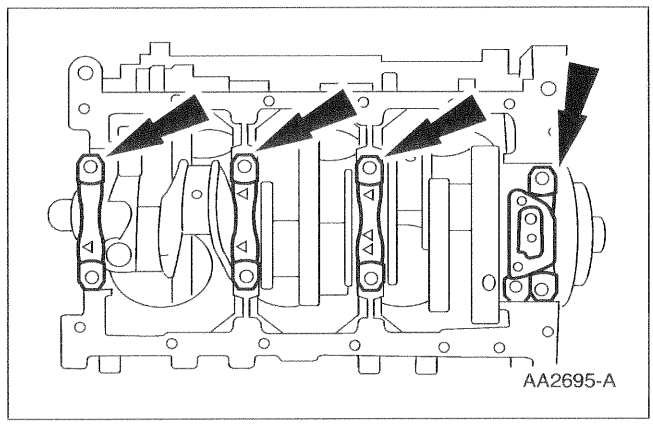
4. Apply two dots of gasket maker between the rear bearing cap and the cylinder block.



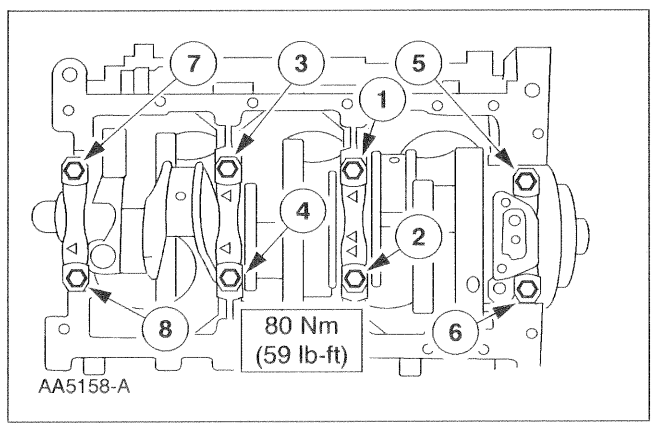
5. Install the crankshaft lower main bearings.



6. Install the main bearing caps.

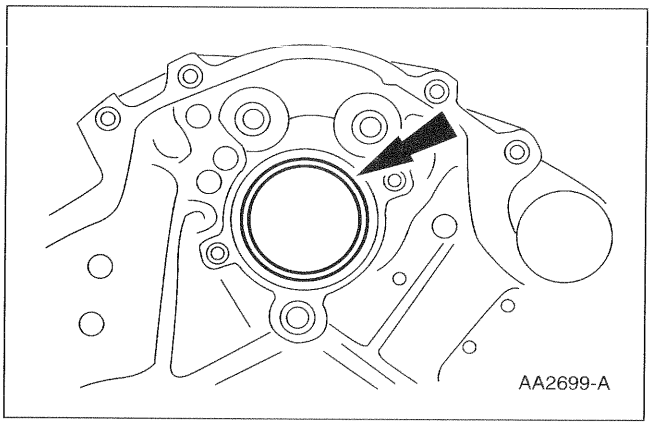


7. Install the main bearing cap bolts in the sequence shown.
   - Tighten the bolts in pairs.
   - Carry out the crankshaft and crankshaft bearing component tests. For additional information, refer to Section 303-00.

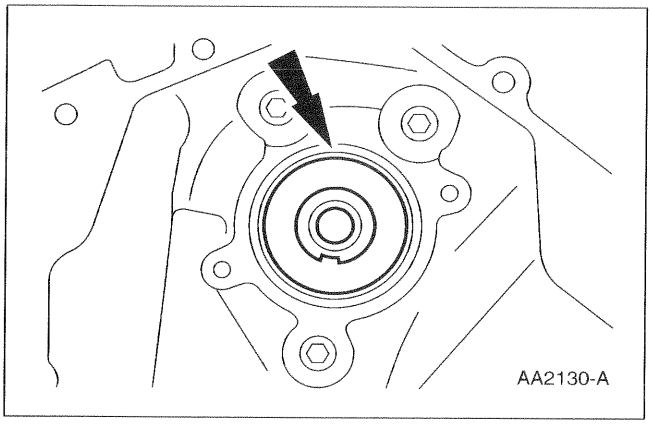


ASSEMBLY (Continued)

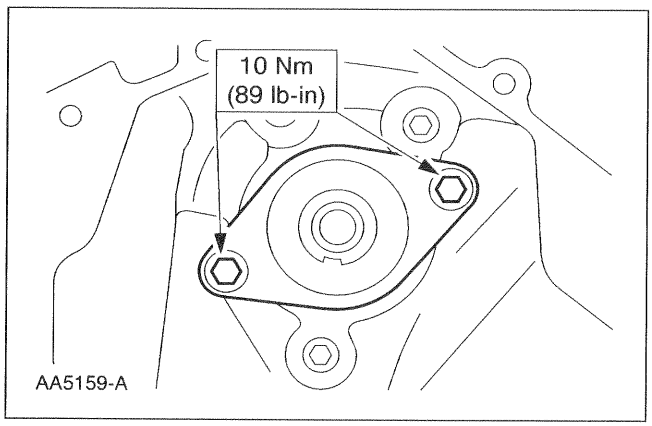
8. If removed, install the camshaft bearings.



9. **NOTE:** Lubricate the camshaft and the camshaft bearings with clean engine oil.
   Install the camshaft.

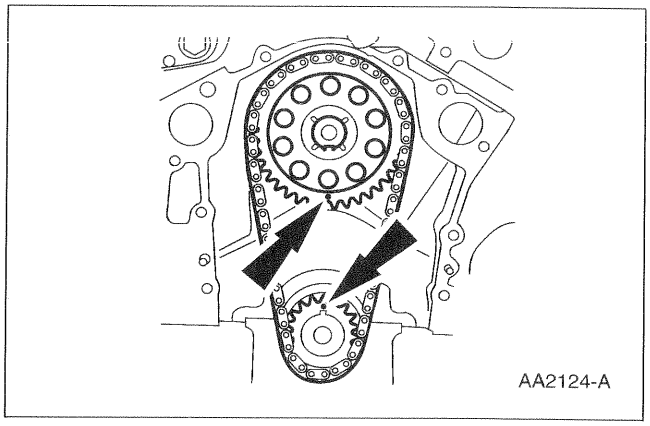


10. Install the camshaft thrust plate.

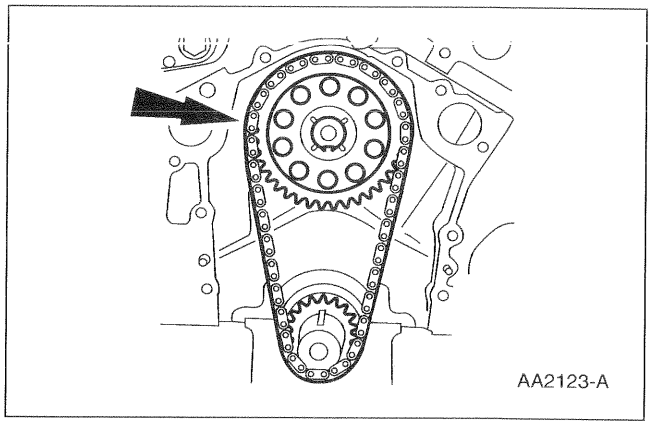


11. Inspect the camshaft end play. For additional information, refer to Section 303-00.

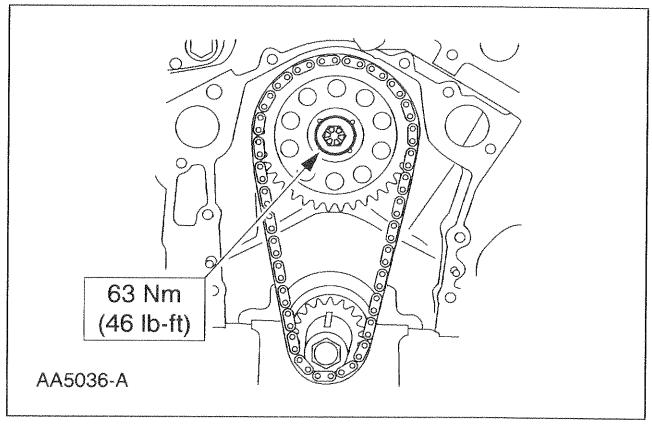
12. Align the timing marks.



13. Install the timing chain, the camshaft sprocket and the crankshaft sprocket as an assembly.



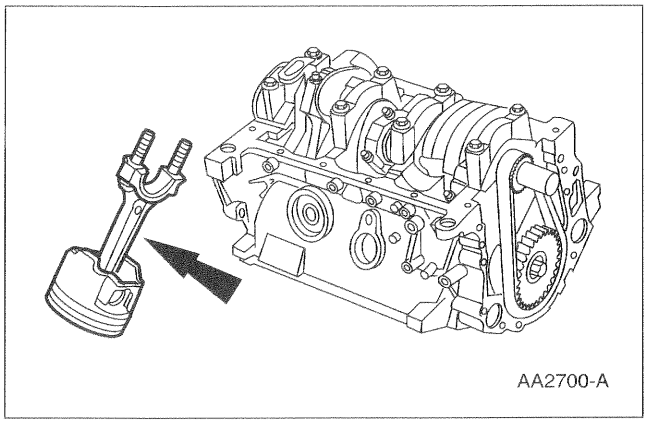
14. Install the camshaft sprocket bolt.



ASSEMBLY (Continued)

15. **NOTE:** Lubricate the piston and connecting rod assemblies with clean engine oil.

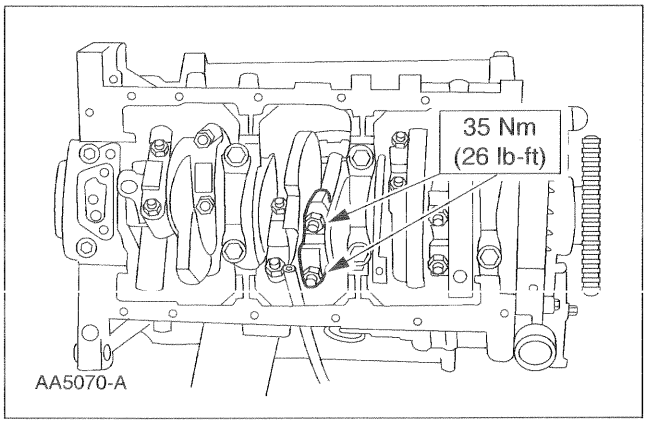
    Install the piston and connecting rod assemblies.



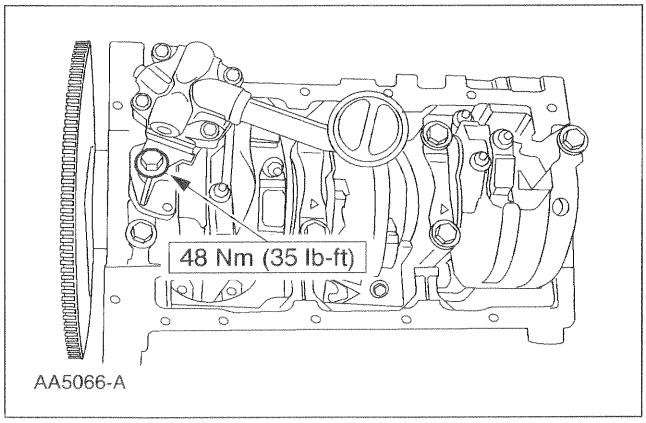
16. **NOTE:** Lubricate the connecting rod bearings with clean engine oil.

    Install the connecting rod bearings.

17. Install the connecting rod caps and nuts.
    - Tighten the nuts in pairs.

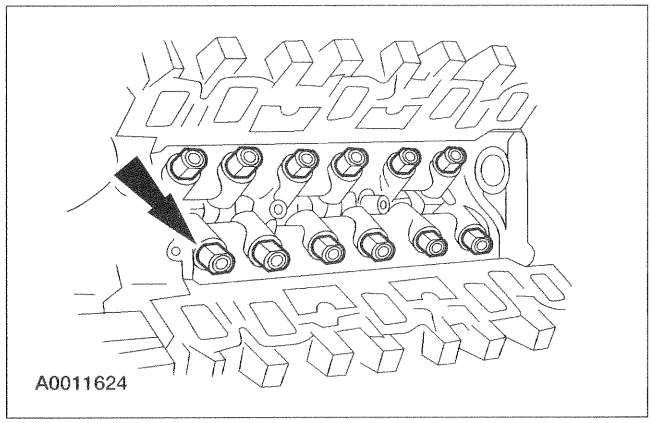


18. Install the oil pump.

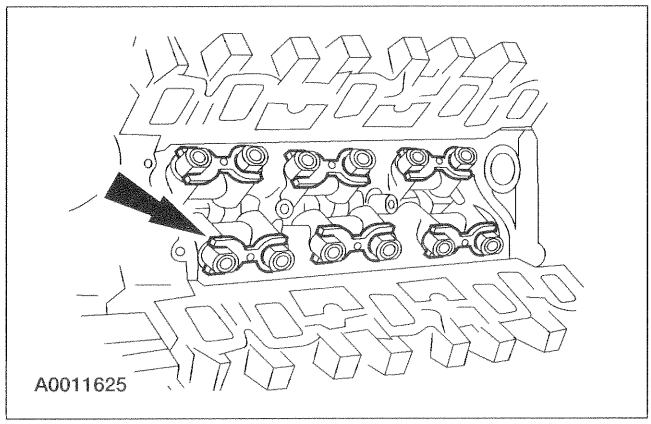


19. **NOTE:** Lubricate the valve tappets with clean engine oil.

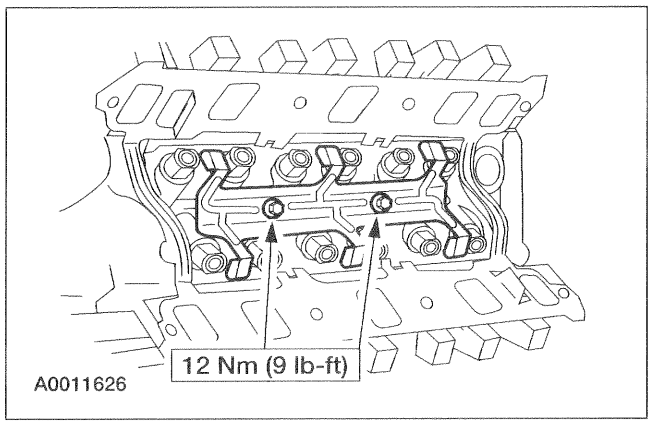
    Install the valve tappets.



20. Install the valve tappet guide plates.

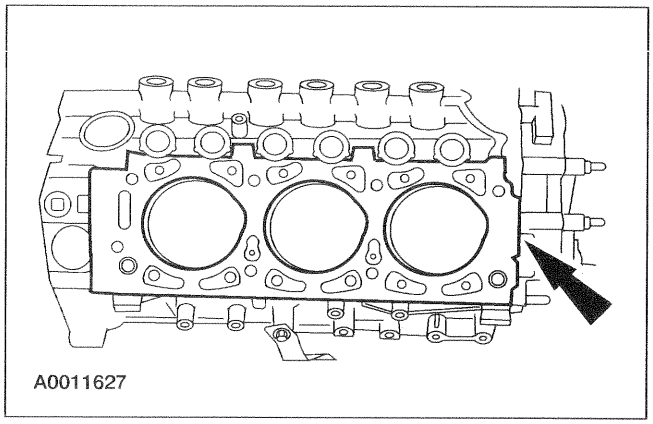


21. Install the valve tappet guide plate retainer.

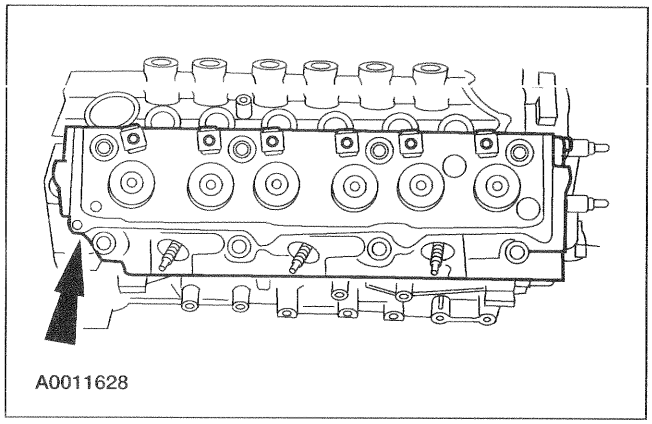


ASSEMBLY (Continued)

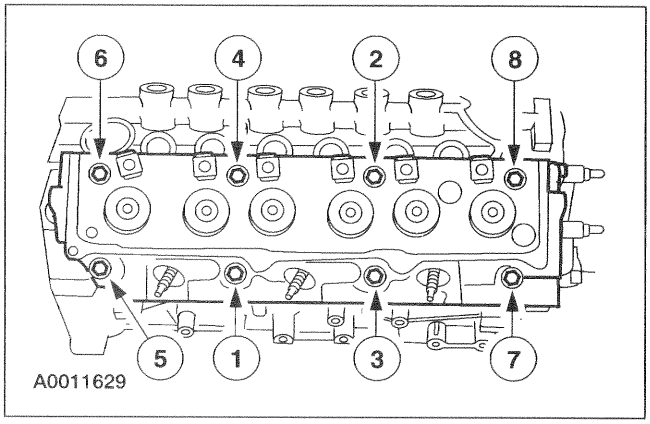
22. Install new cylinder head gaskets.



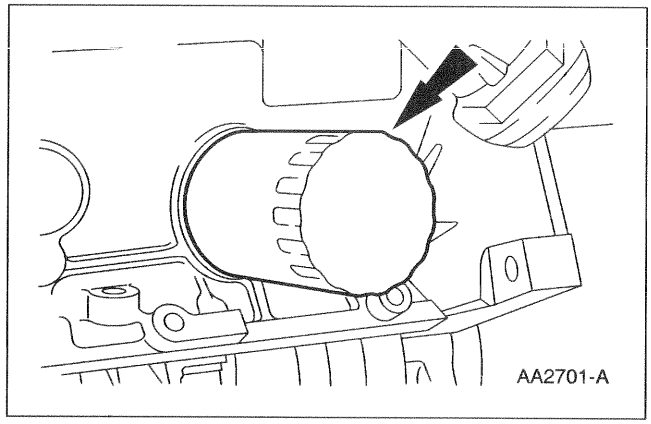
23. Position the cylinder heads.



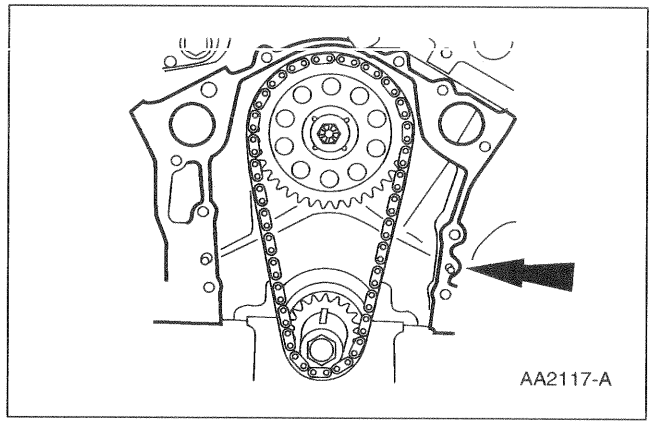
24. Install the bolts. Tighten the bolts in five stages in the sequence shown.
    - Stage 1: Tighten the bolts to 50 Nm (37 lb-in).
    - Stage 2: Loosen the bolts one full turn.
    - Stage 3: Tighten to 30 Nm (22 lb-ft).
    - Stage 4: Rotate 90 degrees.
    - Stage 5: Rotate an additional 90 degrees.



25. Install the oil filter.

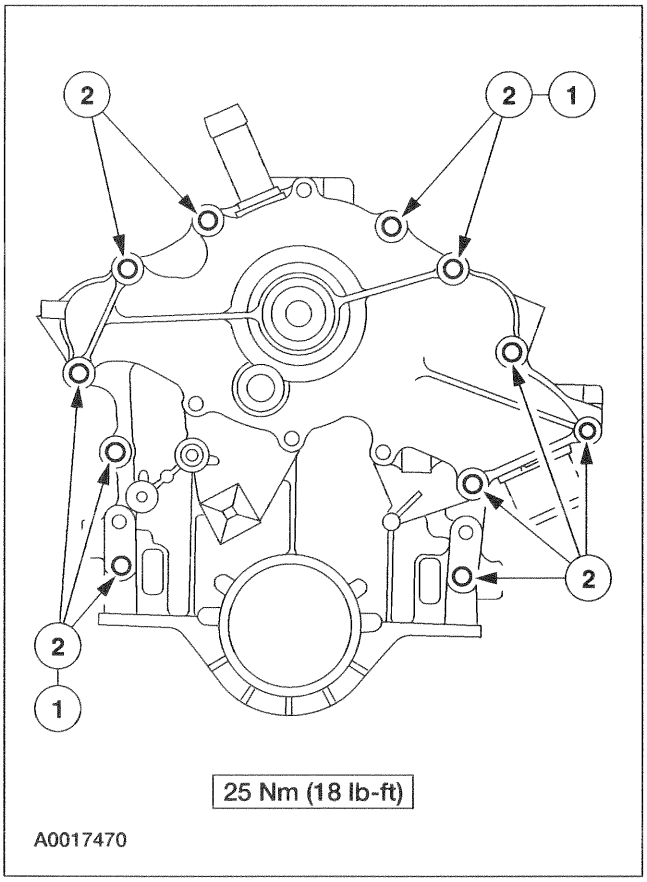


26. Install a new engine front cover gasket and the engine front cover.

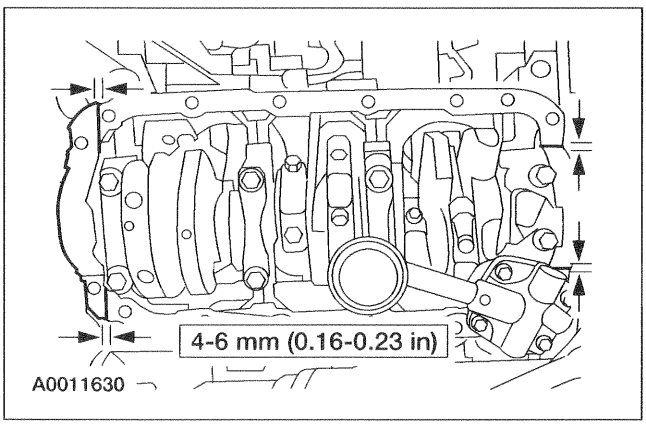


ASSEMBLY (Continued)

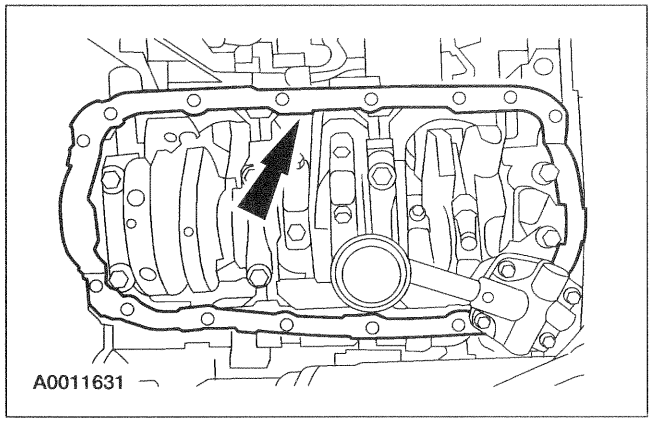
27. Install the engine front cover and water pump assembly.
    1 Apply pipe sealant with Teflon® to the bolts indicated.
    2 Install the bolts.



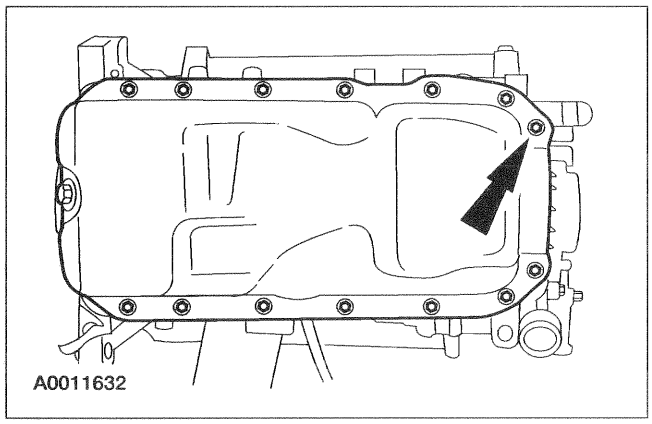
28. Apply four beads of gasket maker as shown.



29. Position the oil pan gasket.

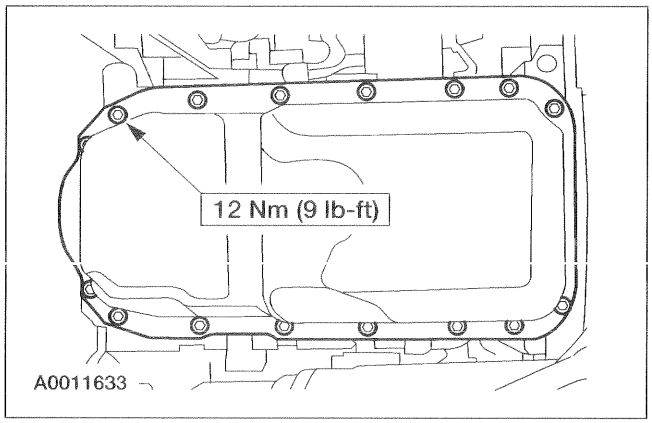


30. Position the oil pan and hand-start the bolts.



ASSEMBLY (Continued)

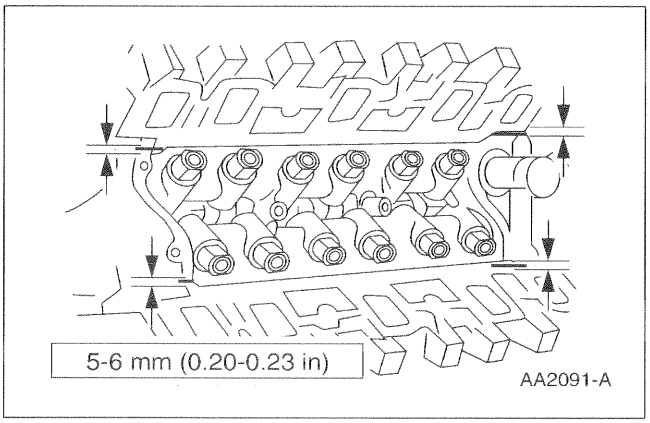
31. Install the bolts. Tighten the bolts in four stages.
    - Stage 1: Tighten the four corner bolts to 12 Nm (9 lb-in).
    - Stage 2: Tighten the remaining bolts to 12 Nm (9 lb-in).
    - Stage 3: Loosen all the bolts one turn.
    - Stage 4: Tighten all the bolts to 12 Nm (9 lb-in).



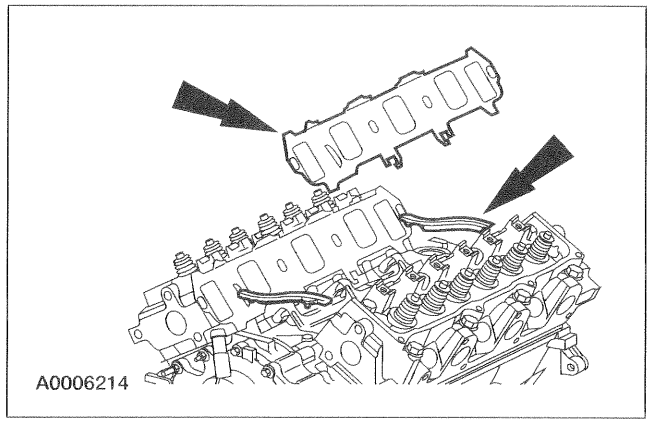
32. Install the camshaft synchronizer. For additional information, refer to Section 303-14.

33. **NOTE:** If the lower intake manifold is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

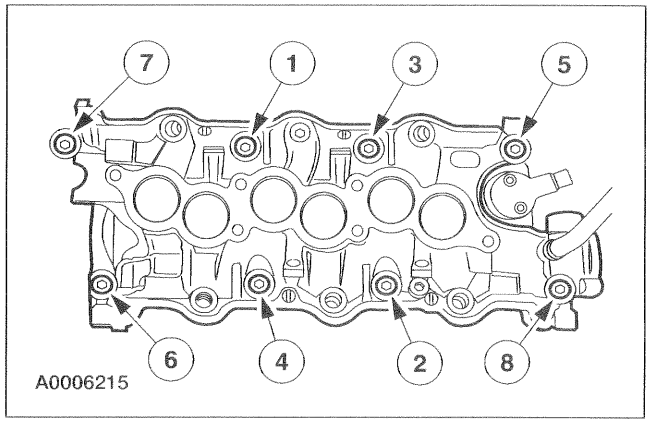
    Apply four beads of silicone gasket and sealant.



34. Position the intake manifold gaskets and end seals.

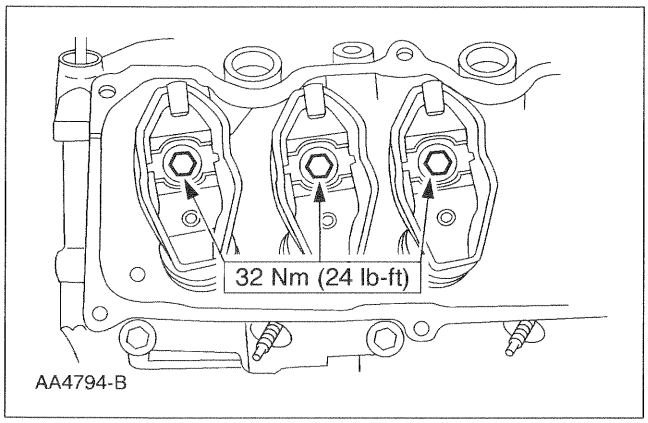


35. Install the lower intake manifold. Tighten the bolts in two stages in the sequence shown.
    - Stage 1: Tighten to 15 Nm (11 lb-ft).
    - Stage 2: Tighten to 32 Nm (24 lb-ft).



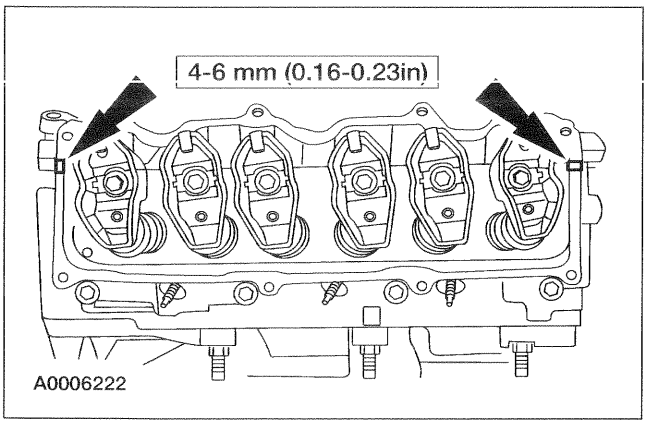
ASSEMBLY (Continued)

36. Install the push rods and the rocker arms. Tighten the rocker arm bolts in two stages
    - Stage 1: Tighten the bolts to 10 Nm (89 lb-in).
    - Stage 2: Tighten the bolts to 32 Nm (24 lb-ft).

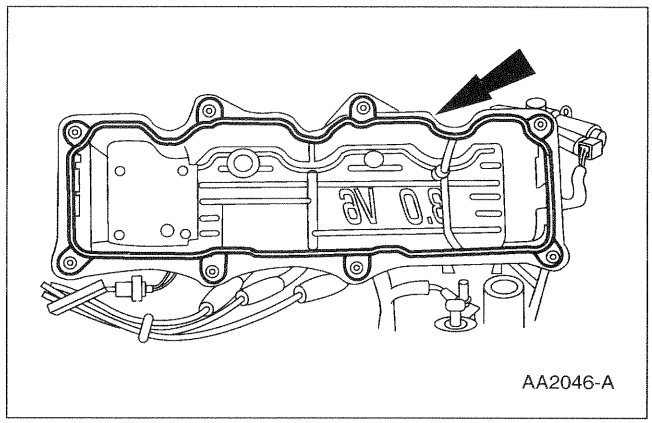


37. **NOTE:** If the valve covers are not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

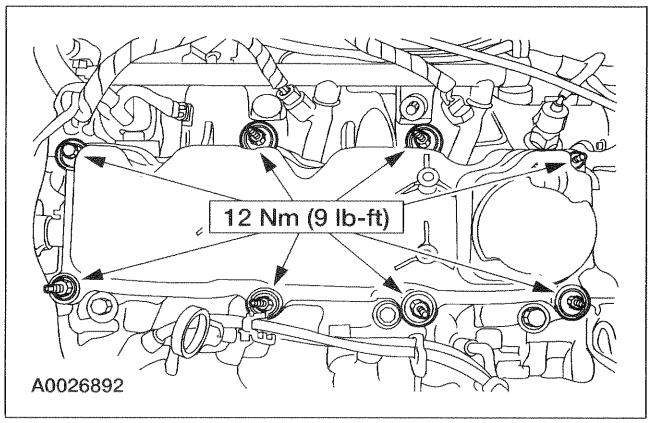
    Apply a bead of silicone gasket and sealant to the four intake-to-cylinder head seams.



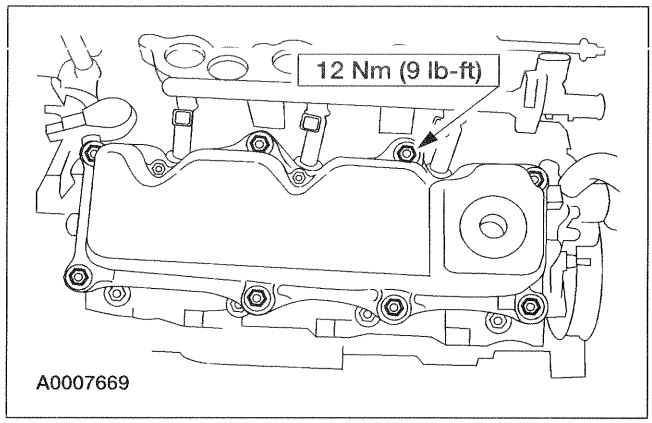
38. If removed, install the valve cover gaskets.



39. Install the LH valve cover.

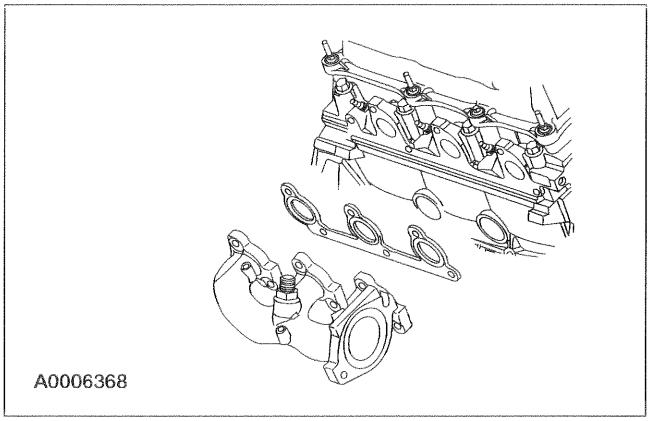


40. Install the RH valve cover.

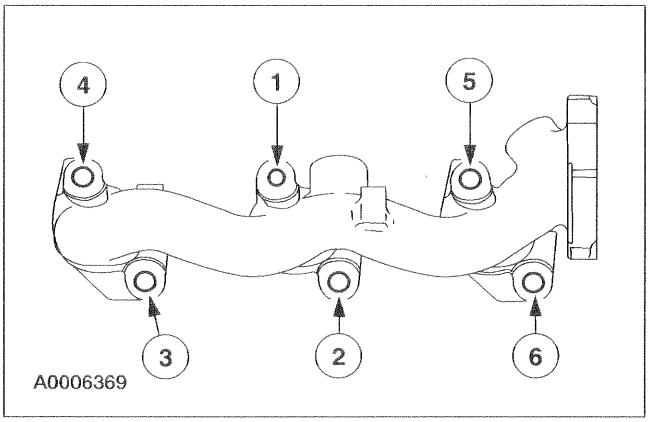


ASSEMBLY (Continued)

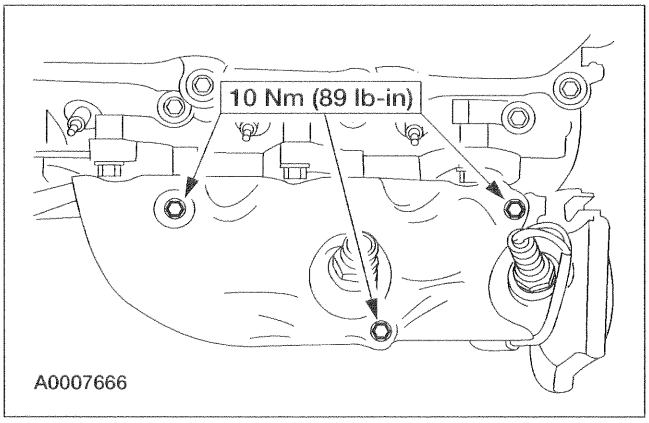
41. Position a new exhaust manifold gasket and install the RH exhaust manifold.



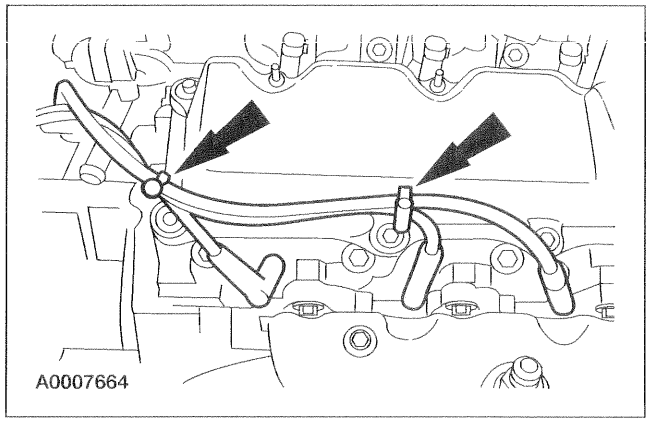
42. Install the bolts. Tighten the exhaust manifold bolts in two stages in the sequence shown.
    - Stage 1: Tighten to 10 Nm (89 lb-in).
    - Stage 2: Tighten to 22 Nm (16 lb-ft).



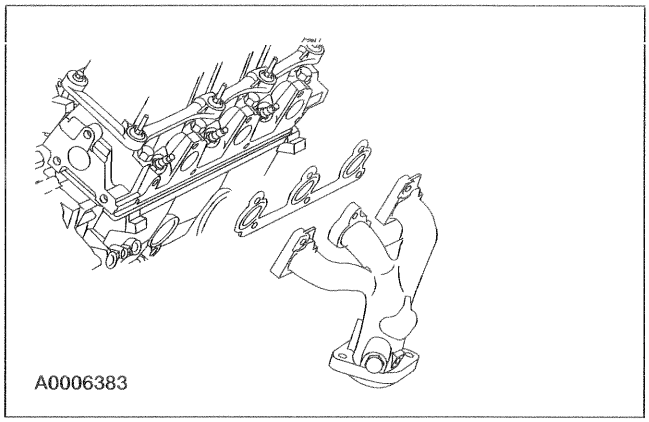
43. Install the RH exhaust manifold heat shield.



