Power Products

The Source for Power...
Worldwide™

ESG-642
4.2 LITER

INDUSTRIAL ENGINE SERVICE MANUAL

FPP-194-309
April, 2001

Power
Products

The Source for Power...
Worldwide™

Ford Power Products
28333 Telegraph Rd., Suite 300
Southfield, MI 48034
248 945 4500
(Fax) 248 945 4501

Ford Power Products, LTD
20/586 Arisdale Avenue
South Ockendon
Essex, RM 15 5TJ England
44 1708 672 415
(Fax) 44 1708 672 815

Ford Power Products, GmbH
Stolberger Str. 313
D-50933 Köln, Germany
49 221 94700 551
(Fax) 49 221 94700 560

HEALTH & SAFETY

⚠ WARNING: THE FOLLOWING HEALTH AND SAFETY RECOMMENDATIONS SHOULD BE CAREFULLY OBSERVED.

CARRYING OUT CERTAIN OPERATIONS AND HANDLING SOME SUBSTANCES CAN BE DANGEROUS OR HARMFUL TO THE OPERATOR IF THE CORRECT SAFETY PRECAUTIONS ARE NOT OBSERVED. SOME SUCH PRECAUTIONS ARE RECOMMENDED AT THE APPROPRIATE POINTS IN THIS BOOK.

WHILE IT IS IMPORTANT THAT THESE RECOMMENDED SAFETY PRECAUTIONS ARE OBSERVED, CARE NEAR MACHINERY IS ALWAYS NECESSARY, AND NO LIST CAN BE EXHAUSTIVE. ALWAYS BE CAUTIOUS TO AVIOD POTENTIAL SAFETY RISKS.

The following recommendations are for general guidance:

1. Always wear correctly fitting protective clothing which should be laundered regularly. Loose or baggy clothing can be extremely dangerous when working on running engines or machinery. Clothing which becomes impregnated with oil or other substances can constitute a health hazard due to prolonged contact with the skin even through underclothing.

2. So far as practicable, work on or close to engines or machinery only when they are stopped. If this is not practicable, remember to keep tools, test equipment and all parts of the body well away from the moving parts of the engine or equipment—fans, drive belts and pulleys are particularly dangerous. The electric cooling fan used on some installations is actuated automatically when the coolant reaches a specified temperature. For this reason, care should be taken to ensure that the ignition/isolating switch is OFF when working in the vicinity of the fan as an increase in coolant temperature may cause the fan suddenly to operate.

3. Avoid contact with exhaust pipes, exhaust manifolds and silencers when an engine is, or has recently been running; these can be very hot and can cause severe burns.

4. Many liquids used in engines or vehicles are harmful if taken internally or splashed into the eyes. In the event of accidentally swallowing gasoline (petrol), oil, diesel fuel, antifreeze, battery acid etc, DO NOT ENCOURAGE VOMITING AND OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

Wear protective goggles when handling liquids which are harmful to the eyes; these include ammonia and battery acid. If any of these substances are splashed in the eyes, wash out thoroughly with clean water and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

⚠ WARNING: ⚠

The Engine Exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all industrial engines as well as the personal safety of the individual doing the work. This Service Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

Section Index

Ford Power Products policy is one of continuous improvement and while every effort is made to ensure that this publication is up to date and correct in all respects, the right to change prices, specifications and equipment at any time without notice is reserved. Accordingly this publication is not to be regarded as a final description of any individual engine.

INDEX

DESCRIPTION

Introduction

This section covers various engine tests, adjustments, service procedures and cleaning/ inspection procedures. Engine assembly and service specifications appear at the end of the Section 02.

For engine disassembly, assembly, installation, adjustment procedures and specifications, refer to Section 02.

The ESG 642 engine incorporates a closed-type crankcase ventilation system.

To maintain the required performance level, the fuel system, ignition system and engine must be kept in good operating condition and meet recommended adjustment specifications.

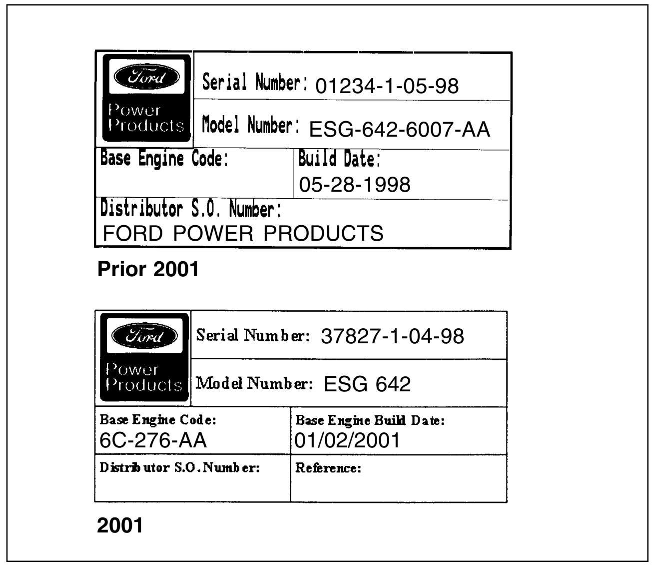
Before replacing damaged or worn engine components such as the crankshaft, cylinder head, valve guide, valves, camshaft or cylinder block, make sure part(s) is not serviceable.

WARNING: TO AVOID THE POSSIBILITY OF PERSONAL INJURY OR DAMAGE, DO NOT OPERATE THE ENGINE UNTIL THE FAN BLADE HAS FIRST BEEN EXAMINED FOR POSSIBLE CRACKS OR SEPARATION.

CAUTION: Use of abrasive grinding discs to remove gasket material from the engine sealing surfaces during repair procedures can contribute to engine damage and wear. Airborne debris and abrasive grit from the grinding disc may enter the engine through exposed cavities causing premature wear and eventual engine damage.

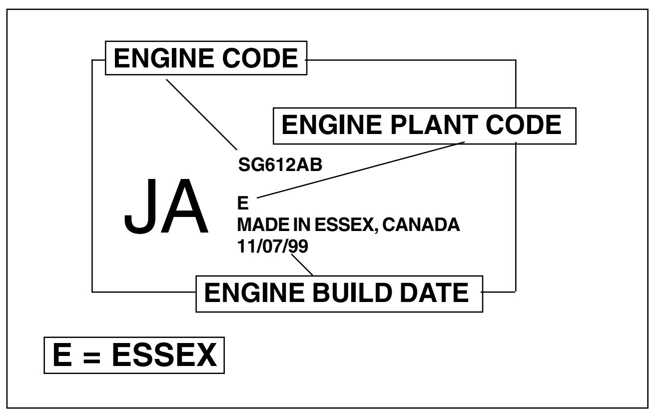
Ford Power Products does not recommend using abrasive grinding discs to remove engine gasket material. Use manual gasket scrapers for removing gasket material from the engine sealing surfaces.

Take added care to prevent scratching or gouging aluminum sealing surfaces.



Engine Identification Nameplate

For quick engine identification, refer to the Engine Identification Nameplate. The nameplates lists engine information required for proper servicing of the engine. The Engine Identification Nameplate and identification label provide information pertaining to engine displacement, serial number, model number, S.O./Options, and model code.



Engine Code Decal

An engine code decal is attached to the engine front cover. The symbol code on the decal identifies each engine for determining parts usage.

SAFETY NOTICE

There are numerous variations in procedures, techniques, tools and parts for servicing equipment, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that neither personal safety nor equipment integrity are compromised by the choice of methods, tools or parts.

NOTES, CAUTIONS, AND WARNINGS

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES gives you added information that will help you to complete a particuar procedure. CAUTIONS are given to prevent you from making an error that could damage the equipment. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on the equipment.

GENERAL WARNINGS:

TO HELP AVOID INJURY:

- **ALWAYS WEAR SAFETY GLASSES FOR EYE PROTECTION.**
- **USE SAFETY STANDS WHENEVER A PROCEDURE REQUIRES YOU TO BE UNDER THE EQUIPMENT.**
- **BE SURE THAT THE IGNITION SWITCH IS ALWAYS IN THE OFF POSITION, UNLESS OTHERWISE REQUIRED BY THE PROCEDURE.**
- **SET THE PARKING BRAKE (IF EQUIPPED) WHEN WORKING ON THE EQUIPMENT. IF YOU HAVE AN AUTOMATIC TRANSMISSION, SET IT IN PARK (ENGINE OFF) OR NEUTRAL (ENGINE ON) UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. PLACE WOOD BLOCKS (4"X 4" OR LARGER) TO THE FRONT AND REAR SURFACES OF THE TIRES TO PROVIDE FURTHER RESTRAINT FROM INADVERTENT EQUIPMENT MOVEMENT.**
- **OPERATE THE ENGINE ONLY IN A WELL VENTILATED AREA TO AVOID THE DANGER OF CARBON MONOXIDE.**
- **KEEP YOURSELF AND YOUR CLOTHING AWAY FROM MOVING PARTS WHEN THE ENGINE IS RUNNING, ESPECIALLY THE FAN BELTS.**
- **TO PREVENT SERIOUS BURNS, AVOID CONTACT WITH HOT METAL PARTS SUCH AS THE RADIATOR, EXHAUST MANIFOLD, TAIL PIPE, CATALYTIC CONVERTER AND MUFFLER.**
- **DO NOT SMOKE WHILE WORKING ON THE EQUIPMENT.**
- **ALWAYS REMOVE RINGS, WATCHES, LOOSE HANGING JEWELRY, AND LOOSE CLOTHING BEFORE BEGINNING TO WORK ON THE EQUIPMENT. TIE LONG HAIR SECURELY BEHIND THE HEAD.**
- **KEEP HANDS AND OTHER OBJECTS CLEAR OF THE RADIATOR FAN BLADES. ELECTRIC COOLING FANS CAN START TO OPERATE AT ANY TIME BY AN INCREASE IN UNDERHOOD TEMPERATURES, EVEN THOUGH THE IGNITION IS IN THE OFF POSITION. THEREFORE, CARE SHOULD BE TAKEN TO ENSURE THAT THE ELECTRIC COOLING FAN IS COMPLETELY DISCONNECTED WHEN WORKING UNDER THE HOOD.**

Battery Handling and Charging

The handling and correct use of lead acid batteries is not as hazardous provided that sensible precautions are observed and that operatives have been trained in their use and are adequately supervised.

It is important that all labelling on the battery is carefully read, understood and complied with. The format of the following symbols and labels is common to most brands of lead acid battery.

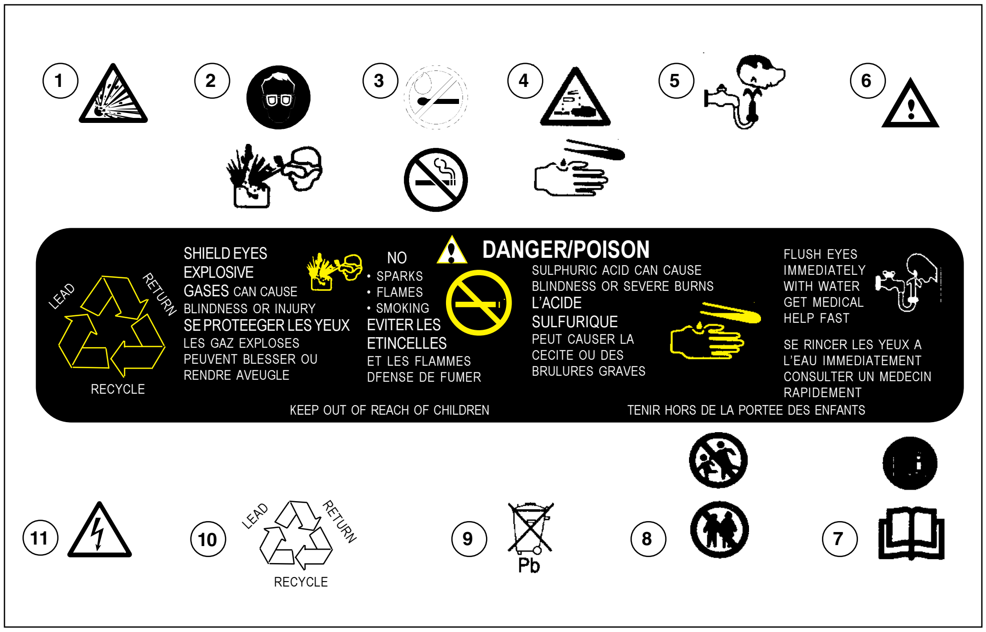


Fig. 1—Typical Battery Labelling

1. *Explosive gases*
2. *Eye protection must be WORN*
3. *No smoking or naked flames*
4. *Corrosive acid*
5. *Flush eyes immediately when contacted with acid*
6. *CAUTION/IMPORTANT notice*
7. *Read relevant instructions*
8. *Keep away from children*
9. *Do not dispose of as household waste*
10. *Recycle (via recognized disposal system)*
11. *Electrical current may cause injury to personnel.*

NOTE: Observe all manufacturers' instructions when using charging equipment.

CAUTION: **Batteries should not be charged in the vehicle or equipment. May damage electrical components**

FOREWORD

This book contains operating and maintenance instructions for the engine(s) listed on the title page.

The life of your engine unit and the delivery of the high performance built into it will depend on the care it receives throughout its life. It is the operator's responsibility to ensure that the engine is correctly operated and that the maintenance operations outlined in this book are carried out regularly after the specified hours of operation have been reached. We consider it to be in your interests to enlist the aid of an authorized Ford Dealer (Europe) or Ford Power Products Distributor (USA) not only when repairs are required but also for regular maintenance. Distributors are listed at the back of this manual.

Regular maintenance will result in minimal operating costs.

Engines manufactured by Ford Motor Company are available through Ford Power Products Dealers or Distributors. When in need of parts or service, contact your local Authorized Dealer or Distributor. In overseas territories, in the event of difficulties, communicate directly with the supervising Ford affiliated Company in your area whose address appears at the end of this book.

Where the terms "Right" or "Left" occur in this publication, they refer to the respective sides of the engine when viewed from the rear or flywheel end.

Pistons and valves are numbered from the front or timing cover end of the engine commencing at No. 1.

You may find that your engine assembly includes optional equipment not specifically covered in the following text. Nevertheless, the maintenance procedures outlined in this book still apply to your engine.

ENGINE IDENTIFICATION

Because Ford Power Products markets such a wide range of industrial engines – manufactured both in the U.S. and overseas – it is important that you have as complete identification of the engine as possible in order to provide the correct replacement parts. New engines being shipped include a standard parts listing describing the parts which does not tell the owner the part number. It remains a distributor function to identify the part number. The key to identifying the engine is the identification decal mounted on the engine rocker cover. That decal provides not only the engine serial number, but also the exact model or type, options and S.O. (Special Order). The combination of that data permits you to isolate the precise engine, build level and customer so you can determine the correct replacement parts.