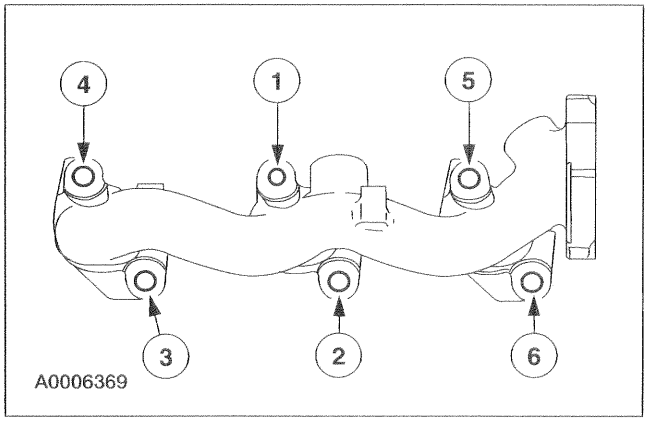
44. Position and connect the RH spark plug wires.



45. Position a new exhaust manifold gasket and install the LH exhaust manifold.



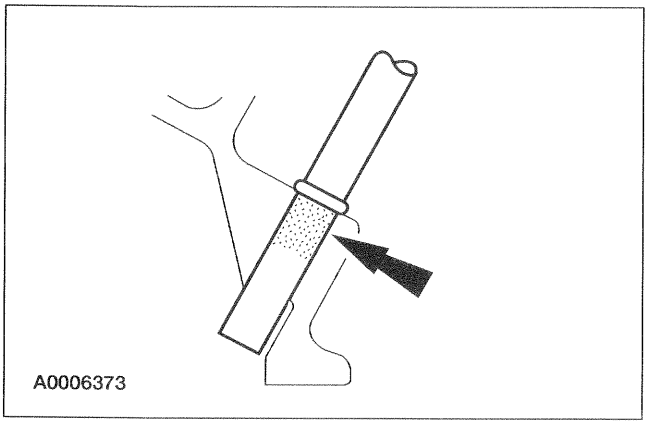
46. Install the four bolts and two stud bolts. Tighten the exhaust manifold bolts in two stages in the sequence shown.
    - Stage 1: Tighten to 10 Nm (89 lb-in).
    - Stage 2: Tighten to 22 Nm (16 lb-ft).



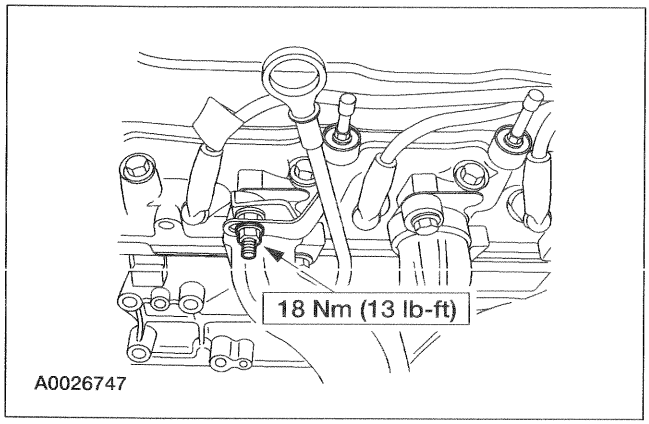
ASSEMBLY (Continued)

47. **NOTE:** If the oil level indicator tube is not secured within four minutes, the sealant must be removed and the sealing area cleaned with metal surface cleaner. Allow to dry until there is no sign of wetness or four minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

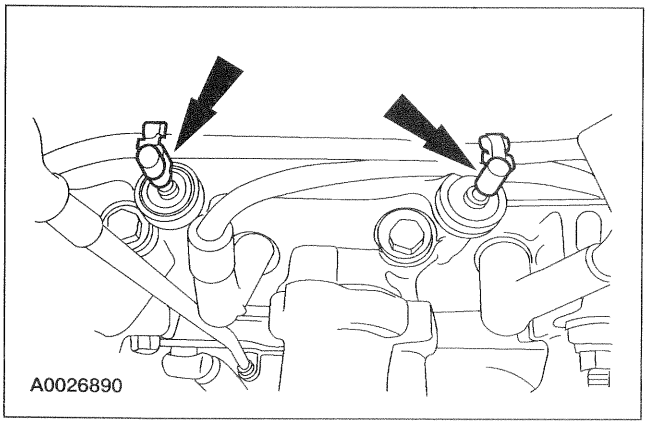
    Coat the sealing surface of the oil level indicator tube with silicone gasket and sealant.



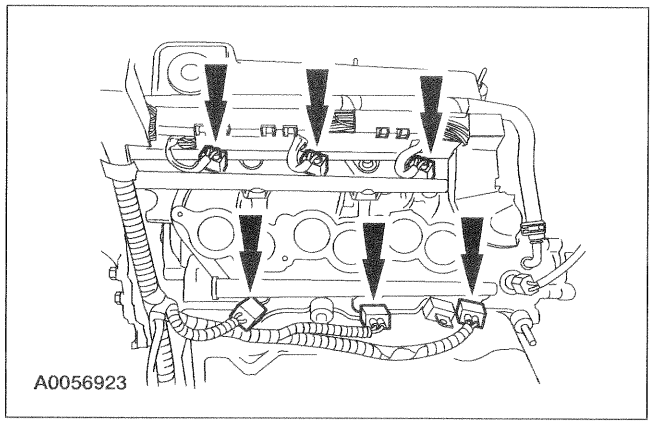
48. Install the oil level indicator and tube.



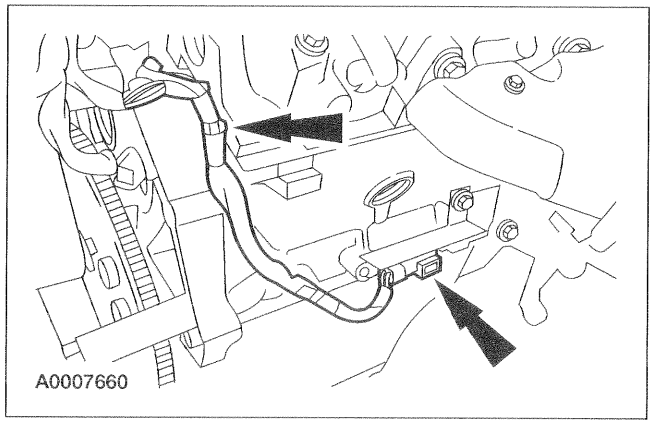
49. Position and connect the LH spark plug wires.



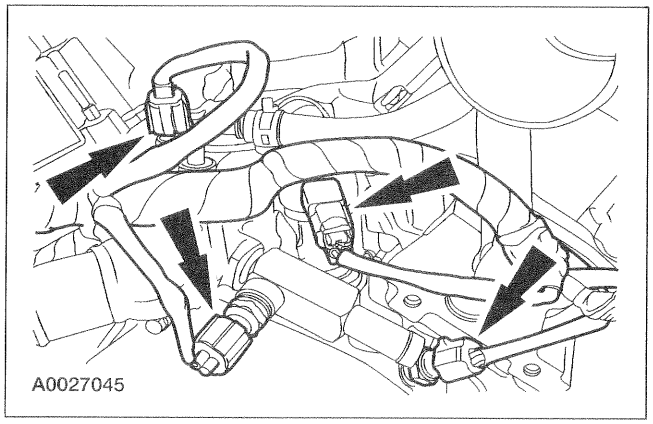
50. Position the engine control sensor wiring harness and connect the fuel injector electrical connectors.



51. Position the wire harness along the cylinder block and install the pin-type retainers.

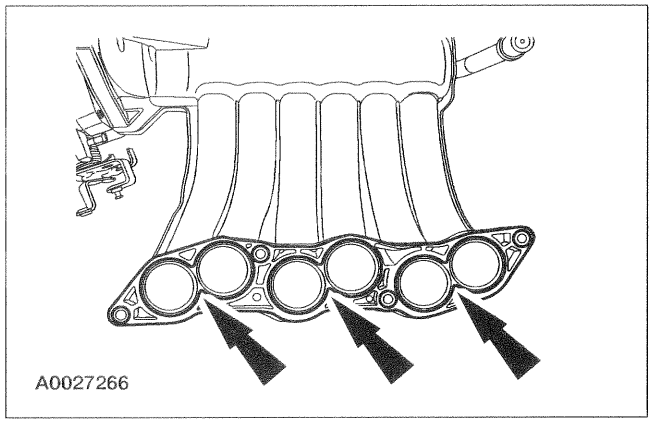


52. Connect the camshaft position (CMP) sensor, engine coolant temperature (ECT) sensor, ECT sender and the oil pressure switch electrical connectors.

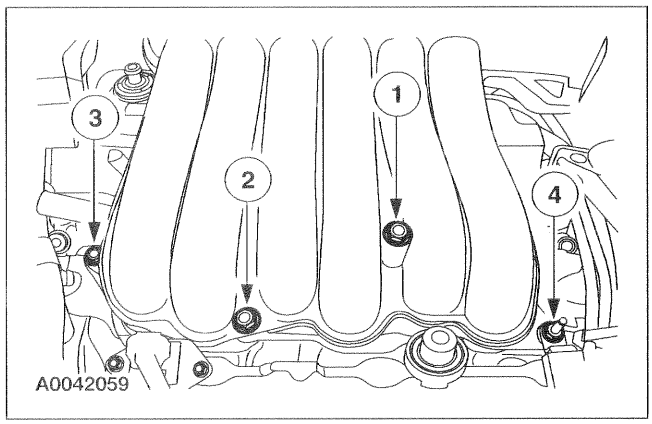


ASSEMBLY (Continued)

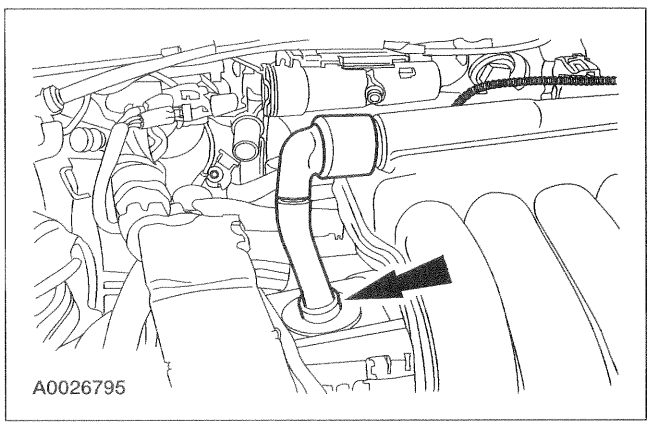
53. Inspect the upper intake manifold gasket. Install a new gasket, if required.



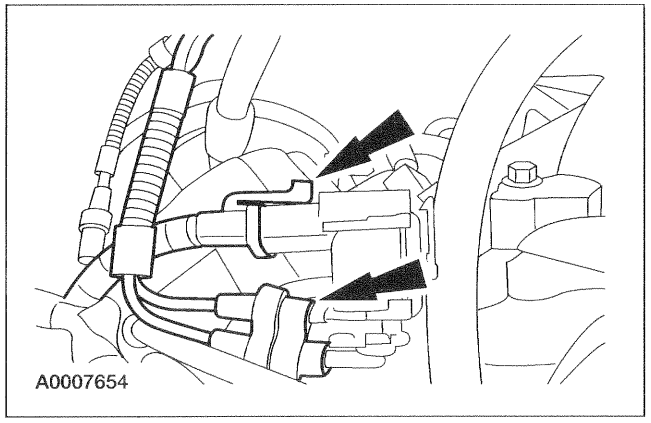
54. Install the upper intake manifold. Tighten the bolts in two stages in the sequence shown.
    1 Stage 1: Tighten hand tight.
    2 Stage 2: Tighten to 10 Nm (89 lb-ft).



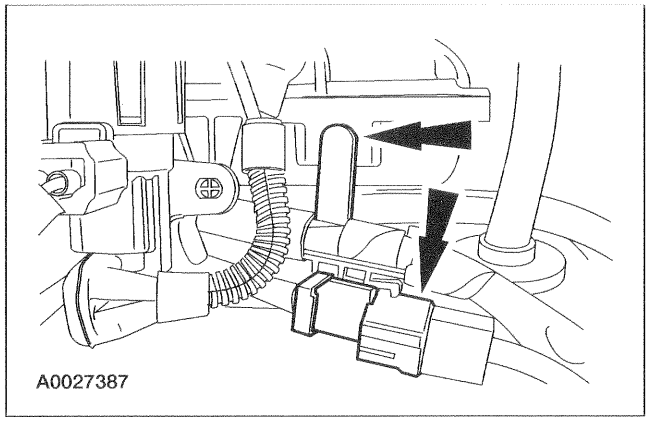
55. Connect the positive crankcase ventilation (PCV) valve.



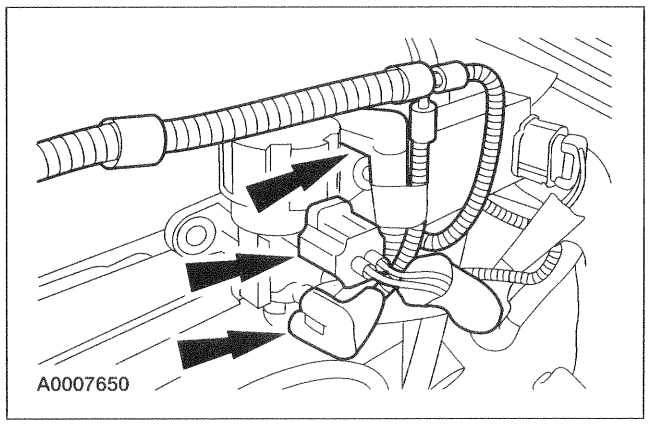
56. Connect the secondary air injection control solenoid electrical and vacuum connections.



57. Install and connect the oxygen sensor electrical connector.

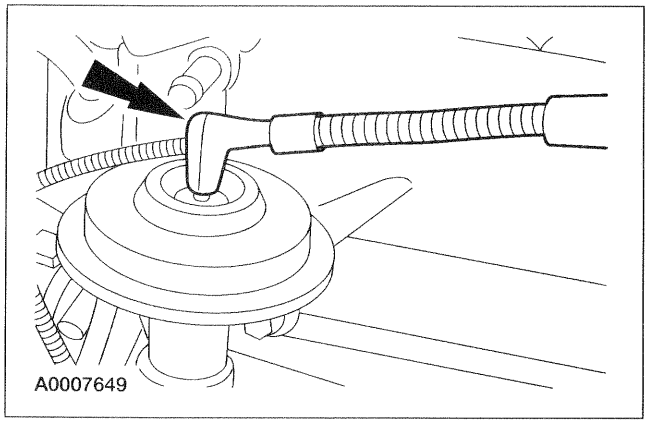


58. Connect the following:
    - Connect the vacuum harness connection to the upper intake manifold.
    - Connect the EGR vacuum regulator solenoid electrical and vacuum connections.

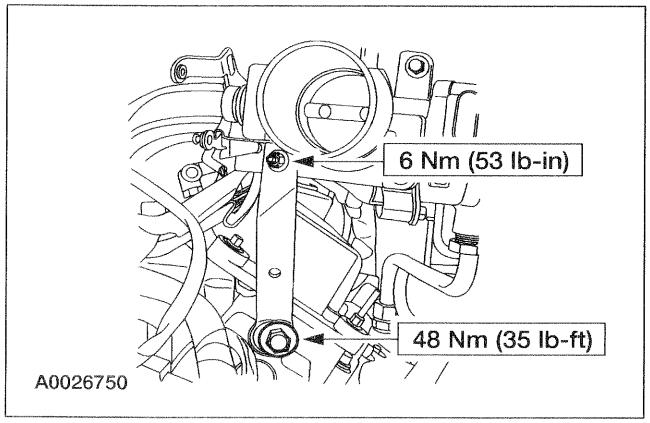


ASSEMBLY (Continued)

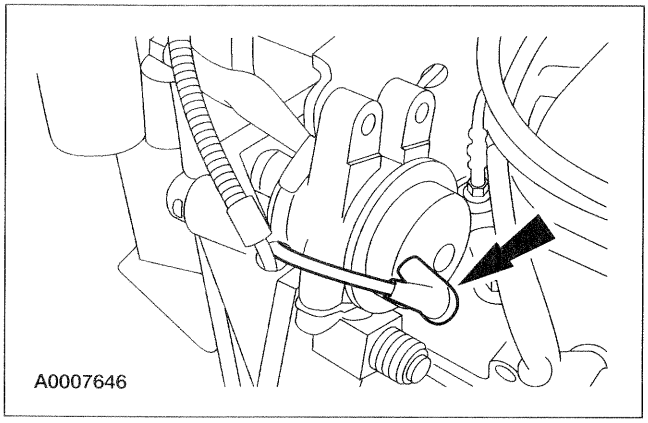
59. Connect the EGR valve vacuum hose.



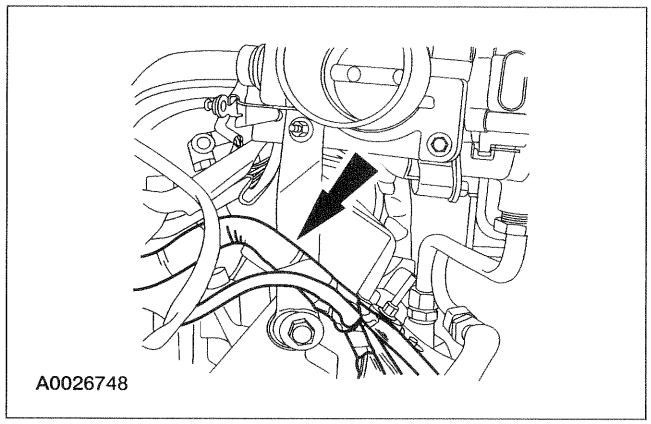
60. Install the upper intake manifold support bracket.



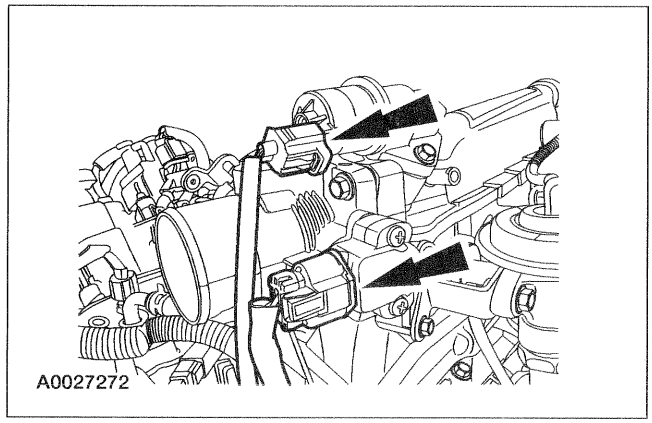
61. Connect the vacuum tube to the secondary air injection valve.



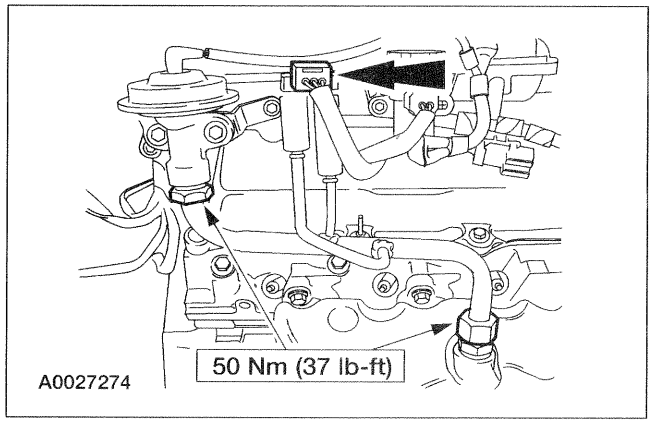
62. Position the wiring harness and install the pin-type retainers.



63. Connect the idle air control (IAC) valve and throttle position (TP) sensor electrical connectors.



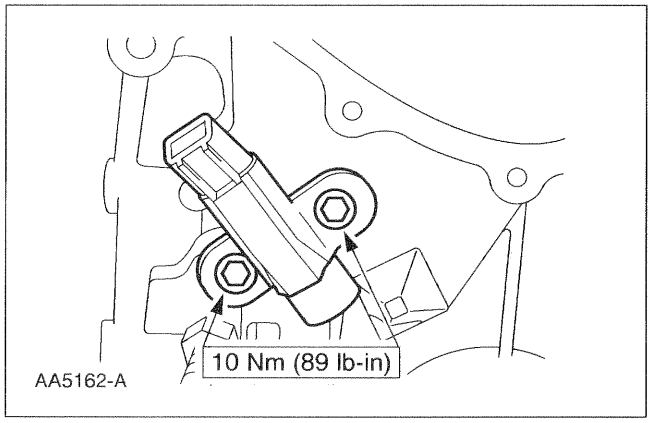
64. Install the EGR tube.
    - Connect the electrical connector.
    - Tighten the two compression nuts.



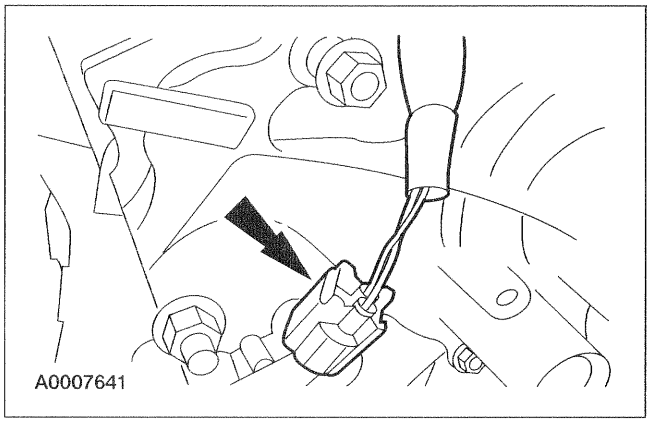
ASSEMBLY (Continued)

65. Install the crankshaft damper and crankshaft pulley. For additional information, refer to Crankshaft Pulley in this section.

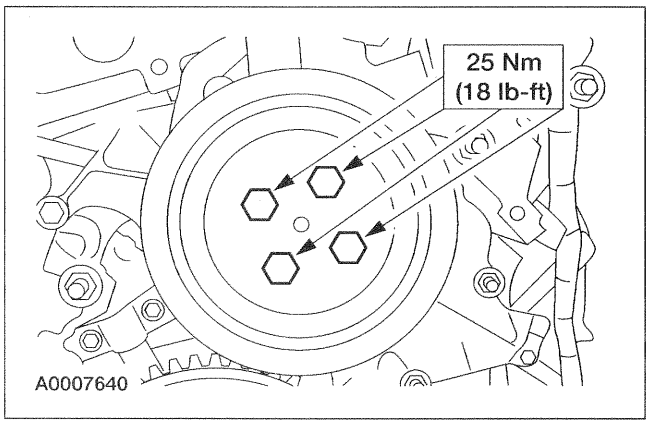
66. Install the crankshaft position (CKP) sensor.



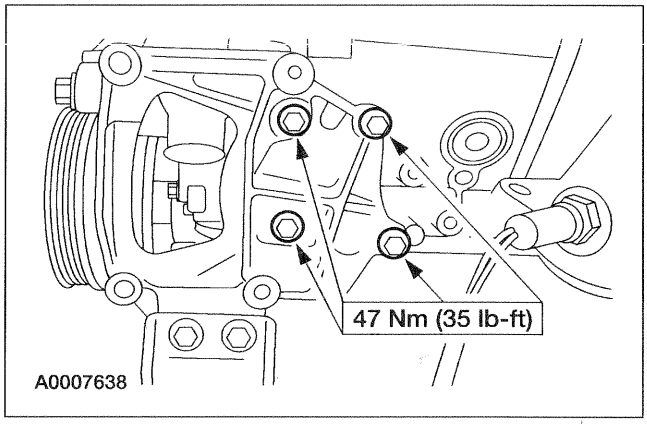
67. Connect the CKP sensor electrical connector.



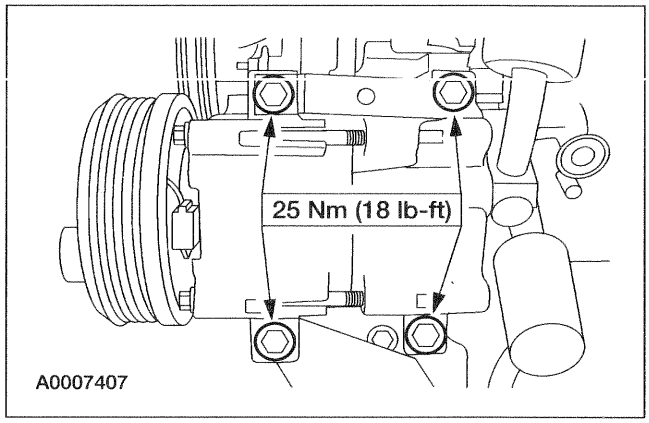
68. Install the water pump pulley.



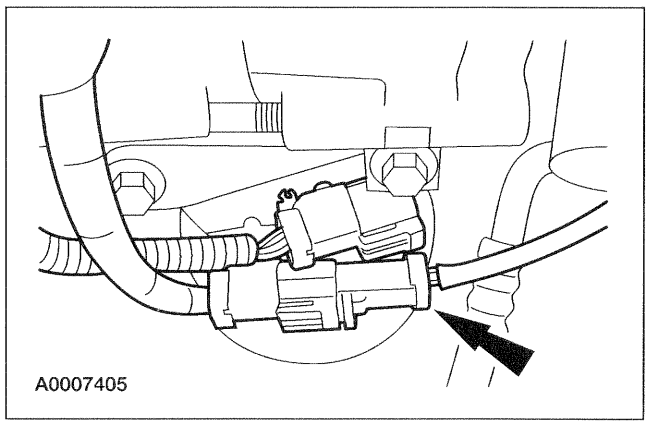
69. Install the A/C compressor mounting bracket.



70. Install the A/C compressor.

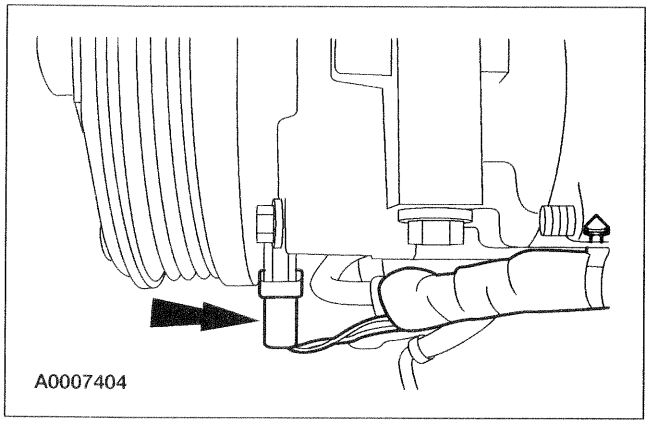


71. Install the wiring harness connectors on the bracket and connect the oxygen sensor electrical connector.

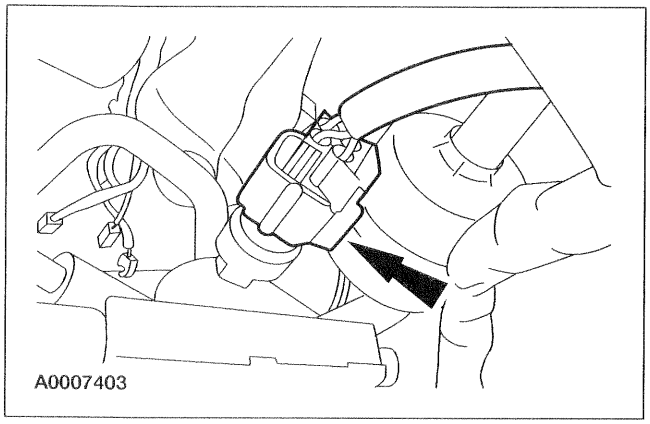


ASSEMBLY (Continued)

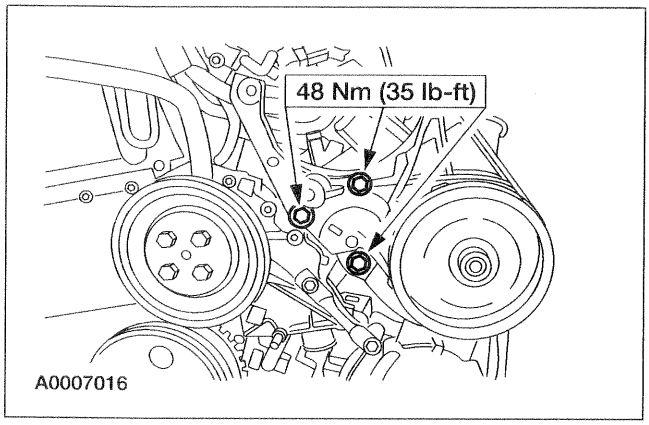
72. Connect the A/C compressor clutch coil electrical connector.



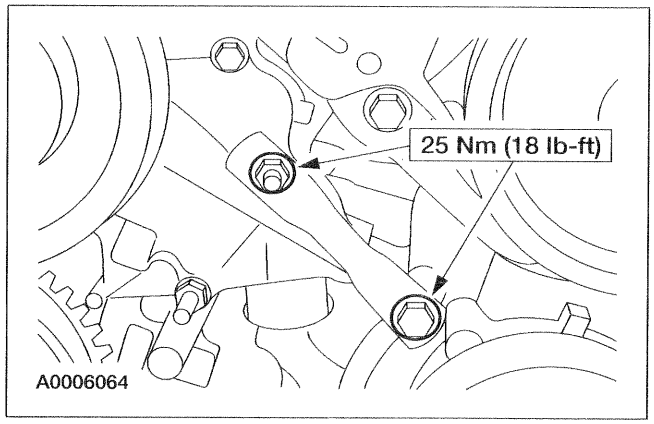
73. Connect the A/C high pressure cutoff switch electrical connector.



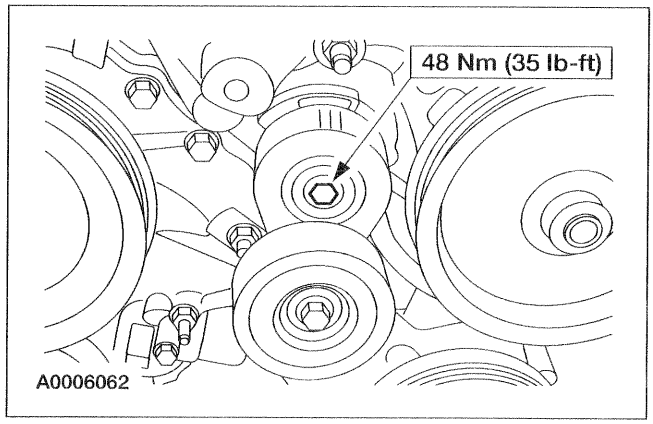
74. Install the power steering pump and bracket assembly.



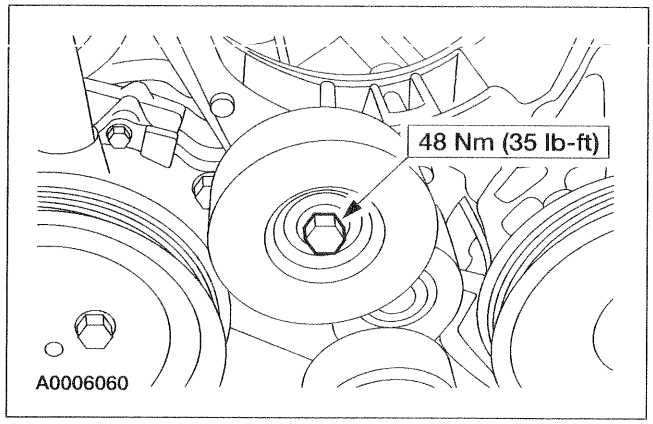
75. Install the support bracket.



76. Install the drive belt tensioner.

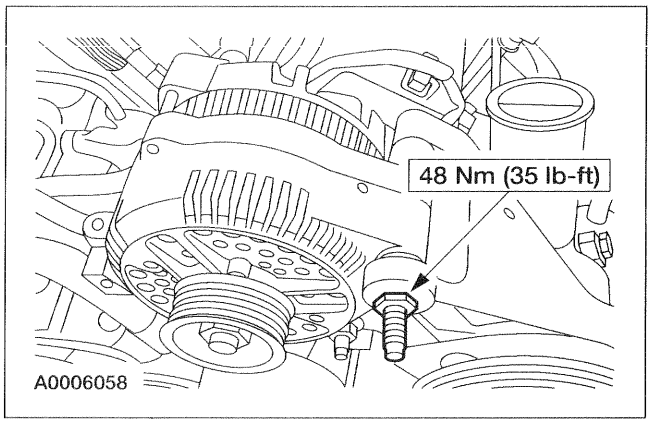


77. Install the drive belt idler pulley.

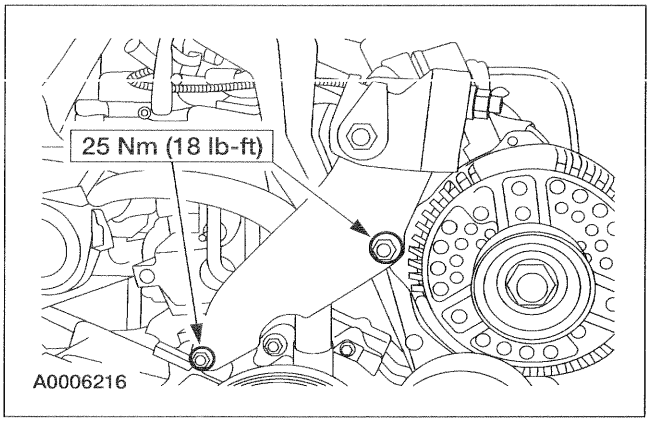


ASSEMBLY (Continued)

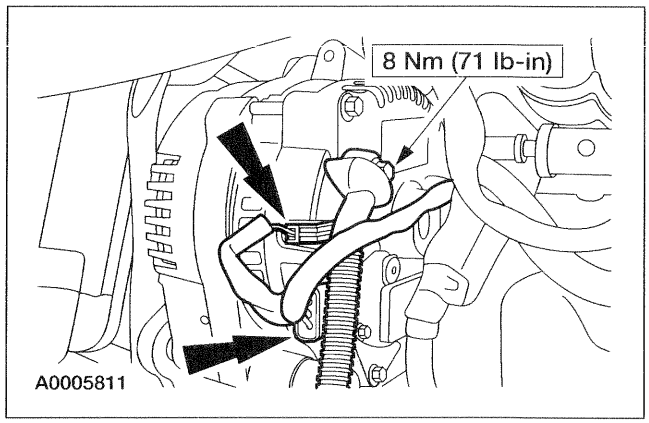
78. Install the generator.



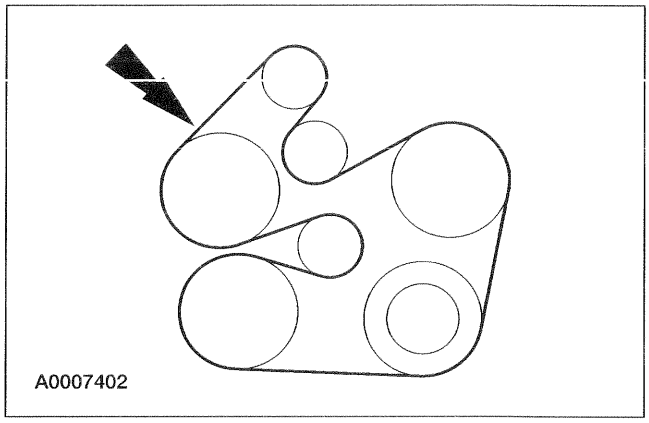
79. Install the generator support bracket.



80. Connect the generator electrical connections.



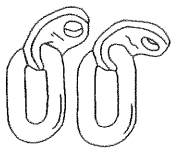
81. Install the drive belt.



INSTALLATION

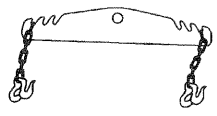
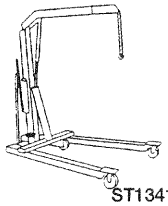
Engine

Special Tool(s)

 ST1682-A	Powertrain Lift With Tilting Plate 014-00765 or equivalent
 ST1831-A	Lifting Eyes 303-D030 (D81L-6001-D) or equivalent

(Continued)

Special Tool(s)

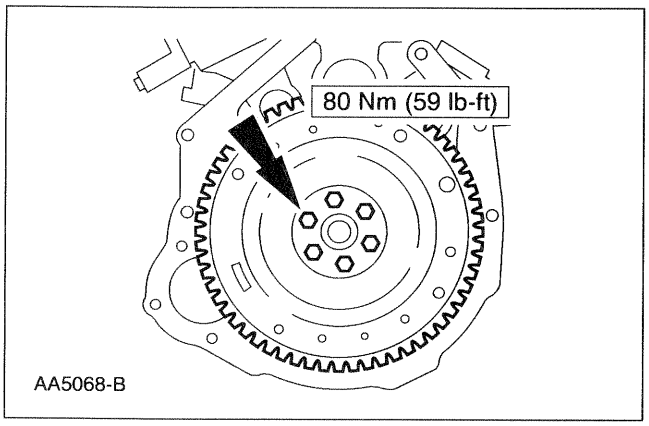
 ST1602-A	Spreader Bar 303-D089 (D93P-6001-A3) or equivalent
 ST1341-A	Heavy Duty Floor Crane 014-00072 or equivalent

INSTALLATION (Continued)

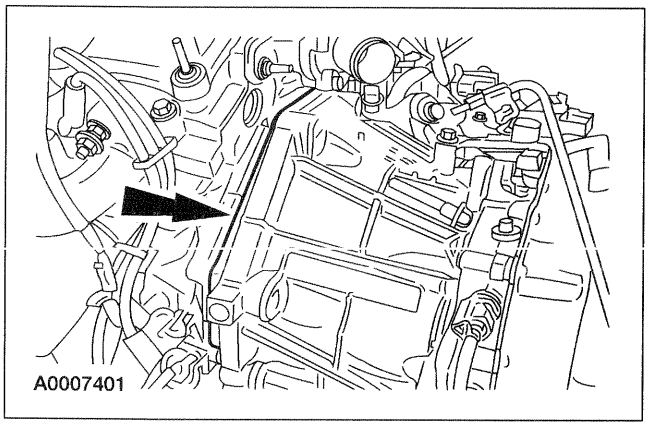
Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

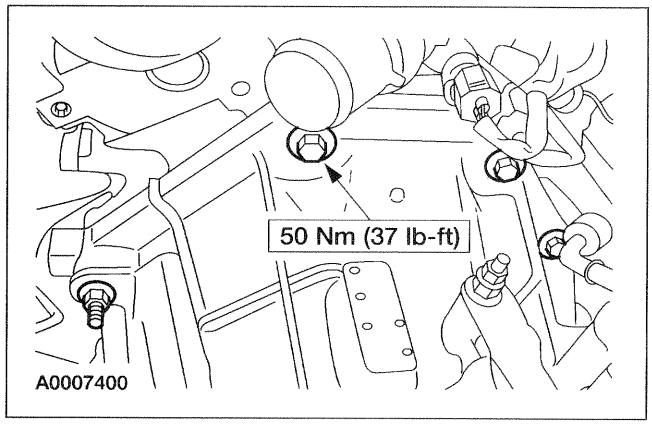
1. Install the flexplate and the bolts. Tighten the bolts in a criss-cross pattern.



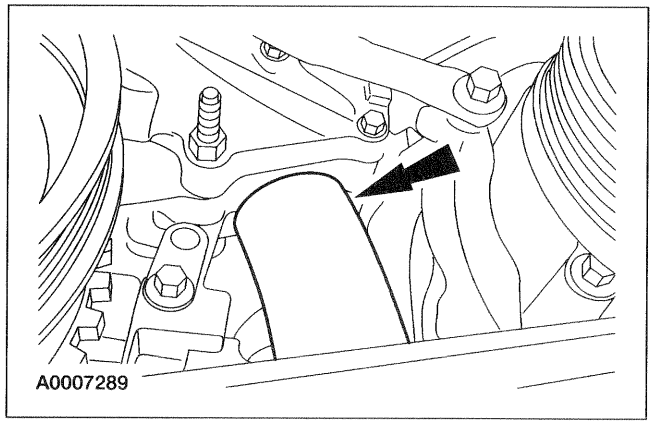
2. Position the engine on the subframe and transmission assembly.



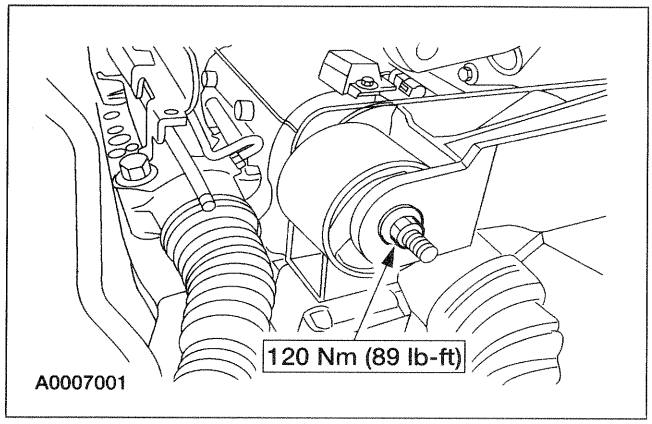
3. Install the transmission-to-engine bolts.
   - Install five bolts.
   - Install one stud bolt.



4. Connect the lower radiator hose to the water pump.

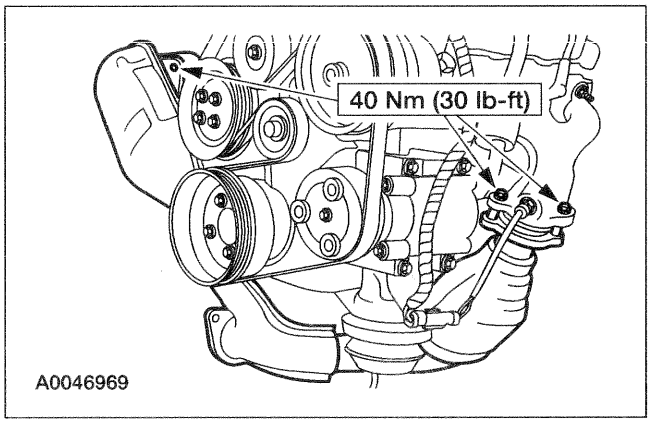


5. Install the RH engine support insulator through bolt.

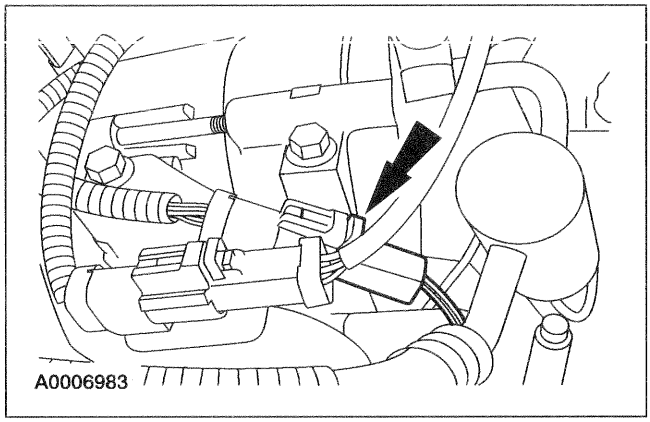


INSTALLATION (Continued)

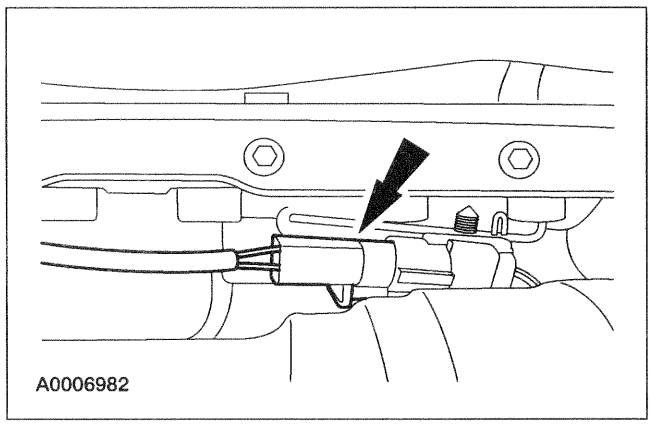
6. Install the dual converter Y-pipe and the bolts.



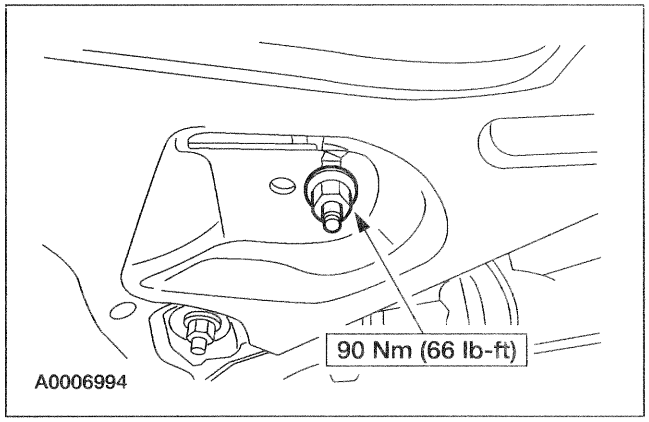
7. Connect the catalyst monitor sensor electrical connector.



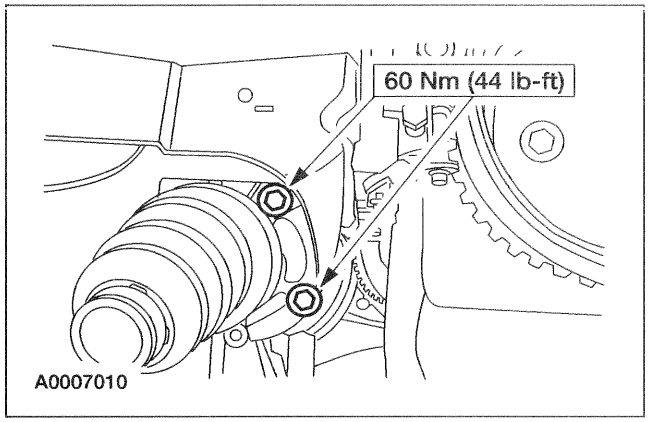
8. Connect the catalyst monitor sensor electrical connector.



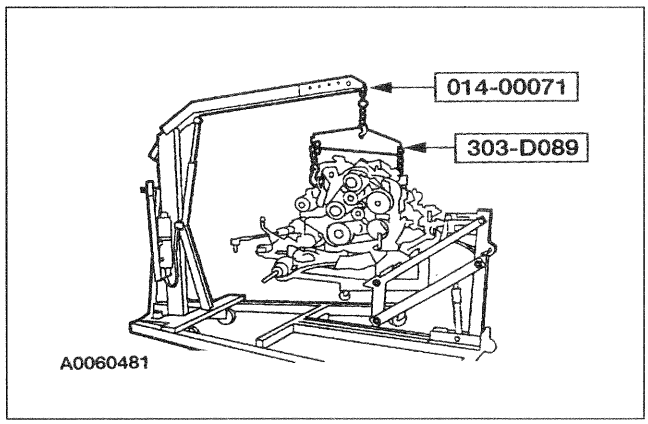
9. Install the LH engine support insulator-to-subframe nut.



10. Install the two RH engine support insulator-to-transmission bolts.

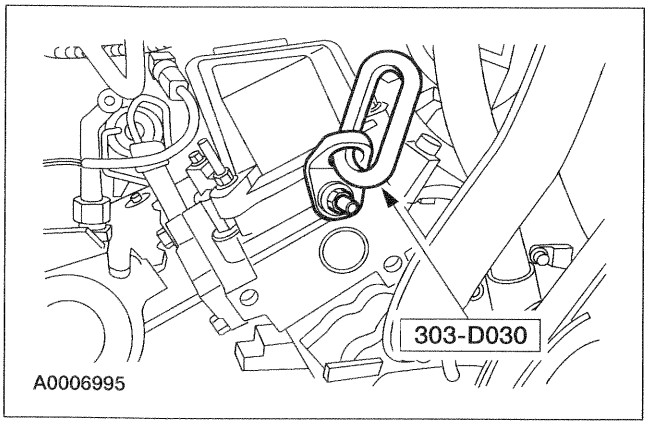


11. Remove the special tools.

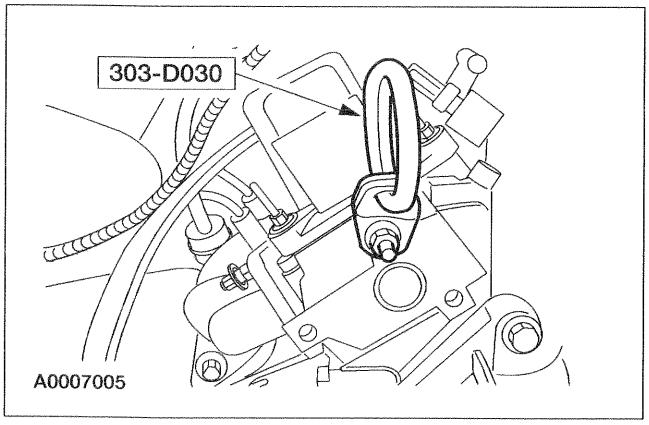


INSTALLATION (Continued)

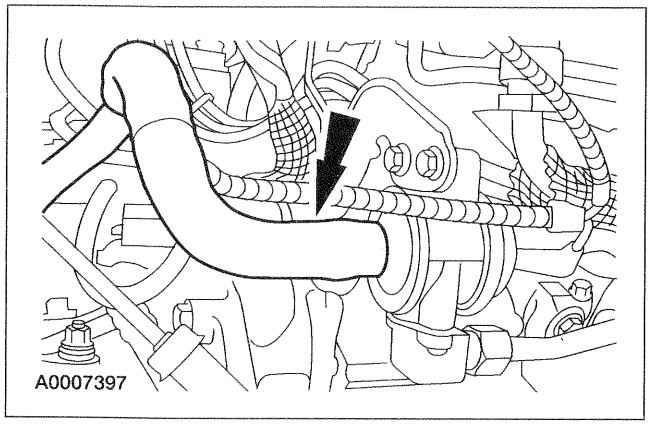
12. Remove the special tool from the RH side of the engine.



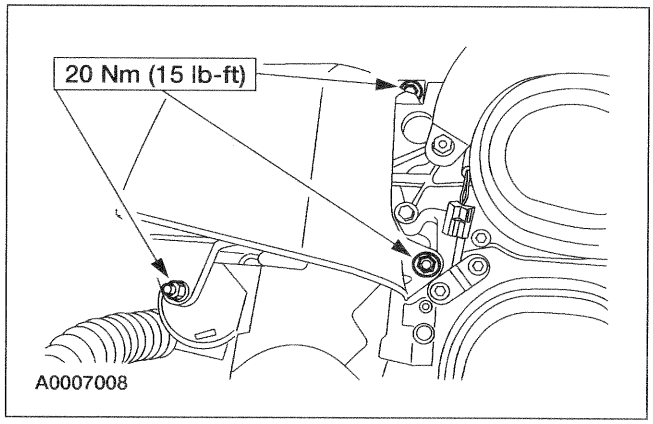
13. Remove the special tool from the LH side of the engine.



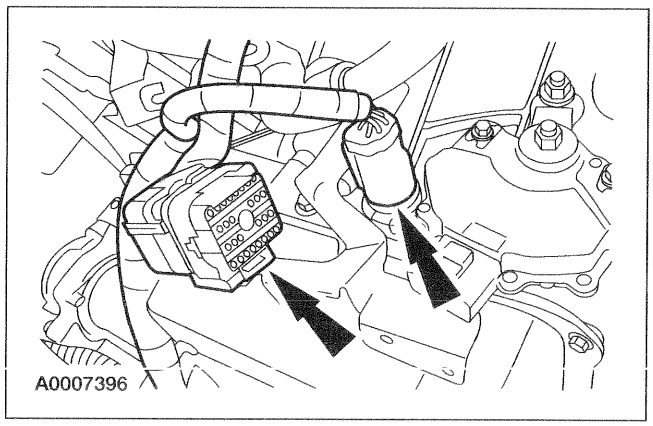
14. Install the secondary air injection hose, if equipped.



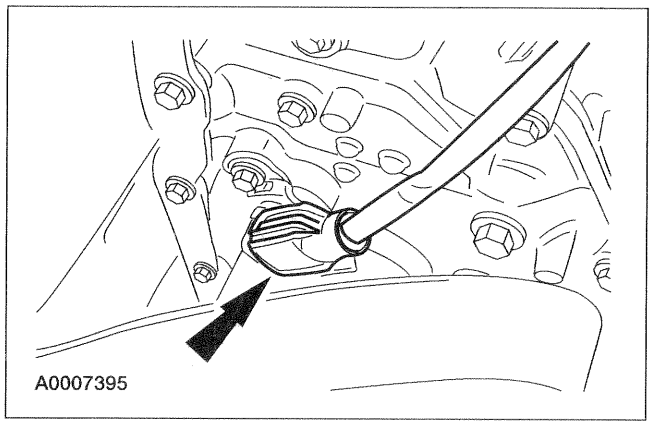
15. Install the RH catalytic converter heat shield.
    - Install the two nuts.
    - Position the ground strap and install the bolt.



16. Position the 42-pin connector on the bracket and connect the transaxle harness electrical connector.

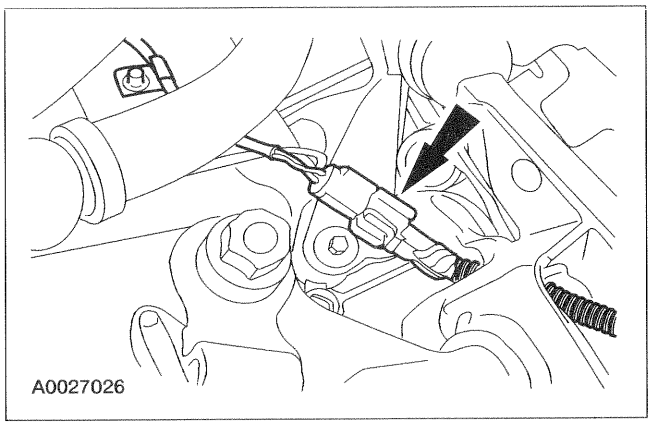


17. Connect the turbine shaft speed (TSS) sensor electrical connector.

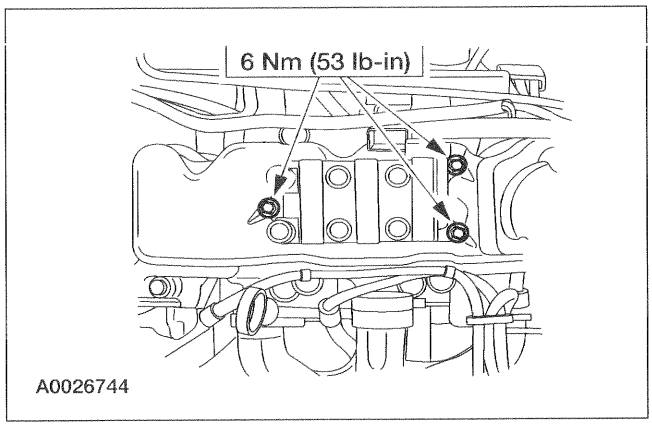


INSTALLATION (Continued)

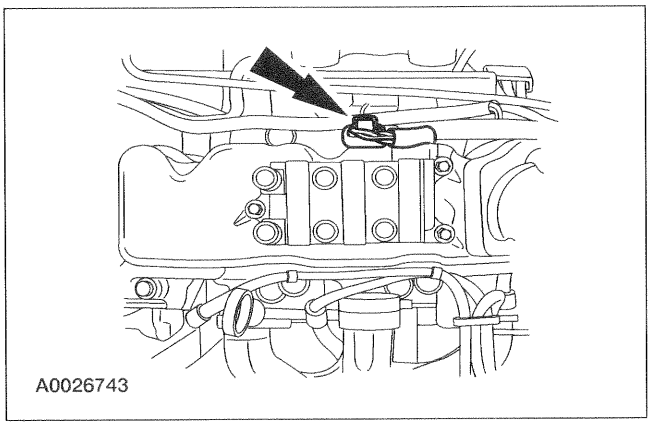
18. Connect the output speed sensor (OSS) electrical connector.



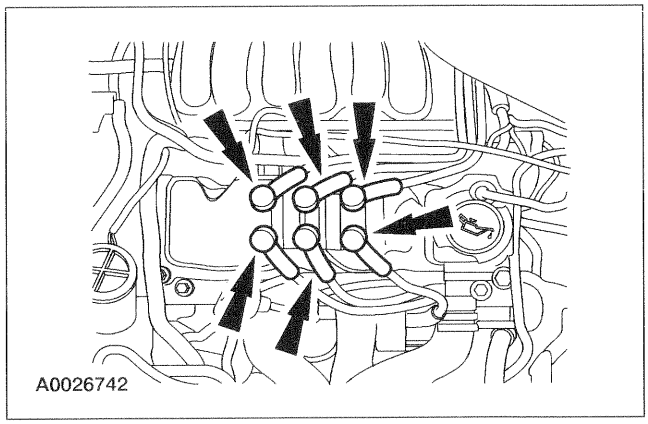
19. Install the ignition coil and the bolts.



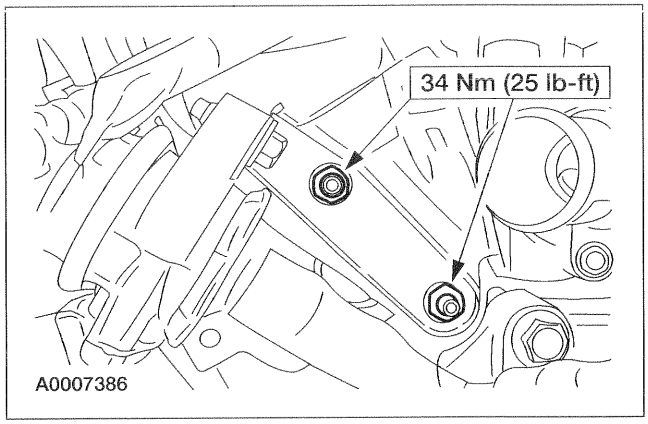
20. Connect the ignition coil electrical connector.



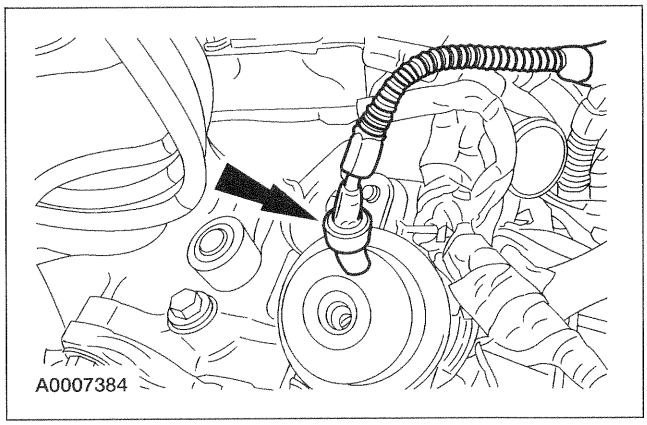
21. Connect the spark plug wires to the ignition coil.



22. Install the secondary air injection valve and bracket, if equipped.

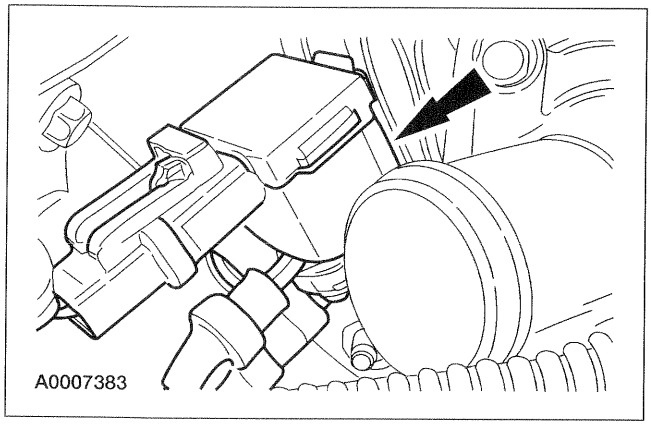


23. Connect the secondary air injection valve vacuum tube, if equipped.

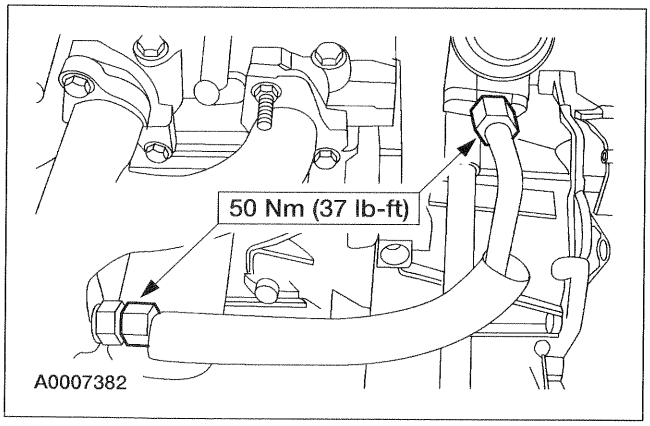


INSTALLATION (Continued)

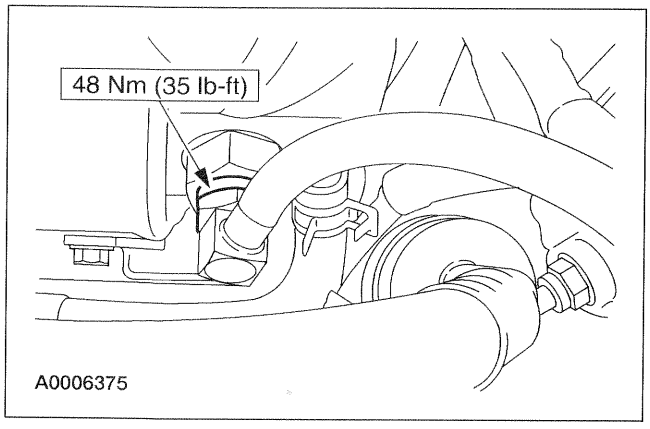
24. Connect the control valve solenoid to the bracket, if equipped.



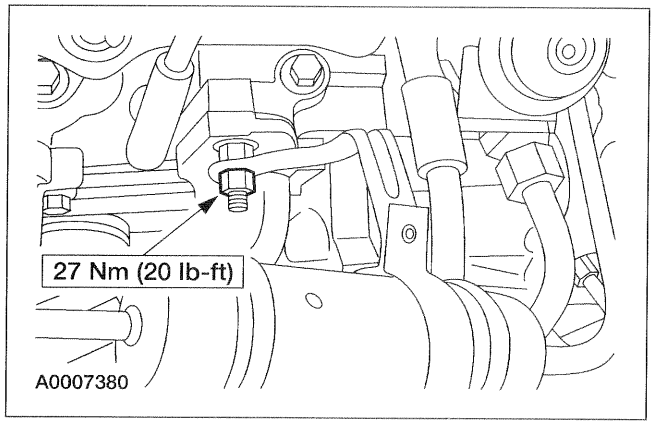
25. Install the LH secondary air injection tube, if equipped.



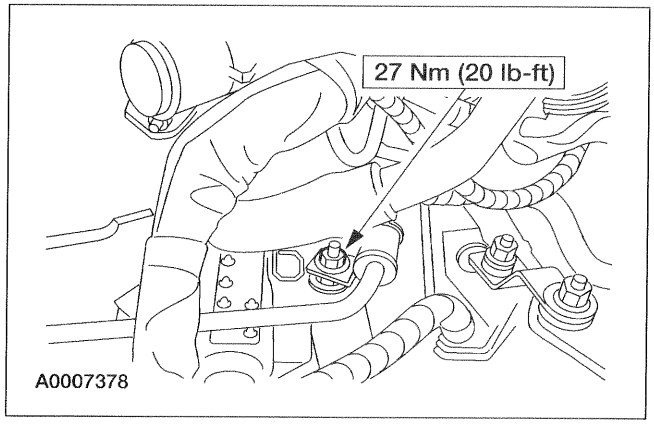
26. Connect the power steering pressure tube to the power steering pump.



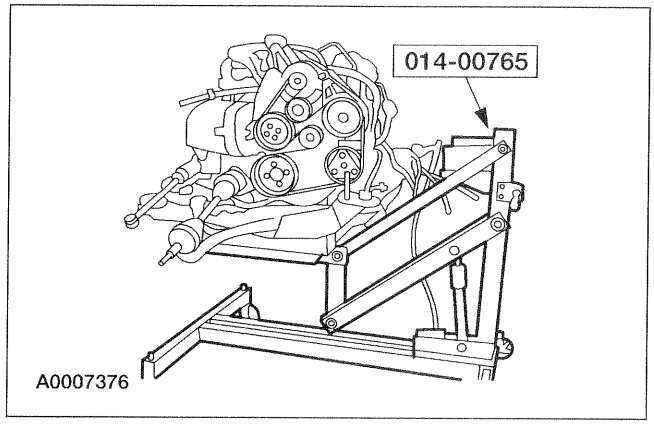
27. Install the power steering pressure tube bracket and the nut.



28. Install the power steering pressure tube bracket and the nut.

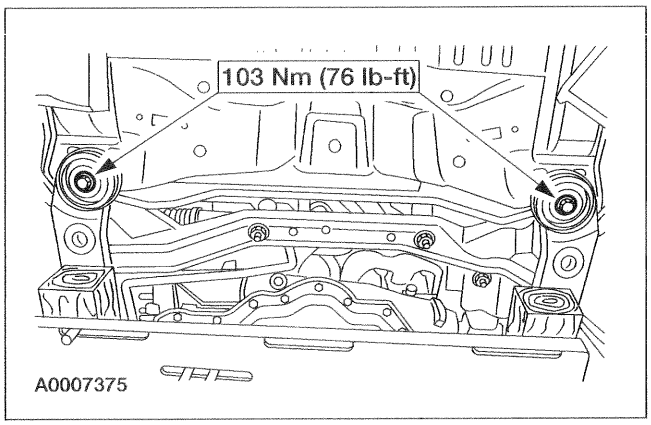


29. Using the special tool, raise the engine, transmission and subframe into the vehicle.

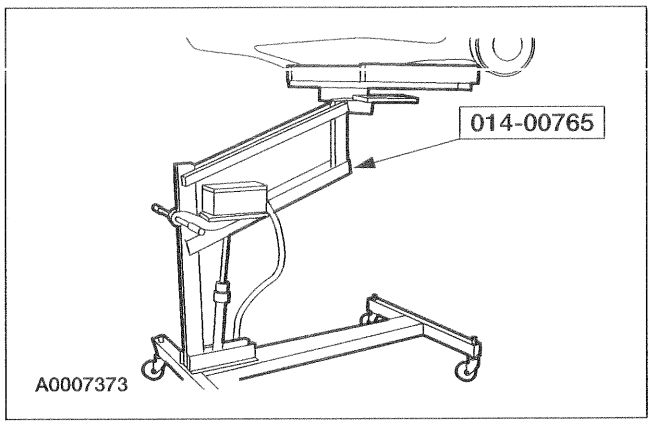


INSTALLATION (Continued)

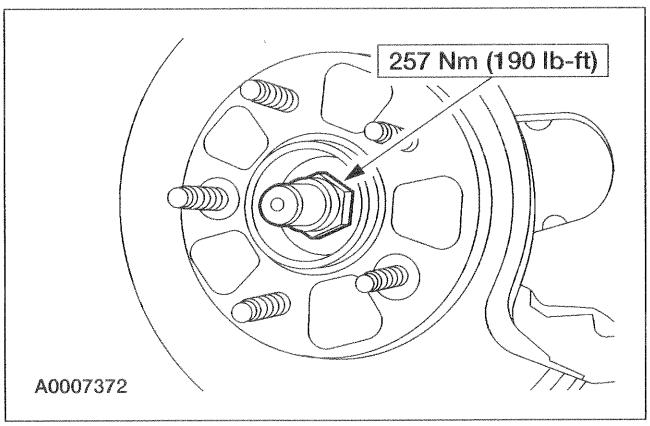
30. Install the four front subframe-to-body bolts.



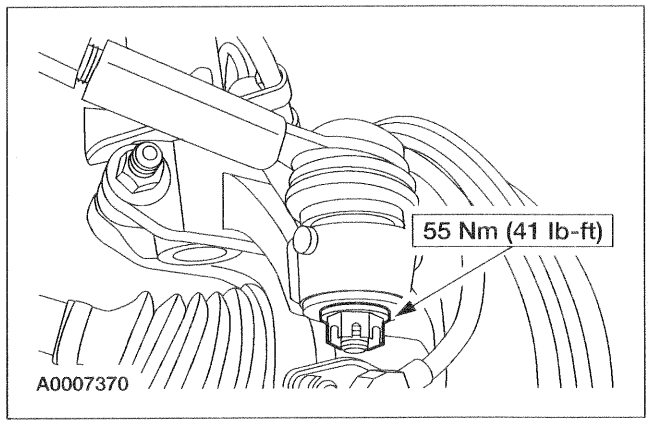
31. Lower the special tool and position it aside.



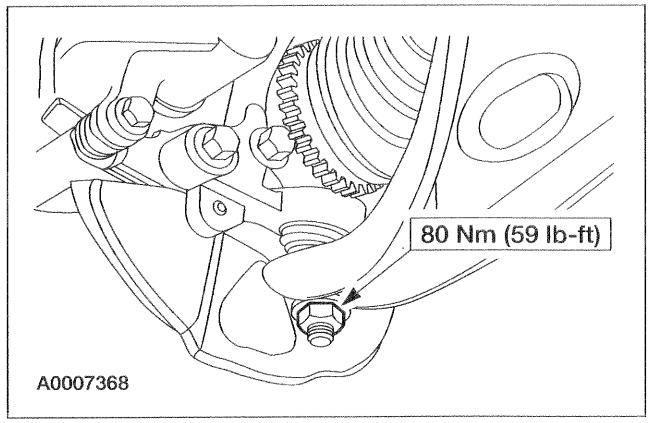
32. Install the LH and RH half shafts to the steering knuckles.



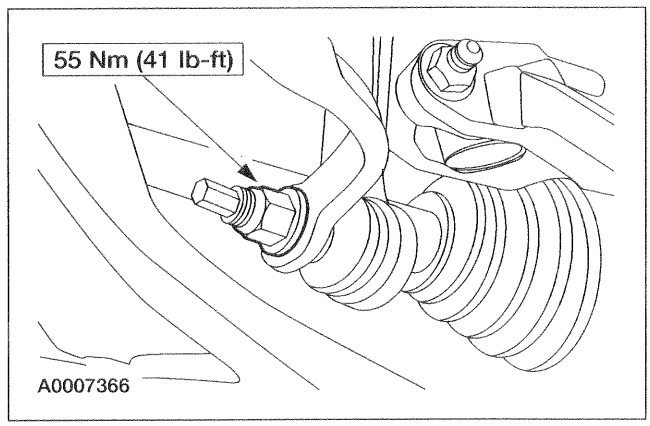
33. Connect the LH and RH tie rod ends to the steering knuckles.



34. Connect the LH and RH lower control arms to the steering knuckles.

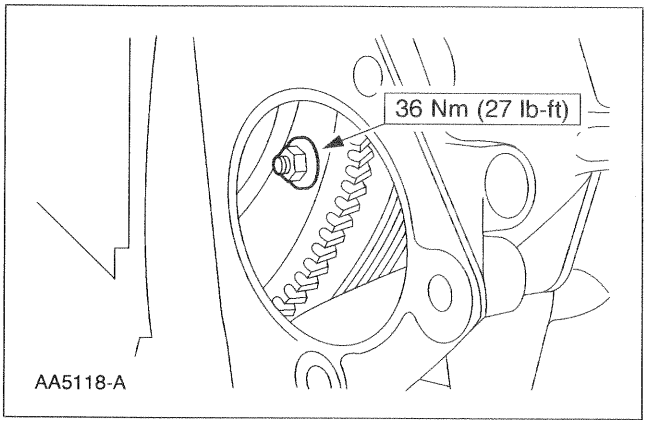


35. Connect the LH and RH stabilizer links to the stabilizer bar.

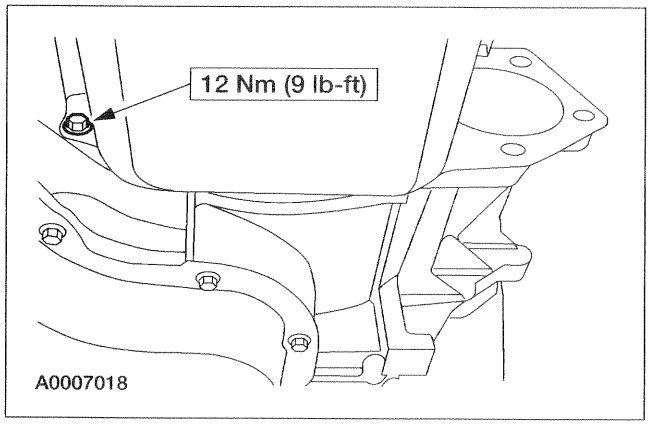


INSTALLATION (Continued)

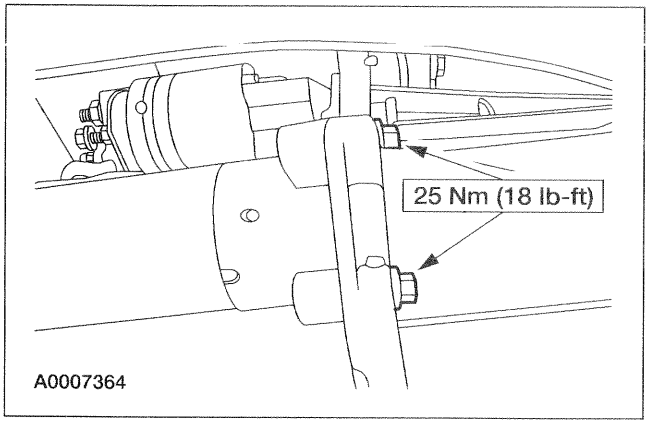
36. Install the four torque converter nuts.



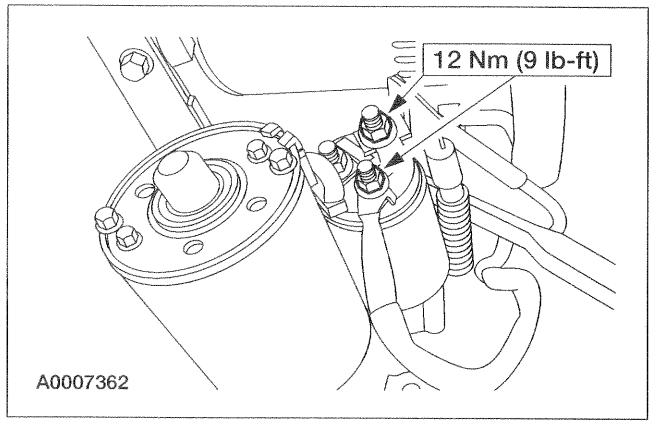
37. Install the engine rear plate.



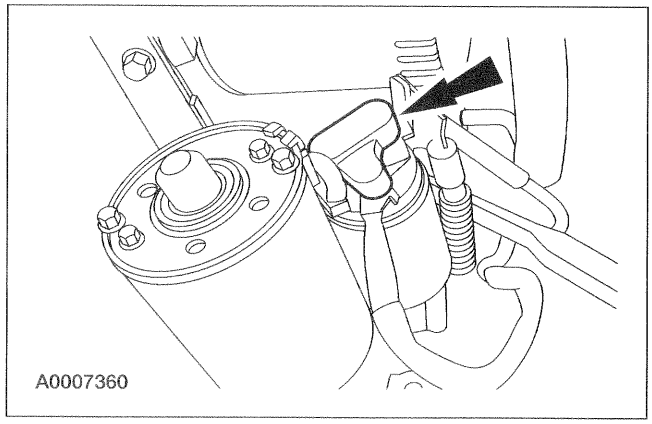
38. Install the starter motor.



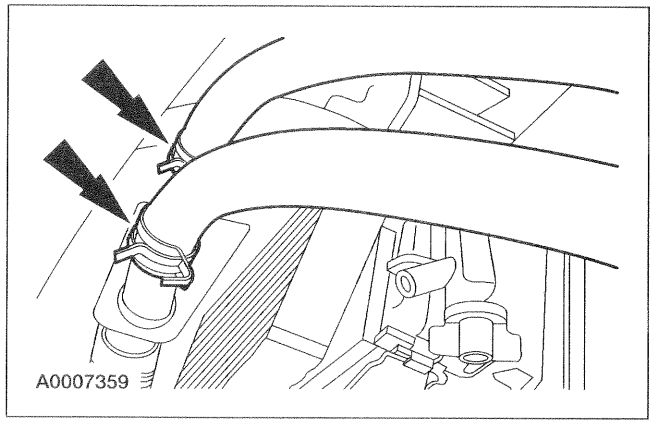
39. Connect the starter motor electrical connectors.



40. Install the starter motor electrical connector cover.

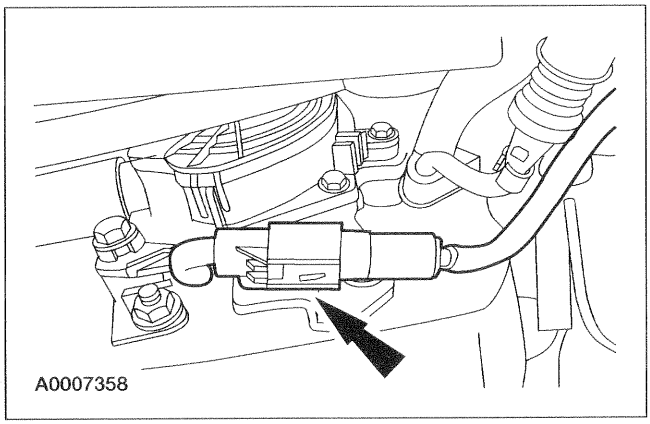


41. Connect the auxiliary oil cooler assembly.
    - Connect the transmission oil cooler hose, if equipped.
    - Connect the power steering return hose.