EUROPEAN SERVICE IDENTIFICATION PLATE

This plate (Fig. 2) is fixed to the engine in a prominent position. Panels 1 to 11 on the plate refer to various engine details as listed here.

Detail Title

1. Engine model identification.

2. Engine capacity.

3. Serial No: This identifies the engine as supplied by Power Products Engineering.

Date: The two letters following the serial No. indicate the year and month in which the specified build components were assembled - refer to the chart, Fig 3.

NOTE: These markings should not be confused with any that may be stamped or etched into the crankcase of the basic engine.

4. Selective Build Number indicates the complete specification. The digit to the extreme right hand side is the build chart issue number.

5. Engine operating rpm. An asterisk denotes speed set by customer.

6. Not applicable.

7. Not applicable.

8.
9. Applicable to diesel engines only.
10.

11. This box is provided for Equipment Manufacturers' use when extra equipment is fitted outside of the Ford Motor Company. Reference should be made to the Equipment Manufacturer for any information or parts required.

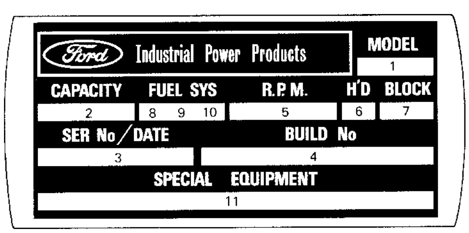


Fig. 2 – Service Identification Plate

1997	U	B	R	A	G	C	K	D	E	L	Y	S	T
1998	V	J	U	M	P	B	R	A	G	C	K	D	E
1999	W	L	Y	S	T	J	U	M	P	B	R	A	G
2000	X	C	K	D	E	L	Y	S	T	J	U	M	P
2001	Y	B	R	A	G	C	K	D	E	L	Y	S	T
2002	Z	J	U	M	P	B	R	A	G	C	K	D	E

Fig. 3 – Build Date Chart

NOTES: The letters I, O and Q are not used in the year column. The letter representing the month repeats every five years.

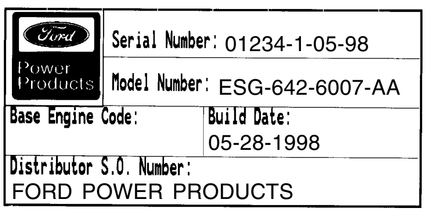
U.S.A. ENGINE IDENTIFICATION DECAL

An identification Decal is affixed to the valve cover of the engine. The decal contains the engine serial number which identifies this unit from all others. Use all numbers when seeking information or ordering replacement parts for this engine.
01 - Serial Number: Has a total of 10 numbers.
02 - Model Number

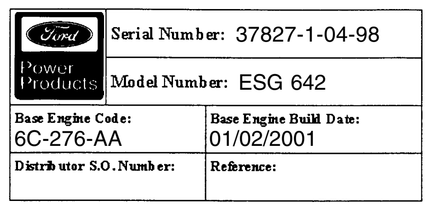
For a handy reference, this information is recorded on your Ford Power Products Operations Engine Registration copy (Form #194-103-D).

PARTS AND SERVICE
Replacement parts can be obtained through your local Ford Power Products Distributors or Dealers listed in the back portion of this handbook. They also may be found in the yellow pages under “Engines” or contact Ford Power Products: 1-800 833-4773 U.S.A., 49221-94700551 Europe, or 441708-858415 Great Britain.

Ford Power Products Distributors and Dealers are equipped to perform major and minor repairs. They are anxious to see that all of your maintenance and service needs are quickly and courteously completed.



Prior 2001



2001

DESCRIPTION AND OPERATION

Engine System

This section covers general procedures and diagnosis and testing of the engine system, including exhaust emission control devices, which are also covered in the EFI Diagnostic Manual.[1]

The engines incorporate the following features:

• A closed positive crankcase ventilation (PCV) system.

• An exhaust emission control system.

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 Maintenance and Operator's Manual 194-308 or call 1-800-833-4773 for the nearest Ford Power Product's Distributor/Dealer. They are also listed in the back section of this manual.

Correct engine identification is required to order parts.

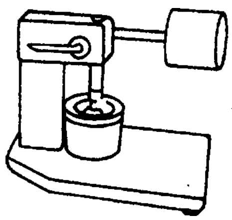
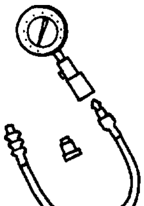
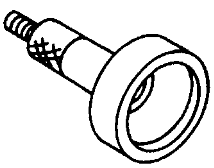
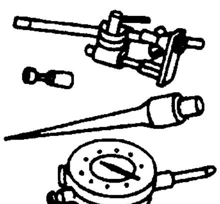
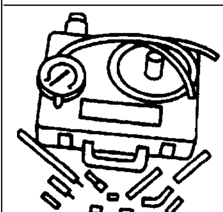
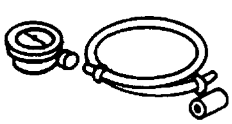
For complete vehicle and engine identification codes, refer to this Section.

[1] Can be purchased as a separate item PFF-194-306 from your nearest Ford Power Products Distributor/Dealer listed in back section of this manual.

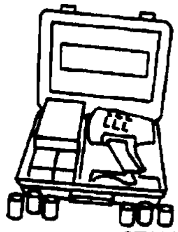
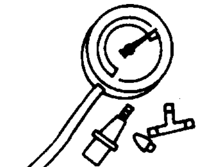
DIAGNOSIS AND TESTING

Engine System

Special Tool(s)

	Commercially Available Leakdown Tester
 ST1299-A	Compression Tester 014-00707 or Equivalent
 ST1272-A	Cup Shaped Adapter TOOL-6565-AB or Equivalent
 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent
 ST1298-A	Engine Cylinder Leak Detection/Air Pressurization Kit 014-00705 or Equivalent
 ST1296-A	Engine Oil Pressure Gauge T73L-6600-A

Special Tool(s)

 ST1300-A	12 Volt Master UV Diagnostic Inspection Kit 164-R0756 or Equivalent
 ST1297-A	Vacuum/Pressure Tester 164-R0253 or Equivalent

Inspection and Verification

1. Verify the customer concern by operating the engine to duplicate the condition.

2. Visually inspect for obvious signs of mechanical and electrical damage. Refer to the following chart.

Visual Inspection Chart

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

3. If the inspection reveals obvious concerns that can be readily identified, repair as required.

4. If the concerns remain after the inspection, determine the symptoms and go to the symptom chart.

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

DIAGNOSIS AND TESTING

Symptom Chart

ENGINE OPERATION

Condition	Possible Source	Action
• Difficult Starting	• Damaged starting system. • Damaged charging system/ battery. • Burnt valve. • Worn piston. • Worn piston rings. • Worn cylinder. • Damaged cylinder head gasket. • Damaged fuel system. • Damaged ignition system.	• REFER to Section 07 • REFER to Section 06 • REPLACE valve. • REPLACE piston and pin. • REPAIR or REPLACE cylinder blocks. • REPLACE cylinder head gasket. • Refer to Section 04. • Refer to Section 03.
• Poor Idling	• Damaged hydraulic valve tappet or hydraulic lash adjuster. • Damaged hydraulic valve tappet guide or hydraulic lash adjuster. • Improper valve-to-valve seat contact. • Damaged cylinder head gasket. • Malfunctioning or damaged fuel system. • Malfunctioning or damaged ignition system. • Malfunctioning or damaged IAC motor or system.	• REPLACE hydraulic valve tappet or hydraulic lash adjuster. • REPLACE hydraulic valve tappet guide or hydraulic lash adjuster. • REPLACE valve or valve seat. • REPLACE cylinder head gasket. • Refer to EFI Diagnostic Manual or Section 04 of this manual[2]. • Refer to EFI Diagnostic Manual or Section 03 of this manual[2]. • Section 03 of this manual.
• Abnormal Combustion	• Damaged hydraulic valve tappet or hydraulic lash adjuster. • Damaged hydraulic valve tappet guide or hydraulic lash adjuster. • Burnt or sticking valve. • Weak or broken valve spring. • Carbon accumulation in combustion chamber. • Malfunctioning or damaged fuel system. • Malfunctioning or damaged ignition system.	• REPLACE hydraulic valve tappet or hydraulic lash adjuster. • REPLACE hydraulic valve tappet guide or hydraulic lash adjuster. • REPAIR or REPLACE valve. • REPLACE valve spring. • ELIMINATE carbon buildup. • Refer to EFI Diagnostic Manual or Section 04 of this manual[2]. • Refer to EFI Diagnostic Manual or Section 03 of this manual[2].

[2] Can be purchased as a separate item PFF-194-306 from your nearest Ford Power Products Distributor/Dealer listed in back section of this manual.

DIAGNOSIS AND TESTING (Continued)

ENGINE OPERATION

Condition	Possible Source	Action
• Excessive Oil Consumption	• Worn piston ring groove. • Sticking piston rings. • Worn piston or cylinders. • Worn valve stem seal. • Worn valve stem or valve guide. • Leaking oil.	• REPLACE piston and pin. • REPAIR or REPLACE piston rings. • REPAIR or REPLACE piston or cylinder blocks. • REPLACE valve stem seal. • REPLACE valve stem and guide. • REPAIR oil leakage.
• Engine Noise	• Excessive main bearing oil clearance. • Seized or heat damaged main bearing. • Excessive crankshaft end play. • Excessive connecting rod bearing oil clearance. • Heat damaged connecting rod bearing. • Damaged connecting rod bushing. • Worn cylinder. • Worn piston or piston pin. • Damaged piston rings. • Bent connecting rod. • Malfunctioning hydraulic valve tappet or hydraulic lash adjuster. • Excessive hydraulic valve tappet or hydraulic lash adjuster clearance. • Broken valve spring. • Excessive valve guide clearance. • Malfunctioning or damaged cooling system. • Malfunctioning or damaged fuel system. • Leaking exhaust system. • Improper drive belt tension. • Malfunctioning generator bearing. • Loose timing chain/belt. • Damaged timing belt tensioner. • Malfunctioning water pump bearing.	• ADJUST clearance or REPLACE main bearing. • REPLACE main bearing. • REPLACE crankshaft thrust main bearing. • REPLACE connecting rod. • REPLACE connecting rod bearing. • REPLACE connecting rod bushing. • REPAIR or REPLACE cylinder blocks. • REPLACE piston or piston pin. • REPLACE piston rings. • REPLACE connecting rod. • REPLACE hydraulic valve tappet or hydraulic lash adjuster. • ADJUST clearance or REPLACE hydraulic valve tappet guide or hydraulic lash adjuster. • REPLACE valve spring. • REPAIR clearance or REPLACE valve guide/stem. • REFER to Section 05. • Refer to Section 04. • REPAIR exhaust leakage. • REFER to Section 05. • REFER to Section 06 for diagnosis and testing of the generator. • ADJUST or REPLACE timing chain/belt. • REPLACE timing belt tensioner. • Replace water pump.

DIAGNOSIS AND TESTING (Continued)

ENGINE OPERATION

Condition	Possible Source	Action
• Insufficient Power	• Malfunctioning hydraulic valve tappet or hydraulic lash adjuster. • Damaged hydraulic valve tappet guide or hydraulic lash adjuster. • Compression leakage at valve seat. • Seized valve stem. • Weak or broken valve spring. • Damaged cylinder head gasket. • Cracked or distorted cylinder head. • Damaged, worn or sticking piston ring(s). • Worn or damaged piston. • Malfunctioning or damaged fuel system. • Malfunctioning or damaged ignition system. • Damaged or plugged exhaust system.	• REPLACE hydraulic valve tappet or hydraulic lash adjuster. • REPLACE hydraulic valve tappet guide or hydraulic lash adjuster. • REPAIR or REPLACE valve, valve seat or cylinder head. • REPLACE valve stem. • REPLACE valve spring. • REPLACE cylinder head gasket. • REPLACE cylinder head. • REPAIR OR REPLACE piston ring(s). • REPLACE piston. • Refer to Section 04. • Refer to Section 03. • REPAIR OR REPLACE exhaust system.

Component Tests

Engine Oil Leaks

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

Prior to performing this procedure, clean the cylinder block, cylinder heads, valve covers (6582), oil pan (6675) and flywheel (6375) with a suitable solvent to remove all traces of oil.

Fluorescent Oil Additive Method
Use the 12 Volt Master UV Diagnostic Inspection Kit to perform the following procedure for oil leak diagnosis.

1. Clean the engine with a suitable solvent to remove all traces of oil.
2. Drain engine oil crankcase and refill with recommended oil, premixed with Diesel Engine Oil Dye 164-R3705 meeting Ford specification ESE-M9C103-B1 or equivalent. 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.
3. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the 12 Volt Master UV diagnostic Inspection 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)

4. If necessary, pressurize the main oil gallery system to locate leaks due to improperly sealed, loose or cocked plugs.

5. Repair all leaks as required.

Pressure Method

The crankcase can be pressurized to locate oil leaks. The following materials are required to fabricate the tool to be used:

- air supply and air hose
- air pressure gauge that registers pressure in 4 kPa (1 psi) increments
- air line shutoff valve
- appropriate fittings to attach the above parts to oil fill, PCV grommet hole and crankcase ventilation tube (6758)
- appropriate plugs to seal any openings leading to the crankcase
- a solution of liquid detergent and water to be applied with a suitable applicator such as a squirt bottle or brush

Fabricate the air supply hose to include the air line shutoff valve and the appropriate adapter to permit the air to enter the engine through the crankcase ventilation tube. Fabricate the air pressure gauge to a suitable adapter for installation on the engine at the oil filler opening.

Testing Procedure

- Open the air supply valve until the pressure gauge maintains 34 kPa (5 psi).
- Inspect sealed or gasketed areas for leaks by applying a solution of liquid detergent and water over areas for formation of bubbles which indicates leakage.

Leakage Points

Examine the following areas for oil leakage.

- valve cover gaskets (6584)
- intake manifold gaskets (9461)
- cylinder head gaskets
- oil bypass filter (6714)
- oil pump and filter body (6603)
- oil level indicator tube connection
- oil pressure sensor (9278)

Under Engine

- 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 pump and filter body (4.2L engine)

With Transmission and Flywheel Removed

NOTE: Air leakage in the area around a crankshaft rear oil seal does not necessarily indicate a crankshaft rear oil seal leak. However, if no other cause can be found for oil leakage, assume that the crankshaft rear oil seal is the cause of the oil leak.

NOTE: Light foaming equally around valve cover bolts and crankshaft seals is not detrimental; no repairs are required.

- crankshaft rear oil seal
- rear main bearing cap partling 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 pressurizing the crankcase.

Compression Tests

Compression Gauge Check

1. Make sure the oil in the crankcase is of the correct viscosity and at the proper level and that the battery (10655) is properly 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.