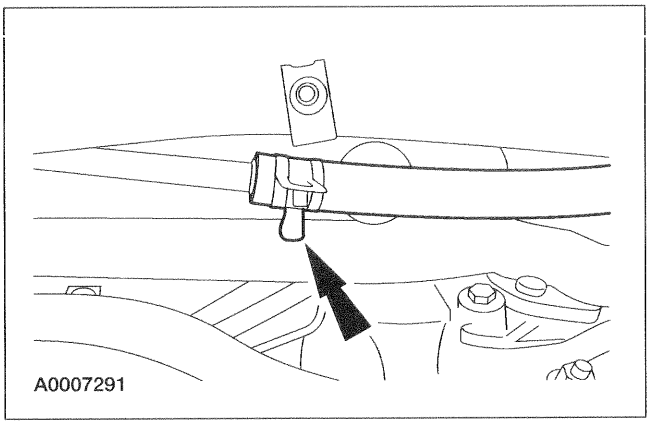


INSTALLATION (Continued)

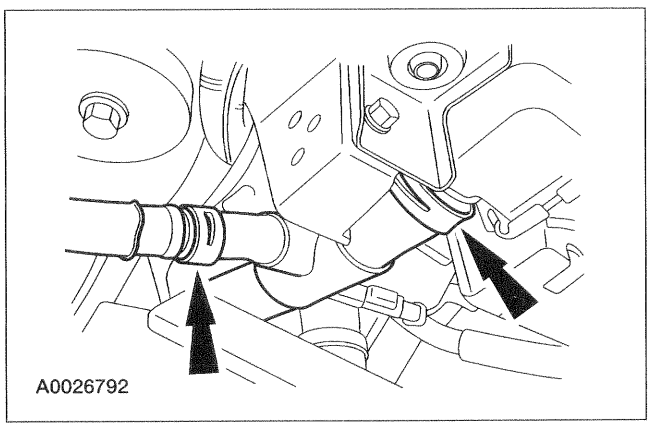
42. Connect the wiring harness electrical connector, if equipped.



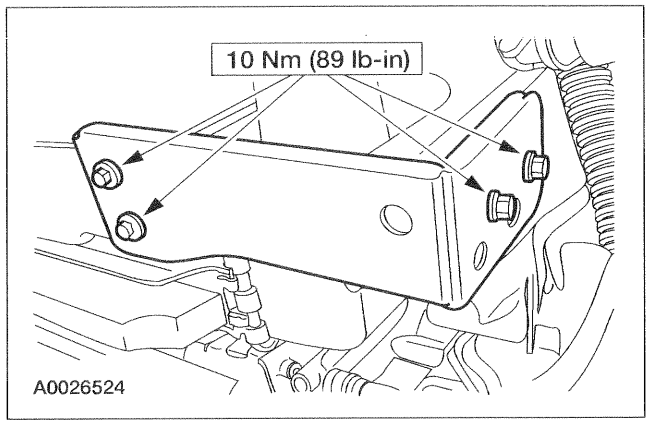
43. Connect the transmission oil cooler hose.



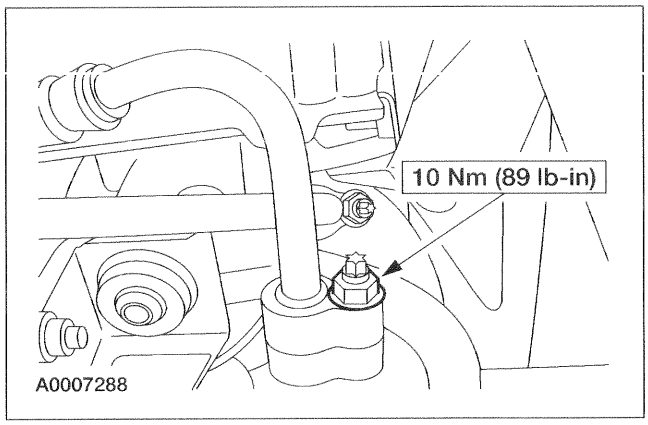
44. Connect the lower radiator hose to the radiator and the degas bottle supply hose.



45. Install the radiator support bracket.

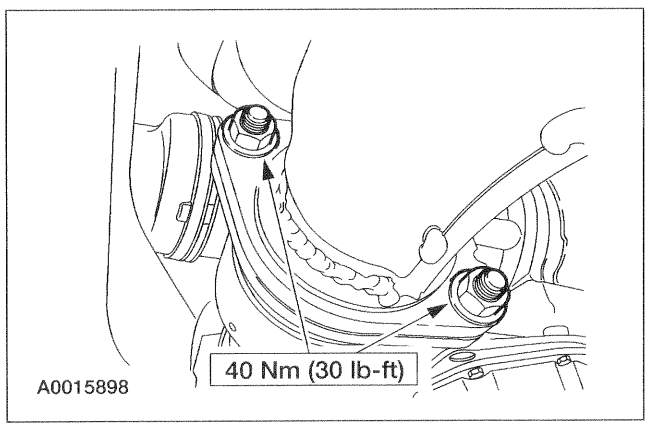


46. Connect the A/C discharge tube.



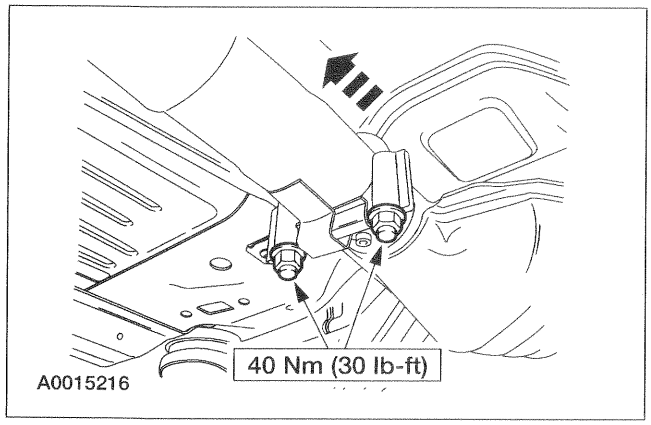
47. Install a new gasket into the Y-pipe flange.

48. Connect the three-way converter to the dual converter Y-pipe and the muffler pipe.



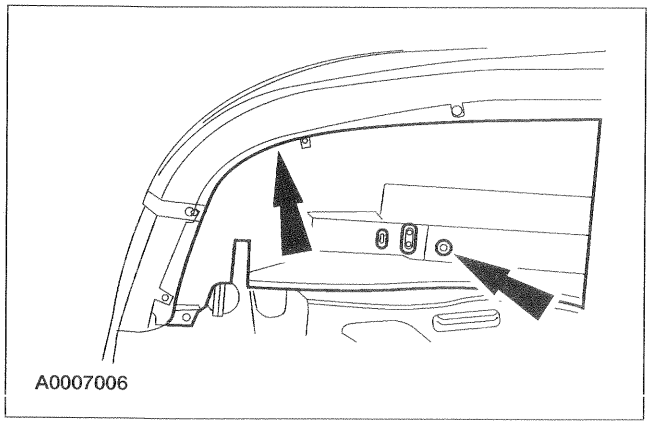
INSTALLATION (Continued)

49. Install the exhaust clamp.



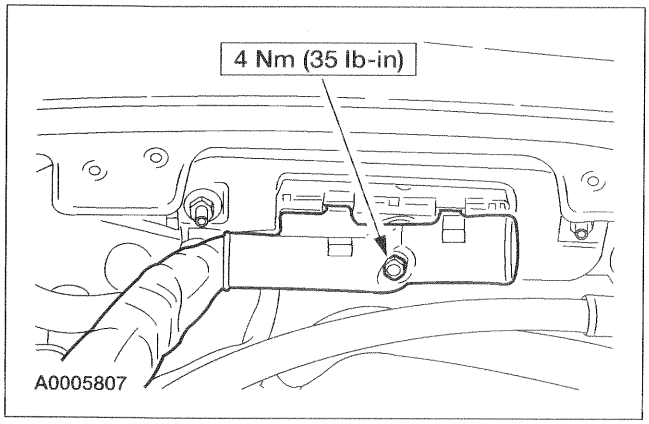
50. Install the front wheels.

51. Install the front splash shield.
    - Install the three screws.
    - Install the nine pin-type retainers.

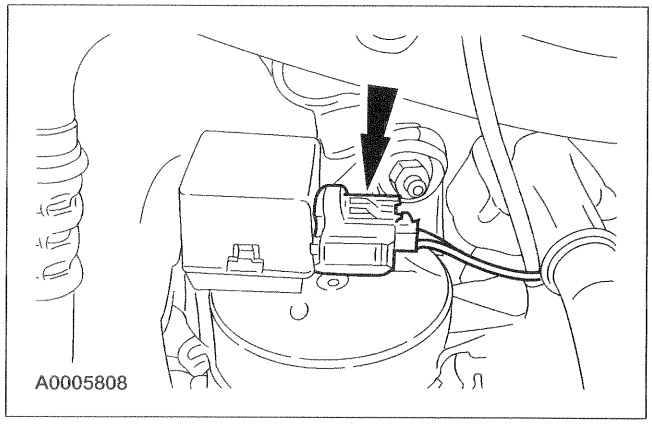


52. Lower the vehicle.

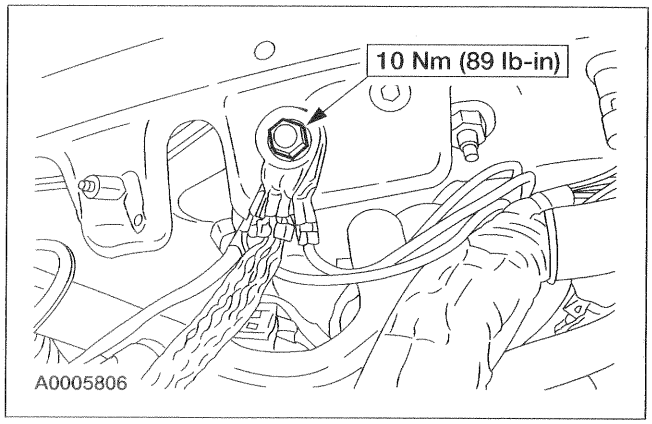
53. Connect the powertrain control module (PCM) electrical connector.



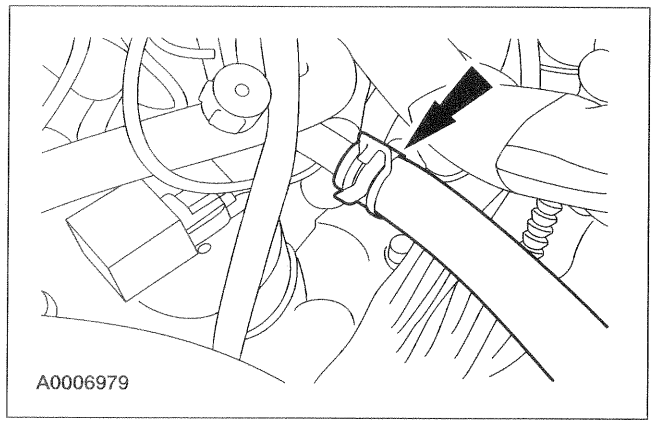
54. Connect the evaporative emissions (EVAP) canister purge valve electrical connector.



55. Connect the ground electrical connectors and install the bolt.

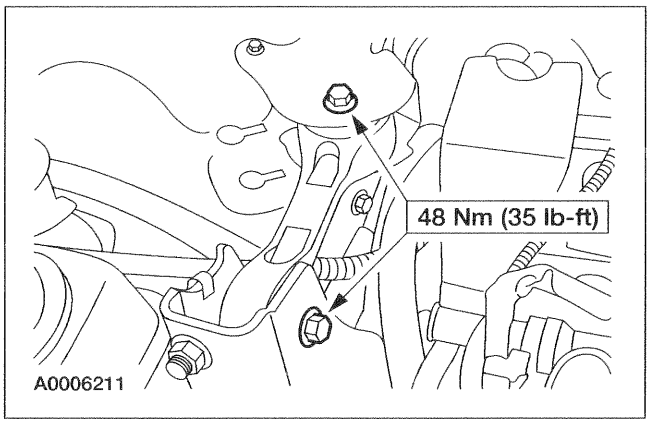


56. Connect the heater water hose.

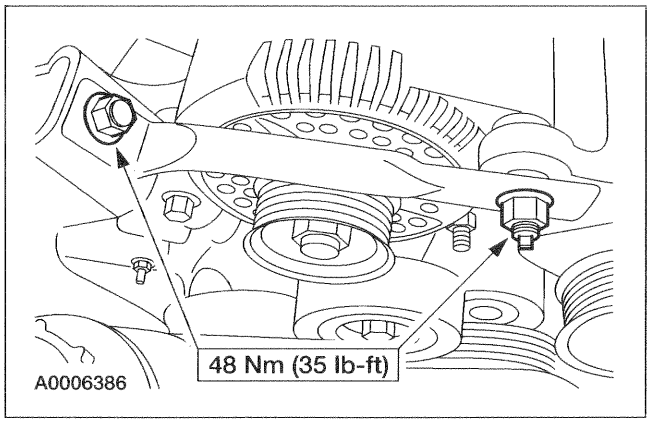


INSTALLATION (Continued)

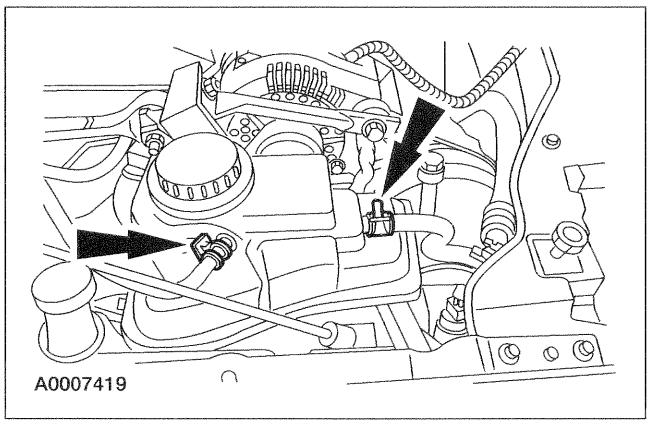
57. Install the engine roll restrictor and install the bolts.



58. Install the engine roll restrictor brace and install the nut and bolt.



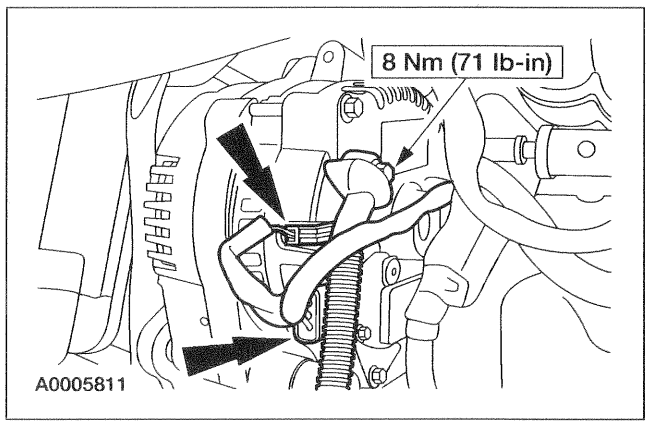
59. Connect the hoses to the degas bottle.



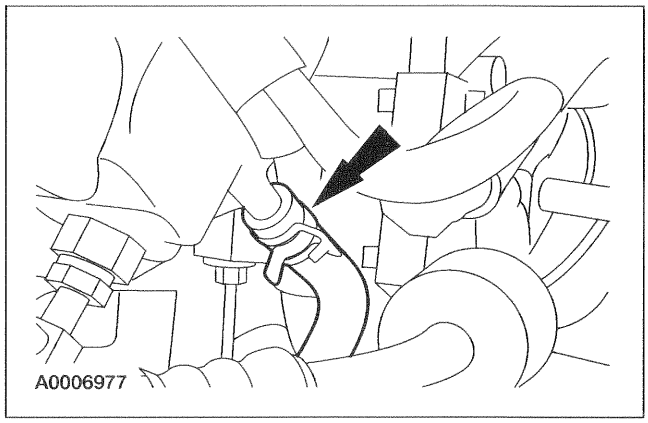
60. Connect the fuel tube spring lock coupling. For additional information, refer to Section 310-00.

61. Connect the A/C suction tube to the accumulator drier. For additional information, refer to Section 412-00.

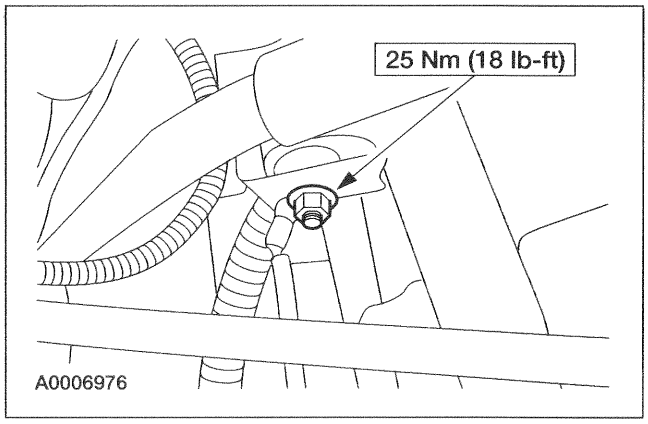
62. Connect the generator electrical connections.



63. Connect the power steering return hose.

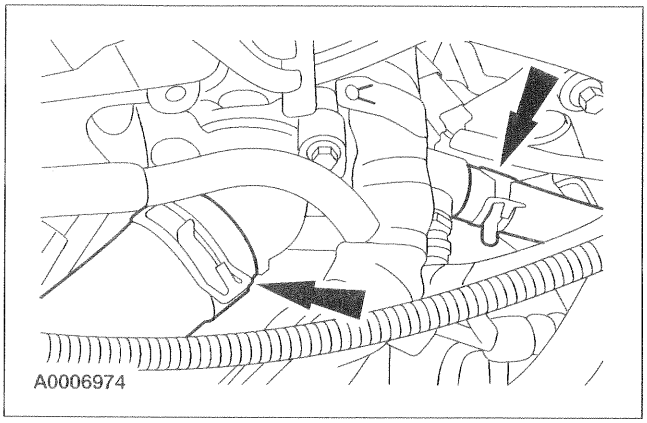


64. Connect the ground strap electrical connector.

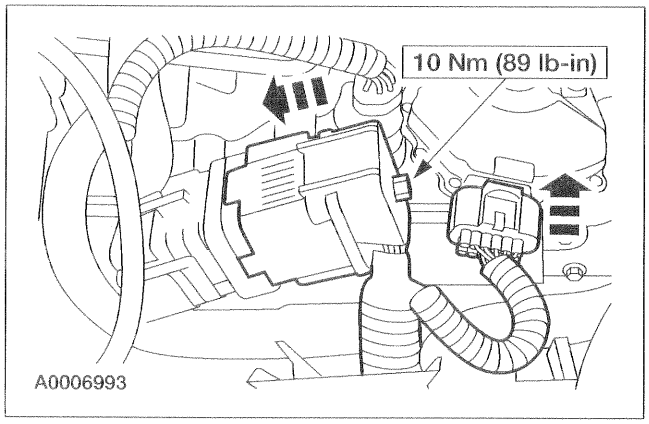


INSTALLATION (Continued)

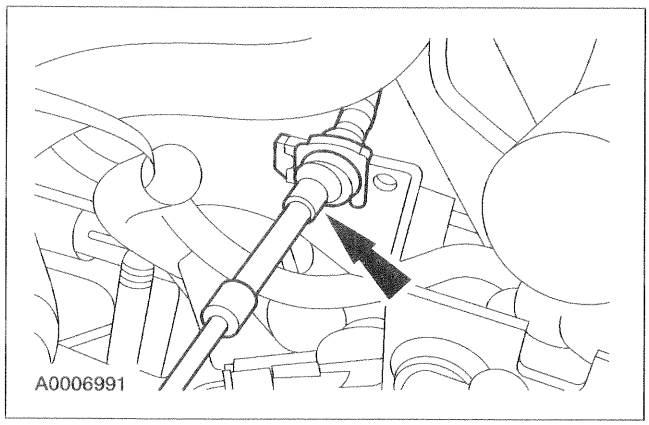
65. Connect the upper radiator hose and heater water hose to the thermostat housing.



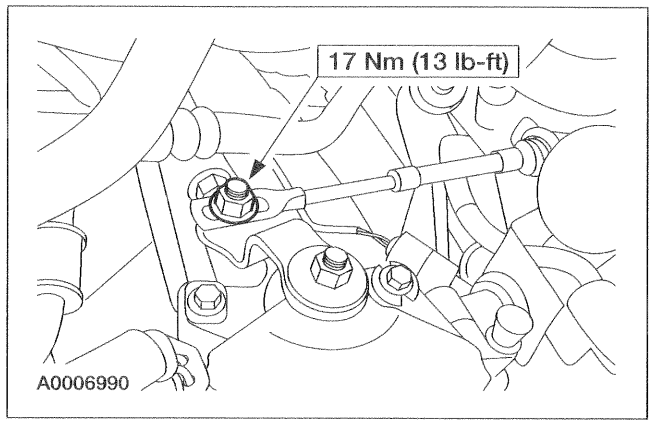
66. Connect the transmission range (TR) sensor and the 42-pin electrical connectors.



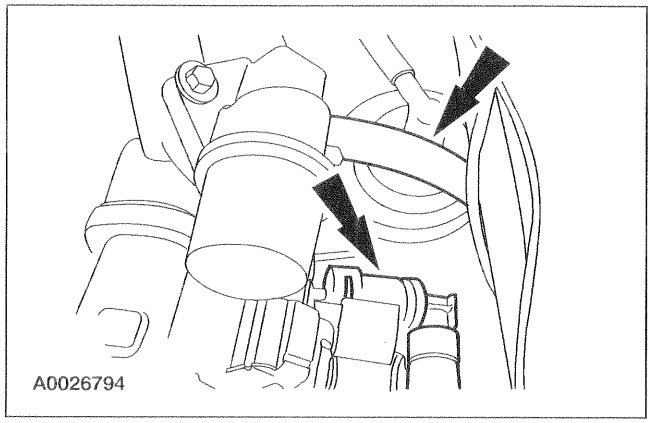
67. Install the manual control lever cable.



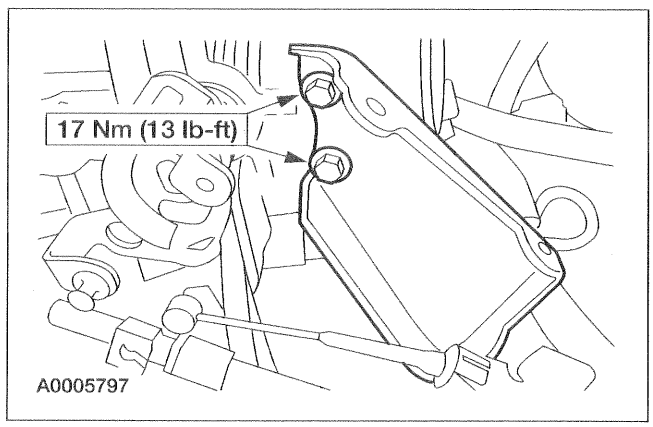
68. Connect the manual control lever cable to the manual control lever and install the nut.



69. Connect the chassis vacuum hose.

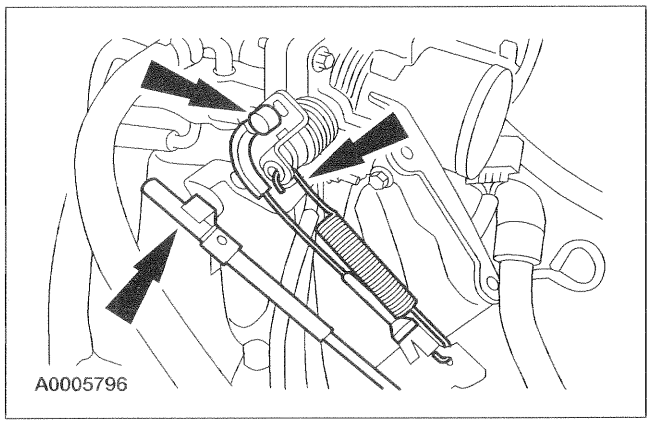


70. Install the accelerator cable bracket and install the bolts.

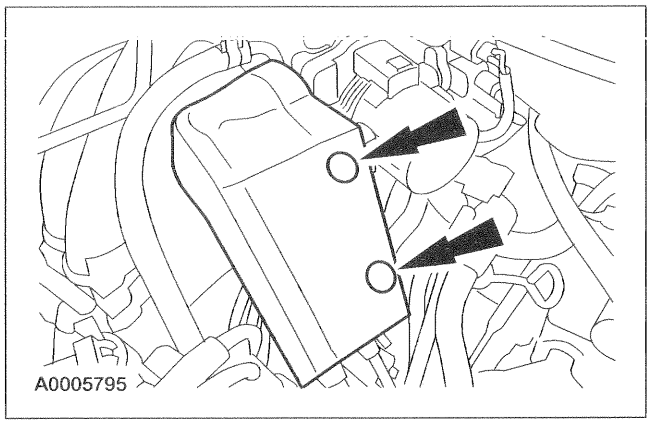


INSTALLATION (Continued)

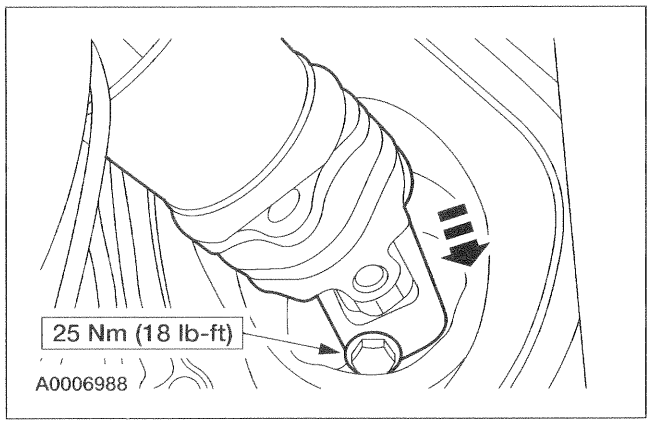
71. Connect the accelerator cable, speed control cable and throttle return spring.



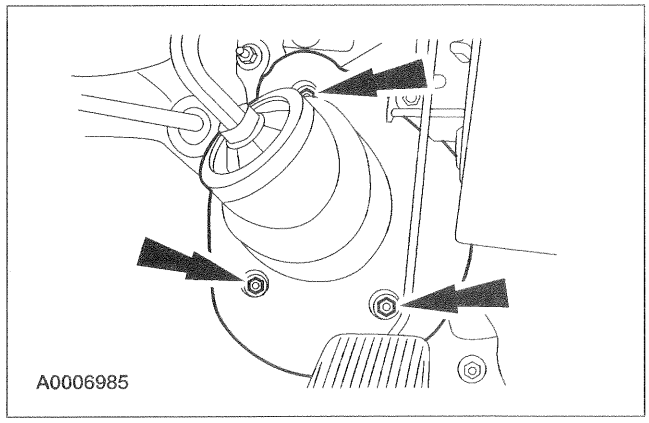
72. Install the snow shield.



73. Connect the steering column to the steering gear input shaft and install the bolt.



74. Position the steering column input shaft coupling boot and install the nuts.



75. Install the engine air cleaner and the engine air cleaner outlet tube. For additional information, refer to Section 303-12.

76. Install the cowl extension and cowl vent screen. For additional information, refer to Section 501-02.

77. Install the battery and connect the battery ground cable. For additional information, refer to Section 414-01.

78. Fill the engine with clean engine oil.

79. Fill and bleed the engine cooling system. For additional information, refer to Section 303-03.

80. Charge the A/C system. For additional information, refer to Section 412-00.

81. Fill and bleed the power steering system. For additional information, refer to Section 211-00.

82. Inspect the engine and cooling system for leaks.

SECTION 303-03 Engine Cooling

CONTENTS PAGE

SPECIFICATIONS

General Specifications

Item	Specification
Cooling System Capacities	
Cooling system capacity 3.0L (2V)	12.0 liters (3.17 gal)
Cooling system capacity 3.0L (4V)	10.0 liters (2.65 gal)
Coolant Types	
Motorcraft Premium Engine Coolant (green color) VC-4-A (in Oregon VC-5, in Canada CXC-10)	ESE-M97B44-A
Motorcraft Premium Gold Engine Coolant (yellow color) VC-7-A (in Oregon VC-7-B)	WSS-M97B51-A1
Other Chemicals	
Motorcraft Cooling System Flush VC-1	ESR-M14P7-A
Pipe Sealant with Teflon® D8AZ-19554-A	WSK-M2G350-A2
Cooling System Stop Leak Pellets VC-6	ESE-M99B37-5 except as noted in ES-F6SE-19A511-AA
Cooling System Pressure Test Specifications	
Cooling system	138 kPa (20.02 psi)
Radiator Cap Pressure Test Specifications	
Pressure Release Cap	89-124 kPa (12.9-18 psi)
Thermostat Opening Temperatures	
Thermostat starts to open	83.9°C-87.8°C (183°F-190°F)
Thermostat fully open	98.9°C (210°F)

Torque Specifications

Description	Nm	lb-ft	lb-in
A/C compressor support brace 3.0L (4V)	25	18	—
A/C condenser bolts	10	—	89

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
A/C condenser to radiator bolts	10	—	89
Block heater retaining screw	2	—	18
Electric cooling fan retaining bolts	10	—	89
Degas bottle retaining bolts	10	—	89
Lower radiator support bracket nuts	25	18	—
Power steering cooler to radiator	10	—	89
Roll restrictor bracket 3.0L (2V)	25	18	—
Thermostat housing bolts 3.0L (2V)	12	9	—
Thermostat housing bolts 3.0L (4V)	10	—	89
Water bypass tube 3.0L (4V)	10	—	89
Water pump bolts 3.0L (2V)[a]	—	—	—
Water pump bolts 3.0L (4V)	25	18	—
Water pump pulley bolts 3.0L (2V)	25	18	—
Radiator tube bolts	10	—	89

a Refer to the procedure in this section.

DESCRIPTION AND OPERATION

Engine Cooling

⚠ **CAUTION: Some vehicle cooling systems are filled with Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color). Others are filled with Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color). Always fill the cooling system with the same coolant that is present in the system. Do not mix coolant types.**

NOTE: The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

The cooling system components are:

- engine coolant temperature (ECT) sensor (12A648)
- radiator (8005)
- degas bottle (8A080)
- radiator draincock (8115)
- water pump (8501)
- water temperature indicator sender unit (10884)
- water thermostat (8575)
- three speed fan motor assembly
- fan braking relay
- resistor relay
- HEDF relay
- EDF relay

The water pump circulates the coolant.

The water thermostat:

- controls the engine coolant temperature.
- allows quicker engine warm-up.

The degas bottle:

- provides a location for fill.
- contains coolant expansion and system pressurization.
- provides air separation during operation.
- replenishes the engine coolant to the system.

The fan motor (8C607):

- operates only when the ignition switch is in the RUN position.
- has three speeds and is controlled by four relays.

The engine coolant flows:

- from the lower radiator hose (8286) to the water pump.
- from the water pump to the engine block and the cylinder heads.

A closed water thermostat returns the engine coolant to the water pump; an open water thermostat allows the engine coolant to flow to the radiator.

Engine coolant provides freeze protection, boil protection, cooling efficiency and corrosion protection to the engine and cooling components. In order to obtain these protections, the engine coolant must be maintained at the correct concentration and fluid level in the degas bottle.

When adding engine coolant, use a 50/50 mixture of clean distilled water and engine coolant.

To maintain the integrity of the coolant and the cooling system:

- **NOTE:** The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

  Add Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color), or Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color). Do not mix coolant types.
- Do not add/mix orange-colored Motorcraft Speciality Orange Engine Coolant VC-2 meeting Ford specification WSS-M97B44-D. Mixing coolants may degrade the coolant's corrosion protection.
- Do not add alcohol, methanol or brine, or any engine coolants mixed with alcohol or methanol antifreeze. These can cause engine damage from overheating or freezing.

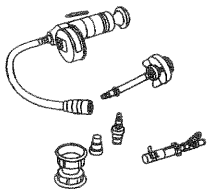
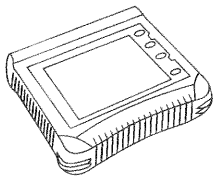
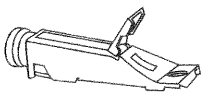
DESCRIPTION AND OPERATION (Continued)

- Do not mix with recycled coolant unless it meets the requirements of Ford specification ESE-M97B44-A or WSS-M97B51-A1. Not all coolant recycling processes meet these Ford specifications. Use of such coolants can harm the engine and cooling system components.

DIAGNOSIS AND TESTING

Engine Cooling

Special Tool(s)

 ST1474-A	Pressure Test Kit 014-R1072 or equivalent
 ST1137-A	73III Automotive Meter 105-R0057 or equivalent
 ST2332-A	Worldwide Diagnostic System (WDS) 418-F224 New Generation STAR (NGS) Tester 418-F052, or equivalent diagnostic tool
 ST1720-A	Battery/Antifreeze Tester 014-R1060 or equivalent

Material

Item	Specification
Motorcraft Premium Engine Coolant (green color) VC-4-A (in Oregon VC-5, in Canada CXC-10)	ESE-M97B44-A
Motorcraft Premium Gold Engine Coolant (yellow color) VC-7-A (in Oregon VC-7-B)	WSS-M97B51-A1
Motorcraft Cooling System Stop Leak Pellets VC-6	ESE-M99B37-5 except as noted in ES-F6SE-19A511-AA

Principles of Operation

Cooling Fans

The cooling fans are controlled by four relays to provide three speeds. If DTC P1474, P1477 or P1479 are present, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual for diagnosis.

In HIGH speed, the cooling fans are wired parallel and the following relays are grounded by the PCM:

- Fan braking relay.
- Engine cooling fan relay.

In MEDIUM speed, the cooling fans are wired parallel through a resistor and the following relays are grounded by the PCM:

- Fan braking relay.

In LOW speed, the cooling fans are wired in series and the following relays are grounded by the PCM:

- Fan braking relay.
- Engine cooling fan relay.
- HEDF and EDF relay.

DIAGNOSIS AND TESTING (Continued)

Inspection and Verification

⚠ WARNING: To avoid personal injury, do not unscrew the coolant pressure relief cap while the engine is operating or hot. The coolant system is under pressure; steam and hot liquid can come out forcefully when the cap is loosened slightly.

⚠ CAUTION: Check the coolant level, engine oil and transmission fluid, top off the coolant if needed, if there is engine coolant in the engine oil or transmission fluid the cause must be corrected and oil/fluid changed or major component damage can occur.

⚠ CAUTION: Some vehicle cooling systems are filled with Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color). Others are filled with Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color). Always fill the cooling system with the same coolant that is present in the system. Do not mix coolant types.

NOTE: The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

1. Verify the customer's concern by operating the engine to duplicate the condition.
2. Inspect to determine if any of the following mechanical or electrical concerns apply.

Visual Inspection Chart

Mechanical	Electrical
• Leaks • Restricted airflow coolant through the condenser/radiator • Damaged hoses • Loose/damaged hose clamps • Damaged water gasket • Damaged head gaskets • Damaged intake manifold gasket • Damaged water pump • Damaged radiator • Damaged degas bottle • Damaged heater core	• Damaged engine coolant temperature (ECT) sensor • Damaged wiring • Electric cooling fans • Fuse • Relay(s) • Circuitry

3. If the inspection reveals an obvious concern that can be readily identified, repair it as necessary.
4. Inspect the coolant condition.
   1. Inspect the coolant color:
      - If Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color) has a clear, light green or blue color, this indicates higher water content than required.
      - **NOTE:** The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

        If Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color) has a clear or pale yellow color, this indicates higher water content than required.
      - Dark brown can indicate unauthorized stop leak may have been used. Use Motorcraft Cooling System Stop Leak Pellets VC-6 or equivalent meeting Ford specification ESE-M99B37-5 except as noted in ES-F6SE-19A511-AA only.

DIAGNOSIS AND TESTING (Continued)

- On 3.0L (2V) engines only, a light or reddish brown color indicates that rust may be present in the cooling system. Flush the system and refill with the correct mixture of clean distilled water and engine coolant.
- An iridescent sheen on top of the coolant can indicate a trace of oil is entering the system. For additional information on engine diagnosis, refer to Section 303-00.
- A milky brown color may indicate that either engine oil or transmission fluid is entering the cooling system. If transmission fluid is suspected the cause may be a leaky radiator, pressure test the cooling system. Refer to component tests in this section. If engine oil is suspected, the cause of the leak may be internal to the engine. For additional information on engine diagnosis, refer to Section 303-00.
- If transmission fluid is contaminated with engine coolant the cause may be a leaky radiator, pressure test the system. Refer to the component tests in this section.

2 If the engine coolant appearance is acceptable, test the engine coolant freezing point range with the Battery/Anti-Freeze Tester. The freezing point should be in the range -50°F to -10°F. If the vehicle is driven in cold climates less than -34°F, it may be necessary to increase the coolant concentration to get adequate freeze protection.

- Maximum coolant concentration is 60/40.
- Minimum coolant concentration is 40/60.

3 Adjust coolant range and level if necessary:

- If coolant is low, add specified coolant mixture only.
- If the engine coolant tests too weak, add straight engine coolant until the readings are within acceptable levels.
- If the engine coolant tests strong, remove some of the engine coolant and add clean distilled water until the readings are within acceptable levels.

5. Verify the cooling system is correctly filled and bled. Refer to Cooling System Draining, Filling and Bleeding in this section.
6. If DTC P1474, P1477 or P1479 are present, refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual for diagnosis.
7. If the concern remains after the inspection, determine the symptom(s). GO to Symptom Chart.

Symptom Chart

SYMPTOM CHART

Condition	Possible Sources	Action
• Loss of engine coolant	• Radiator. • Thermostat housing assembly. • Oil cooler. • Throttle body adapter heating. • Water pump seal. • Radiator hoses. • Heater hoses. • Heater core. • Engine gaskets. • Degas bottle. • Transmission fluid cooler.	• GO to Pinpoint Test A.

DIAGNOSIS AND TESTING (Continued)

SYMPTOM CHART (Continued)

Condition	Possible Sources	Action
• The engine overheats	• Water thermostat. • Airlock in the system. • Water pump. • Internal engine coolant leak. • Radiator. • Radiator airflow obstruction. • Cooling fan. • Pressure relief cap.	• GO to Pinpoint Test B.
• The engine does not reach normal operating temperature	• Water thermostat.	• GO to Pinpoint Test C.
• The block heater does not operate correctly	• Block heater power cable. • Block heater.	• CHECK continuity in all three power cable circuits. If any circuit measures greater than 5 ohms, INSTALL a new power cable. • INSTALL a new block heater.
• The cooling fans are inoperative	• Circuitry. • Relay(s). • Cooling fan motor(s).	• GO to Pinpoint Test D.
• The cooling fans stay on all the time	• Circuitry. • Fan braking relay. • A/C dual function pressure switch.	• GO to Pinpoint Test E.

Pinpoint Tests

PINPOINT TEST A: LOSS OF COOLANT

Test Step		Result / Action to Take
A1	CHECK THE ENGINE COOLANT LEVEL	
	⚠ WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth). **NOTE:** Allow the engine to cool before checking the engine coolant level. • Key in OFF position. • Visually check the engine coolant level at the degas bottle. • **Is the engine coolant level within specification?**	**Yes** GO to **A2**. **No** REFILL the engine coolant as necessary. GO to **A2**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: LOSS OF COOLANT (Continued)

Test Step		Result / Action to Take
A2	TEST THE DEGAS BOTTLE PRESSURE RELIEF CAP	**Yes** REFER to Component Tests Pressure Test — Cap. GO to **A3**. **No** CLEAN or INSTALL a new pressure relief cap. TEST the system for normal operation.
	WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth). • Allow the engine to cool. • Remove the pressure relief cap. • Inspect the pressure relief cap for foreign material between the sealing gasket and the diaphragm. • **Is the pressure relief cap OK?**	
A3	CHECK THE ENGINE COOLANT FOR INTERNAL LEAK	**Yes** If engine oil is evident, GO to Section 303-00. **No** GO to **A4**.
	WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth). • Key in OFF position. • Inspect the engine coolant in the degas bottle for signs of engine oil. • **Is oil evident in the coolant?**	
A4	CHECK THE ENGINE FOR COOLANT	**Yes** If coolant is in the engine, GO to Section 303-00. **No** GO to **A5**.
	• Remove the oil level dipsticks from the engine. • **Is coolant evident in the oil?**	
A5	CHECK THE ENGINE COOLANT FOR TRANSMISSION FLUID	**Yes** INSTALL a new radiator. **No** GO to **A6**.
	WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth). • Inspect the engine coolant in the degas bottle for signs of transmission fluid. • **Is transmission fluid evident in the coolant?**	
A6	PRESSURE TEST THE ENGINE COOLING SYSTEM	**Yes** REPAIR or INSTALL new components. TEST the system for normal operation. **No** The cooling system is operational. GO to Symptom Chart.
	• Pressure test the engine cooling system. Refer to the Component Tests in this section. • **Does the engine cooling system leak?**	

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST B: THE ENGINE OVERHEATS

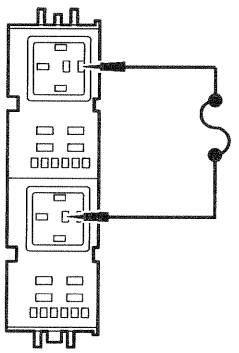
Test Step		Result / Action to Take
B1	CHECK THE ENGINE COOLANT LEVEL	
	NOTE: If the engine is hot, allow the engine to cool before proceeding. • Key in OFF position. ⚠ **WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth).** Check the engine coolant level at the degas bottle. • **Is the engine coolant OK?**	**Yes** GO to **B2**. **No** REFILL the engine coolant at the degas bottle. GO to Pinpoint Test A.
B2	CHECK THE COOLANT CONDITION	
	• Check the coolant for dirt, rust or contamination. • **Is the coolant condition OK?**	**Yes** GO to **B3**. **No** FLUSH the engine cooling system. REFER to Cooling System Draining, Filling and Bleeding in this section. TEST the system for normal operation.
B3	CHECK FOR AN AIRFLOW OBSTRUCTION	
	• Inspect the A/C condenser core and radiator for obstructions such as leaves or dirt. • **Is there an obstruction?**	**Yes** REMOVE the obstruction. CLEAN the A/C condenser core and radiator. TEST the system for normal operation. **No** GO to **B4**.
B4	CHECK THE WATER THERMOSTAT OPERATION	
	• Key in START position. Start the engine and allow the engine to run for 10 minutes. • Key in OFF position. • Feel the upper and lower radiator hose. • **Are the upper and lower radiator hoses cold?**	**Yes** CARRY OUT thermostat component tests. **No** GO to **B5**.
B5	CHECK THE COOLING FAN OPERATION	
	• Using the diagnostic tool, cycle the cooling fans to the HIGH and LOW positions. • **Do the cooling fans operate?**	**Yes** REFER to Section 303-00 for diagnosis and testing of the engine. **No** GO to Pinpoint Test E to diagnose cooling fans.

PINPOINT TEST C: THE ENGINE DOES NOT REACH NORMAL OPERATING TEMPERATURE

Test Step		Result / Action to Take
C1	CHECK THE ENGINE TEMPERATURE	
	• Key in START position. Start the engine and allow the engine to idle for 10 minutes. • Key in OFF position. Feel the upper and lower radiator hoses. • **Are the upper and lower radiator hoses cold?**	**Yes** CARRY OUT thermostat component tests. **No** REFER to Section 413-01 for diagnosis and testing of the engine coolant temperature gauge.

DIAGNOSIS AND TESTING (Continued)

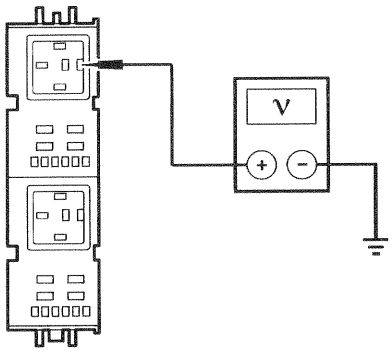
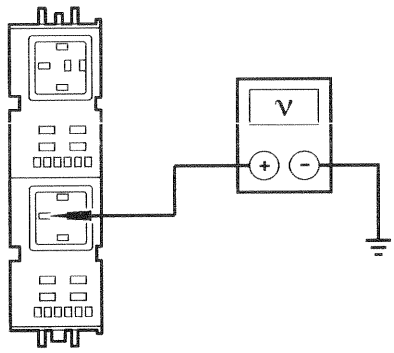
PINPOINT TEST D: THE COOLING FANS ARE INOPERATIVE

Test Step		Result / Action to Take
D1	**CHECK FAN CONTROL FAULT PIDS TO VERIFY FAN CONTROL PRIMARY CIRCUITS**	
	• Key in ON position. • Verify A/C is OFF, and engine temperature is below the temperature where the cooling fan would come on. • Access the LFCF, MFCF and HFCF PIDs. • **Does the LFCF, MFCF and HFCF PID indicate a fault (or YES)?**	**Yes** REFER to Powertrain Control/Emissions Diagnosis (PC/ED) manual to diagnose the cooling fan system. **No** GO to **D2**.
D2	**CHECK OPERATION OF THE COOLING FANS (LOW/HIGH SPEED)**	
	• Using the diagnostic tool, command the cooling fans on HIGH and LOW. • **Do the cooling fans operate?**	**Yes** GO to **D3**. **No** If the driver and passenger side cooling fans do not operate at any speed, GO to **D4**. If the driver/passenger side cooling fans do not operate at LOW speed, GO to **D8**. If the driver side cooling fan does not operate at HIGH speed, GO to **D8**. If the passenger side cooling fan does not operate at HIGH speed, GO to **D12**.
D3	**CHECK OPERATION OF THE COOLING FANS (MEDIUM SPEED)**	
	• Key in OFF position. • Disconnect: Fan Braking Relay C1028. • Disconnect: Resistor Relay C1055. • Key in ON position. • Using a fused jumper, jumper between fan braking relay C1028 pin 5, circuit 228 (DB) and resistor relay C1055 pin 4, circuit 229 (RD/OG) harness side.  A0041792 • **Do the cooling fans operate?**	**Yes** System OK. GO to Symptom Chart for further diagnosis. **No** GO to **D15**.
D4	**CHECK THE FAN BRAKING RELAY**	
	• Key in OFF position. • Disconnect: Fan Braking Relay C1028. • Carry-out the Fan Braking Relay component test. Refer to Wiring Diagrams Cell 149 for component testing. • **Did the fan braking relay pass the component test?**	**Yes** GO to **D5**. **No** INSTALL a new fan braking relay. TEST the system for normal operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

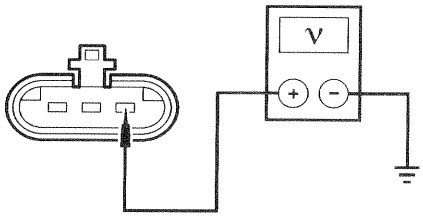
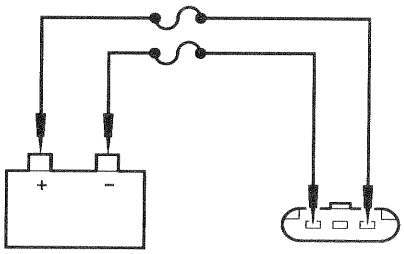
PINPOINT TEST D: THE COOLING FANS ARE INOPERATIVE (Continued)

Test Step		Result / Action to Take
D5	CHECK VOLTAGE TO THE FAN BRAKING RELAY	
	• Key in ON position. • Measure the voltage between the fan braking relay C1028 pin 87, circuit 228 (DB) harness side and ground.  A0041793 • **Is the voltage greater than 10 volts?**	**Yes** GO to **D6**. **No** REPAIR the supply circuit. TEST the system for normal operation.
D6	CHECK THE RESISTOR RELAY	
	• Key in OFF position. • Disconnect: Resistor Relay C1055. • Carry-out the Resistor Relay component test. Refer to Wiring Diagrams Cell 149 for component testing. • **Did the resistor relay pass the component test?**	**Yes** GO to **D7**. **No** INSTALL a new resistor relay. TEST the system for normal operation.
D7	CHECK VOLTAGE TO THE RESISTOR RELAY	
	• Key in ON position. • Connect: Fan Braking Relay C1028. • Enter the following diagnostic mode on the diagnostic tool: Cycle the Cooling Fans to the HIGH Position. • Measure the voltage between the resistor relay C1055 pin 30, circuit 3850 (LG/VT) harness side and ground.  A0041794 • **Is the voltage greater than 10 volts?**	**Yes** CONNECT the resistor relay C1055. GO to **D8**. **No** REPAIR the circuit. TEST the system for normal operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

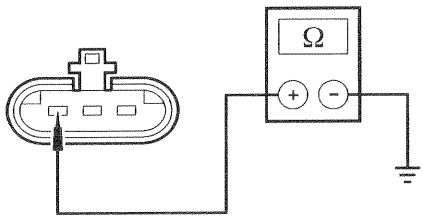
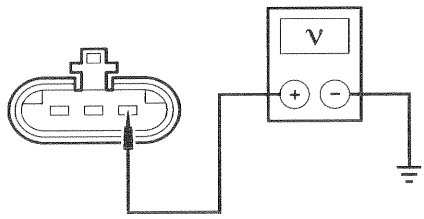
PINPOINT TEST D: THE COOLING FANS ARE INOPERATIVE (Continued)

Test Step		Result / Action to Take
D8	CHECK VOLTAGE TO THE DRIVER SIDE COOLING FAN	
	• Key in ON position. • Disconnect: Driver Side Cooling Fan Motor C1077. • Enter the following diagnostic mode on the diagnostic tool: Cycle the Cooling Fans to the HIGH Position. • Measure the voltage between the driver side cooling fan C1077, circuit 229 (RD/OG) harness side and ground.  A0041795 • **Is the voltage greater than 10 volts?**	**Yes** GO to **D9**. **No** REPAIR the circuit. TEST the system for normal operation.
D9	CHECK DRIVER SIDE COOLING FAN	
	• Connect a fused (40A) jumper wire between the positive battery post and driver side cooling fan motor C1077, circuit 229 (RD/OG) pin 3, component side and connect a fused (40A) jumper wire between the negative battery post and driver side cooling fan motor C1077 pin 1, circuit 57 (BK) component side.  A0041796 • **Does the driver side cooling fan operate?**	**Yes** GO to **D10**. **No** INSTALL a new cooling fan motor. TEST the system for normal operation.
D10	CHECK THE HEDF RELAY	
	• Key in OFF position. • Disconnect: HEDF Relay. • Carry out the HEDF Relay component test. Refer to Wiring Diagrams Cell 149 for component testing. • **Did the HEDF relay pass the component test?**	**Yes** GO to **D11**. **No** INSTALL a new HEDF relay. TEST the system for normal operation.

(Continued)

DIAGNOSIS AND TESTING (Continued)

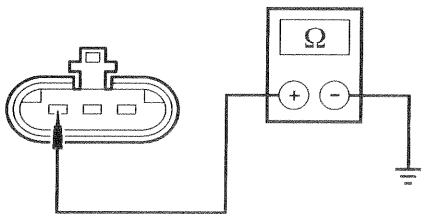
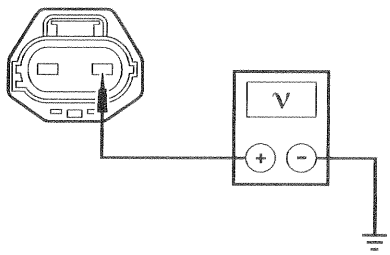
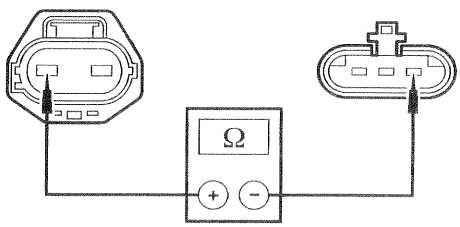
PINPOINT TEST D: THE COOLING FANS ARE INOPERATIVE (Continued)

Test Step	Result / Action to Take
D11 CHECK CIRCUIT 57 (BK)	
• Connect: HEDF Relay. • Measure the resistance between the driver side cooling fan C1077 pin 1, circuit 57 (BK) harness side and ground.  A0041797 • **Is the resistance less than 5 ohms?**	**Yes** GO to **D12**. **No** REPAIR the circuit. TEST the system for normal operation.
D12 CHECK VOLTAGE TO THE PASSENGER SIDE COOLING FAN	
• Connect: Driver Side Cooling Fan C1077. • Disconnect: Passenger Side Cooling Fan C1074. • Key in ON position. • Enter the following diagnostic mode on the diagnostic tool: Command the Cooling Fans on HIGH and LOW. • Measure the voltage between the passenger side cooling fan C1074 pin 3, circuit 229 (RD/OG) harness side and ground.  A0041795 • **Is the voltage greater than 10 volts?**	**Yes** If the voltage is greater than 10 volts when the cooling fans are commanded HIGH and LOW, GO to **D14**. If the voltage is greater than 10 volts when the cooling fans are commanded LOW only, GO to **D13**. If the voltage is greater than 10 volts when the cooling fans are commanded HIGH only, REPAIR circuit 229 (RD/OG). TEST system for normal operation. **No** REPAIR the circuit. TEST the system for normal operation.
D13 CHECK THE EDF RELAY	
• Disconnect: EDF Relay. • Carry out the EDF Relay component test. Refer to Wiring Diagrams Cell 149 for component testing. • **Did the EDF relay pass the component test?**	**Yes** REPAIR circuit 229 (RD/OG). TEST the system for normal operation. **No** INSTALL a new EDF relay. TEST the system for normal operation.

(Continued)

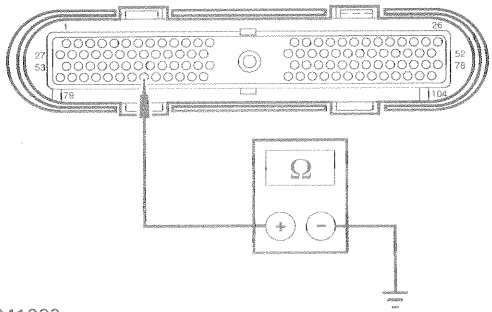
DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST D: THE COOLING FANS ARE INOPERATIVE (Continued)

Test Step	Result / Action to Take
D14 CHECK PASSENGER SIDE COOLING FAN GROUND	
• Measure the resistance between the passenger side cooling fan C1074, circuit 57 (BK) harness side and ground.  A0041797 • **Is the resistance less than 5 ohms?**	**Yes** INSTALL a new passenger side cooling fan. TEST the system for normal operation. **No** REPAIR the circuit. TEST the system for normal operation.
D15 CHECK VOLTAGE TO THE RESISTOR	
• Disconnect: Resistor C1027. • Measure the voltage between the resistor C1027 pin 1, circuit 229 (DB) harness side and ground.  A0041798 • **Is the voltage greater than 10 volts?**	**Yes** GO to **D16**. **No** REPAIR the circuit. TEST the system for normal operation.
D16 CHECK CIRCUIT 229 (RD/OG) FOR AN OPEN	
• Disconnect: Driver Side Cooling Fan Motor C1077. • Measure the resistance between the resistor C1027 pin 2, circuit 229 (RD/OG) and driver side cooling fan motor C1077 circuit 229 (RD/OG) harness side.  A0041799 • **Is the resistance less than 5 ohms?**	**Yes** INSTALL a new resistor. TEST the system for normal operation. **No** REPAIR the circuit. TEST the system for normal operation.

DIAGNOSIS AND TESTING (Continued)

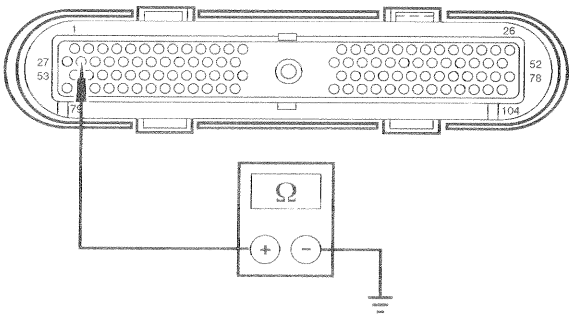
PINPOINT TEST E: THE COOLING FANS STAY ON ALL THE TIME

Test Step		Result / Action to Take
E1	CHECK THE A/C DUAL FUNCTION PRESSURE SWITCH INPUT TO PCM	
	• Key in START position. • Verify the A/C is OFF. • Monitor the A/C dual function pressure switch ACP PID. • **Does the A/C dual function pressure switch ACP PID read CLOSED?**	**Yes** GO to **E2**. **No** GO to **E4**.
E2	CHECK A/C HIGH PRESSURE SWITCH	
	• Disconnect: A/C Dual Function Pressure Switch C1062. • Monitor the A/C dual function pressure switch ACP PID. • **Does the A/C dual function pressure switch ACP PID read CLOSED?**	**Yes** GO to **E3**. **No** If the A/C system is working correctly, INSTALL a new A/C high pressure switch. If the A/C system is not working correctly, REFER to Section 412-00 to diagnose the A/C system.
E3	CHECK CIRCUIT 347 (BK/YE) FOR A SHORT TO GROUND	
	• Key in OFF position. • Disconnect: PCM C175. • Measure the resistance between the PCM C175 pin 86, circuit 347 (BK/YE) harness side and ground.  A0041823 • **Is the resistance greater than 10,000 ohms?**	**Yes** INSTALL a new PCM. REFER to Powertrain Control/Emissions Diagnosis (PC/ED) manual . **No** REPAIR the circuit. TEST the system for normal operation.
E4	CHECK FAN BRAKING RELAY	
	• Disconnect: Fan Braking Relay. • **Did the cooling fans stop?**	**Yes** INSTALL a new fan braking relay. TEST the system for normal operation. **No** GO to **E6**.

(Continued)

DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST E: THE COOLING FANS STAY ON ALL THE TIME (Continued)

Test Step	Result / Action to Take
E5 CHECK CIRCUIT 386 (LB) FOR A SHORT TO GROUND.	
• Key in OFF position. • Disconnect: PCM C175. • Measure the resistance between PCM C175 pin 28, circuit 386 (LB) harness side and ground. •  A0057310 • Is the resistance greater than 10,000 ohms?	**Yes** GO to **E6**. **No** INSTALL a new engine wiring harness. TEST the system for normal operation.
E6 CHECK CIRCUIT 3850 (LG/VT) AND 229 (RD/OG) FOR A SHORT TO POWER	
• Disconnect: Resistor Relay. • **Did the cooling fans stop?**	**Yes** REPAIR circuit 3850 (LG/VT). TEST the system for normal operation. **No** REPAIR circuit 229 (RD/OG). TEST the system for normal operation.

Component Tests

Pressure Test

1. Turn the engine OFF.
2. ⚠ **WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth).**

   Check the engine coolant level. Refer to Cooling System Draining, Filling and Bleeding in this section.
3. Connect the Radiator/Heater Core Pressure Tester to the degas bottle nipple and overflow hose. Install a pressure test pump to the quick-connect fitting of the test adapter.
4. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

   Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.
5. If the pressure relief cap does not hold pressure, remove and wash the pressure relief cap in clean water to dislodge all foreign particles from the gaskets. Check the sealing surface in the filler neck.
6. Pressure check the pressure relief cap. If 8-9 kPa (13 psi) cannot be reached or if more than 12 kPa (18 psi) show on the gauge, install a new pressure relief cap.

DIAGNOSIS AND TESTING (Continued)

7. **NOTE:** If the pressure drops, check for leaks at the engine to heater core hoses, engine-to-radiator hoses, water valve hose (if applicable), oil cooler return tube gasket (6N789), radiator and heater core or other system components and connections. Any leaks which are found must be corrected and the system rechecked.

   Pressurize the engine cooling system as described in Step 4 (using a pressure relief cap that operates within the specified upper and lower pressure limits). Observe the gauge reading for approximately two minutes; refer to General Specifications. Pressure should not drop during this time.

8. Release the system pressure by loosening the pressure relief cap. Check the engine coolant level and replenish, if necessary, with the correct engine coolant mixture. Refer to Cooling System Draining, Filling and Bleeding in this section.

Cap

⚠ **WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, turn and remove the pressure relief cap (still with a cloth).**

1. Make sure the engine is cool.
2. Wrap a thick cloth around the coolant pressure relief cap on the coolant reservoir. Slowly turn the cap counterclockwise (left) until the pressure begins to release.
3. Step back while the pressure releases.
4. When you are sure all the pressure has been released, use the cloth to turn and remove the cap.
5. Immerse the pressure relief cap in water and install it on the shallow filler neck of Radiator/Heater Core Pressure Tester and Radiator Cap Adapter, part of Radiator/Heater Core Pressure Tester.
6. Immerse the filler neck seal in water and install it in the filler neck adapter.
7. Install the filler neck adapter with the filler neck seal to the Radiator Cap Adapter.
8. Connect the female quick-connect fitting of the pressure test pump to the male quick-connect fitting of the filler neck adapter.
9. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

   Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

10. Release the pressure by turning the relief screw counterclockwise. Then tighten the pressure relief screw and repeat Step 6 (at least twice) to make sure the reading is repeatable within the specifications of the pressure relief cap.
11. If the pressure test gauge readings are not within specifications, install a new pressure relief cap. If the pressure test gauge readings are within specifications, carry out the cooling system Pressure Test.

Thermostat—Water

A new water thermostat should be installed only after the following electrical and mechanical tests have been carried out.

Thermostat—Electrical Test

NOTE: The electrical thermostat test is most accurate if carried out indoors at less than 37.8°C (100°F) ambient air. This test may be carried out with or without the hood open and with the engine warm or cold.

1. Check the engine coolant level. Fill as needed.

DIAGNOSIS AND TESTING (Continued)

2. With the ignition OFF, remove the engine coolant temperature (ECT) sensor harness connector and attach ECT Sensor "T" Cable as a jumper between the powertrain control module and the ECT Sensor. Attach the 73III Automotive Meter to the ECT Sensor "T" Cable. Voltage values (0-5 V) may now be monitored while the sensor retains its connection to the wiring harness.

   A Diagnostic tool or the Service Bay Diagnostic System (SBDS) may be used to monitor the ECT on vehicles equipped with data link connector (DLC). The SBDS sequence to use for the screen is: Toolbox-Electronic Engine Control and DCL-Item.

3. **NOTE:** Running this test with the vehicle in gear or with the A/C compressor clutch engaged (running) will cause incorrect diagnosis.

   Place the transmission in PARK (P) or NEUTRAL (N).

4. Start the engine and allow the engine to idle throughout this test. Allow the engine to run for two minutes, then record the ECT voltage. Record the ECT voltage every 60 seconds. When the ECT voltage trend changes direction or only changes slightly (0.03 volt or less) from the previous reading, record this as the thermostat opening voltage. Use the voltage and corresponding coolant temperature chart listed below.

Coolant Temperature °C (°F)	ECT (Volts)
22 (71)	3.00
43 (109)	2.01
71 (159)	1.01
82 (180)	0.75
91 (195)	0.59
97 (206)	0.50
105 (221)	0.40

5. If the thermostat opening voltage is greater than 0.75 volt and less than 82°C (180°F), or less than 0.50 and greater than 97°C (206°F), install a new water thermostat.

6. If the thermostat opening voltage is less than 0.75 volt and greater than 82°C (180°F) or less than 0.50 and greater than 97°C (206°F), the water thermostat is good and a new thermostat should not be installed. GO to Symptom Chart for further instructions.

Thermostat—Mechanical Test

1. Remove the water thermostat.
2. Check the water thermostat for seating. Hold the water thermostat up to a lighted background. Leakage of light around the thermostat valve at room temperature indicates a new water thermostat should be installed. Some water thermostats have a small leakage notch at one location on the perimeter of the thermostat valve, which is considered normal.
3. Immerse the water thermostat in a boiling antifreeze and water mixture.
4. See the General Specifications chart for water thermostat opening temperatures.

Radiator Leak Test, Removed From the Vehicle

⚠ **CAUTION: Never leak test an aluminum radiator in the same water that copper/brass radiators are tested in. Flux and caustic cleaners may be present in the cleaning tank and they will damage aluminum radiators.**

NOTE: Always install plugs in the transmission fluid cooler fittings before leak testing or cleaning any radiator.

NOTE: Clean the radiator before leak testing to avoid contamination of tank.

1. Leak-test the radiator in clean water with 138 kPa (20 psi) air pressure.

GENERAL PROCEDURES

Cooling System Draining, Filling and Bleeding

Material

Item	Specification
Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) (green color)	ESE-M97B44-A
Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) (yellow color)	WSS-M97B51-A1

Draining

⚠ WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. Failure to follow these instructions can result in damage to the cooling system or engine or personal injury. To avoid having scalding hot coolant or steam blow out of the degas bottle when removing the pressure relief cap, wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, (still with a cloth) turn and remove the pressure relief cap. Failure to follow these instructions can result in personal injury.

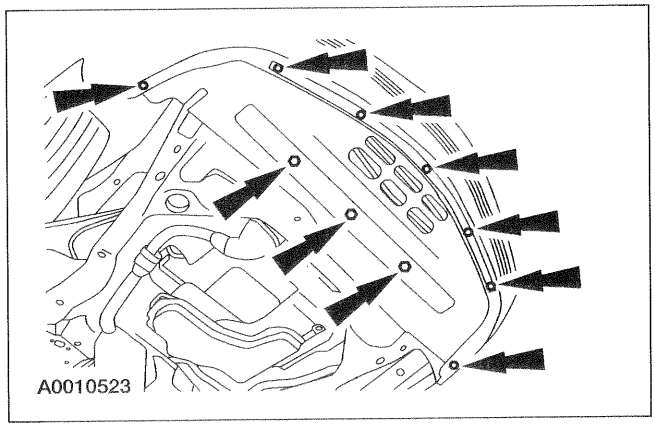
⚠ CAUTION: The coolant must be recovered in a suitable, clean container for reuse. If the coolant is contaminated it must be recycled or disposed of correctly.

⚠ CAUTION: Some vehicle cooling systems are filled with Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color). Others are filled with Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color). Always fill the cooling system with the same coolant that is present in the system. Do not mix coolant types.

NOTE: The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

NOTE: Less than 80% of coolant capacity can be recovered with the engine in the vehicle. Dirty, rusty or contaminated coolant requires replacement.

1. Release the pressure in the cooling system by slowly turning the pressure relief cap one half to one turn counterclockwise to the first stop on the filler neck. When the pressure has been released, remove the pressure relief cap.
2. Raise and support the vehicle. For additional information, refer to Section 100-02.
3. Remove the front splash shield.



4. Place a suitable container below the radiator draincock. Drain the coolant.
5. Close the radiator draincock when finished.

Filling

⚠ CAUTION: Engine coolant provides freeze protection, boil protection, cooling efficiency and corrosion protection to the engine and cooling components. In order to obtain these protections, the engine coolant must be maintained at the correct concentration and fluid level. When adding engine coolant, use a 50/50 mixture of engine coolant and clean, distilled water.

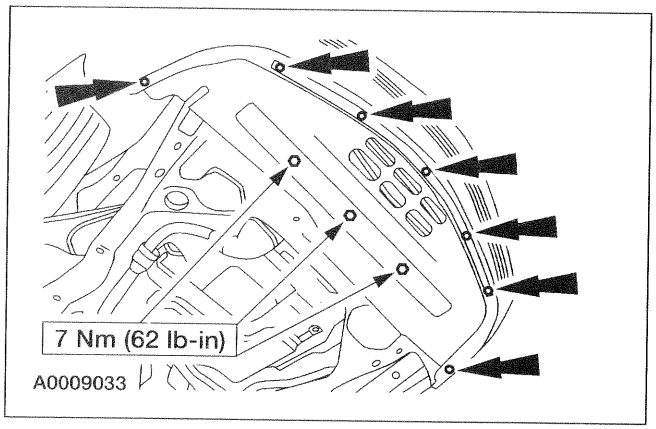
To maintain the integrity of the coolant and the cooling system:

GENERAL PROCEDURES (Continued)

- **Add Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10) or equivalent meeting Ford specification ESE-M97B44-A (green color), or Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon VC-7-B) or equivalent meeting Ford specification WSS-M97B51-A1 (yellow color). Use the same coolant that was drained from the cooling system. Do not mix coolant types.**
- **Do not add Motorcraft Specialty Engine Coolant such as VC-2 or an equivalent meeting Ford specification WSS-M97B44-D. Mixing coolants can degrade the coolant's corrosion protection.**
- **Do not add alcohol, methanol, or brine, or any engine coolants mixed with alcohol or methanol antifreeze. These can cause engine damage from overheating or freezing.**
- **Do not mix with recycled coolant unless it meets the requirements of Ford specification ESE-M97B44-A or WSS-M97B51-A1. Not all coolant recycling processes meet this Ford specification. Use of such coolant can harm the engine and cooling system components.**

NOTE: The addition of Motorcraft Cooling System Stop Leak Pellets, VC-6, darkens Motorcraft Premium Gold Engine Coolant from yellow to golden tan.

1. Install the front splash shield.



2. Lower the vehicle.
3. Fill the degas bottle with the correct engine coolant mixture.
4. Install the pressure relief cap.
5. Move the temperature blend selector to the full warm position.
6. ⚠ **WARNING: Do not stand in line with or near the engine cooling fan blade when revving the engine.**

   Run the engine until it reaches operating temperature.
7. Add the correct engine coolant mixture to the degas bottle until the coolant level is between the COOLANT FILL LEVEL marks.
8. Turn off the engine and allow the cooling system to cool. Recheck the coolant level and fill the cooling system to the FULL mark on the degas bottle.
9. ⚠ **WARNING: Do not stand in line with or near the engine cooling fan blade when revving the engine.**

   Repeat Steps 3 through 8 until the reservoir level is OK.

GENERAL PROCEDURES (Continued)

Bleeding

1. Bleed the cooling system as follows:
   - Select the maximum heater temperature and blower motor speed settings. Position the control to discharge air from the A/C vents in the instrument panel.
   - **⚠ WARNING: Do not stand in line with or near the engine cooling fan blade when revving the engine.**

     Start the engine and allow it to idle. While the engine is idling, feel for hot air from the A/C vents.
   - **⚠ CAUTION: If the air discharge remains cool and the engine coolant temperature gauge does not move, the engine coolant level is low in the engine and must be filled. Stop the engine, allow it to cool and fill the cooling system.**

     Start the engine and allow it to idle until the normal operating temperature is reached. Hot air should discharge from the A/C vents. The engine coolant temperature gauge should maintain a stabilized reading in the middle of the normal range, and the upper radiator hose should feel hot to the touch.
   - Shut the engine off and allow it to cool.
   - Check the engine for coolant leaks.
   - Check the engine coolant level in the degas bottle and fill it as necessary.

REMOVAL AND INSTALLATION

Block Heater

Removal and Installation

1. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
2. Raise the vehicle. For additional information, refer to Section 100-02.

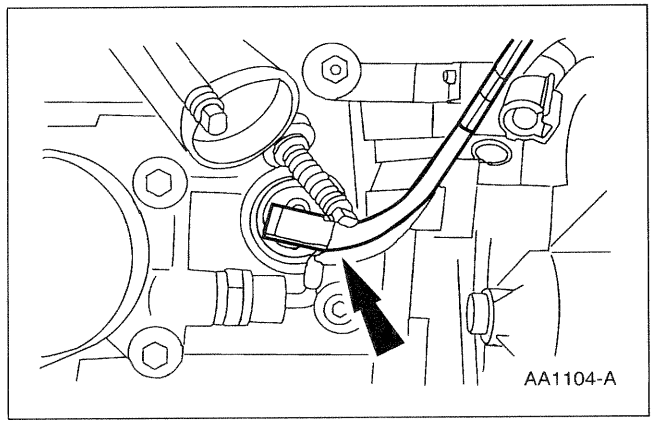
Cooling System Flushing

Material

Item	Specification
Premium Cooling System Flush F1AZ-19A503	ESR-M14P7-A

1. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
2. Remove the water thermostat (8575).
3. Install the water hose connection (8592) without the water thermostat.
4. Using a suitable coolant system flushing tool and premium flush, flush the engine and radiator.
5. Install the water thermostat.
6. Backflush the heater core (18476) if necessary.
7. Fill the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

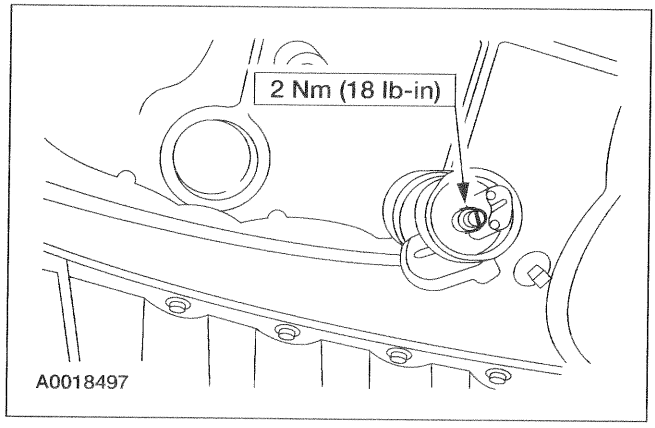
3. Disconnect the block heater power cable from the block heater (6A051).



REMOVAL AND INSTALLATION (Continued)

4. **CAUTION: Do not loosen the block heater retaining screw more than necessary for removal.**

   Remove the block heater.



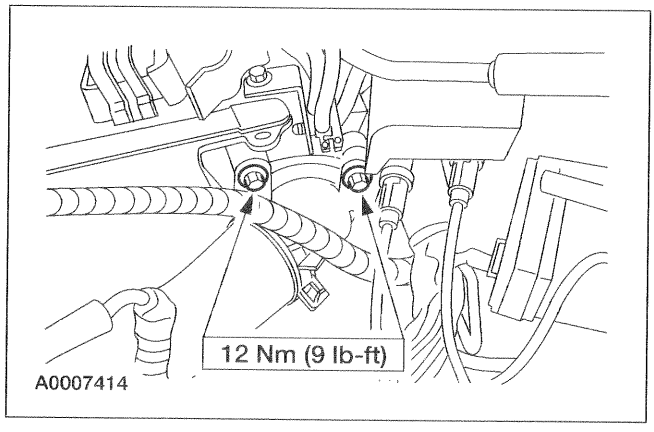
5. **CAUTION: Make sure the power cable is routed and secured away from rotating or hot components or damage to the cable may occur.**

   To install, reverse the removal procedure.

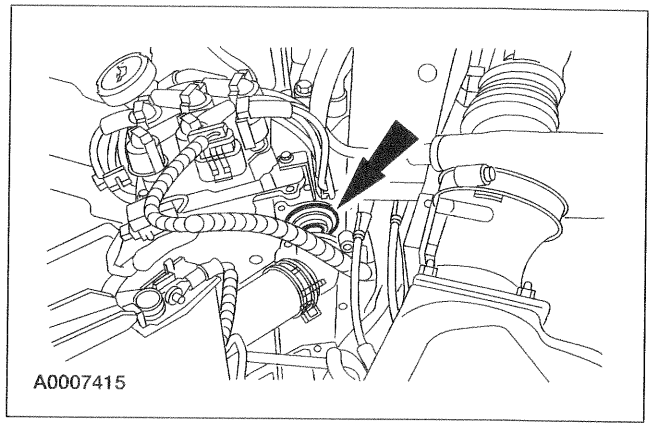
Thermostat — 3.0L (2V)

Removal and Installation

1. Drain the engine cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
2. Remove the three thermostat housing bolts.



3. Remove the thermostat O-ring seal.
   - Inspect the sealing surfaces.

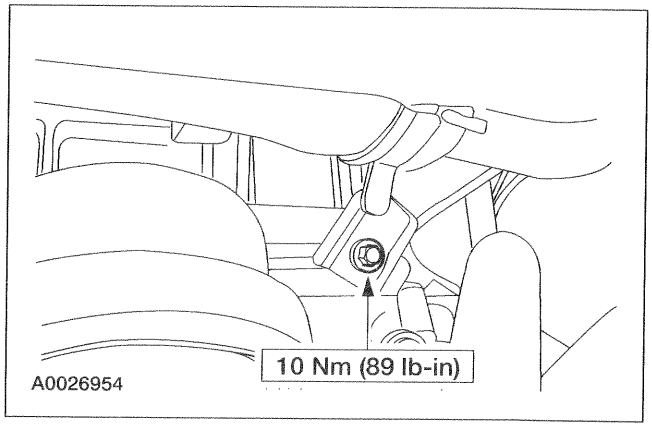


4. To install, reverse the removal procedure.

Thermostat — 3.0L (4V)

Removal and Installation

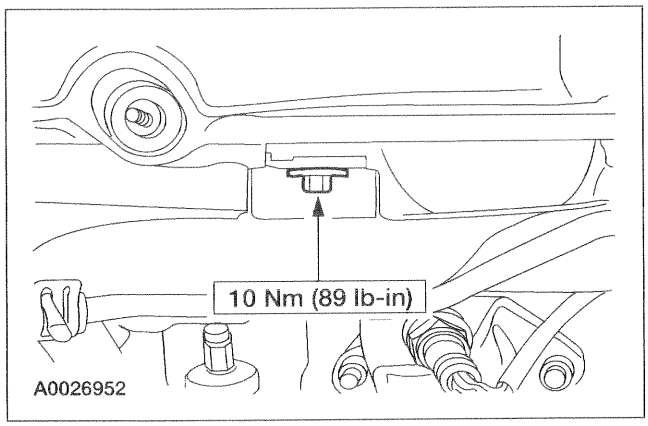
1. Raise and support the vehicle. For additional information, refer to Section 100-02.
2. Remove the front splash shield. For additional information, refer to Section 501-02.
3. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
4. Remove the cooling tube bolt.



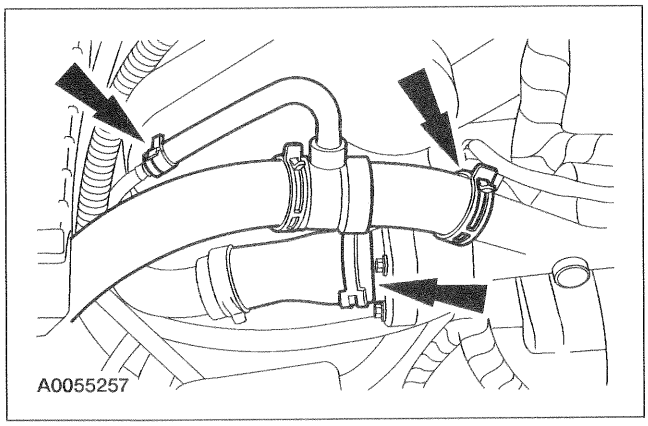
5. Lower the vehicle.