DIAGNOSIS AND TESTING (Continued)

3. Install a Compression Tester in the No. 1 cylinder.

4. Install an auxiliary starter switch in the starting circuit. With the ignition switch (11572) 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.

Test Results

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

Compression Pressure Limit Chart

Maximum psi	Minimum psi	Maximum psi	Minimum psi	Maximum psi	Minimum psi	Maximum psi	Minimum psi
924 kPa (134 psi)	696 kPa (101 psi)	1131 kPa (164 psi)	848 kPa (123 psi)	1338 kPa (194 psi)	1000 kPa (146 psi)	1154 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)
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)	1225 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)	872 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 clean engine oil meeting Ford specification ESE-M2C153-E on top of the pistons in the low-reading cylinders. Repeat the compression pressure check on these cylinders.

Interpreting Compression Readings

1. If compression improves considerably, piston rings are faulty.

2. If compression does not improve, valves are sticking or seating improperly.

DIAGNOSIS AND TESTING (Continued)

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.

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 blocks or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator (8005).

Oil Leak and Valve Stem Seal Test

The cylinder leakage detector tests for engine oil leaks and checks the valve stem seals for leakage.

1. Plug all crankcase openings except the one used for connecting the leakage detector.
2. Connect the Engine Cylinder Leak Detection/ Air Pressurization Kit to a crankcase opening (an oil level indicator tube (6754) is convenient). Adjust the air pressure to approximately 34 kPa (5psi).
3. Using a solution of liquid soap and water, brush the solution along the gasket sealing surfaces and bearing seals. Look for bubbles or foam.
4. Remove the spark plugs and rotate the crankshaft slowly with a wrench. Check for large amounts of air escaping into the cylinders as each intake valve and exhaust valve opens.
5. The spark plugs on the leaking cylinders will probably show deposits of burned oil.

Intake Manifold Vacuum Test

Bring the engine to normal operating temperature. Connect the Vacuum/Pressure Tester to the intake manifold (9424). 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.

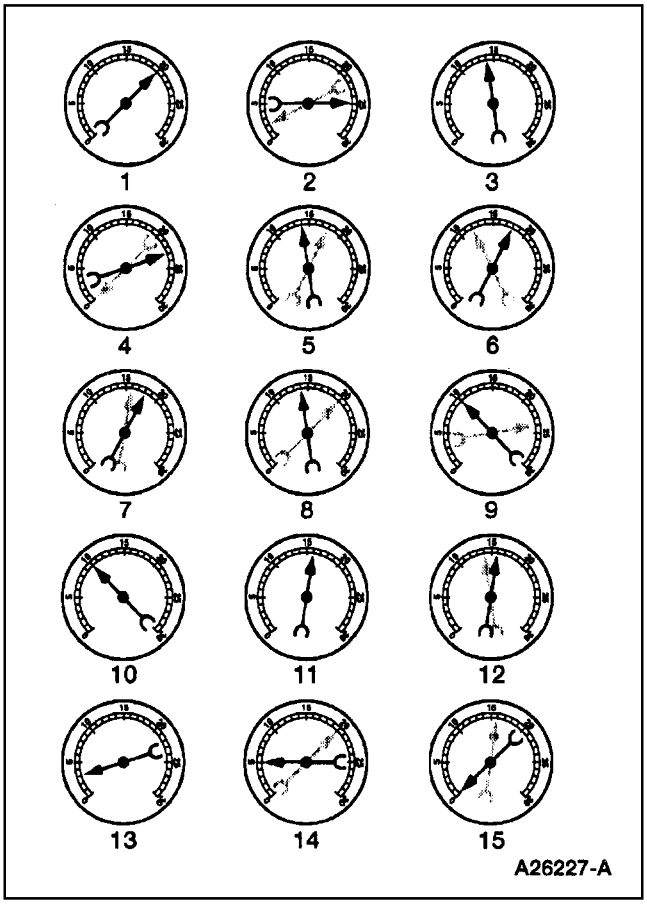
Interpreting Vacuum Gauge Readings

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 DEACCELERATION: 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.

DIAGNOSIS AND TESTING (Continued)

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, 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.

    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 340 hours or 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:

• severe loading applications

• sustained high speed operation

Engines need oil to lubricate the following internal components:

• cylinder block cylinder walls

• pistons, piston pins 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 engine 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 size

• operator driving habits

• ambient temperature

• quality and viscosity of the oil

Operating under varying conditions can frequently be misleading. An engine that has been run for short hours or in below-freezing ambient temperatures may have consumed a “normal” amount of oil. However, when checking engine oil level, it may measure up to the full mark on the oil level dipstick (6750) due to dilution (condensation and fuel) in the engine crankcase. The engine might then be run at high speeds 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 3 to 3-1/2 hours. This perceived 3 to 3-1/2 hours per liter (quart) oil consumption rate causes customer concern even though the actual overall oil consumption rate is about 50 hours per liter (quart).

Make sure the selected engine oil meets Ford specification WSS-M2C153-F and the recommended API performance category “SJ” or higher and SAE viscosity grade as shown in the equipment Owner’s or Operators Engine handbook. It is also important that the engine oil is changed at the intervals specified. Refer to the Vehicle Owner’s Guide or Engine Operator’s handbook.

Oil Consumption Test

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

DIAGNOSIS AND TESTING (Continued)

1. **NOTE:** Oil use is normally greater during the first 300 hours of service. As hours increase, oil use generally decreases. Vehicles in normal service should get at least 30 hours per liter (900 miles per quart) after 300 hours of service. High speeds, heavy loads, high ambient temperature and other factors may result in greater oil use.

   Define excessive oil consumption, such as the number of hours per liter (quart) of oil used. Also determine customer's engine load habits, such as sustained high speed operation, extended idle, heavy work loads 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.

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 the top of the cross-hatched area and the letter F in FULL. If significantly overfilled, perform steps 5a through 5d.

5. Perform an oil consumption test:

   a. Drain the engine oil, remove the oil bypass filter 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. **NOTE:** (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. 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 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. This level may range from slightly below the top of the cross-hatched area to slightly below the letter F in FULL.

   e. Record the vehicle mileage or hours.

   f. Instruct the customer to run engine as usual and perform the following:

   - Check the oil level regularly at intervals of 3 to 3-1/2 hours.
   - Return to the service point when the oil level drops below the lower (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.

   g. Check the oil level under the same conditions and at the same location as in Steps 5c and 5d.

   - 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 hours run during the oil test by the result. This quantity is the approximate oil consumption rate in hours per liter or in hours per quart.

   h. If the oil consumption rate is unacceptable, go to Step 6.

6. Check the positive crankcase ventilation (PCV) system. Make sure the system is not plugged.

7. Check for plugged oil drain-back holes in the cylinder heads and cylinder blocks.

8. If the condition still exists after performing the above steps, go to Step 9.

DIAGNOSIS AND TESTING (Continued)

9. 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.

10. **NOTE:** After determining if worn parts should be replaced, make sure correct replacement parts are used.

    Check valve guides for excessive guide clearances. REPLACE all valve stem seals after verifying valve guide clearance.

11. 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, cylinder heads, oil pan and oil pump (6600).

    b. Check piston ring clearance, ring gap and ring orientation. Repair as required.

    c. Check for excessive bearing clearance. Repair as required.

12. Perform the oil consumption test to confirm the oil consumption concern has been resolved.

Oil Pressure Test

1. Disconnect and remove the oil pressure sensor from the engine.

2. Connect the Engine Oil Pressure Gauge and Transmission Test Adapter to the oil pressure sender oil gallery port.

3. Run the engine until normal operating temperature is reached.

4. Run the engine at 3000 rpm and record the gauge reading.

5. The oil pressure should be within specifications.

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

Valve Train Analysis – Static (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.

Rocker Arm

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

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, hydraulic lash adjusters (HLA) or cylinder heads.

Camshaft – Overhead Camshaft Engines

- Check for broken or damaged parts.
- Check the bolts on the intake manifold.

Push Rods

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

Valve Springs

- Check for broken or damaged parts.

DIAGNOSIS AND TESTING (Continued)

Valve Spring Retainer and Valve Spring Retainer Keys

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

Valve Spring Retainer Keys

- Check for proper seating on the valve stem.

Valves and Cylinder Head

- Check the head gasket for proper installation.
- 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 – Dynamic

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

Rocker Arm

- Check for plugged oil in the rocker arms or cylinder head.
- Check for proper overhead valve train lubrication.

If insufficient oiling is suspected, accelerate the engine to 1200 rpm $\pm$ 100 rpm with the transmission in NEUTRAL or load removed and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and rocker arms are well oiled or, with the valve covers off, oil splash may overshoot the rocker arms. If oiling is insufficient for this to occur, check oil passages for blockage.

Push Rods

- Check for bent push rods and restriction in oil passage.

Positive Rotator and Valve Spring Retainer Keys

- Check for proper operation of positive rotator.

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.

If insufficient oiling is suspected, check oil passages for blockage, then accelerate the engine to 1200 rpm with the transmission in NEUTRAL or load removed 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 off, some oil splash may overshoot camshaft roller followers.

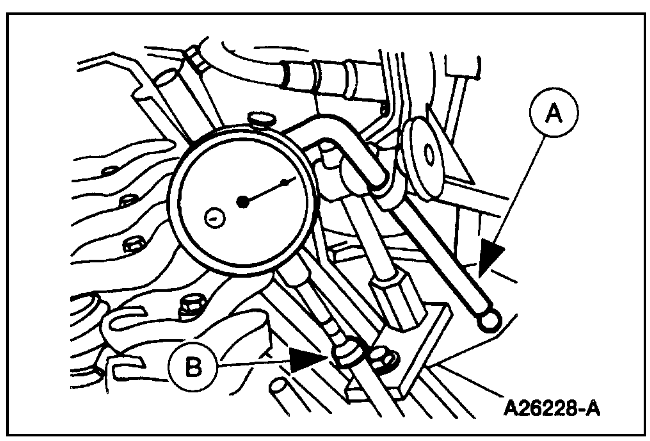
Camshaft Lobe Lift

OHV Engines

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



DIAGNOSIS AND TESTING (Continued)

3. Make sure the valve tappet is seated against camshaft (6250). Install the (A) dial Indicator with Bracketry so the ball socket adapter of the indicator is on top of the hydraulic lash adjuster or the (B) Cup Shaped Adapter is on top of the push rod and in the same plane as the valve tappet push rod movement.

4. Remove the spark plugs.

5. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch in the OFF position. Bump the crankshaft over until the hydraulic lash adjuster is on the base circle of the camshaft lobe. At this point, the hydraulic lash adjuster will be in its lowest position. If checking during engine assembly, turn the crankshaft using a socket or ratchet.

6. Zero the dial indicator. Continue to rotate the crankshaft slowly until the valve tappet is in the fully-raised position (highest indicator reading).

7. **NOTE:** If the lift on any lobe is below specified service limits, the camshaft and hydraulic lash adjuster operating on worn lobes must be replaced, as well as any hydraulic lash adjuster showing roller wear or needle bearing damage.

   Compare the total lift recorded on the dial indicator with specifications.

8. To check the accuracy of the original dial indicator reading, continue to rotate the crankshaft until the indicator reads zero.

9. Remove the dial indicator, adapter and auxiliary starter switch.

10. ⚠ **CAUTION: After installing rocker arms, do not rotate the crankshaft until valve tappets have had sufficient time to bleed down. To do otherwise may cause serious valve damage. Manually bleeding-down valve tappets will reduce waiting time.**

    Install the rocker arm seats, rocker arms and rocker arm seat bolts.

11. Install the valve covers.

12. Install the spark plugs.

Hydraulic Valve Tappet

Hydraulic valve tappet noise can be caused by any of the following:

- excessive collapsed valve tappet gap
- sticking valve tappet plunger
- valve tappet check valve not functioning properly
- air in lubrication system
- leakdown rate too rapid
- excessive valve guide wear

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, rocker arm, 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.

A sticking valve tappet plunger can be caused by dirt, chips or varnish inside the valve tappet.

A valve tappet check valve that is not functioning can be caused by an obstruction such as dirt or chips that prevent it from closing when the camshaft lobe is lifting the valve tappet. It may also be caused by a broken check valve spring.

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.

If the leakdown time is below the specified time for used valve tappets, noisy operation can result. If no other cause for noisy valve tappets can be found, the leakdown rate should be checked and any valve tappets outside the specification should be replaced.

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. Test the valve tappets as follows:

DIAGNOSIS AND TESTING (Continued)

Leakdown Testing

1. **NOTE:** Do not mix parts from different hydraulic lash adjusters (HLA). Parts are select-fit and are not interchangeable.

   Clean the valve tappet to remove all traces of engine oil.

2. **NOTE:** Valve tappets cannot be checked with engine oil in them. Use only testing fluid.

   Place the valve tappet in the tester with the plunger facing upward. Pour hydraulic tester fluid into a cup to a level that will cover the valve tappet. The fluid can be purchased from the tester's manufacturer. Using kerosene or any other fluid will not provide an accurate test.

3. Adjust the length of the ram so the pointer is 1.59 mm (0.062 inch) below the starting mark when the ram contracts the tappet plunger to facilitate timing as the pointer passes Start Timing mark.

   Use the center mark on the pointer scale as the Stop Timing point instead of the original Stop Timing mark at the top of the scale.

4. Work the valve tappet plunger up and down until the valve tappet fills with fluid and all traces of air bubbles have disappeared.

5. Allow the ram and weight to force the valve tappet plunger downward. Measure the exact time it takes for the pointer to travel from the Start Timing to Stop Timing marks of the tester.

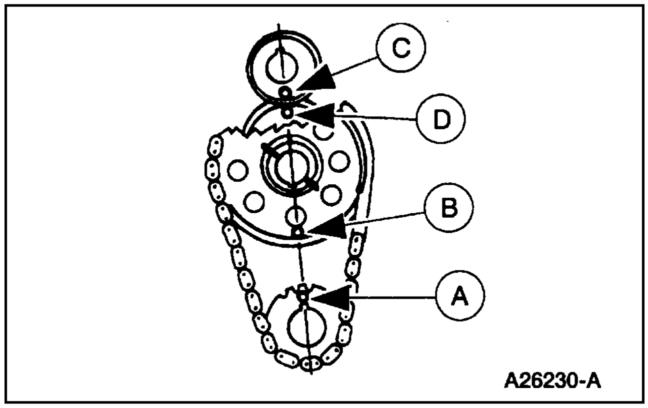
6. A satisfactory valve tappet must have a leakdown rate (time in seconds) within specified minimum and maximum limits.

7. If the valve tappet is not within specification, replace it with a new valve tappet. Do not disassemble and clean new valve tappets before testing because oil contained in the new valve tappets is test fluid.

8. Remove the fluid from the cup and bleed the fluid form the valve tappet by working the plunger up and down. This step will aid in depressing the valve tappet plungers when checking valve clearance.