REMOVAL AND INSTALLATION (Continued)

6. Remove the radiator upper cooling tube bolt.

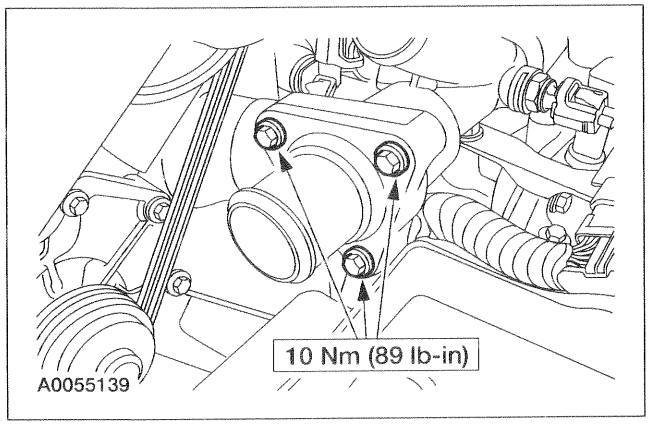


7. Disconnect the upper radiator hose, engine vent hose and thermostat housing hose.



8. **NOTE:** Battery removed for clarity.

   Remove the three bolts, and separate the thermostat housing. Remove the thermostat and the O-ring. Discard the O-ring.

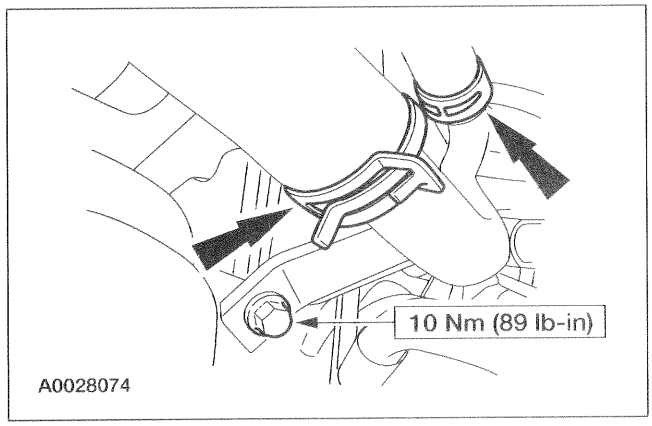


9. To install, reverse the removal procedure.
   - Clean all sealing surfaces.

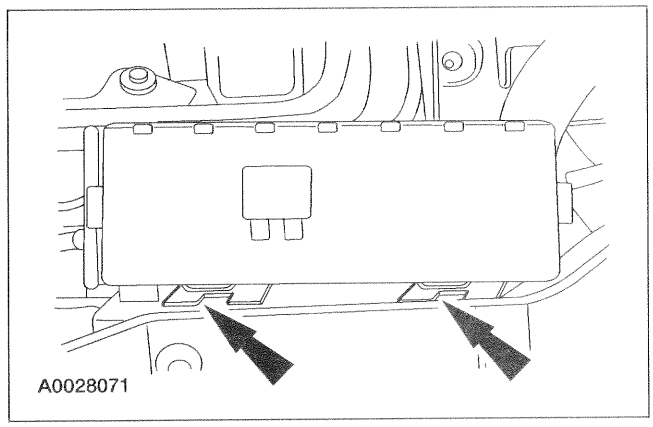
Radiator Hose — Tube Assembly, 3.0L (4V)

Removal and Installation

1. Raise and support the vehicle. For additional information, refer to Section 100-02.
2. Remove the front splash shield. For additional information, refer to Section 501-02.
3. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
4. Disconnect the lower radiator hose and the reservoir supply hose, and remove the radiator lower tube bolt.

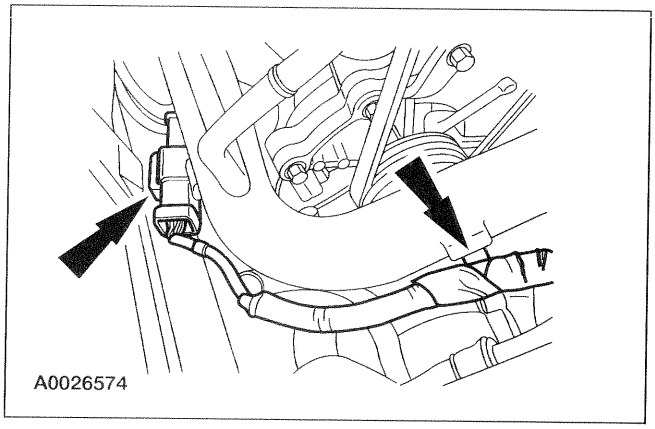


5. Lower the vehicle.
6. Release the tabs on the power distribution box and position aside.

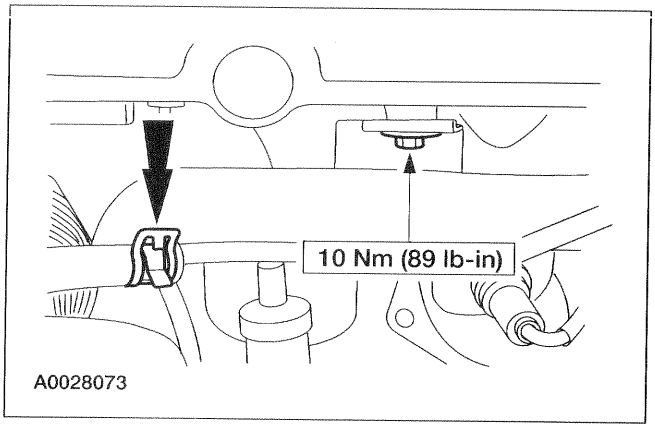


REMOVAL AND INSTALLATION (Continued)

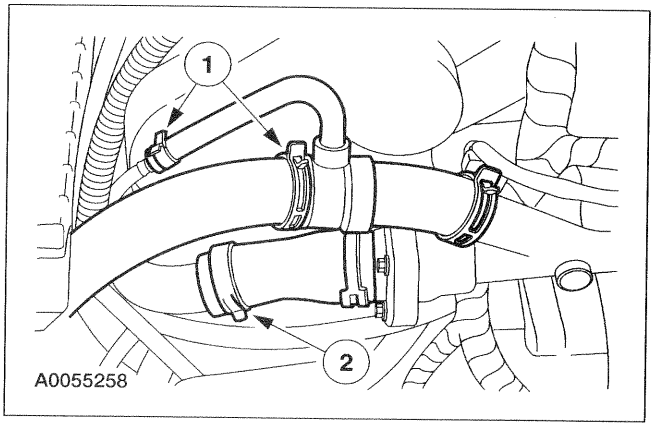
7. Disconnect the oxygen sensor connector retainer and harness pin-type retainer.



8. Remove the radiator upper tube bolt, and disconnect the radiator vent tube.



9. Remove the radiator tube assembly.
   1 Disconnect the upper radiator hose and the engine vent hose, and position aside.
   2 Disconnect the radiator tube assembly and remove from the vehicle.

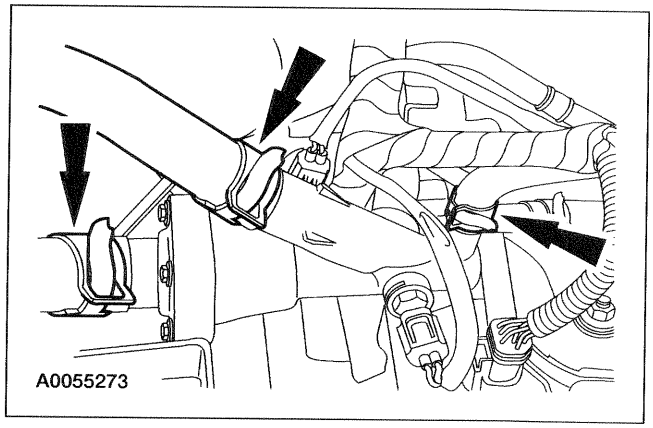


10. To install, reverse the removal procedure.

Bypass Tube — 3.0L (4V)

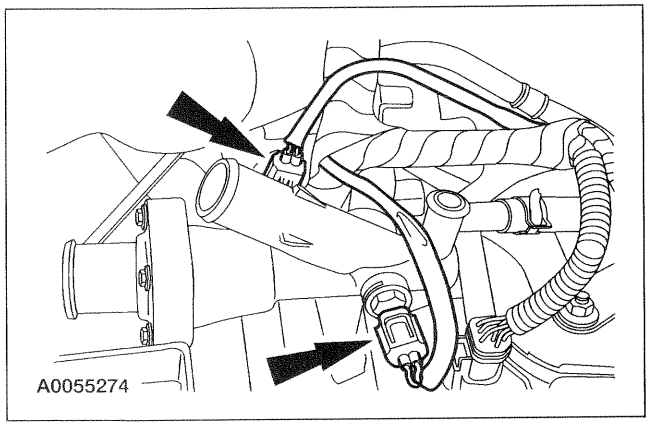
Removal and Installation

1. Raise and support the vehicle. For additional information, refer to Section 100-02.
2. Remove the front splash shield. For additional information, refer to Section 501-02.
3. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.
4. Lower the vehicle.
5. Remove the air cleaner assembly. For additional information, refer to Section 303-12.
6. Remove the battery and battery tray. For additional information, refer to Section 414-01.
7. Disconnect the upper radiator hose, the thermostat housing hose and the heater water hose.

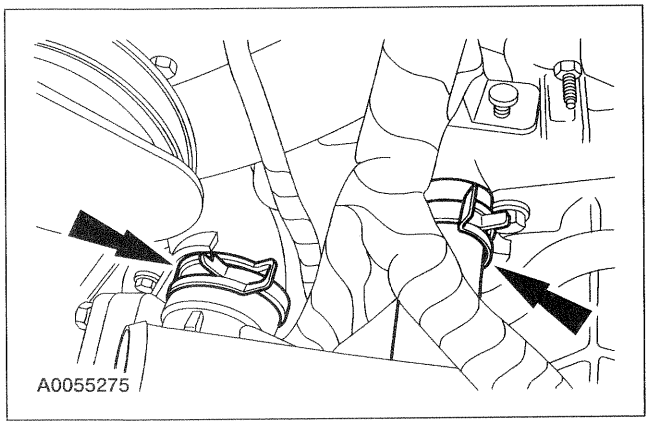


REMOVAL AND INSTALLATION (Continued)

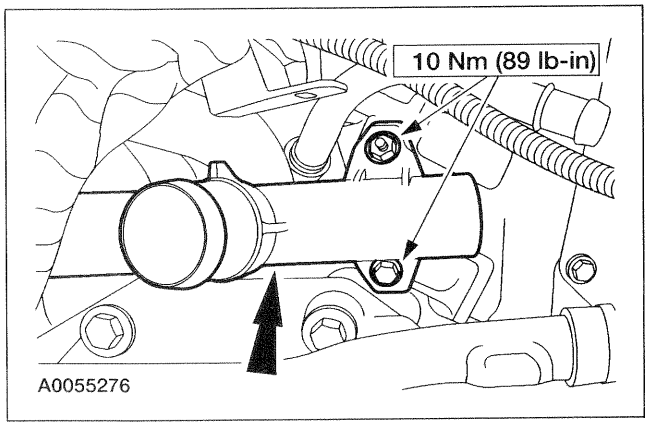
8. Disconnect the engine coolant temperature (ECT) sensor and the water temperature sender electrical connector.



9. Disconnect and remove the radiator bypass hose assembly.



10. Remove the bolt, the stud and the water pump bypass tube.
    - Remove and discard the O-ring and gasket.



11. To install, reverse the removal procedure.

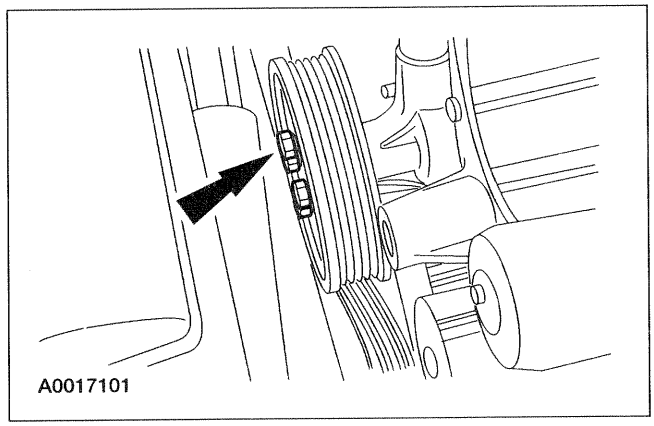
12. Clean the sealing surfaces and install a new gasket and O-ring.

Water Pump — 3.0L (2V)

Removal

1. Drain the engine cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

2. Loosen the water pump pulley.

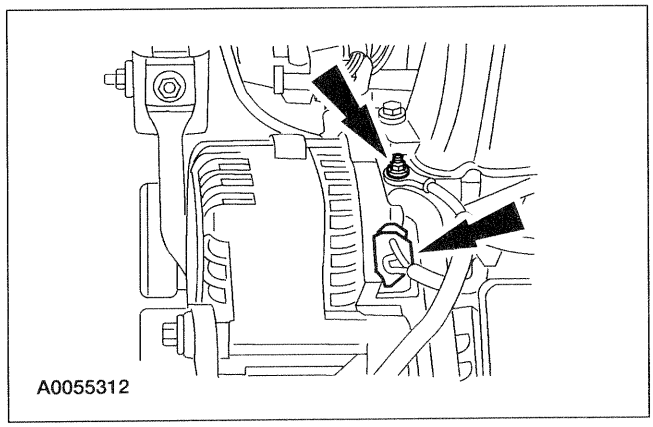


3. Remove the accessory drive belt. For additional information, refer to Section 303-05.

4. Remove the degas bottle. For additional information, refer to Degas Bottle in this section.

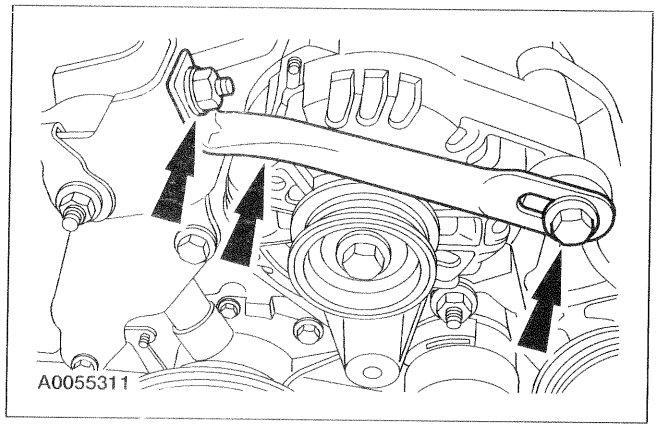
5. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

6. Disconnect the generator B+ cable and the voltage regulator electrical connector.

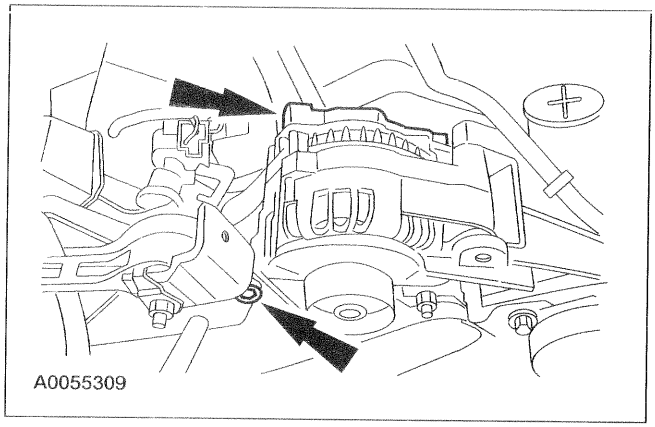


REMOVAL AND INSTALLATION (Continued)

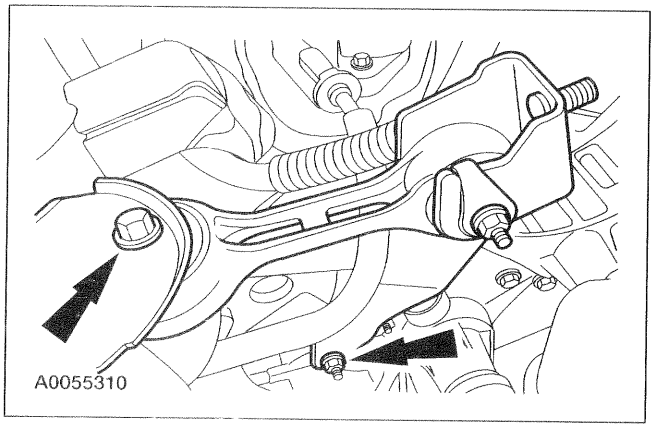
7. Remove the nut, the bolt and the generator brace.



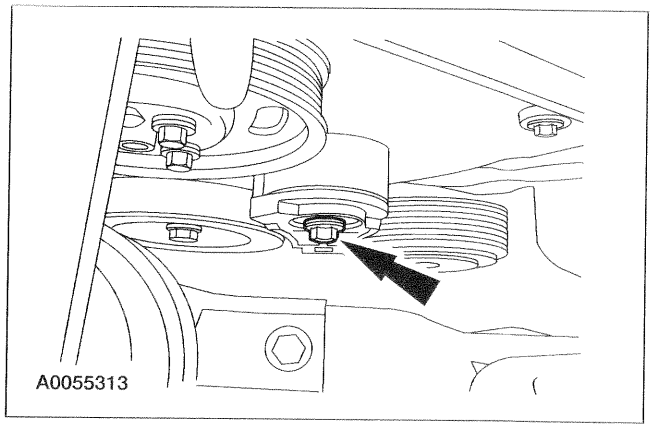
8. Remove the generator mounting bolt and the generator.



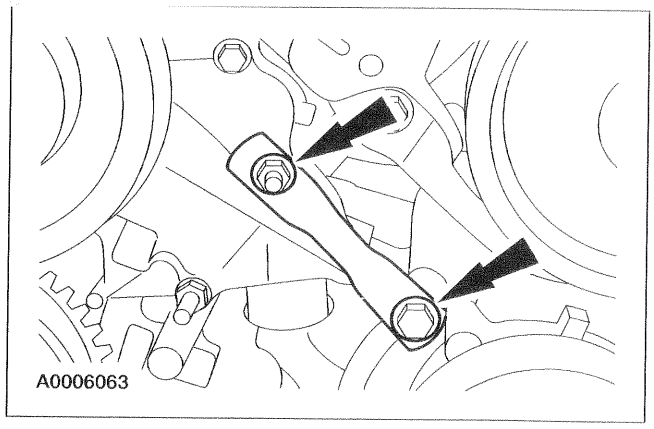
9. Remove the bolt and the nut, and position the roll restrictor bracket out of the way.



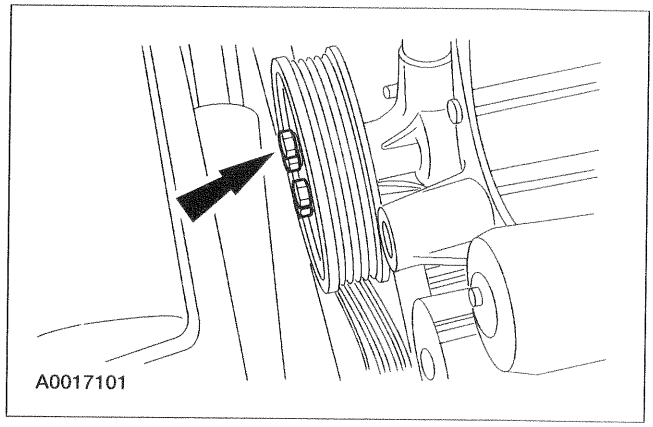
10. Remove the bolt and the accessory drive belt tensioner.



11. Remove the nut, the bolt and the support bracket.

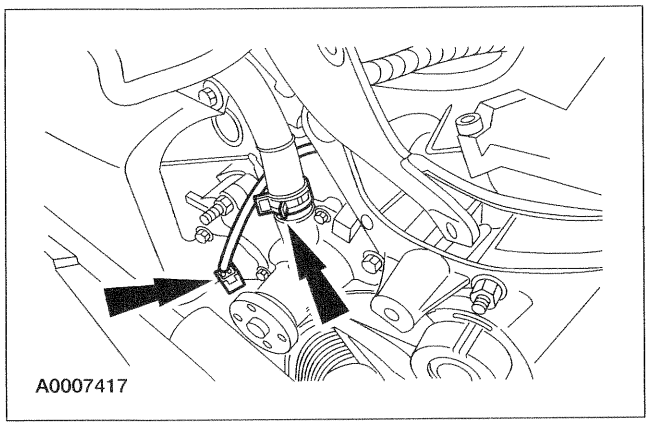


12. Remove the bolts and the water pump pulley.

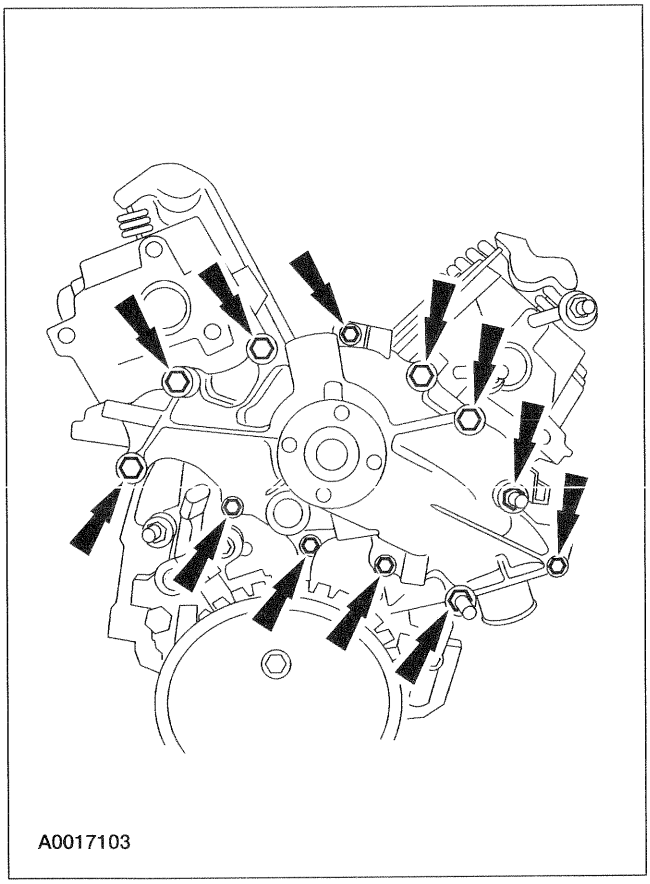


REMOVAL AND INSTALLATION (Continued)

13. Disconnect the water pump inlet hose and the crankshaft position sensor electrical connector.

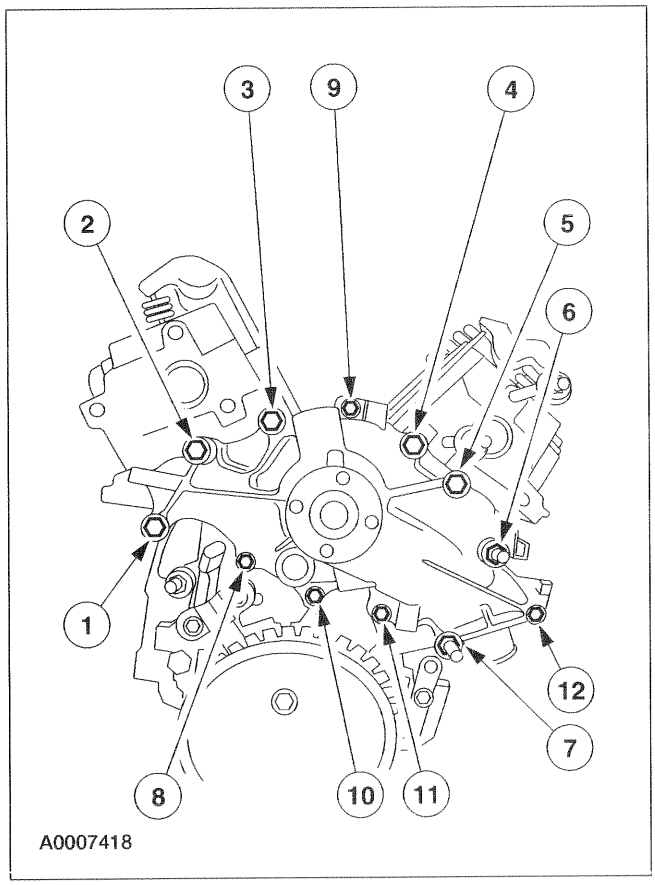


14. Remove the bolts and the water pump, and clean the sealing surfaces.

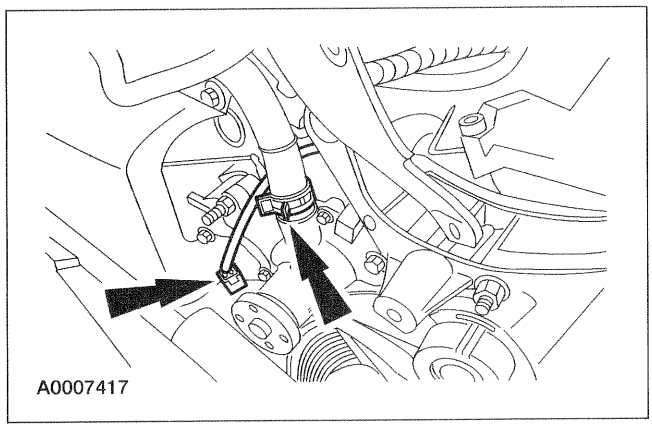


Installation

1. Install the water pump. Tighten bolts in the sequence shown:
   - Tighten numbers 1-7 to 25 Nm (18 lb-ft).
   - Tighten numbers 8-12 to 10 Nm (89 lb-in).

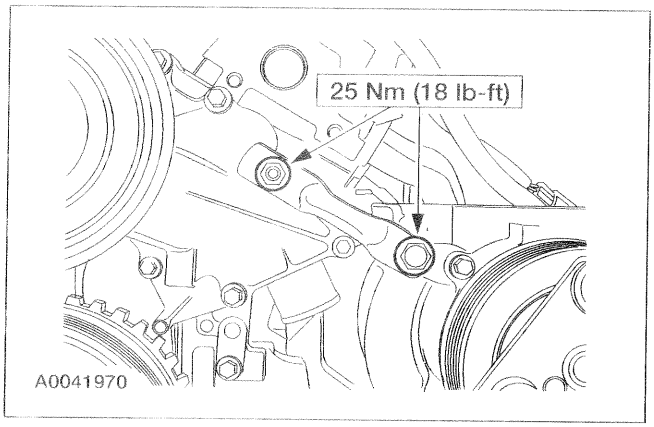


2. Connect the crankshaft position sensor electrical connector and the water pump inlet hose.

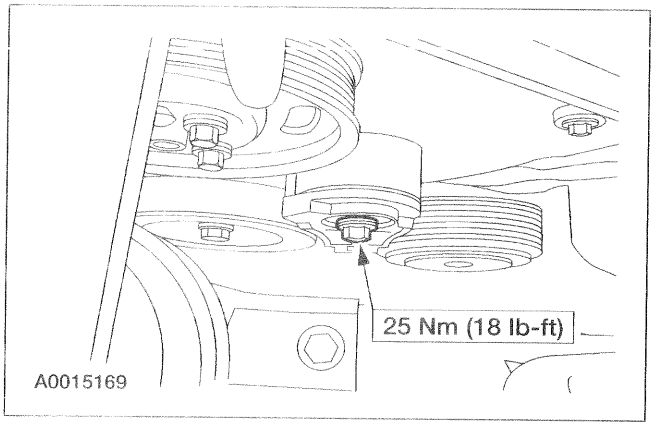


REMOVAL AND INSTALLATION (Continued)

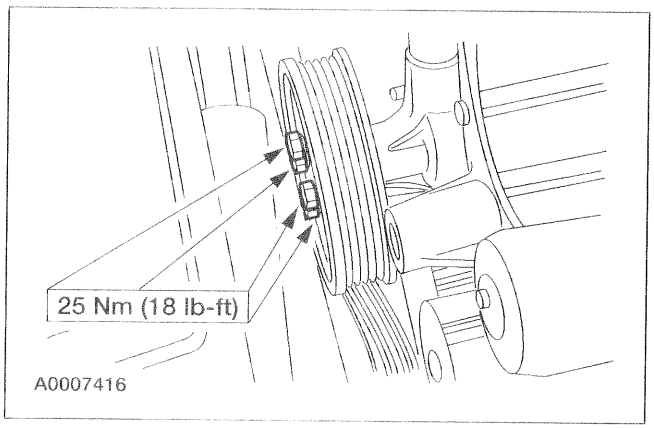
3. Install the support bracket, the nut and the bolt.



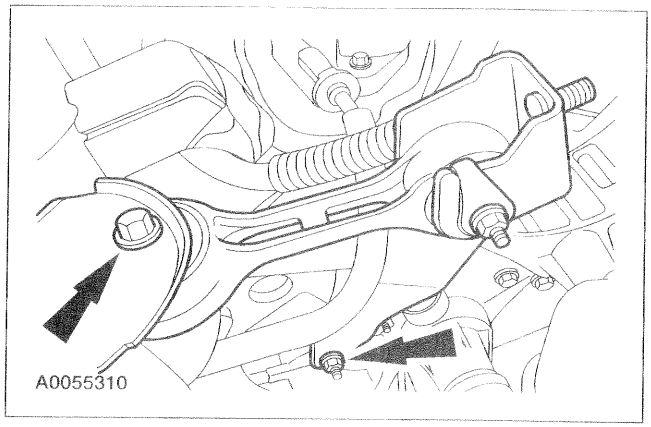
4. Install the accessory drive belt tensioner and the bolt.



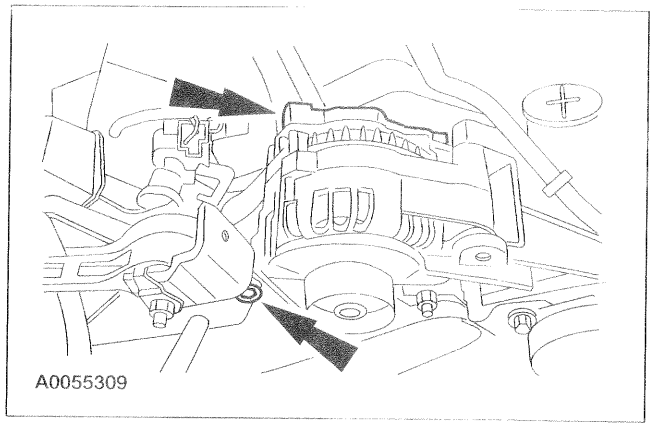
5. Install the water pump pulley and the bolts.



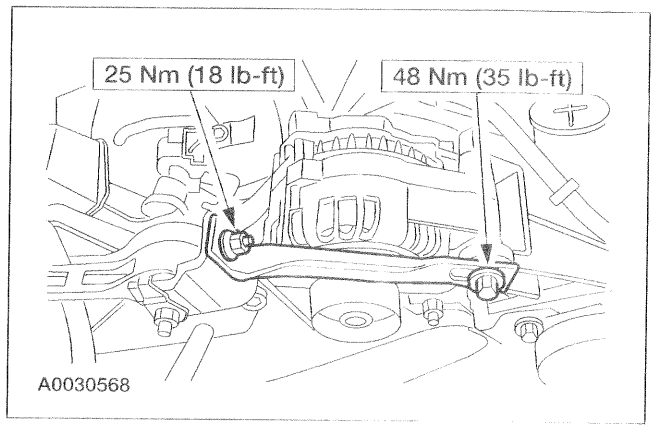
6. Install the roll restrictor bracket, the bolt and the nut. Do not tighten at this time.



7. Install the generator and the mounting bolt. Do not tighten at this time.

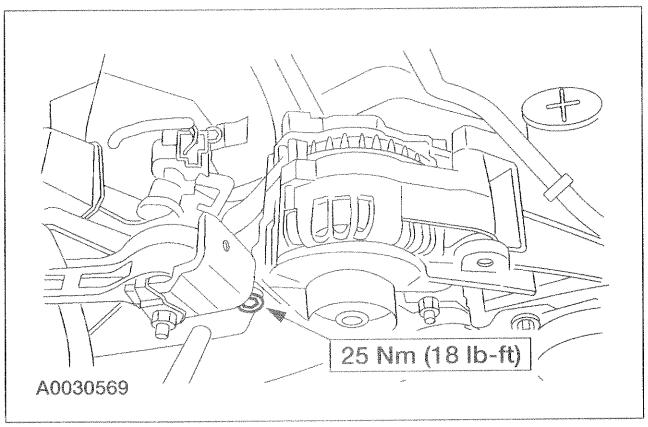


8. Install the generator brace, the nut and the bolt.

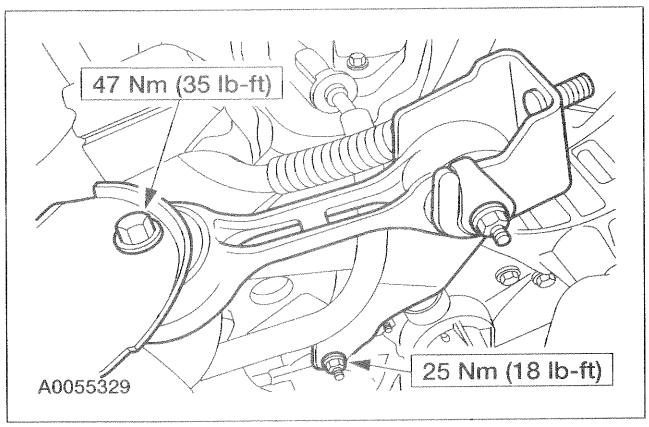


REMOVAL AND INSTALLATION (Continued)

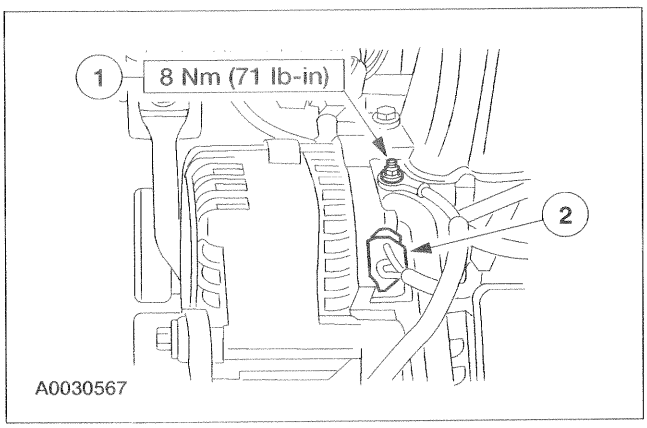
9. Tighten the generator lower mounting bolt.



10. Tighten the roll restrictor bracket bolt and nut.



11. Connect the generator electrical connectors.
    1 Connect the B+ cable.
    2 Connect the voltage regulator electrical connector.



12. Install the accessory drive belt. For additional information, refer to Section 303-05.

13. Install the degas bottle. For additional information, refer to Degas Bottle in this section.

14. Connect the battery ground cable. For additional information, refer to Section 414-01.

15. Fill the engine cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

Water Pump — 3.0L (4V)

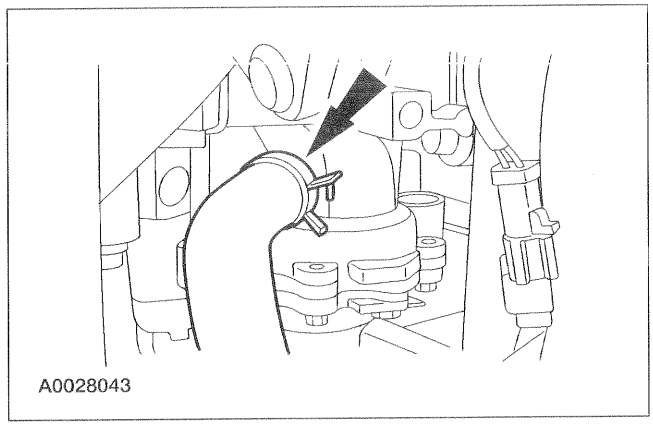
Removal

1. Raise and support the vehicle. For additional information, refer to Section 100-02.

2. Remove the splash shield. For additional information, refer to Section 501-02.

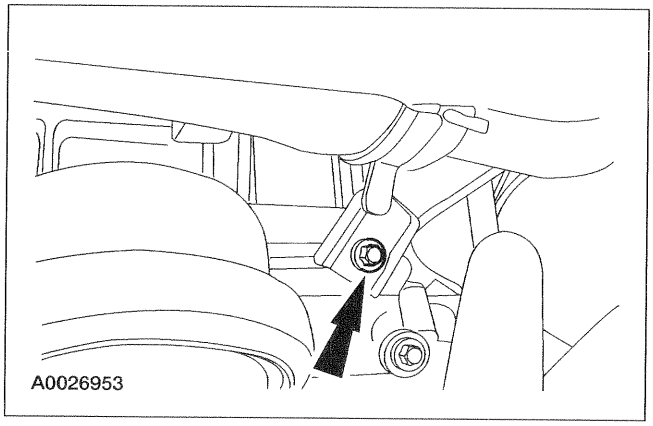
3. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

4. Disconnect the heater water hose from the bottom of the water pump.



REMOVAL AND INSTALLATION (Continued)

5. Remove the radiator lower tube bolt.



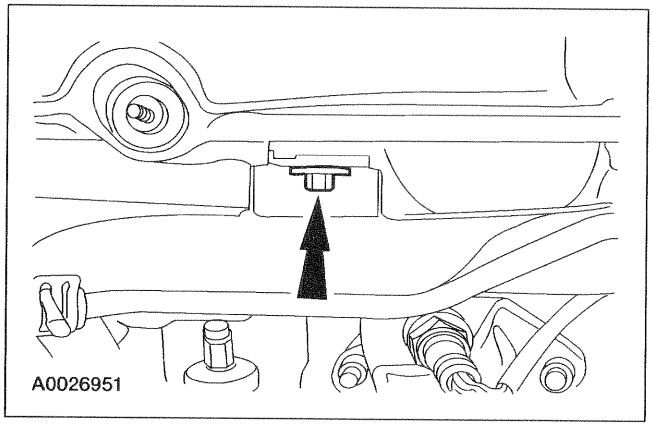
6. Lower the vehicle.

7. Remove the air cleaner assembly. For additional information, refer to Section 303-12.

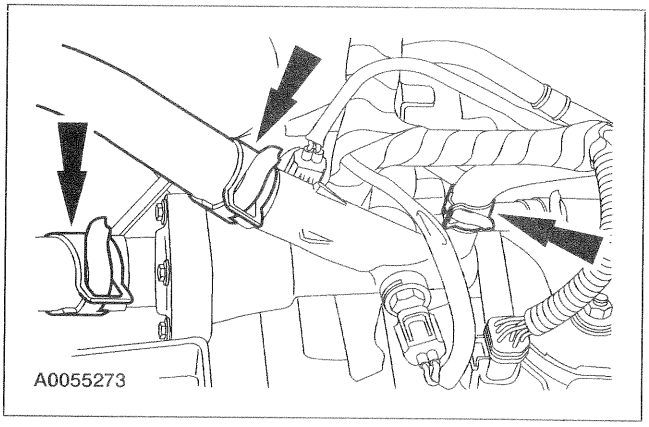
8. Remove the battery and the battery tray. For additional information, refer to Section 414-01.