Timing Chain

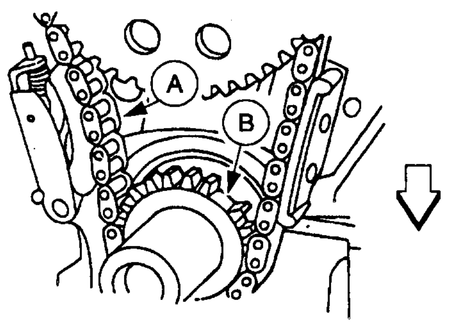
Refer to Section 02 for the removal and installation of timing chain belts, sprockets and tensioners.



Make sure the timing marks on the (A) crankshaft sprocket (6306) and (B) camshaft sprocket (6256) are positioned across from each other as shown in illustration. The (C) engine balance shaft driven gear (6A304) and (D) engine balance shaft drive gear (6A303) must be positioned as illustrated.

GENERAL SERVICE PROCEDURES

Sprockets



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.

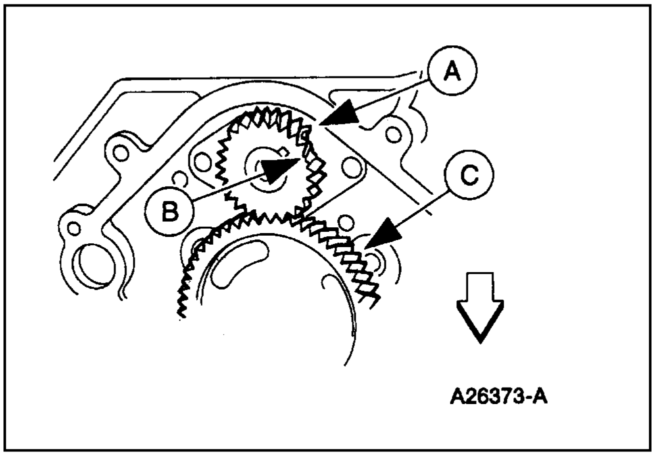
NOTE: If a component fails to meet the specifications, it is necessary to replace or refinish. If the component can be refinished, wear limits are provided as an aid to making a decision. Any component that fails to meet specifications and cannot be refinished must be replaced.

1. Inspect the (A) chain and the (B) sprockets.

   • Replace as necessary.

GENERAL SERVICE PROCEDURES (Continued)

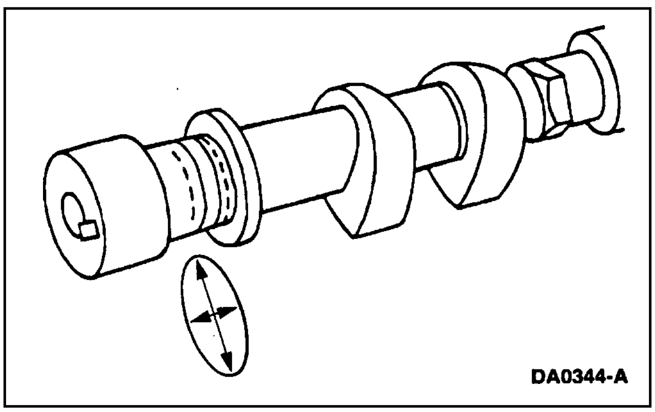
Gears



1. Inspect the (A) thrust plate, the (B) cam gear and the (C) crank gear.

   • Replace as necessary.

Camshaft Journal Diameter

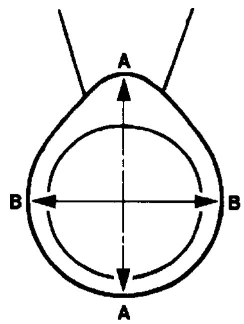


1. Measure each camshaft journal diameter in two directions.

   • If it is out of specification, replace as necessary.

GENERAL SERVICE PROCEDURES (Continued)

Camshaft Journal Clearance – OHV Engines



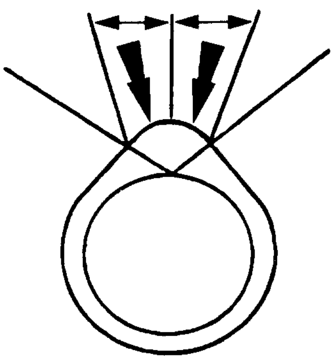
DA0345-A

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

   Measure each camshaft bearing in two directions.

   • Subtract the camshaft journal diameter from the camshaft bearing diameter

Camshaft Lobe Surface

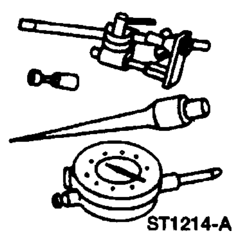

DA0350-A

1. Inspect camshaft lobes for pitting or damage in the active area. Minor pitting is acceptable outside the active area.

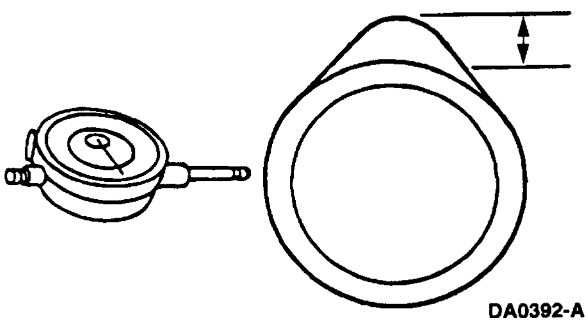
GENERAL SERVICE PROCEDURES (Continued)

Camshaft Lobe Lift

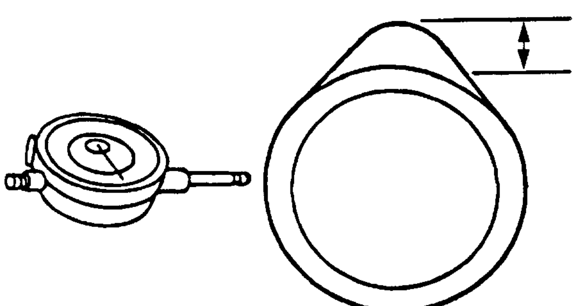
Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).


DA0392-A

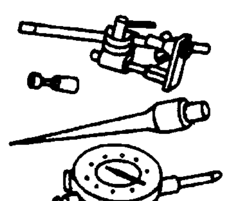
1. Use the Dial Indicator with Bracketry to measure camshaft intake lobe life.
   - Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the camshaft lobe lift.


DA0392-A

2. Use the Dial Indicator with Bracketry to measure camshaft exhaust lobe life.
   - Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the camshaft lobe lift.

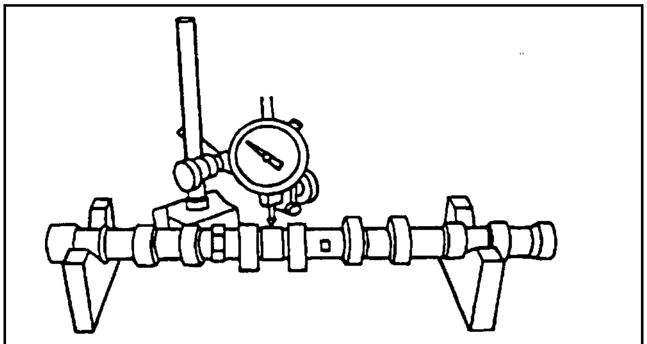
Camshaft Runout

Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

GENERAL SERVICE PROCEDURES (Continued)

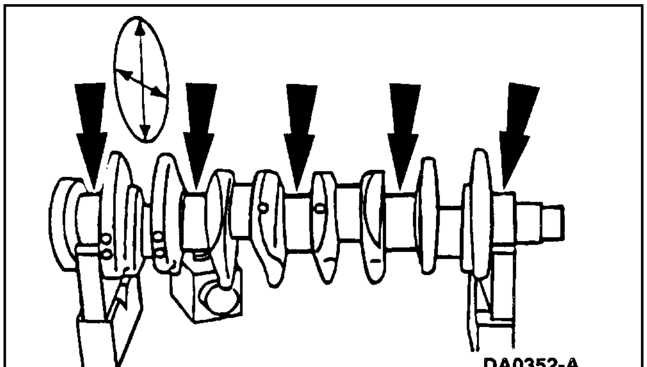


DA0351-A

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

1. Use the Dial Indicator with Bracketry to measure the camshaft runout.
   - Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading.

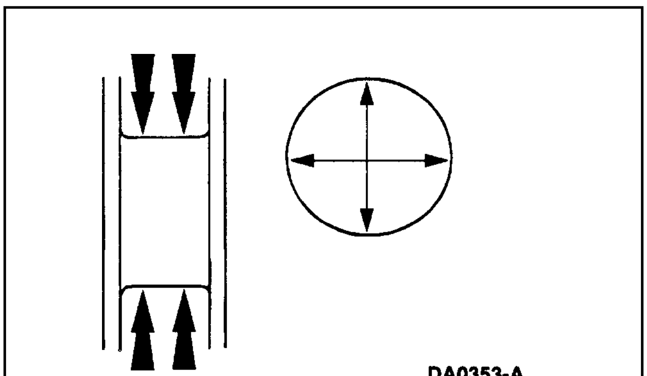
Crankshaft Main Bearing Journal Diameter



DA0352-A

1. Measure each of the crankshaft main bearing journal diameters in at least two directions.
   - If it is out of specification, replace as necessary.

Crankshaft Main Bearing Journal Taper



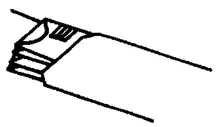
DA0353-A

1. Measure each of the crankshaft main bearing journal diameters in at least two directions at each end of the main bearing journal.
   - If it is out of specifications, replace as necessary.

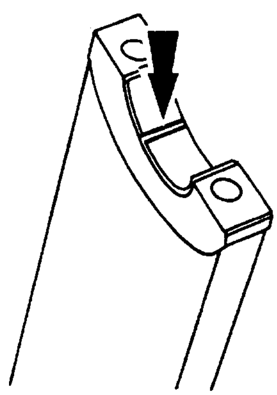
GENERAL SERVICE PROCEDURES (Continued)

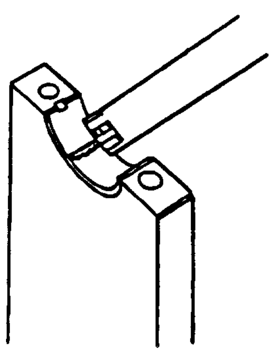
Crankshaft Main Bearing Journal Clearance

Special Tool(s)

 ST1280-A	Plastigage® D81L-6002-B or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).


A26392-A


DA0354-A

CAUTION: Before removing main bearing, the cylinder heads must be removed first on the ESG-642 engine. The main bearing and head bolts are torque to yield and must be discarded and replaced after this diagnostic test.

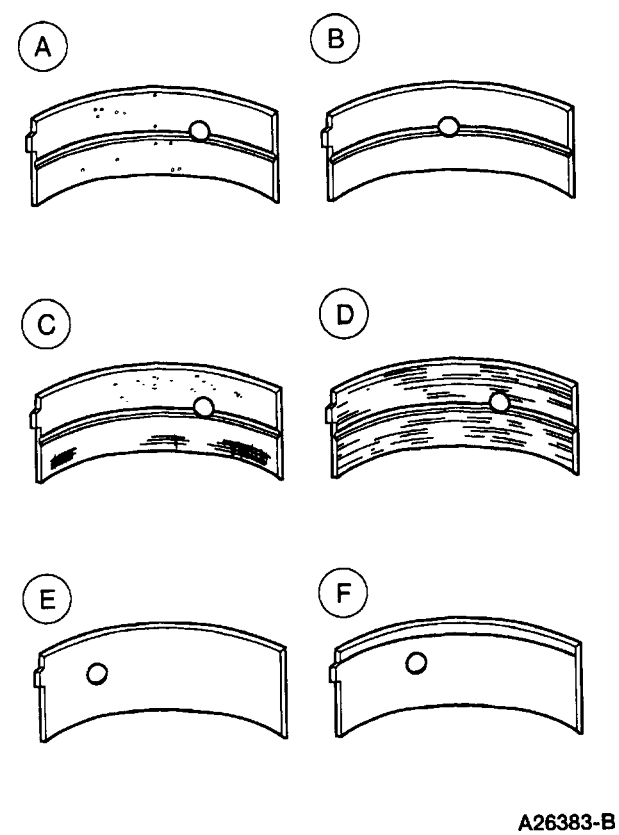
NOTE: Crankshaft main bearing journals must be within specifications before checking journal clearance.

1. Remove the crankshaft main bearing caps and bearings.
2. Lay a piece of Plastigage® across the face of each crankshaft main surface.
3. **NOTE:** Do not turn the crankshaft while doing this procedure.

   Install and remove the crankshaft main bearing cap.
4. Verify the crankshaft journal clearance.
   - If it is out of specification, replace as necessary.

GENERAL SERVICE PROCEDURES (Continued)

Bearing Inspection

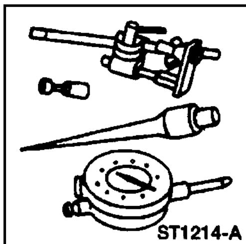


1. Inspect bearings for the following defects. Possible causes are shown:

   - Cratering – fatigue failure (A)
   - Spot polishing – improper seating (B)
   - Scratching – dirty (C)
   - Base exposed – poor lubrication (D)
   - Both edges worn – journal damaged (E)
   - One edge worn – journal tapered or bearing not seated (F)

Crankcase End Play

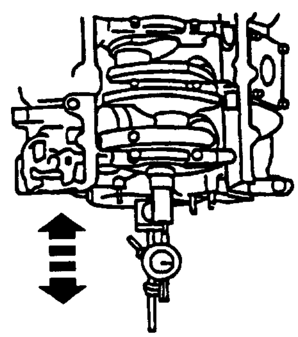
Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

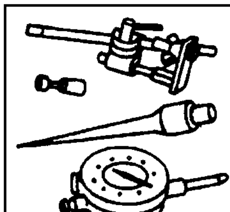
1. Measure the crankshaft end play. Use the Dial Indicator with Bracketry to measure crankshaft end play.
2. Position the crankshaft to the rear of the cylinder block.
3. Zero the Dial Indicator with Bracketry.

GENERAL SERVICE PROCEDURES (Continued)

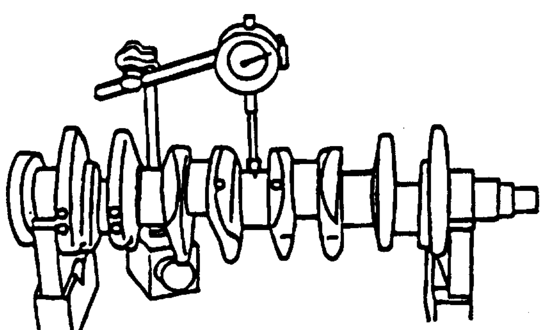


4. Move the crankshaft to the front of the cylinder block. Note and record the camshaft end play.
   - If camshaft end play exceeds specifications, replace the crankshaft thrust washers or thrust bearing.

Special Tool(s)

	Dial Indicator with Bracketry TOOL-4201-C or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

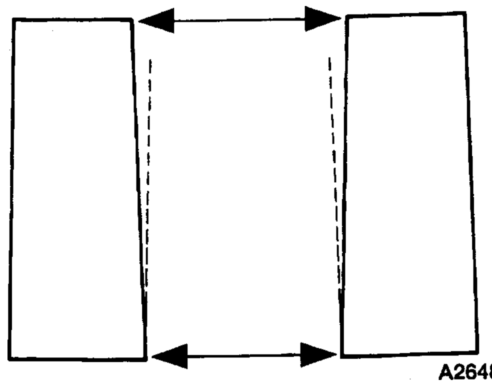


NOTE: Crankshaft main bearing journals must be within specifications before checking runout.

1. Use the Dial Indicator with Bracketry to measure the crankshaft runout.
   - 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, replace as necessary.

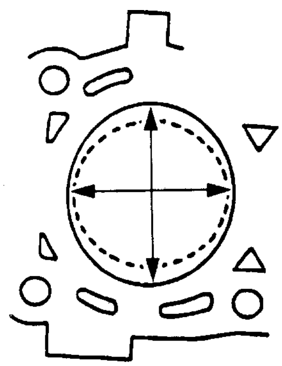
GENERAL SERVICE PROCEDURES (Continued)

Cylinder Bore Taper


A26481-A

1. Measure the cylinder bore at the top and bottom. Verify the cylinder bore is within the wear limit. The difference indicates the cylinder bore taper. Bore the cylinder to the next oversize.

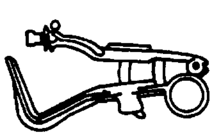
Cylinder Bore Out-of-Round


DA0357-A

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.

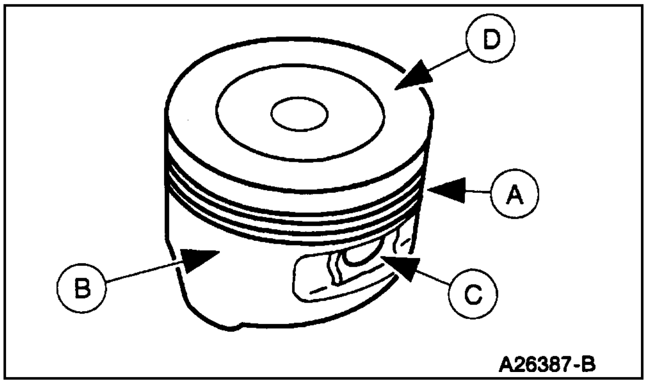
Piston Inspection

Special Tool(s)

 ST1279-A	Piston Ring Groove Cleaner D81L-6002-D or Equivalent

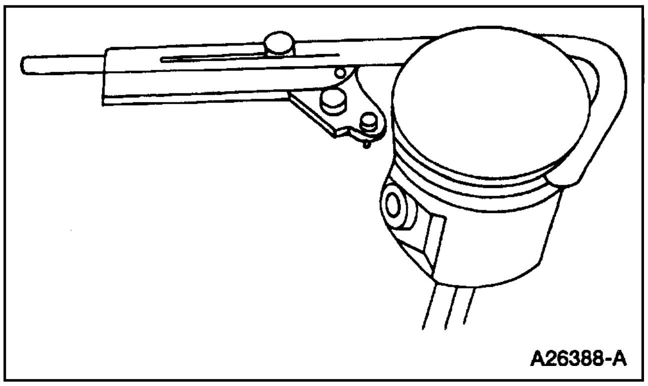
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

GENERAL SERVICE PROCEDURES (Continued)



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

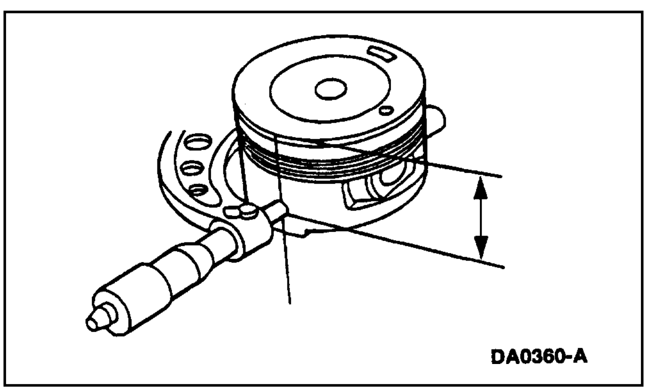
1. Clean and inspect the (A) ring lands, (B) skirts, (C) pin bosses, and the (D) tops of the pistons. If wear marks or polishing is found on the piston skirt, check for a bent or twisted connecting rod.



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

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Piston Diameter



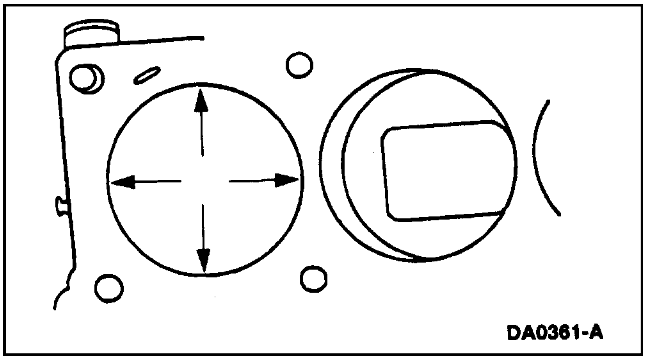
1. Measure the piston skirt diameter.

Piston to Cylinder Bore Clearance

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

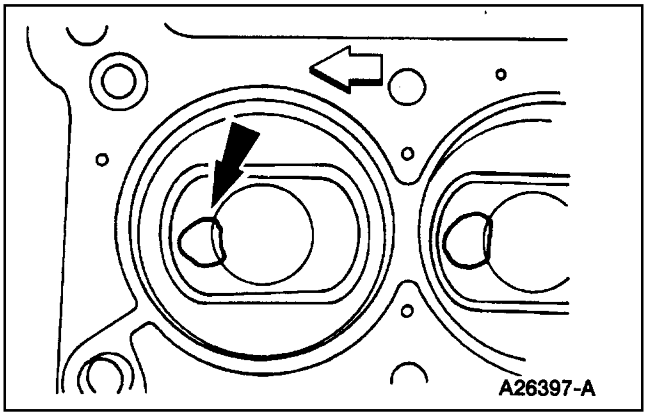
GENERAL SERVICE PROCEDURES (Continued)

Piston Selection


DA0361-A

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.


A26397-A

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 proper paint color.

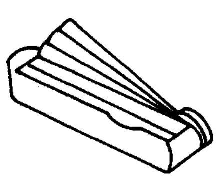
   • Red – in the lower third of the size range.

   • Blue – in the middle third of the size range.

   • Yellow – in the upper third of the size range.

Piston Ring End Gap

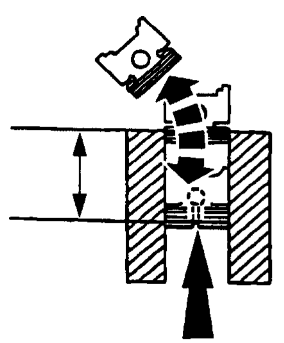
Special Tool(s)

 ST1271-A	Feeler Gauge D81L-4201-A or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

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

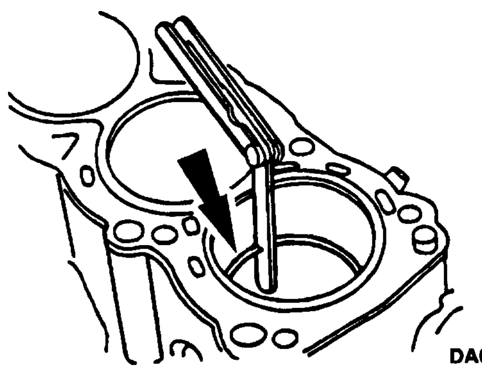
CAUTION: Piston rings should not be transferred from one piston to another to prevent damage to cylinder worn or piston.


DA0362-A

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

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

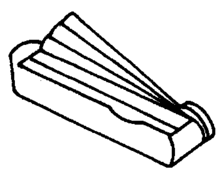
GENERAL SERVICE PROCEDURES (Continued)



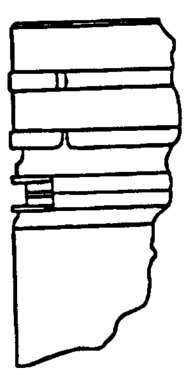
2. Use a feeler gauge to measure the top piston ring end gap and the second piston ring end gap.

Piston Ring-to-Groove Clearance

Special Tool(s)

 ST1271-A	Feeler Gauge D81L-4201-A or Equivalent

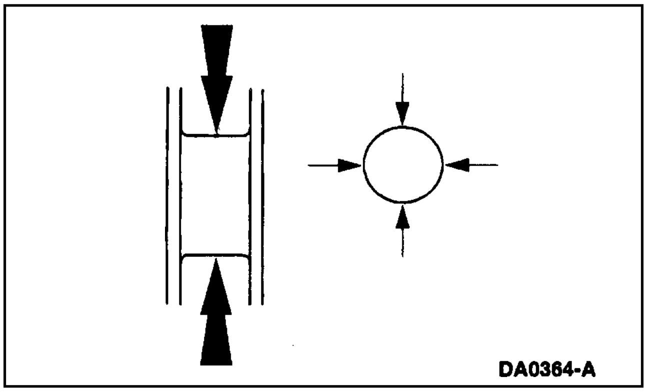
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).



1. Inspect for a stop in the grooves.
2. Measure the piston-to-groove clearance.

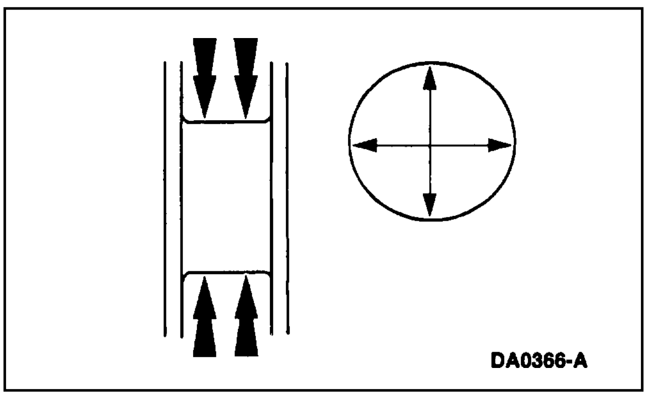
GENERAL SERVICE PROCEDURES (Continued)

Crankshaft Connecting Rod Journal Diameter



1. Measure the crankshaft connecting rod journal diameters in at least two directions perpendicular to one another. The difference between the measurements is the out-of-round. Verify the journal is within the wear limit specification.

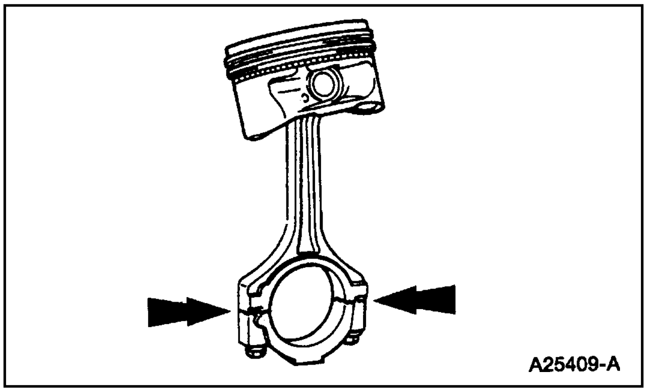
Crankshaft Connecting Rod Journal Taper



1. Measure the crankshaft 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.

GENERAL SERVICE PROCEDURES (Continued)

Connecting Rod Cleaning

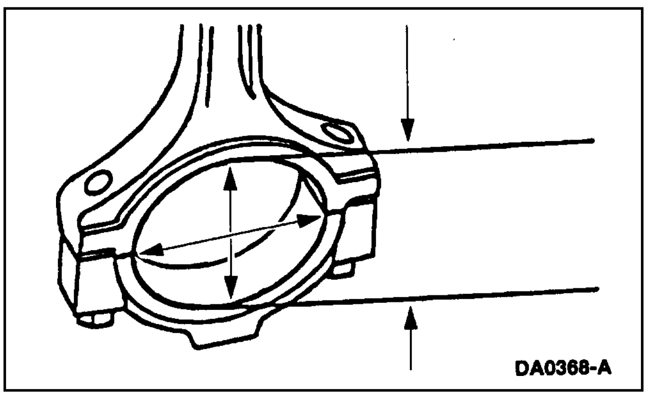


CAUTION: Do not use a caustic cleaning solution or damage to connecting rods can occur.

1. **NOTE:** The connecting rod large end is mechanically split or cracked to produce a unique parting face. This produces a locking joint. Parts are not interchangeable.

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

Connecting Rod Larger End Bore

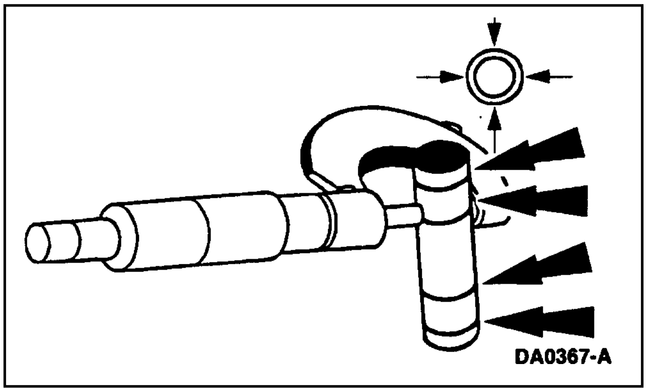


1. Measure the bore in two directions. The difference is the connecting rod bore out-of-round. Verify the out-of-round is within specification.

CAUTION: The connecting rod bolts are torque to yield and must be discarded and replaced after this diagnostic test.