9. Remove the water pump belt. For additional information, refer to Section 303-05.

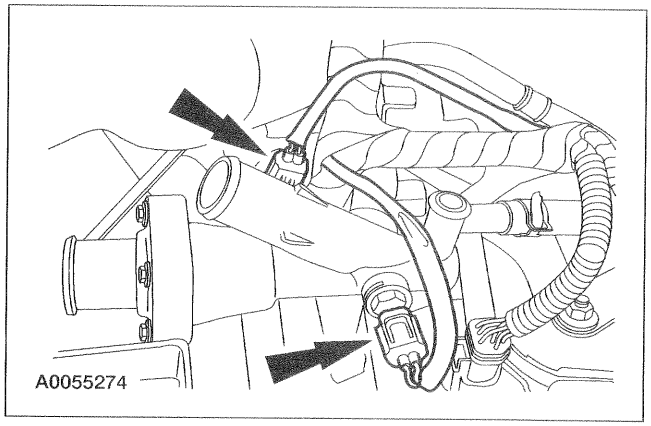
10. Remove the radiator upper front tube bolt.



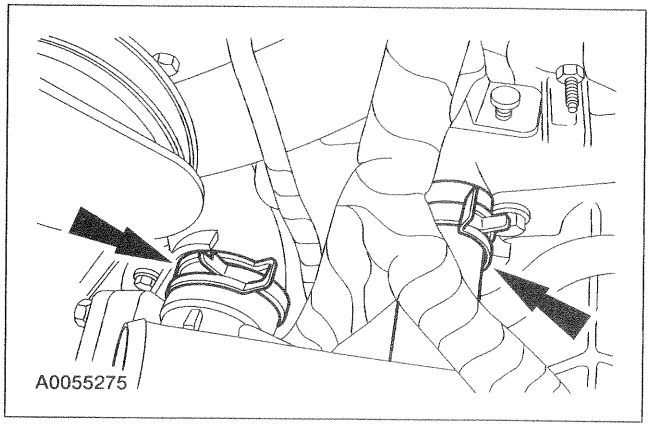
11. Disconnect the upper radiator hose, the heater water hose and the thermostat housing hose.



12. Disconnect the engine coolant temperature (ECT) sensor and the water temperature sender electrical connectors.

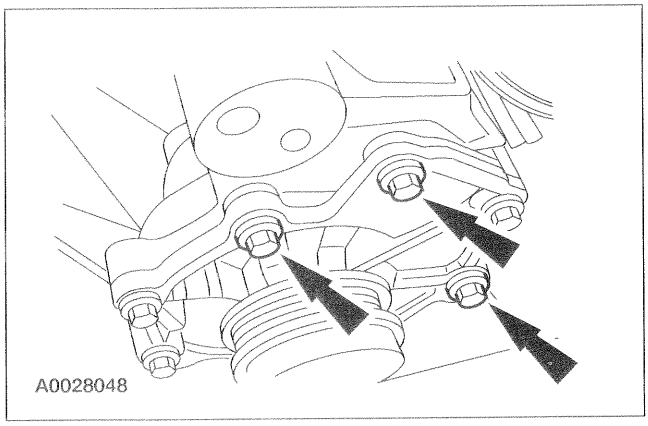


13. Remove the radiator bypass hose assembly.

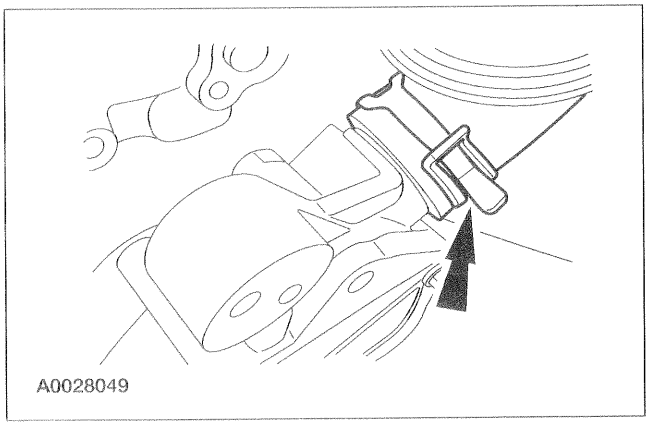


REMOVAL AND INSTALLATION (Continued)

14. Remove the three bolts, and detach the water pump.

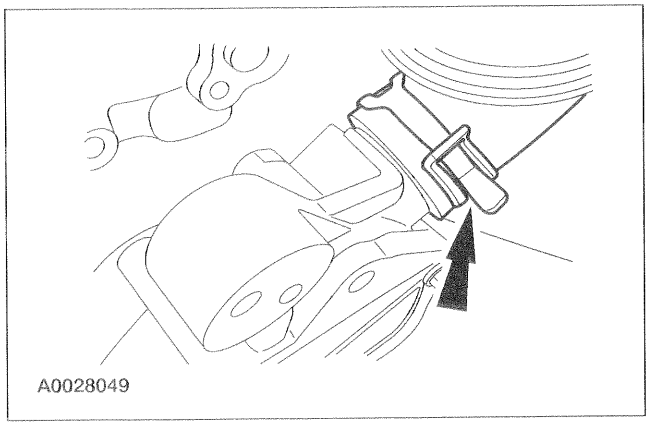


15. Disconnect the connector hose, and remove the water pump.

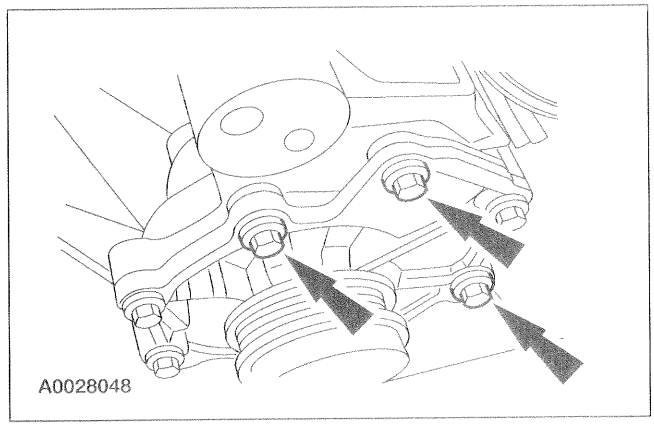


Installation

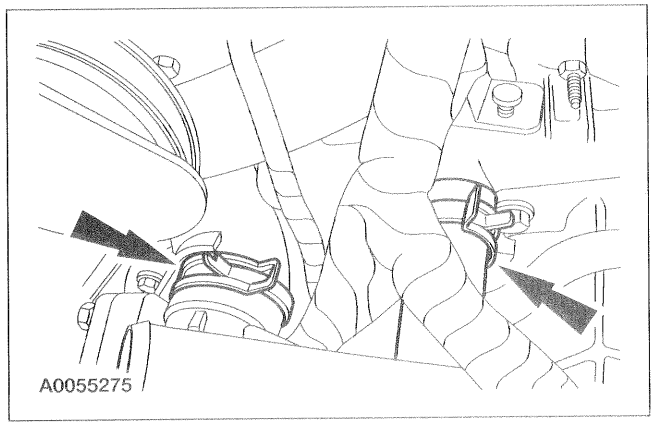
1. Connect the connector hose to the water pump.



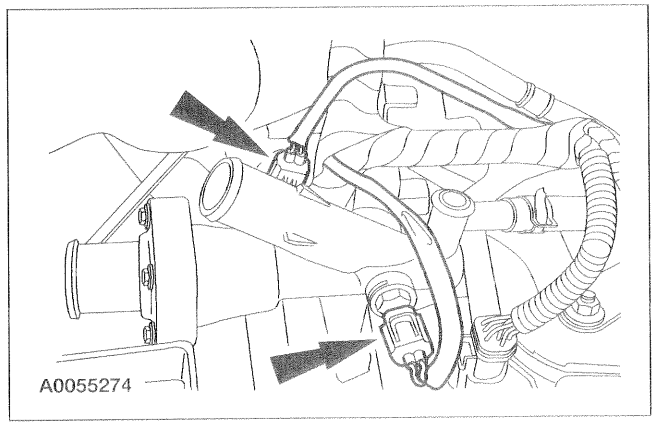
2. Position the water pump and install the mounting bolts. Tighten the bolts in two stages:
   - Stage 1: Tighten to 10 Nm (89 lb-in).
   - Stage 2: Tighten an additional 90 degrees.



3. Install the radiator bypass hose assembly.

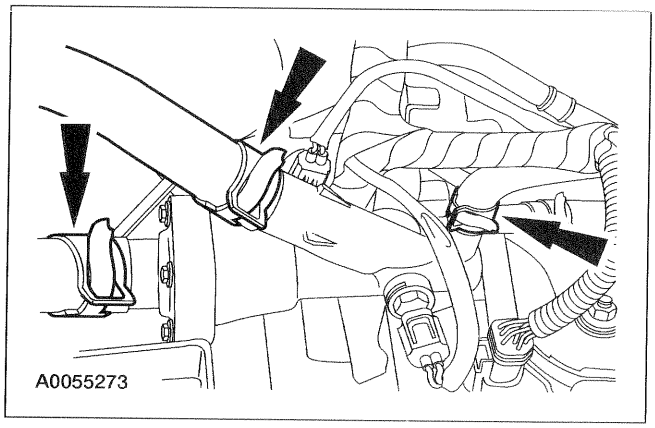


4. Connect the engine coolant temperature (ECT) sender and the water temperature sender electrical connectors.

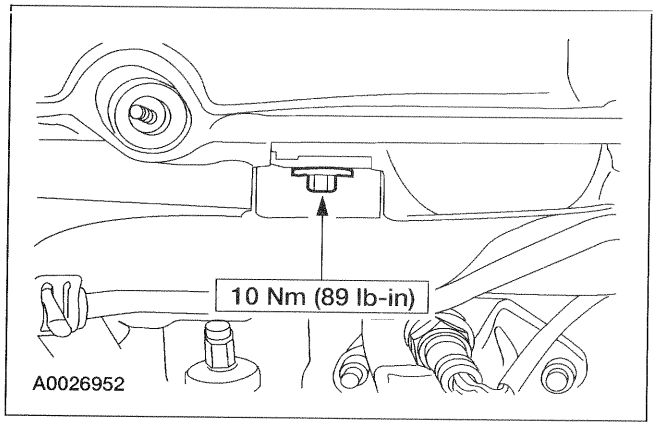


REMOVAL AND INSTALLATION (Continued)

5. Connect the upper radiator hose, the heater water hose and thermostat housing the hose.



6. Install the radiator upper front cooling tube bolt.



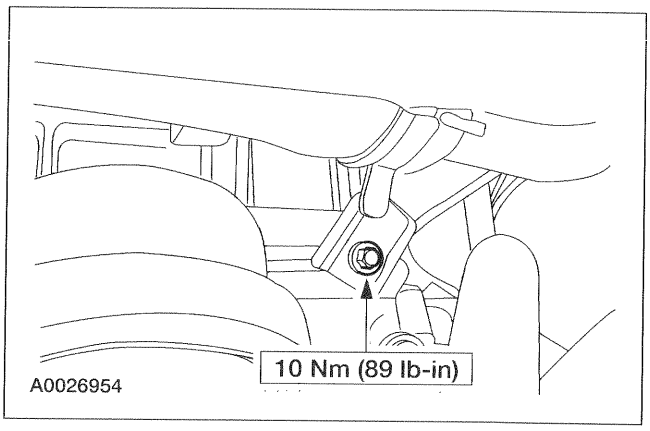
7. Install the water pump belt. For additional information, refer to Section 303-05.

8. Install the battery and the battery tray. For additional information, refer to Section 414-01.

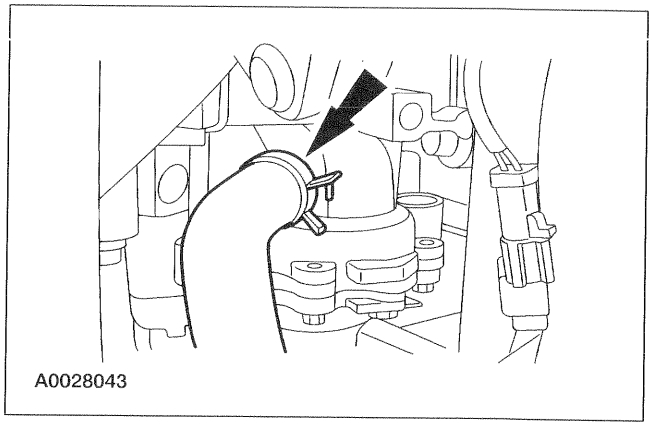
9. Install the air cleaner assembly. For additional information, refer to Section 303-12.

10. Raise and support the vehicle. For additional information, refer to Section 100-02.

11. Install the lower cooling tube bolt.



12. Connect the heater water hose to the bottom of the water pump.

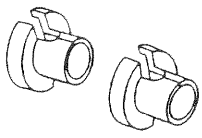


13. Install the splash shield. For additional information, refer to Section 501-02.

14. Fill the engine cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

Radiator

Special Tool(s)

 ST1399-A	Disconnect Tool, Spring Lock Coupling 310-S039 (T90T-9550-S)

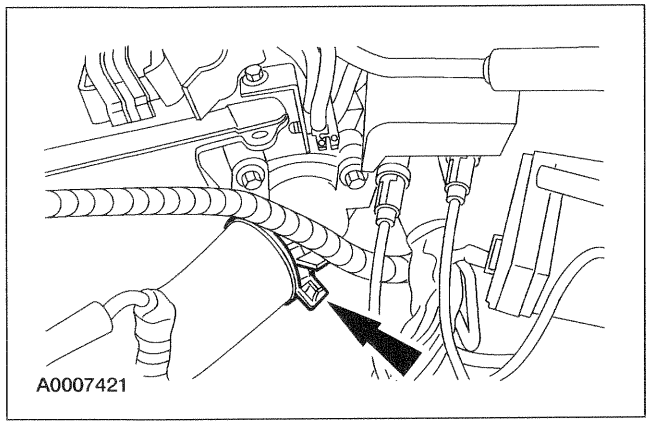
REMOVAL AND INSTALLATION (Continued)

Removal and Installation

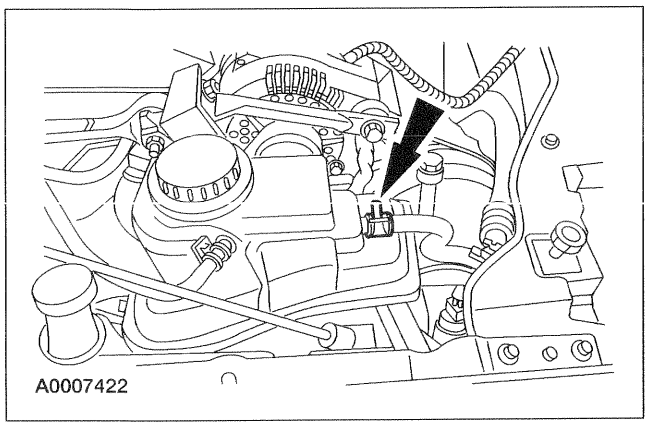
1. **NOTE:** 3.0L (2V) shown, 3.0L (4V) similar.
   Remove the battery and battery tray. For additional information, refer to Section 414-01.

2. Drain the cooling system. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

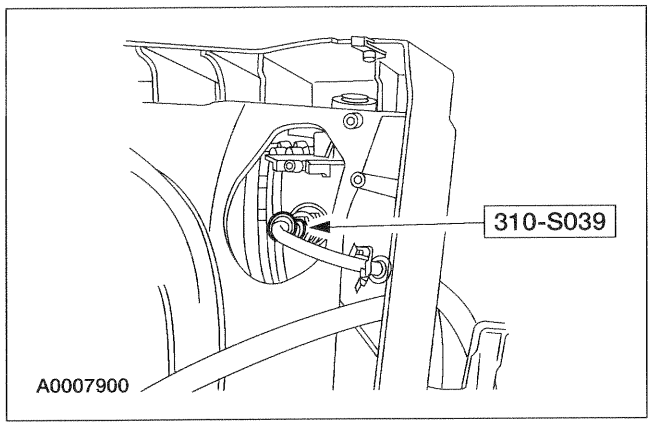
3. Disconnect the upper radiator hose.



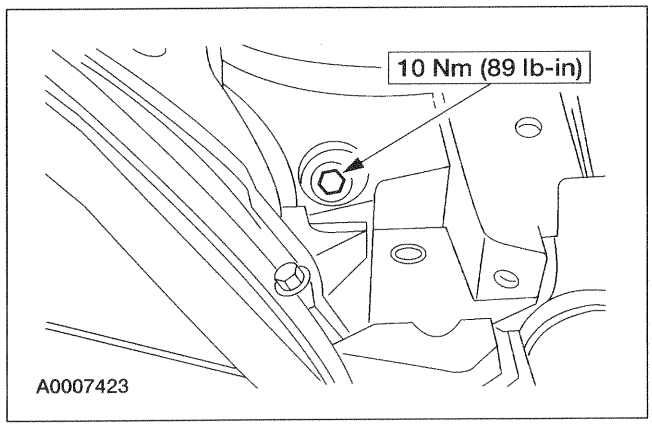
4. Disconnect the degas return hose.



5. Using the special tool, disconnect the upper transmission cooler line.

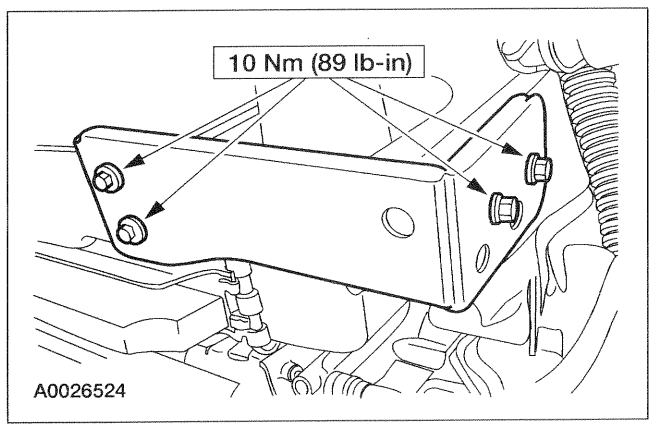


6. Remove the two A/C condenser retaining bolts.



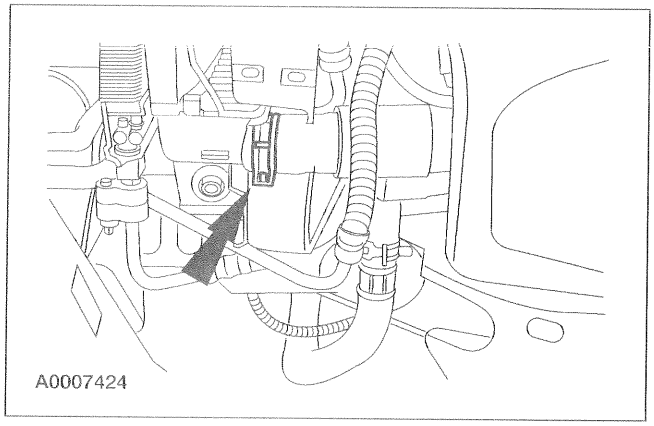
7. Raise and support the vehicle. For additional information, refer to Section 100-02.

8. Remove the radiator support bracket bolts and the radiator support bracket.



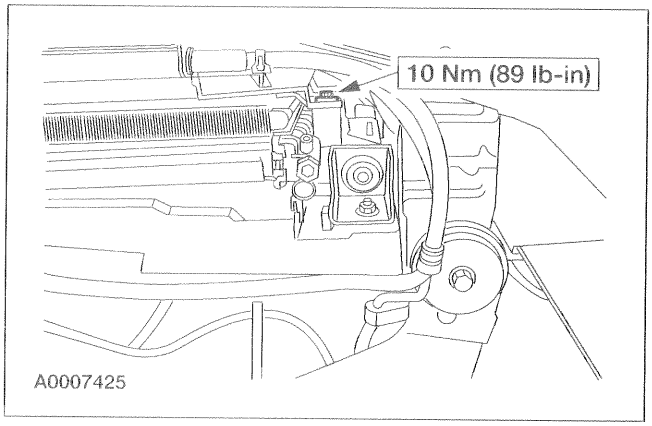
REMOVAL AND INSTALLATION (Continued)

9. Disconnect the lower radiator hose.



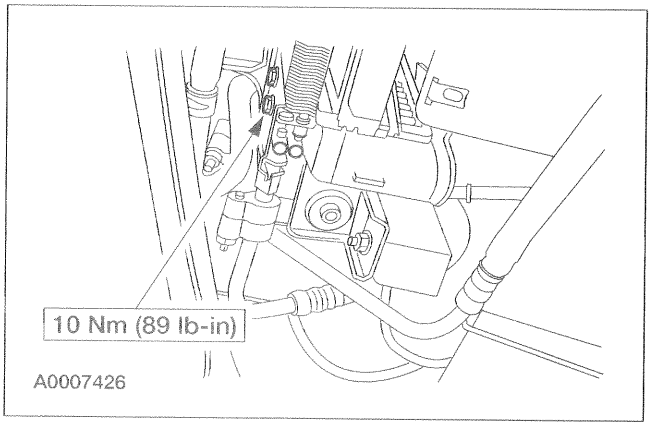
10. Disconnect the lower transmission cooler line.

11. Remove the two bolts retaining the condenser to the radiator.

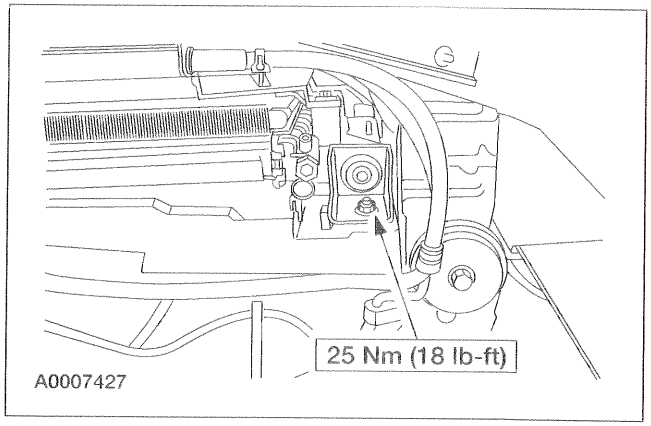


12. Secure the A/C condenser.

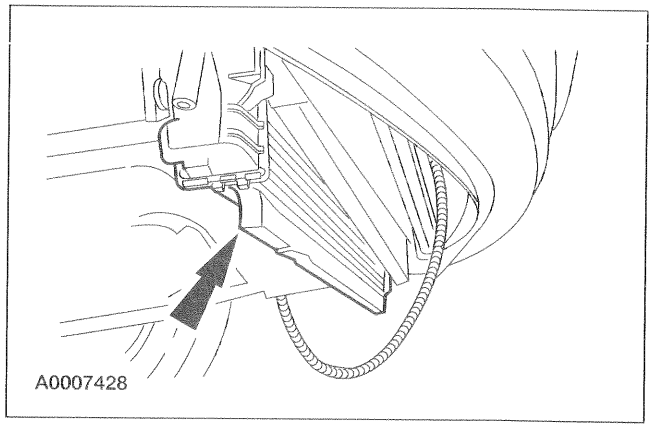
13. Remove the bolt retaining the P/S cooler to the radiator.



14. Remove the nuts and the radiator support brackets.



15. Remove the radiator from the vehicle.



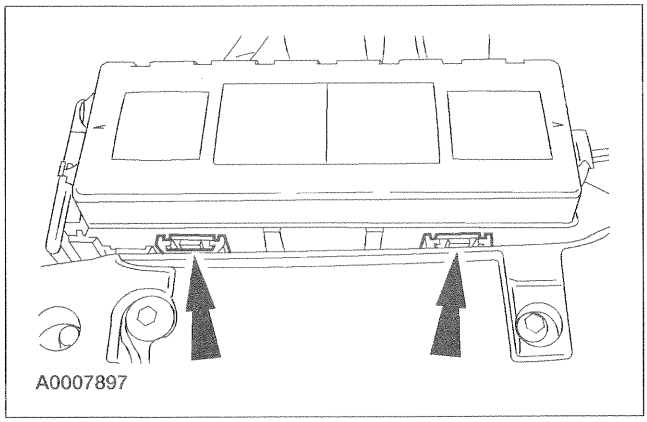
16. To install, reverse the removal procedure.

REMOVAL AND INSTALLATION (Continued)

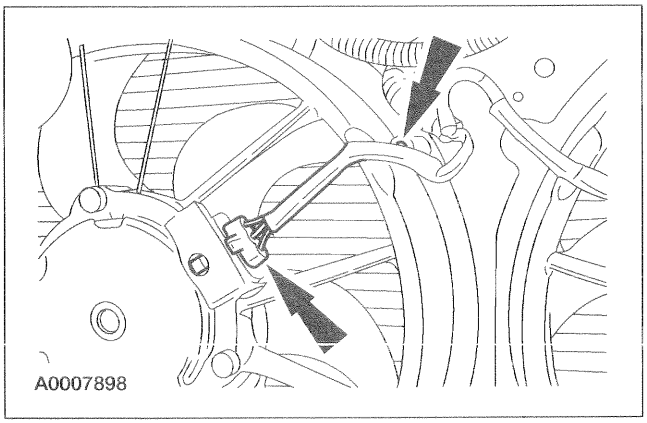
Cooling Fan

Removal and Installation

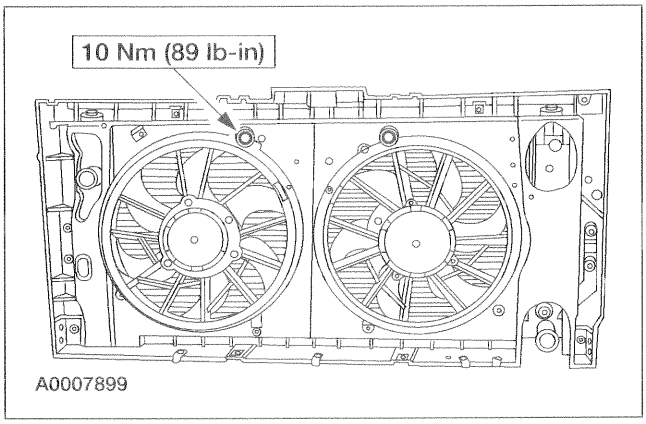
1. **NOTE:** LH shown, RH similar.
   Remove the distribution box and position aside.



2. Disconnect the fan electrical connector.



3. Remove the bolt and the electrical cooling fan.



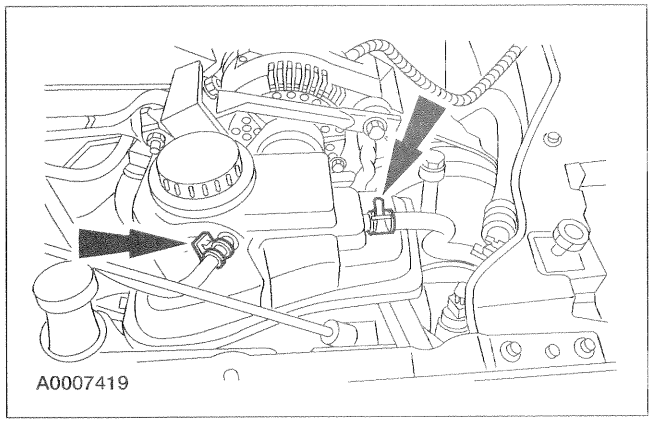
4. To install, reverse the removal procedure.

Degas Bottle

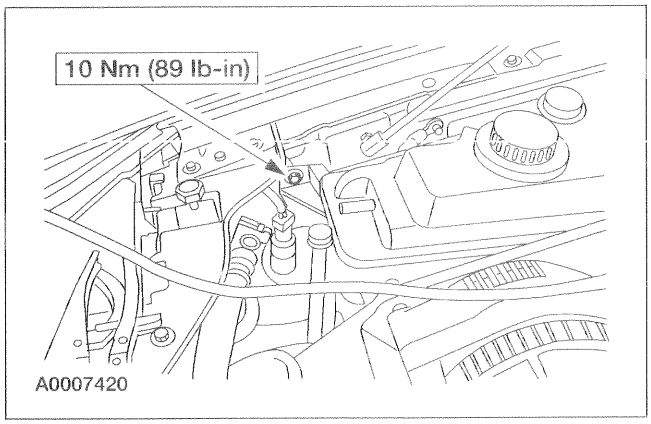
Removal and Installation

1. Drain the coolant below the degas bottle. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

2. Disconnect the hoses.



3. Remove the bolt and the nut, remove the degas bottle.



4. To install, reverse the removal procedure.

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SECTION 303-07A Engine Ignition — 3.0L (2V)

CONTENTS PAGE

SPECIFICATIONS

General Specifications

Item	Specification
Base ignition timing (not adjustable)	10 degrees BTDC
Firing order	1-4-2-5-3-6
Spark plug gap mm (in)	1.07-1.17 (.042-.046)
Original spark plug (gasoline engine)	AWSF-32P and PG
Original spark plug (flex fuel engine)	AWSF22PG or AWSF22P
Service spark plug (gasoline engine)	AGSF-32PP
Service spark plug (flex fuel engine)	AGSF-22PP
Silicone Brake Caliper Grease and Dielectric Compound D7AZ-19A331-A	ESE-M1C171-A

Torque Specifications

Description	Nm	lb-ft	lb-in
Ignition coil bolts	6	—	53
Spark plugs	15	11	—
Secondary air injection diverter valve tube nuts (flex fuel engine)	50	37	—
Secondary air injection diverter valve bracket nuts (flex fuel engine)	34	25	—

DESCRIPTION AND OPERATION

Engine Ignition

The electronic ignition (EI) system for the 3.0L engine consists of the following components:

- ignition coil
- spark plugs
- spark plug wires
- crankshaft position (CKP) sensor

The crankshaft position (CKP) sensor:

- is a variable reluctance sensor.
- is mounted on the engine front cover.
- is triggered by a 36-minus-1 tooth trigger wheel located on the crankshaft pulley and damper.
- provides base timing and crankshaft speed (rpm) to the powertrain control module (PCM).

Refer to Section 303-14 for removal and installation of the CKP sensor.

The ignition coil:

- is controlled by the PCM.
- fires two spark plugs simultaneously.

The spark plug:

- ignites the fuel and air mixture.

The spark plug wire:

- carries high voltage pulses from the ignition coil to the spark plugs.

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual for additional information on ignition coil matched pairs.

DIAGNOSIS AND TESTING

Engine Ignition

Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual for diagnosis and testing of the electronic ignition (EI) system.

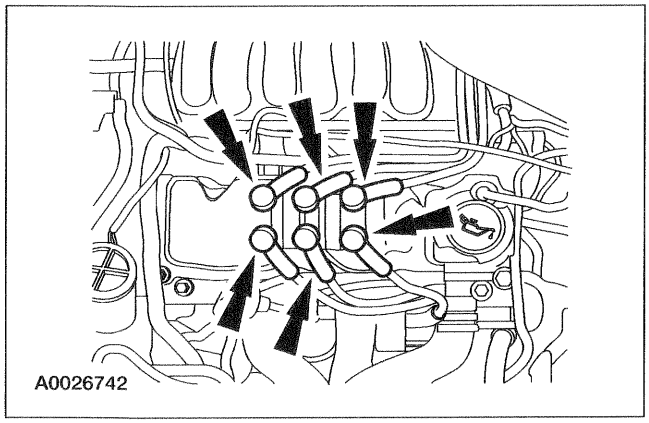
REMOVAL AND INSTALLATION

Ignition Coil

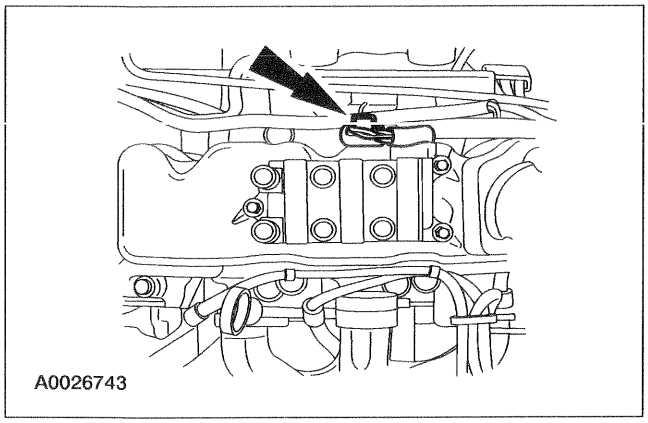
Removal and Installation

1. ⚠ **CAUTION: It is important to twist the spark plug wire boots while pulling upward to avoid possible damage to the spark plug wire.**

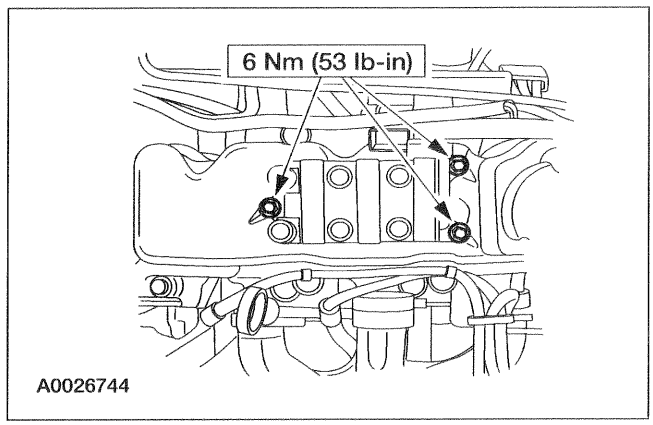
   Disconnect the spark plug wires by twisting while pulling upward.



2. Disconnect the electrical connector from the ignition coil.



3. Remove the ignition coil.
   - Remove the bolts.
   - Wipe the ignition coil towers with a clean cloth dampened with soap and water.

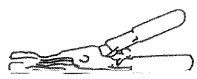


4. ⚠ **CAUTION: Spark plug wires must be connected to the correct ignition coil terminal.**

   To install, reverse the removal procedure.

Spark Plug Wire

Special Tool(s)

 ST1394-A	Spark Plug Wire Remover 303-106 (T74P-6666-A)

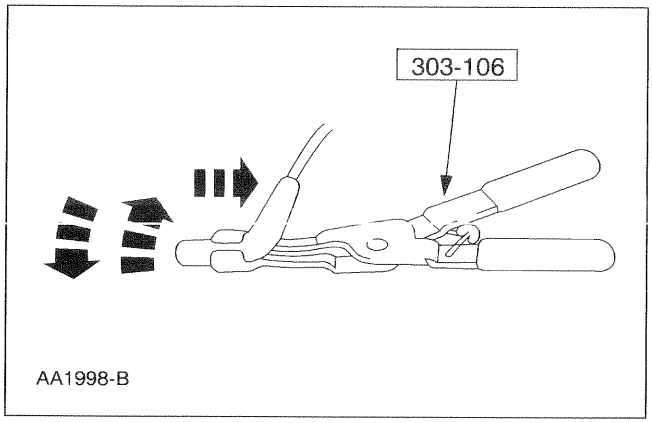
REMOVAL AND INSTALLATION (Continued)

Removal and Installation

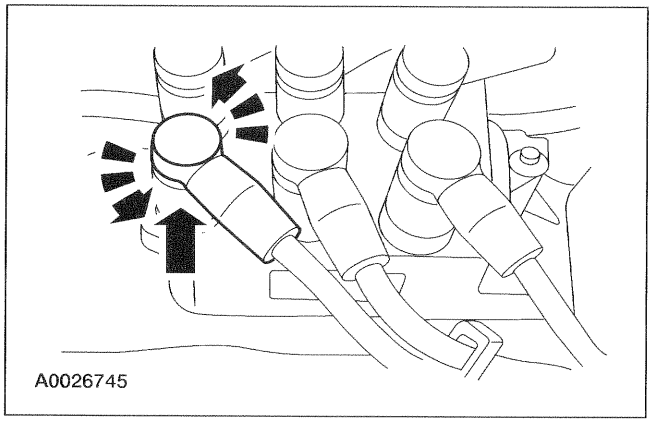
⚠ **CAUTION: Spark plug wires must be connected to the correct ignition coil terminal.**

⚠ **CAUTION: It is important to twist the spark plug wire boots while pulling upward to avoid possible damage to the spark plug wire.**

1. Using the special tool, with a twisting motion pull the spark plug wire off the spark plug.



2. Disconnect the spark plug wire from the ignition coil by twisting while pulling upward.



3. Open the spark plug wire separators and remove the spark plug wire.

4. ⚠ **CAUTION: Be sure to orient the spark plug boots so the spark plug wires do not contact the exhaust manifold.**

   NOTE: Apply Silicone Brake Caliper Grease and Dielectric Compound D7AZ-19A331-A or equivalent meeting Ford specification ESE-M1C171-A to the inside of spark plug and ignition coil boots of the spark plug wire.

   To install, reverse the removal procedure.

Spark Plug

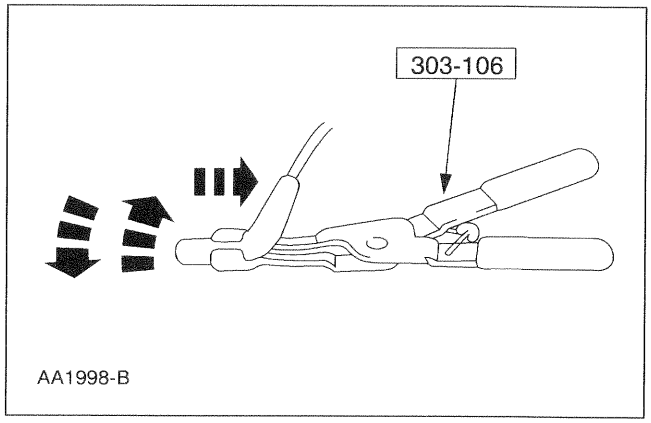
Special Tool(s)

 ST1394-A	Spark Plug Wire Remover 303-106 (T74P-6666-A)

Removal and Installation

1. ⚠ **CAUTION: It is important to twist the spark plug wire boots while pulling upward to avoid possible damage to the spark plug wire.**

   Using the special tool, with a twisting motion pull the spark plug wire off the spark plug.

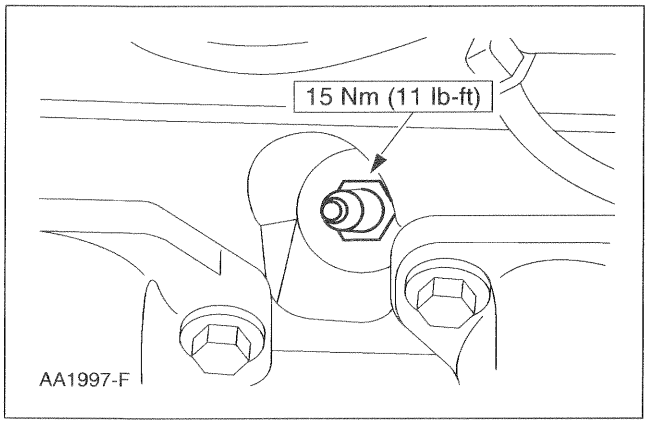


REMOVAL AND INSTALLATION (Continued)

2. **NOTE:** Loosen the spark plug one quarter turn then use compressed air to remove any foreign material in the spark plug well before removing the spark plugs.