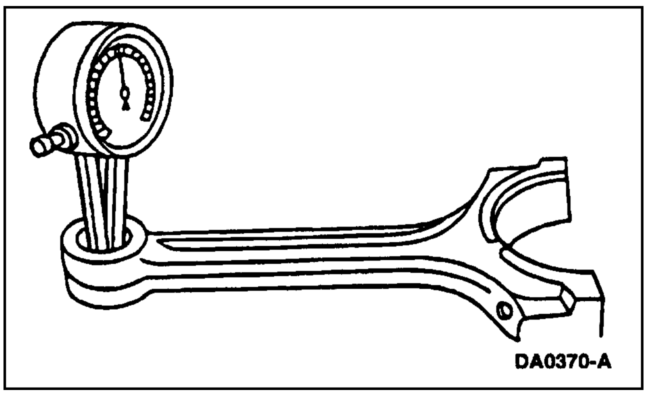
GENERAL SERVICE PROCEDURES (Continued)

Piston Pin Diameter



1. Measure the piston pin diameter in two directions at the points shown. Verify the diameter is within specifications.

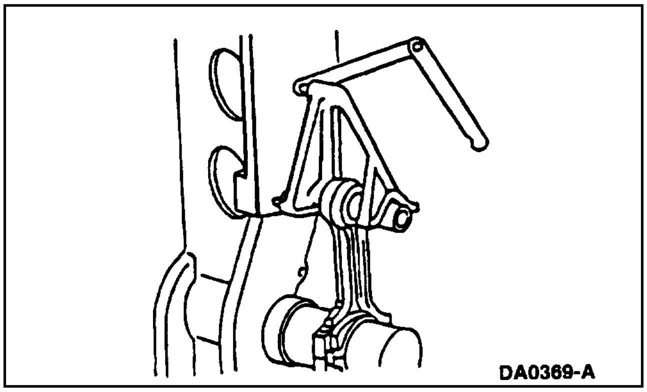
Connecting Rod Bushing Diameter



1. Measure the inner diameter of the connecting rod bushing. Verify the diameter is within specification.

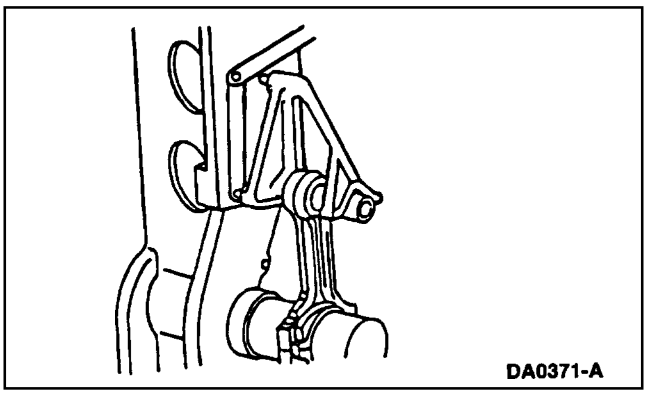
GENERAL SERVICE PROCEDURES (Continued)

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.

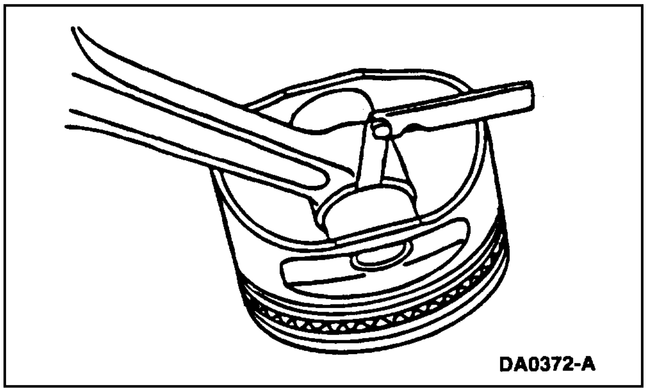
Connecting Rod Twist



1. Measure the connecting rod twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the measurement is within specification.

GENERAL SERVICE PROCEDURES (Continued)

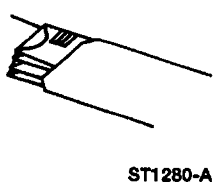
Connecting Rod Piston Pin Side Clearance



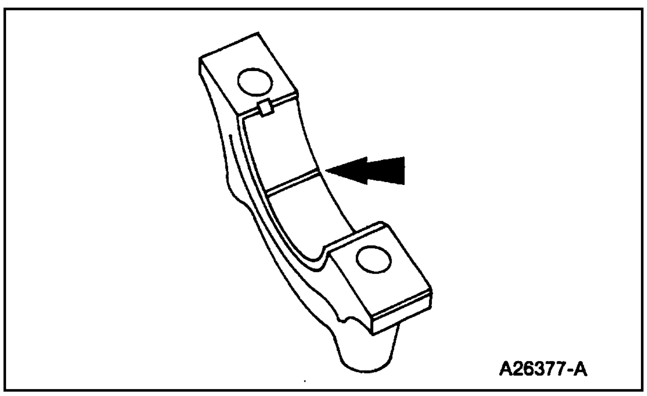
1. Measure the clearance between the connecting rod and the piston. Verify the measurement is within specification.

Connecting Rod Journal Clearance

Special Tool(s)

	Plastigage® D81L-6002-B or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).



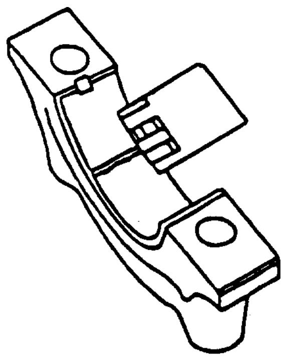
NOTE: The crankshaft connecting rod journals must be within specifications to check the connecting rod bearing journal clearances.

1. Remove the connecting rod bearing cap.

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

CAUTION: The connecting rod bolts are torque to yield and must be discarded and replaced after this diagnostic test.

GENERAL SERVICE PROCEDURES (Continued)



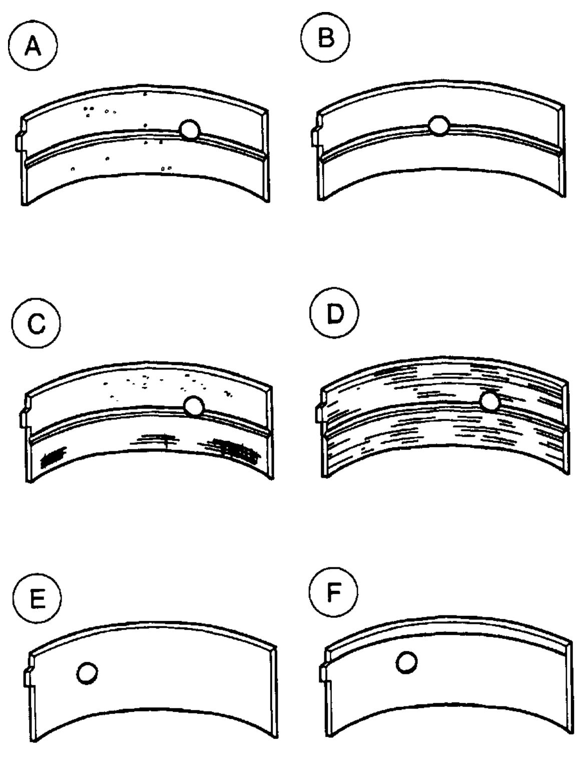
DA0373-A

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

   Install and torque 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 change width indicates a tapered or damaged connecting rod bearing or connecting rod.

Bearing Inspection



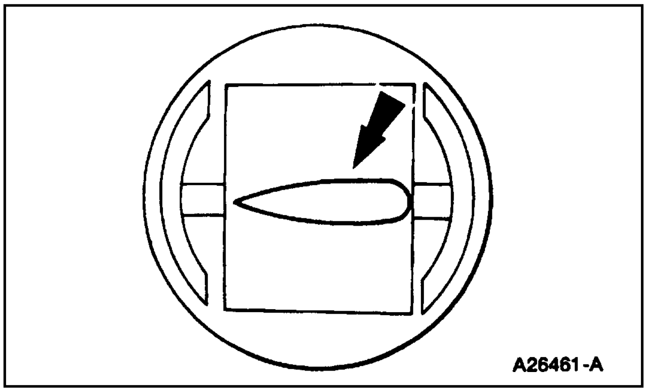
A26383-B

1. Inspect bearings for the following defects. Possible causes are shown:

   - Cratering – fatigue failure (A)
   - Spot polishing – improper seating (B)
   - Scratching – dirty (C)
   - Base exposed – poor lubrication (D)
   - Both edges worn – journal damaged (E)
   - One edge worn – journal tapered or bearing not seated (F)

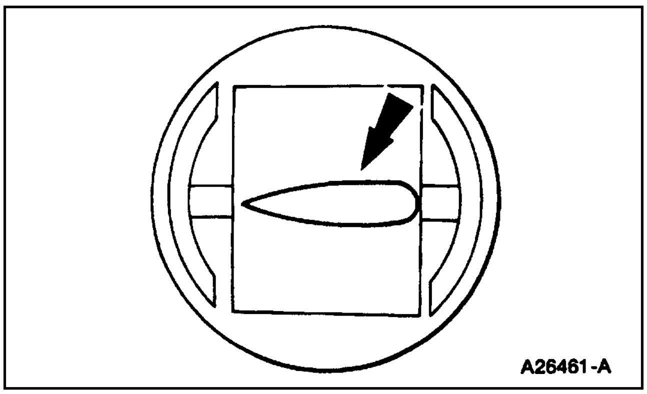
GENERAL SERVICE PROCEDURES (Continued)

Roller Follower Inspection – OHC Engines



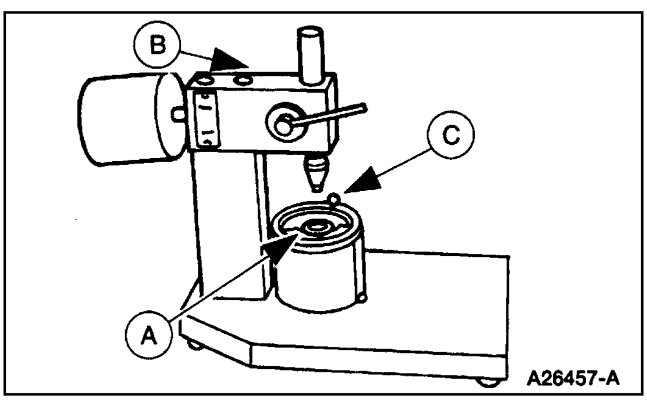
1. Inspect the roller for flat spots or scoring. If any damage is found, inspect the camshaft lobes and hydraulic lash adjusters for damage.

Hydraulic Valve Tappet Inspection – OHV Engines



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

Hydraulic Valve Tappet Leakdown Test – OHV Engines

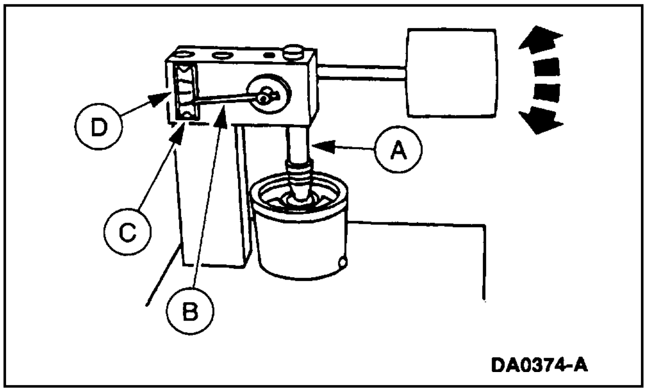


1. **NOTE:** The leakdown test will not be accurate if it is done with engine oil in the hydraulic valve tappet. Use testing fluid. New hydraulic valve tappets are already filled with testing fluid.

   Compress the hydraulic valve tappet to remove the engine oil if necessary.

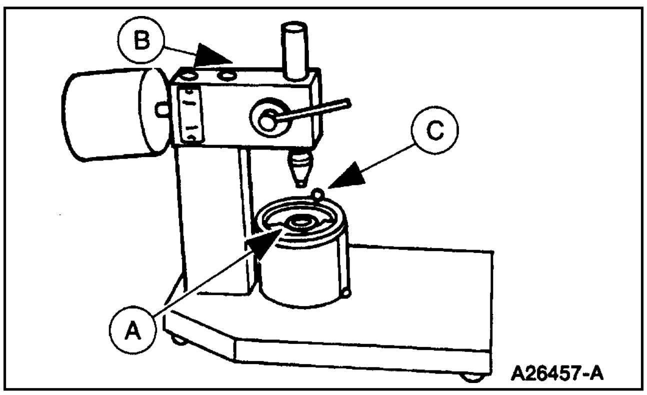
2. Place (A) hydraulic valve tappet in a (B) commercially available hydraulic tappet leakdown tester. Position the (C) steel ball provided in the plunger cap. Add testing fluid to cover the hydraulic tappet and compress Hydraulic Tappet Leakdown Tester until the hydraulic valve tappet is filled with testing fluid.

GENERAL SERVICE PROCEDURES (Continued)



3. Adjust the length of the (A) ram so that the (B) pointer is just below the (C) Start Timing mark when the ram contacts the hydraulic valve tappet. Start timing as the pointer passes the (C) Start Timing mark and end timing as the pointer reaches the (D) center mark.

Hydraulic Lash Adjuster Leakdown Test – OHC Engines

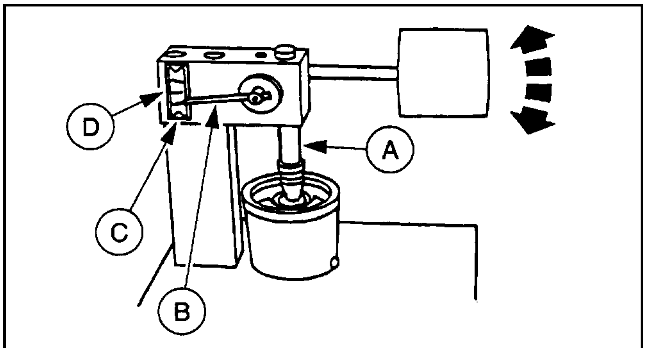


1. **NOTE:** The leakdown test will not be accurate if it is done with engine oil in the hydraulic lash adjuster. Use testing fluid. New hydraulic lash adjusters are already filled with testing fluid.

   Compress the hydraulic lash adjuster to remove the engine oil if necessary.

2. Place (A) hydraulic lash adjuster in a (B) commercially available hydraulic tappet leakdown tester. Position the (C) steel ball provided in the plunger cap. Add testing fluid to cover the hydraulic lash adjuster and compress hydraulic tappet leakdown tester until the hydraulic lash adjuster is filled with testing fluid.

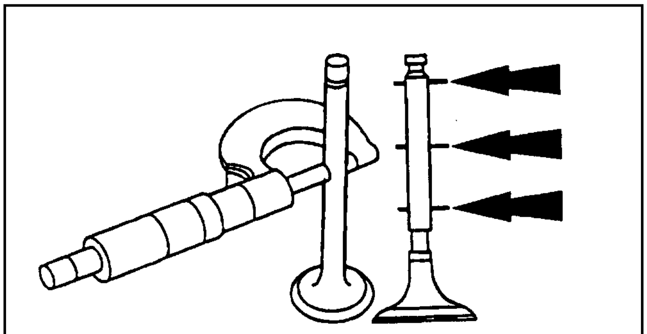
GENERAL SERVICE PROCEDURES (Continued)



DA0374-A

3. Adjust the length of the (A) ram so that the (B) pointer is just below the (C) start timing mark when the ram contacts the hydraulic lash adjuster. Start timing as the pointer passes the (C) start timing mark and end timing as the pointer reaches the (D) center mark.

Valve Stem Diameter

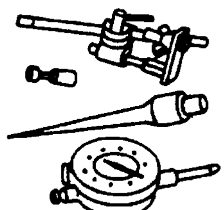
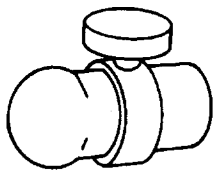

DA0375-A

1. Measure the diameter of each intake and exhaust valve stem at the points shown. Verify the diameter is within specification.

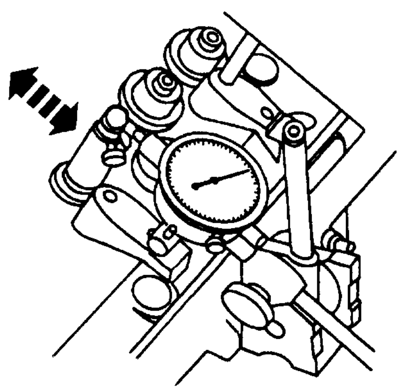
GENERAL SERVICE PROCEDURES (Continued)

Valve Stem-to-Valve Guide Clearance

Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent
 ST1251-A	Valve Stem Clearance Tool TOOL-6505-E or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).



A26460-A

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

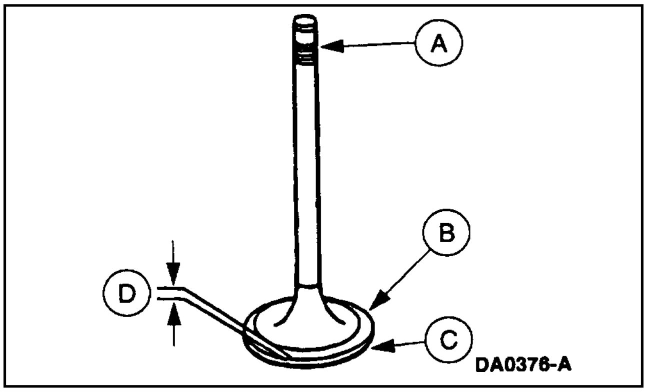
1. **NOTE:** If necessary, use a magnetic base.

   Install the Valve Stem Clearance Tool on the valve stem and install the Dial Indicator with Bracketery. Lower the valve until the Valve Stem Clearance Tool contacts the upper surface of the valve guide.

2. Move the Valve Stem Clearance Tool toward the Dial Indicator and zero the Dial Indicator. Move the Valve Stem Clearance Tool away from the Dial 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.

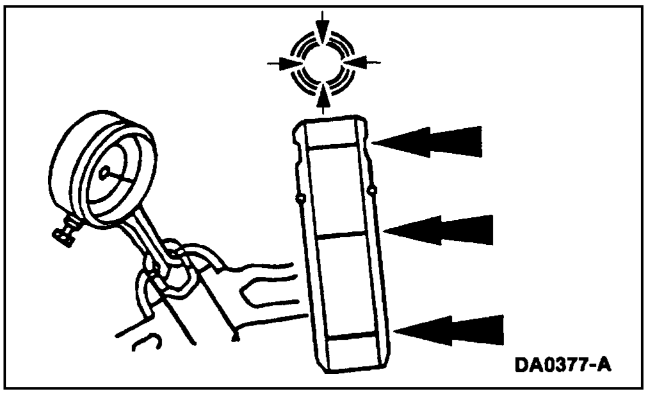
GENERAL SERVICE PROCEDURES (Continued)

Valve Inspection



1. Inspect the following valve areas:
   - The end of the stem for grooves or scoring (A).
   - The valve face and the edge for pits, grooves or scores (B).
   - The valve head for signs of burning, erosion, warpage and cracking. Minor pits, grooves and other abrasions may be removed (C).
   - The valve head thickness for wear (D).

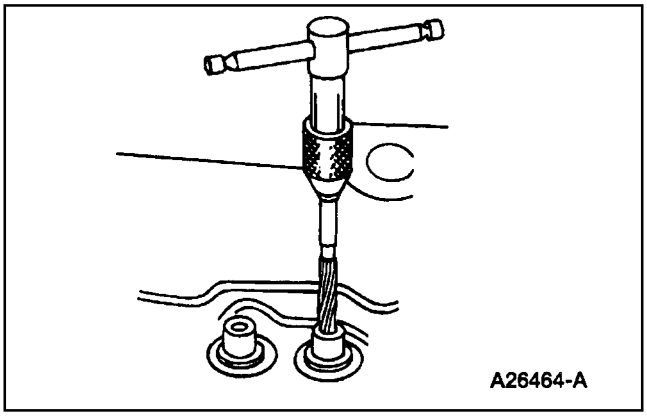
Valve Guide Inner Diameter



1. Measure the inner diameter of the valve guides in two directions where indicated.
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.

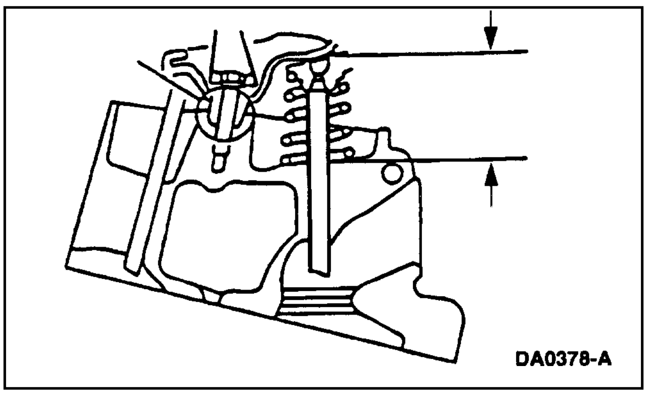
GENERAL SERVICE PROCEDURES (Continued)

Valve Guide Reaming

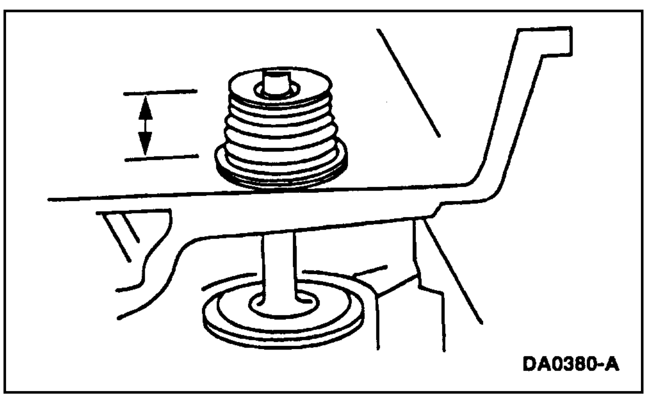


1. Use a hand-reaming kit to ream the valve guide.
2. Reface the valve seat.
3. Clean the sharp edges left by reaming.

Valve Spring Installed Length

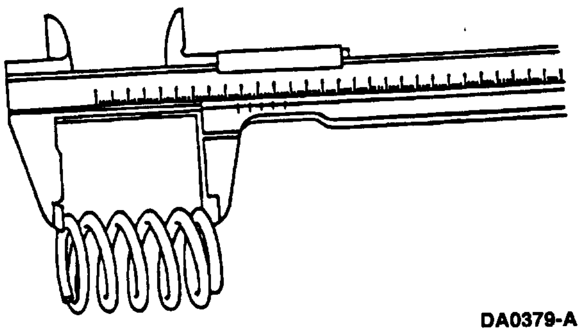


1. Measure the installed length of each valve spring.



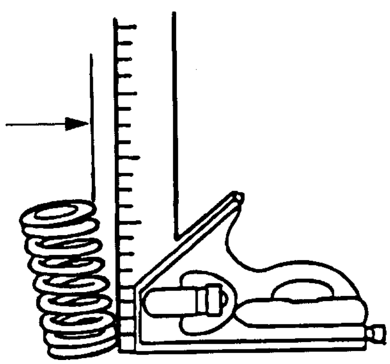
GENERAL SERVICE PROCEDURES (Continued)

Valve Spring Free Length


DA0379-A

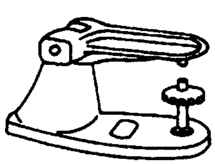
1. Measure the free length of each valve spring.

Valve Spring Out-of-Square


DA0382-A

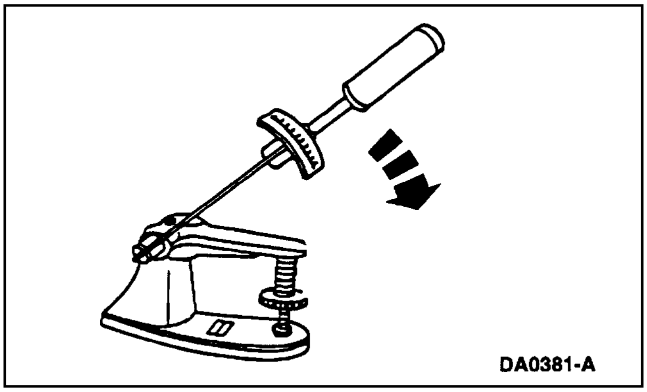
1. Measure the out-of-square on each valve spring.
   - Turn the valve spring and observe the space between the top of the valve spring and the square. Replace the valve spring if out of specification.

Special Tool(s)

 ST1278-A	Valve/Clutch Spring Tester TOOL-6513-DD or Equivalent

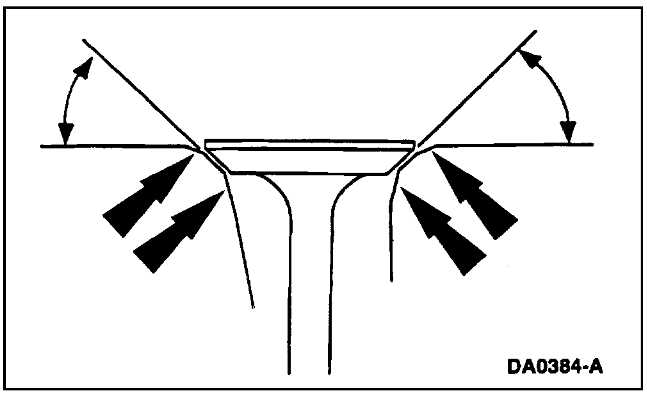
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

GENERAL SERVICE PROCEDURES (Continued)



1. Use the Valve/Clutch Spring Tester to check the valve springs for proper strength at the specified valve spring length.

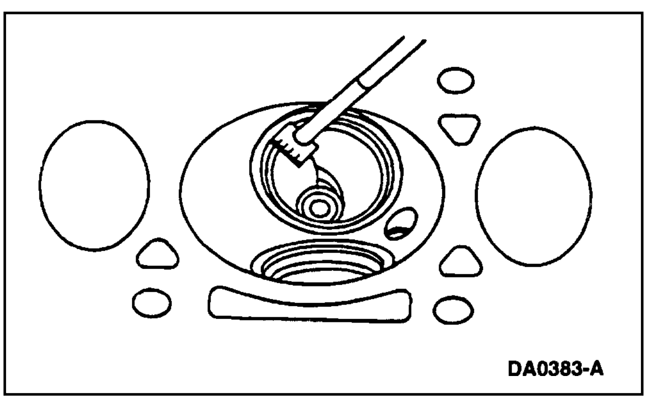
Valve and Seat Refacing Measurements



NOTE: After grinding valves or valve seats, check valve clearance.

1. Check the valve seat and valve angles.

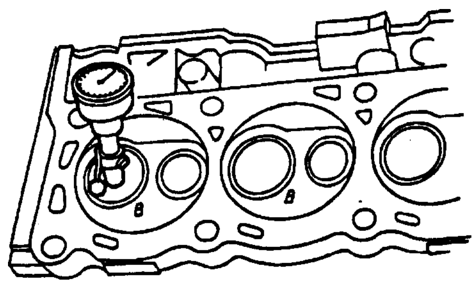
Valve Seat Width



1. Measure the valve seat width. If necessary, grind the valve seat to specification.

GENERAL SERVICE PROCEDURES (Continued)

Valve Seat Runout

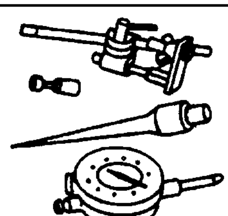


DA0385-A

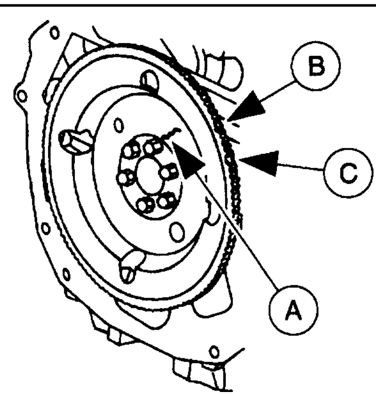
1. Use the Valve Seat Runout Gauge to check valve seat runout.

Flywheel Inspection

Special Tool(s)

 ST1214-A	Dial Indicator with Bracketry TOOL-4201-C or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

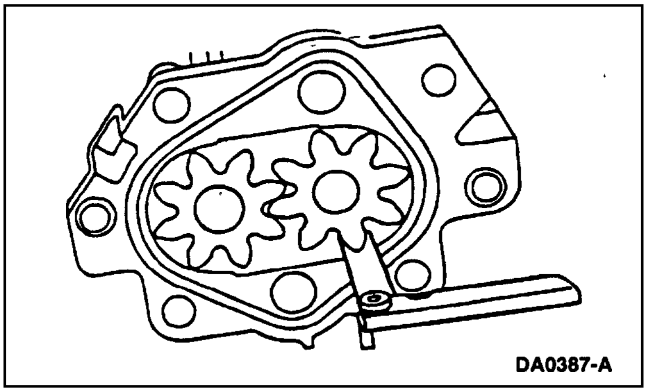


A26473-B

1. Inspect the flywheel for:
   - Cracks (A).
   - Worn ring gear teeth (B).
   - Chipped or cracked ring gear teeth (C).
2. Inspect the flywheel ring gear runout.