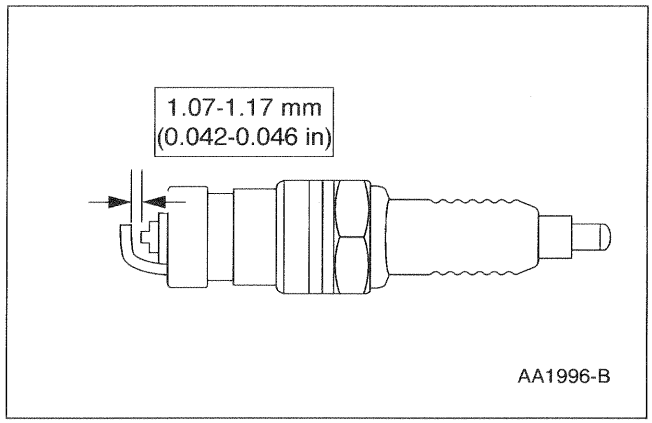
   NOTE: For flexible fuel (FF) vehicles, if an original spark plug is reused, make sure it is installed in the same cylinder from which it was taken. New spark plugs can be used in any cylinder.

   Remove the spark plug.



3. Inspect the spark plug firing tip. For additional information, refer to Section 303-00.

4. Adjust the spark plug gap as necessary.



5. ⚠ **CAUTION: Spark plug wires must be connected correctly.**

   To install, reverse the removal procedure.

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SECTION 303-14 Electronic Engine Controls

CONTENTS PAGE

SPECIFICATIONS

General Specifications

Item	Specification
High Temperature Nickel Anti-Seize Lubricant F6AZ-9L494-AA	ESE-M12A4-A
Penetrating and Lock Lubricant E8AZ-19A501-B	—
SAE 5W-20 Premium Synthetic — Blend Motor Oil	WSS-M2C153-H

Torque Specifications

Description	Nm	lb-ft	lb-in
Camshaft synchronizer bolt 3.0L (2V)	24	18	—
Camshaft position (CMP) sensor bolt 3.0L (4V)	10	—	89

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Crankshaft position (CKP) sensor bolts	10	—	89
Engine coolant temperature (ECT) sensor	16	12	—
Heated oxygen sensor (HO2S)	46	34	—
Idle air control (IAC) valve bolts	10	—	89
Mass air flow (MAF) sensor nuts	10	—	89
Powertrain control module (PCM) connector to module bolt	7	—	62
PCM cover nuts	5	—	44
Knock sensor (KS) bolt	25	18	—
Accelerator cable bracket bolts	17	13	—

DESCRIPTION AND OPERATION

Electronic Engine Controls

The electronic engine controls consist of the following:

- power control module (PCM)
- throttle position (TP) sensor
- idle air control (IAC) valve
- engine coolant temperature (ECT) sensor
- camshaft position (CMP) sensor
- crankshaft position (CKP) sensor
- mass air flow (MAF) sensor
- intake air temperature (IAT) sensor
- heated oxygen sensor (HO2S)
- catalyst monitor sensor
- knock sensor (KS) (4V)
- output shaft speed (OSS) sensor
- power steering pressure (PSP) switch (4V)

The PCM:

- accepts input from various engine sensors to compute the required fuel flow rate necessary to maintain a prescribed air/fuel ratio throughout the entire engine operational range.
- outputs a command to the fuel injectors to meter the appropriate quantity of fuel.
- determines and compensates for the age of the vehicle and its uniqueness, also automatically senses and compensates in altitude (i.e. from sea level to above sea level).

The TP sensor:

- sends the PCM a signal indicating the throttle plate angle.
- is the main input to the PCM from the driver.

The IAC valve:

- is used to control engine idle speed.
- is controlled by the PCM.

The ECT sensor:

- sends the PCM a signal indicating engine temperature.
- resistance decreases as coolant temperature increases.

The CMP sensor:

- provides camshaft position information which is used by the PCM for fuel synchronization.

DESCRIPTION AND OPERATION (Continued)

The CKP sensor:

- sends the PCM a signal indicating crankshaft position.
- is essential for calculating spark timing.

The KS 3.0L (4V):

- is used to detect engine detonation (spark knock).
- sends a voltage signal to the PCM which retards the ignition timing, as necessary.

The MAF sensor:

- uses a hot wire sensing element to measure the amount of air entering the engine.
- sends a signal to the PCM to determine the intake air mass. The PCM will then calculate the required fuel injector pulse width in order to provide the desired air/fuel ratio.

The catalyst monitor sensor:

- has the ability to create a voltage signal dependent on exhaust oxygen content.
- provides feedback information to the PCM used to calculate fuel delivery.

The HO2S:

- monitors oxygen content after it flows through the catalytic converter.
- provides a voltage to the PCM used to calculate catalytic converter integrity.

The PSP switch:

- is a normally closed switch that opens as pressure increases.
- is used to send a signal to the PCM to adjust idle speed. This compensates for the additional load on the engine. For additional information, refer to Section 211-02.

The OSS:

- is able to provide a signal which tells the PCM the vehicle speed. For additional information, refer to Section 307-01A (4X4S) or Section 307-01B (4F50N).

DIAGNOSIS AND TESTING

Electronic Engine Controls

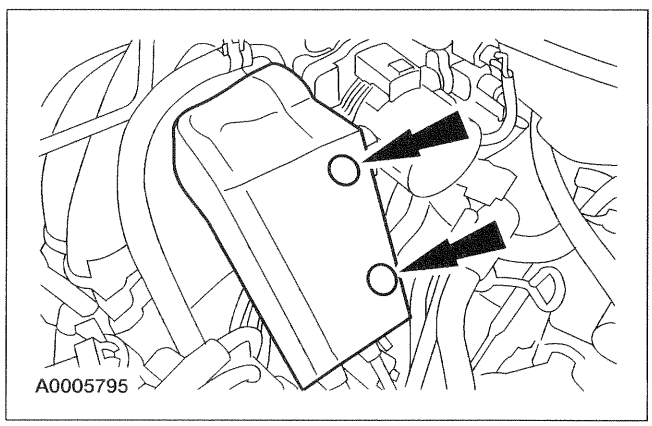
Refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual .

REMOVAL AND INSTALLATION

Camshaft Position (CMP) Sensor — 3.0L (2V)

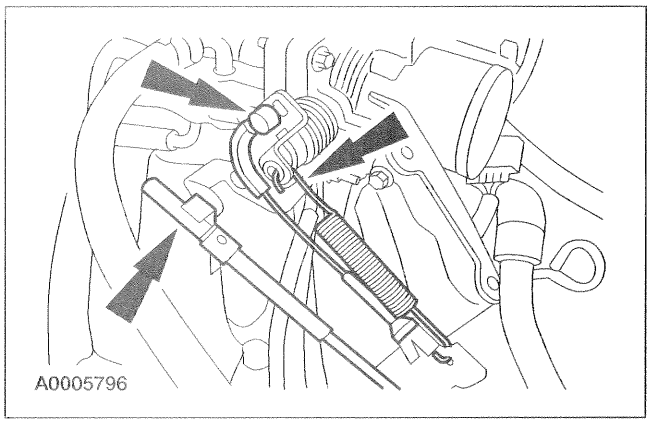
Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Remove the accelerator cable snow shield.

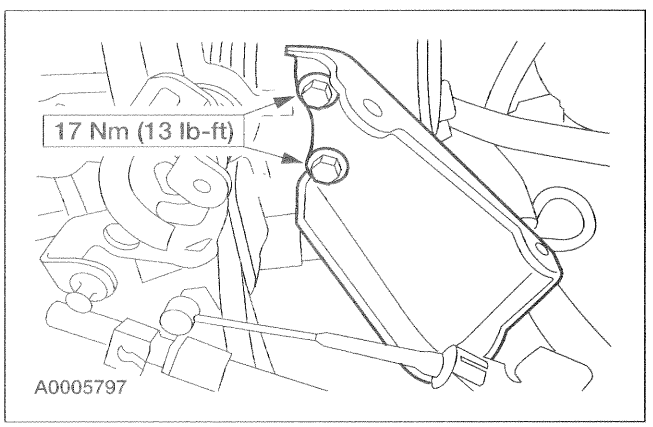


REMOVAL AND INSTALLATION (Continued)

3. Disconnect the accelerator cable, speed control actuator cable, and the throttle return spring from the throttle body lever.

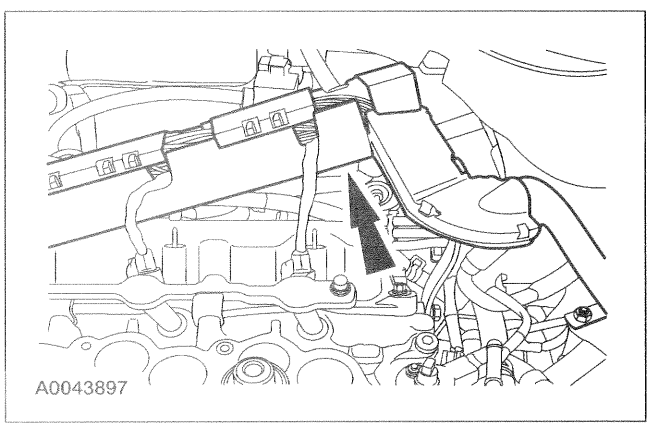


4. Remove the bolts, position the accelerator cable bracket aside.

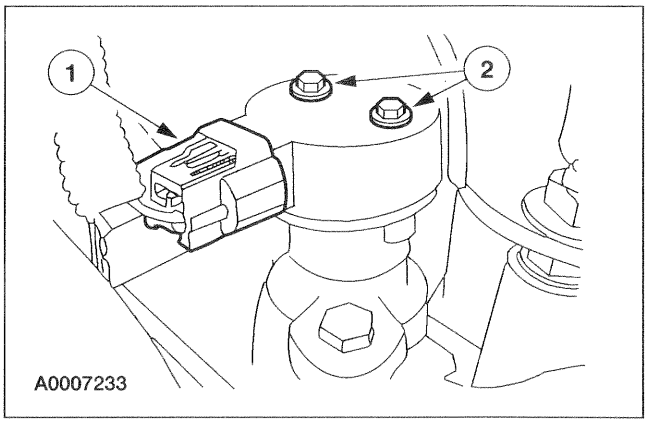


5. Remove the upper intake manifold. For additional information, refer to Section 303-01A.

6. Release the fuel charging wiring harness from the valve cover studs. Position the wiring harness away from the camshaft position sensor.



7. Remove the camshaft position (CMP) sensor.
   1 Disconnect the electrical connector.
   2 Remove the screws and the CMP.



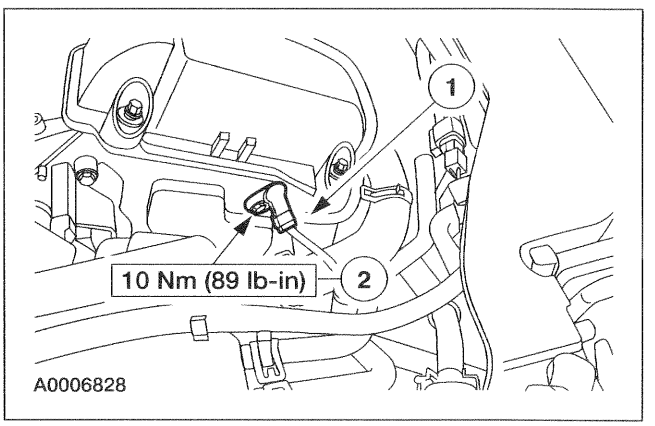
8. To install, reverse the removal procedure.

Camshaft Position (CMP) Sensor — 3.0L (4V)

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

2. Remove the camshaft position (CMP) sensor.
   1 Remove the electrical connector.
   2 Remove the bolt and the CMP sensor.

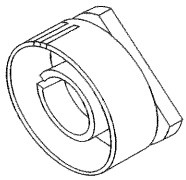


3. To install, reverse the removal procedure.

REMOVAL AND INSTALLATION (Continued)

Camshaft Synchronizer — 3.0L (2V)

Special Tool(s)

 ST2362-A	Alignment Gauge, Synchronizer 303-589

Material

Item	Specification
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP or equivalent	WSS-M2C153-H

Removal

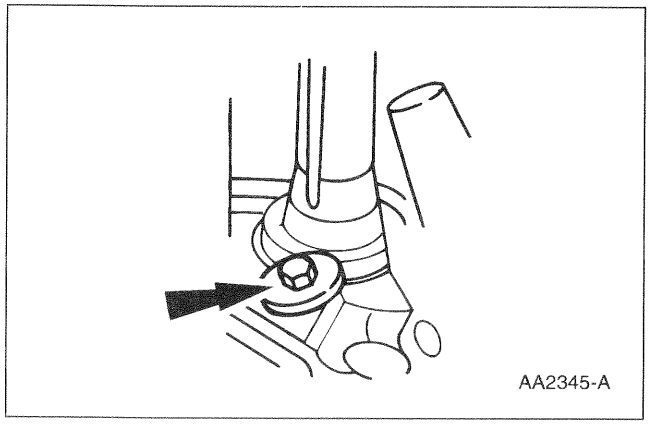
1. ⚠ **CAUTION: Do not turn the crankshaft or the camshaft during the removal and installation procedure or the fuel system timing will be out of time with the engine and possibly cause engine damage.**

   Rotate the crankshaft until the No. 1 cylinder is at TDC of the compression stroke and the TDC mark lines up with the timing mark.

2. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

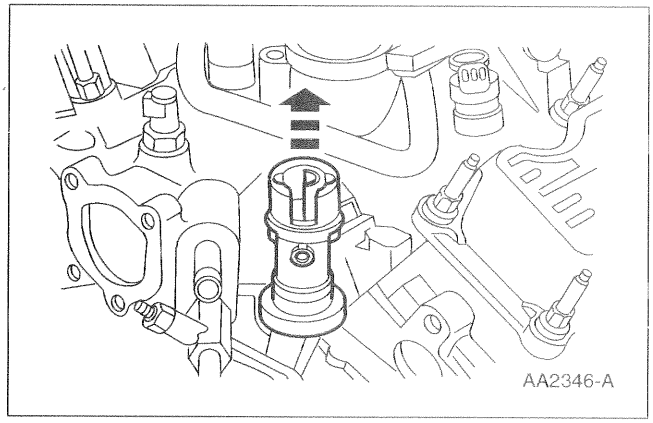
3. Remove the camshaft position (CMP) sensor. For additional information, refer to Camshaft Position (CMP) Sensor—3.0L (2V) in this section.

4. Remove the camshaft synchronizer bolt.



5. **NOTE:** The oil pump driveshaft might come out with the camshaft synchronizer. If so, retrieve the oil pump drive shaft before proceeding.

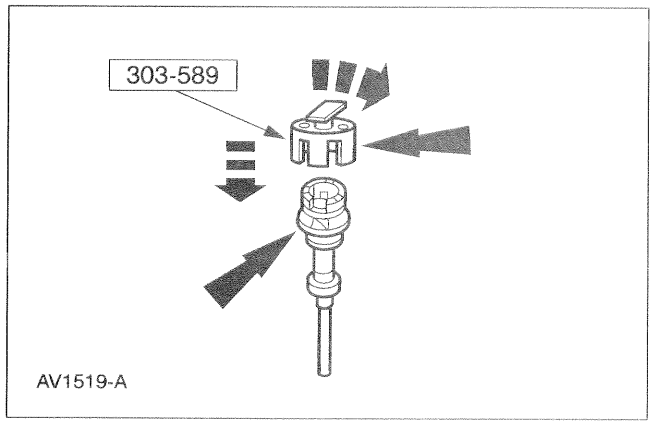
   Remove the camshaft synchronizer.



Installation

1. ⚠ **CAUTION: Do not turn the crankshaft or the camshaft during the removal and installation procedure or the fuel system timing will be out of time with the engine and possibly cause engine damage. A special tool must be used during the installation of the replacement synchronizer assembly. Failure to follow this procedure will result in the fuel system being out of time with the engine, possibly causing engine damage. It is very important to coat the gear on the camshaft synchronizer with clean engine oil prior to installation. Failure to do so could result in gear failure.**

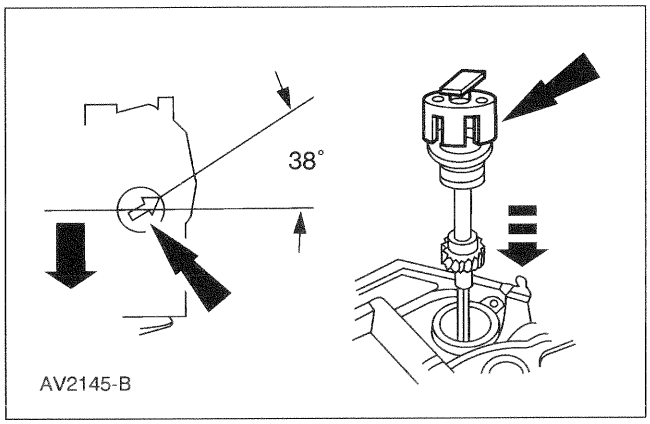
   Install the special tool on the camshaft synchronizer by rotating the tool until it engages the notch in the camshaft synchronizer housing and the armature.



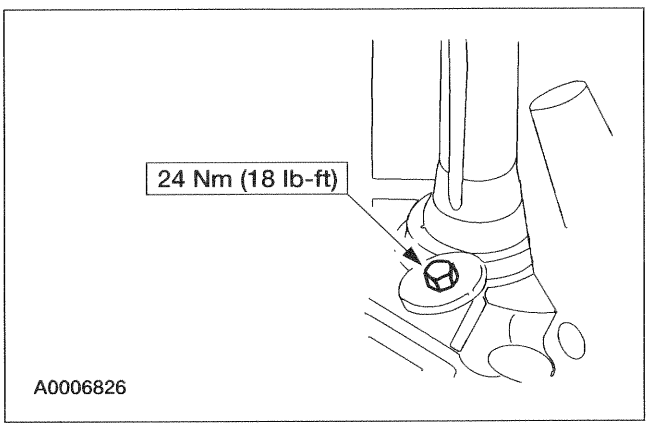
REMOVAL AND INSTALLATION (Continued)

2. **NOTE:** During installation, the arrow on the special tool will rotate clockwise until oil pump intermediate shaft and camshaft gear engages.

   Install the camshaft synchronizer housing assembly so the arrow on the special tool is 38 degrees from the centerline of the engine.



3. Install the camshaft synchronizer bolt.



4. Install the CMP sensor. For additional information, refer to Camshaft Position (CMP) Sensor—3.0L (2V) in this section.

5. Connect the battery ground cable. For additional information, refer to Section 414-01.

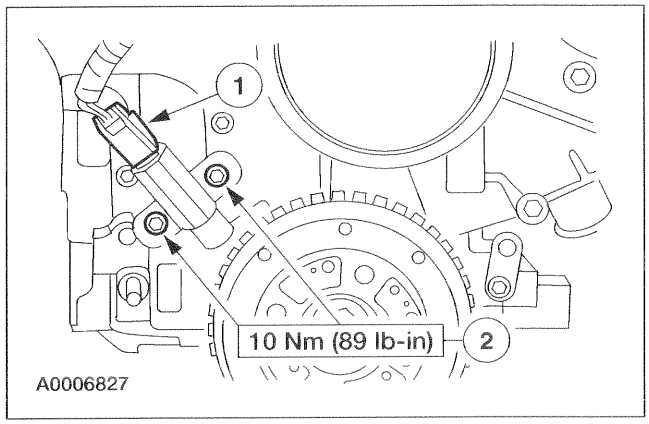
Crankshaft Position (CKP) Sensor — 3.0L (2V)

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

2. Raise and support the vehicle. For additional information, refer to Section 100-02.

3. Remove the crankshaft position (CKP) sensor.
   1 Disconnect the electrical connector.
   2 Remove the bolts and the CKP sensor.



4. To install, reverse the removal procedure.

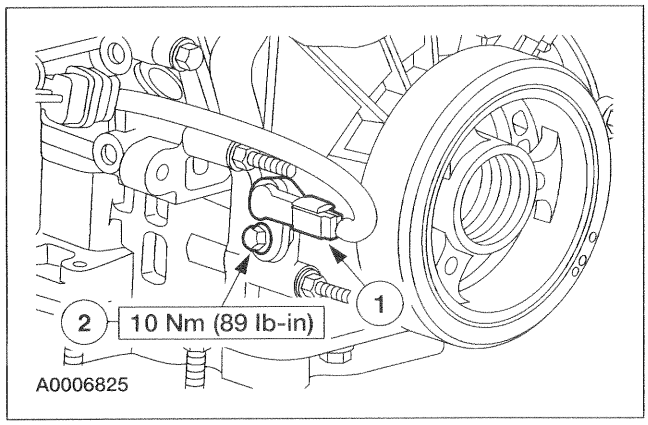
Crankshaft Position (CKP) Sensor — 3.0L (4V)

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

2. Raise and support the vehicle. For additional information, refer to Section 100-02.

3. Remove the crankshaft position (CKP) sensor.
   1 Disconnect the electrical connector.
   2 Remove the bolt and the CKP sensor.



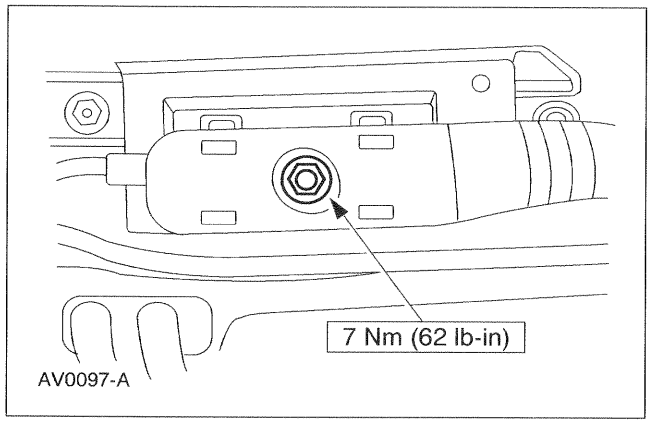
REMOVAL AND INSTALLATION (Continued)

4. To install, reverse the removal procedure.

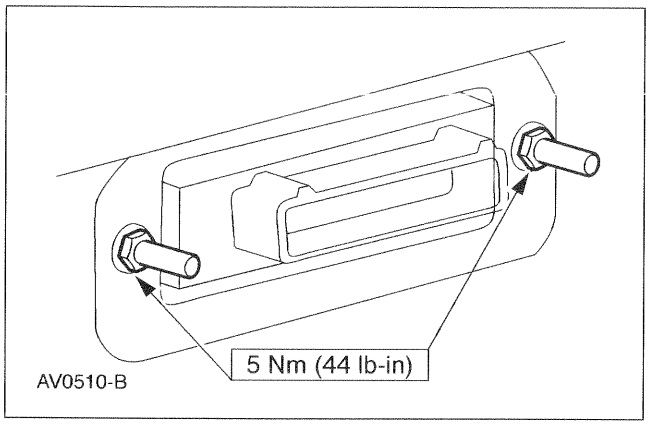
Powertrain Control Module (PCM)

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Remove the powertrain control module (PCM) electrical connector.



3. Remove the PCM.
   - Remove the stud bolts.
   - Remove the cover and the PCM.

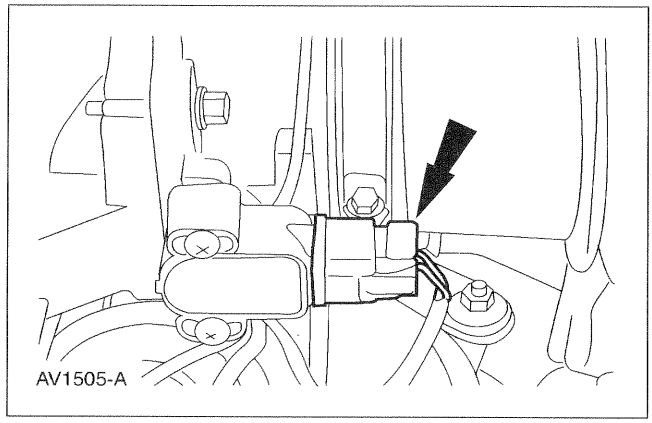


4. To install, reverse the removal procedure.

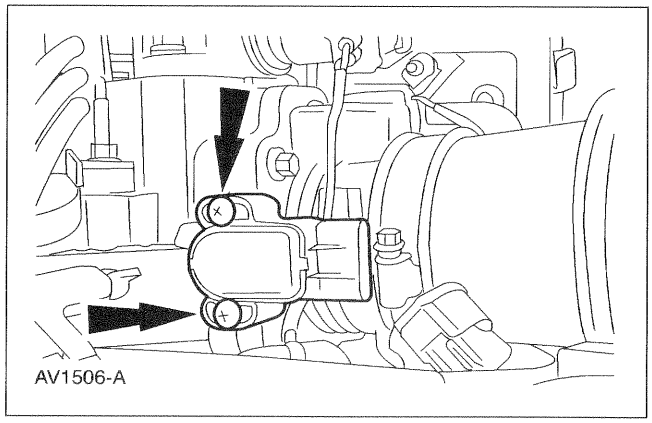
Throttle Position (TP) Sensor

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Disconnect the throttle position (TP) sensor electrical connector.



3. Remove the screws and the TP sensor.



4. To install, reverse the removal procedure.

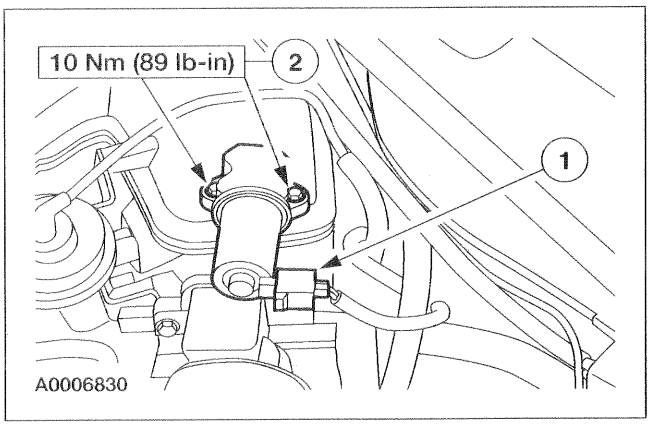
Idle Air Control (IAC) Valve

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

REMOVAL AND INSTALLATION (Continued)

2. Remove the idle air control (IAC) solenoid.
   1 Remove the electrical connector.
   2 Remove the bolts and the IAC solenoid.



3. To install, reverse the removal procedure.

Fuel Pressure Sensor

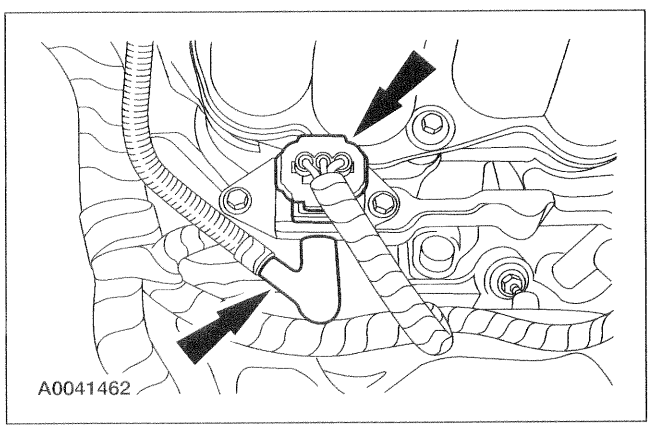
Material

Item	Specification
SAE 5W-20 Motor Oil XO-5W20-QSP	WSS-M2C153-H

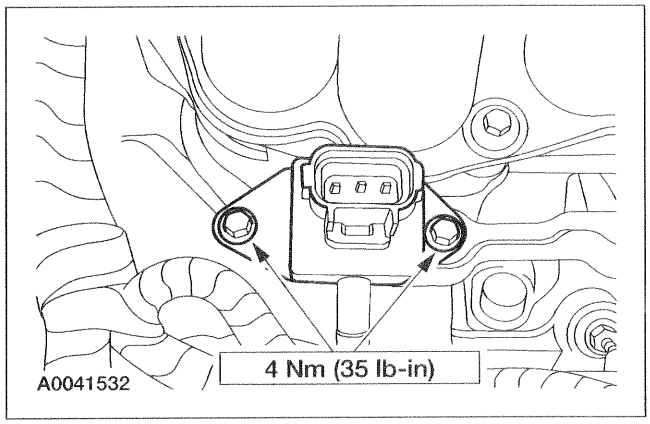
1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

2. Relieve the fuel system pressure. For additional information, refer to Section 310-00.

3. **NOTE:** 2V shown, 4V similar.
   Disconnect the IPR electrical connector and the vacuum hose.



4. Remove the bolts and the IPR.



5. **NOTE:** Before installing the IPR, inspect and lubricate the O-ring seal with clean engine oil.
   NOTE: Hand-tighten both bolts before tightening to specification.
   To install, reverse the removal procedure.

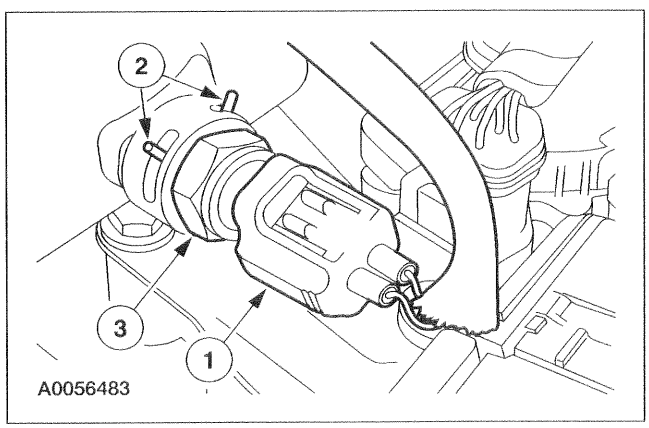
Engine Coolant Temperature (ECT) Sensor

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

2. Partially drain the cooling system. For additional information, refer to Section 303-03.

3. Remove the engine coolant temperature (ECT) sensor.
   1 Disconnect the electrical connector.
   2 Remove the retaining clip.
   3 Remove the ECT sensor.



REMOVAL AND INSTALLATION (Continued)

4. To install, reverse the removal procedure.

Mass Air Flow (MAF) Sensor

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.

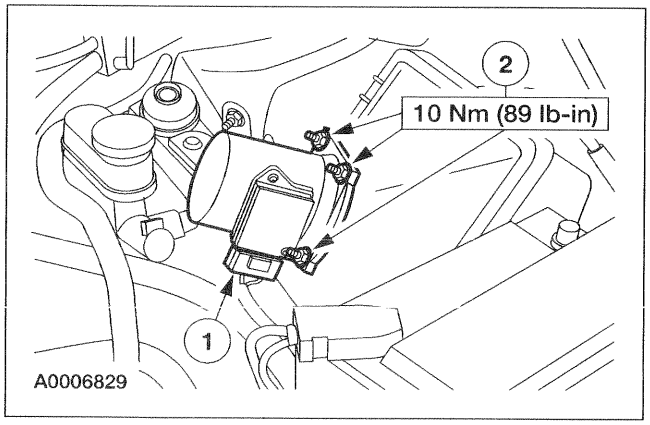
2. Remove the air cleaner outlet tube. For additional information, refer to Section 303-12.

3. **CAUTION: The mass air flow (MAF) is a calibrated unit. Service hot wire element and housing as a complete assembly. Hot wire element should never be cleaned or installed separately. Installing only the element may change the airflow calibration.**

   Remove the MAF sensor.

   1 Disconnect the electrical connector.

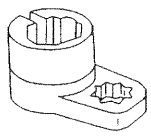
   2 Remove the four nuts and the MAF sensor.



4. To install, reverse the removal procedure.

Heated Oxygen Sensor (HO2S)

Special Tool(s)

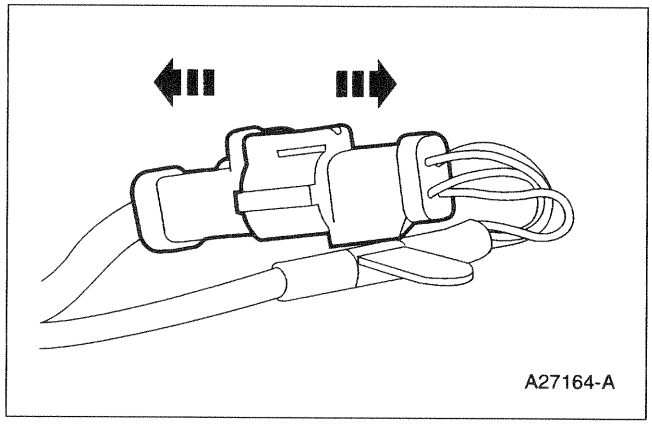
 ST1447-A	Socket, Exhaust Gas Oxygen Sensor 303-476 (T94P-9472-A)

Material

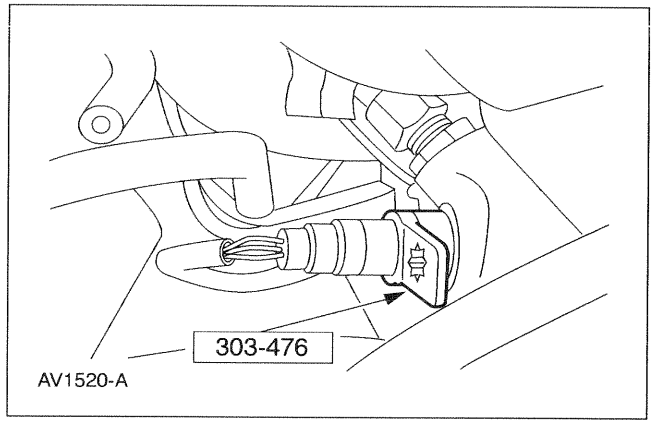
Item	Specification
Penetrating and Lock Lubricant E8AZ-19A501-B	N/A
High Temperature Nickel Anti-Seize Lubricant F6AZ-9L494-AA	ESE-M12A4-A

Removal and Installation

1. Disconnect the HO2S electrical connector.

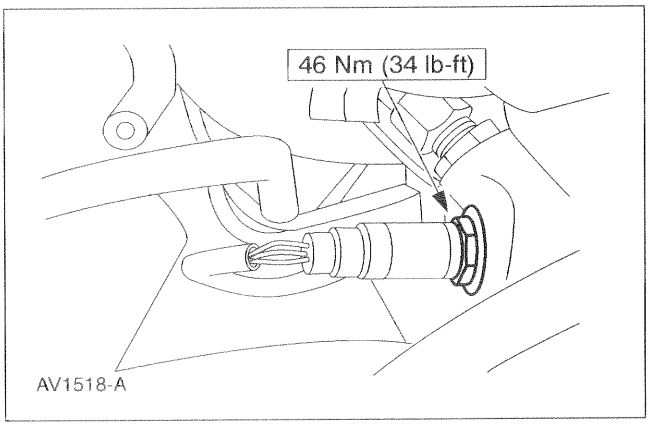


2. Remove the HO2S from the exhaust manifolds using the special tool.
   - If necessary, lubricate the heated oxygen sensors with lock lubricant to assist in removal.



REMOVAL AND INSTALLATION (Continued)

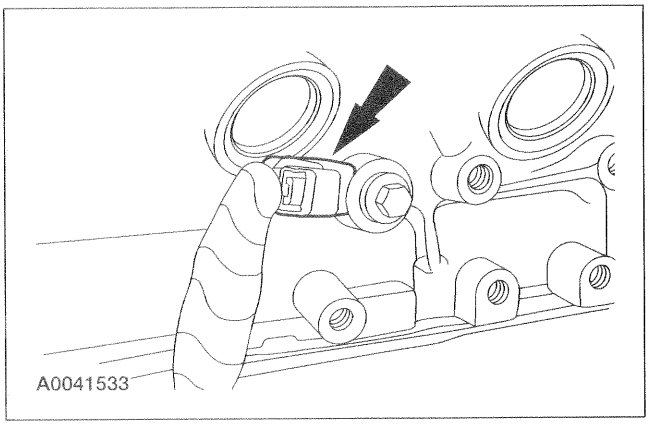
3. To install, reverse the removal procedure.
   - Apply a light coat of anti-seize lubricant to the threads of the heated oxygen sensors (HO2S).



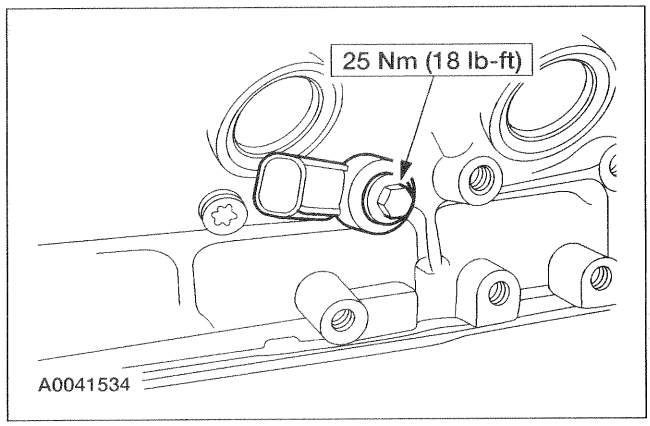
Knock Sensor (KS) — 3.0L (2V)

Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Raise and support the vehicle. For additional information, refer toSection 100-02.
3. Disconnect the KS electrical connector.



4. Remove the bolt and the KS.

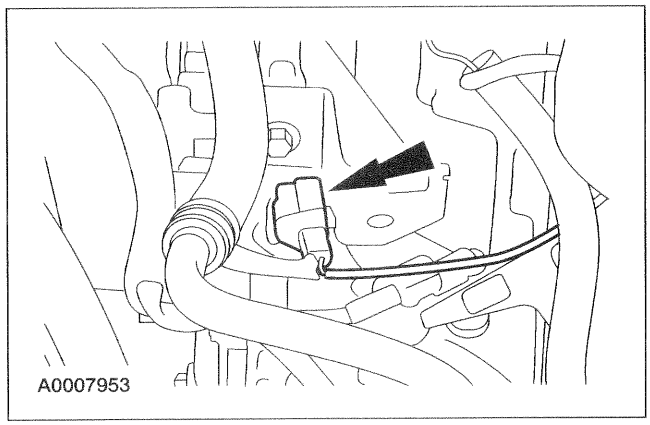


5. To install, reverse the removal procedure.

Knock Sensor (KS) — 3.0L (4V)

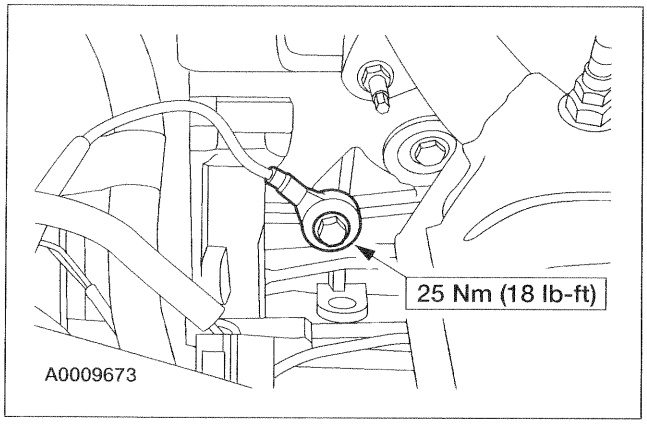
Removal and Installation

1. Disconnect the battery ground cable. For additional information, refer to Section 414-01.
2. Raise and support the vehicle. For additional information, refer to Section 100-02.
3. Disconnect the knock sensor (KS) electrical connector.



REMOVAL AND INSTALLATION (Continued)

4. Remove the bolt and the KS.



5. To install, reverse the removal procedure.

Notes

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