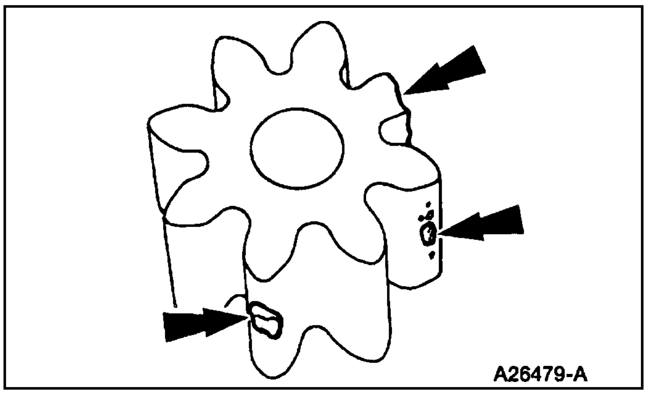
GENERAL SERVICE PROCEDURES (Continued)

Oil Pump Gear Radial Clearance



1. Measure the clearance between the rotor and the pump housing.

Oil Pump Rotor Inspection

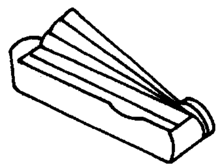


1. Inspect the oil pump rotor tips for damage or wear.

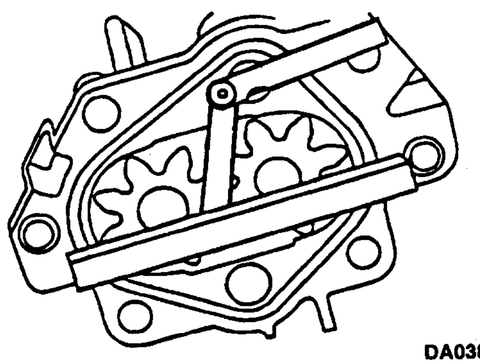
GENERAL SERVICE PROCEDURES (Continued)

Oil Pump Side Clearance

Special Tool(s)

 ST1271-A	Feeler Gauge D81L-4201-A or Equivalent
 ST1246-A	Straight Edge D83L-4201-A or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).



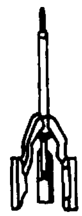
DA0388-A

1. Place the Straight Edge across the top of the oil pump and rotors and use the Feeler Gauge to measure the clearance between the rotors and the Straight Edge.

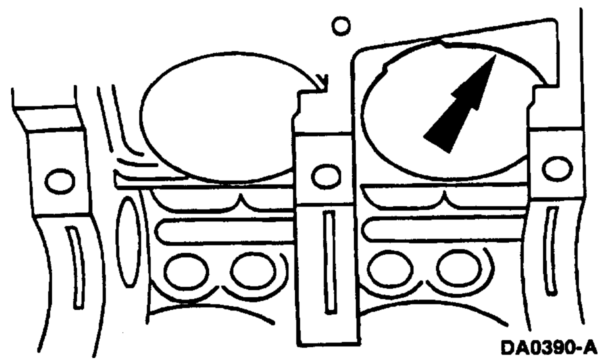
GENERAL SERVICE PROCEDURES (Continued)

Cylinder Bore Honing

Special Tool(s)

 ST1275-A	Engine Cylinder Hone Set T73L-6011-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).


DA0390-A

NOTE: Before any cylinder bore is honed, all main bearing caps must be installed so the crankshaft bearing bores will not become distorted.

NOTE: To correct taper or out-of-round, bore the cylinder block.

1. **NOTE:** Honing should be done when fitting new piston rings or to remove minor surface.

   Hone with the Engine Cylinder Hone Set, at a speed of 300-500 rpm and a hone grit of 180-220 to provide the desired cylinder bore surface finish.

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.

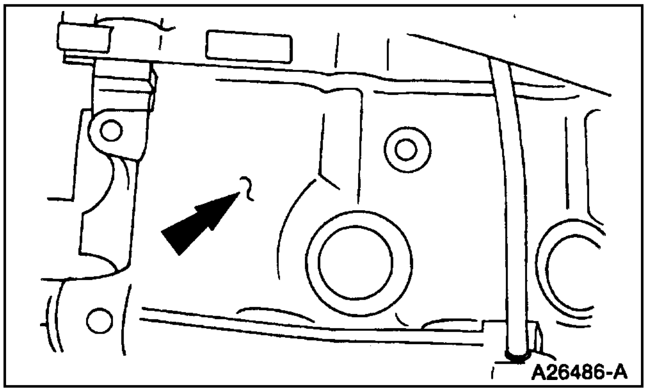
3. Use a clean, lint-free cloth and lubricate the cylinder bores.

   - Use Engine Oil XO-10W30-QSP or -DSP or equivalent meeting Ford specification ESE-M2C153-E.

GENERAL SERVICE PROCEDURES (Continued)

Cylinder Block Repair

Cast Iron Porosity Defects

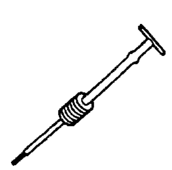


CAUTION: Do not attempt to repair cracks, areas where temperature will exceed 260°C (500°F) or areas exposed to engine coolant or oil. These areas will not repair and could cause future failure.

1. Repair porosity defects with an epoxy sealer meeting Ford specification M3D35-A (E).
   - Clean the surface to be repaired to a bright, oil-free metal surface.
   - Chamfer or undercut the repair area to a greater depth than the rest of the cleaned surface. Solid metal must surround the area to be repaired.
   - Apply the epoxy sealer and heat-cure with a 250-watt lamp placed 254 mm (10 inches) from the repaired surface, or air dry for 10-12 hours at a temperature above 10°C (50°F).
   - Sand or grind the repaired area to blend with the general contour of the surface.
   - Paint the surface to match the rest of the cylinder block.

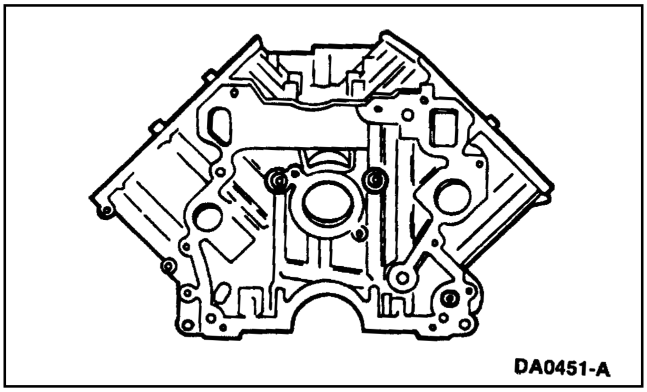
Cylinder Block Core Plug Replacement

Special Tool(s)

	Impact Slide Hammer T50T-100-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

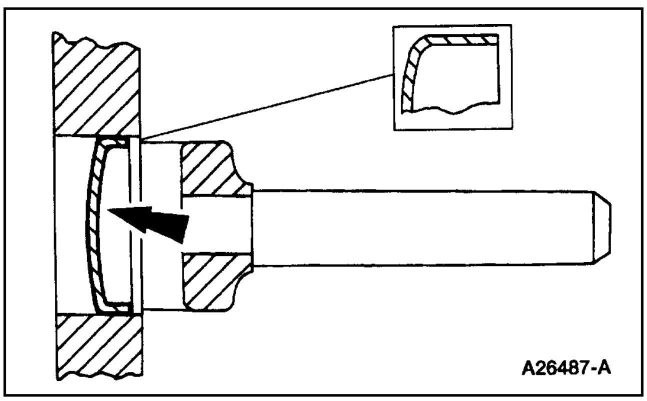
GENERAL SERVICE PROCEDURES (Continued)



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 interfered with the proper 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 E2FZ-19554-B or equivalent meeting Ford specification WSK-M2G351-A6 and install the cylinder block core plug.

Cylinder Block Core Plug – Cup-Type



CAUTION: Do not contact the flange when installing a cup type cylinder block core plug as this could damage the sealing edge and result in leakage.

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

1. Use a fabricated tool to seat the cup type cylinder block core plug.

Cylinder Block Core Plug – Expansion-Type

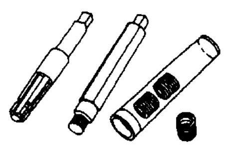
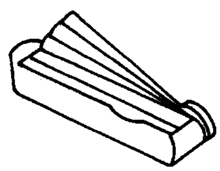
CAUTION: Do not contact the crown when installing an expansion type cylinder block core plug. This could expand the plug before seating and result in leakage.

1. Use a fabricated tool to seat the expansion type cylinder block core plug.

GENERAL SERVICE PROCEDURES (Continued)

Spark Plug Thread Repair

Special Tool(s)

 ST1281-A	Tapersert Installation Kit 107-R0921 or Equivalent
 ST1271-A	Feeler Gauge D81L-4201-A or Equivalent

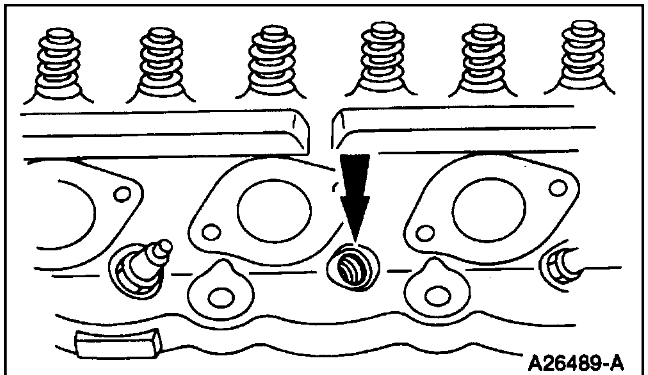
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

CAUTION: The cylinder head must be removed from the engine before installing a tapersert. If this procedure is done with the cylinder head on the engine, the cylinder walls can be damaged by metal chips produced by the thread cutting process.

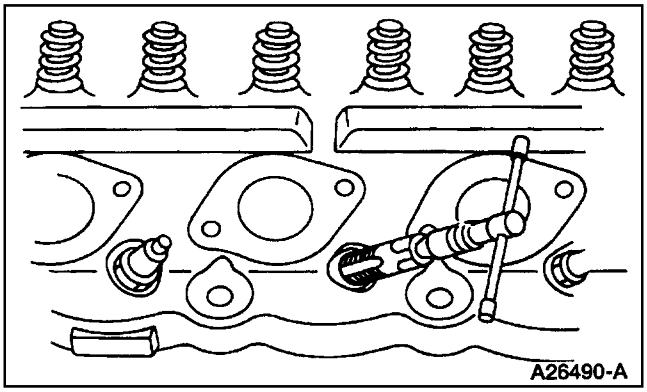
CAUTION: Do not use power or air-driven tools for finishing taperserts.

NOTE: This repair is permanent and will have no effect on cylinder head or spark plug life.

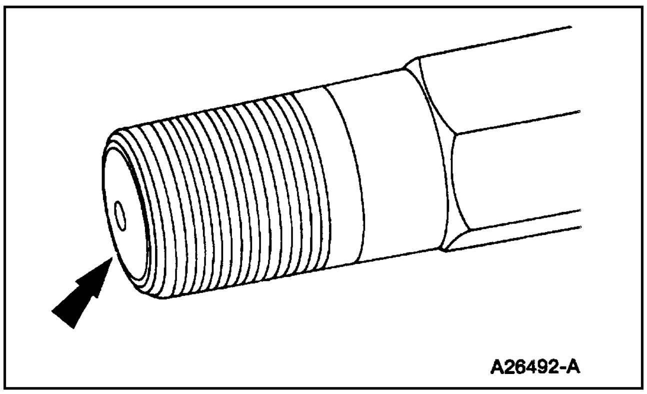
1. Clean the spark plug seat and threads.


A26489-A

GENERAL SERVICE PROCEDURES (Continued)



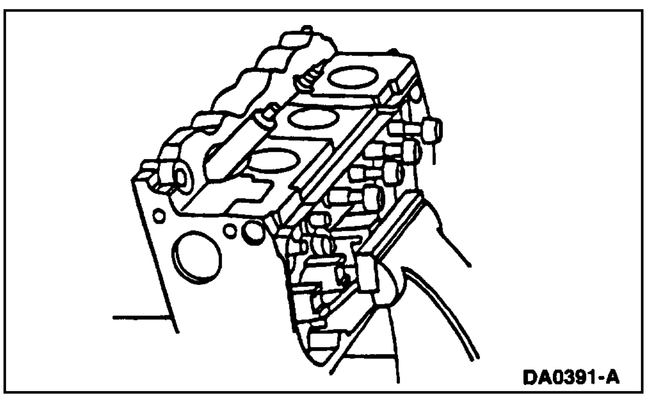
2. Start the tap into the spark plug hole, being careful to keep it properly aligned. As the tap begins to cut new threads, apply aluminum cutting oil.



3. Continue cutting the threads and applying oil until the stop ring bottoms against the spark plug seat.

4. Remove the tap and metal chips.

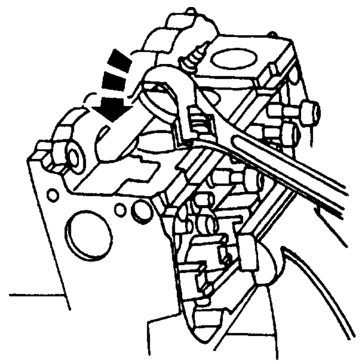
5. Coat the threads of the mandrel with cutting oil. Thread the tapersert onto the mandrel until one thread of the mandrel extends beyond the tapersert.



6. **NOTE:** A properly installed tapersert will be either flush with or 1.0 mm (0.039 inch) below the spark plug gasket seat.

   Tighten the tapersert into the spark plug hole.

GENERAL SERVICE PROCEDURES (Continued)


A26491-A

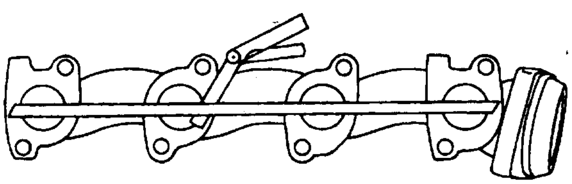
7. Turn the mandrel body approximately one-half turn counterclockwise and remove.

Exhaust Manifold Straightness

Special Tool(s)

 ST1246-A	Straightedge D83L-4201-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).


A26498-B

NOTE: The 4.6L engine exhaust manifold is shown; the 4.2L engine exhaust manifold is similar.

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

SPECIFICATIONS

General Specifications

Item	Specification
Sealants	
Epoxy Sealer	M3D35-A (E)
Threadlock® 262 E2FZ-19554-B	WSK-M2G351-A6

General Specifications

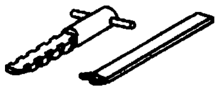
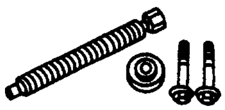
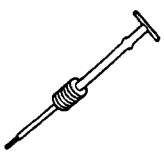
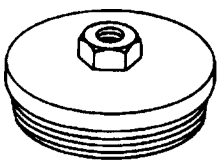
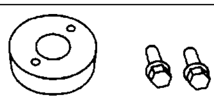
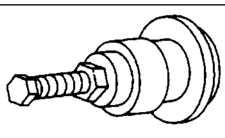
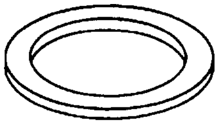
Item	Specification
Oil	
Engine Oil XO-5W20-QSP or -DSP	ESE-M2C153-E

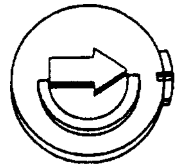
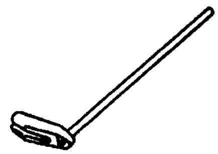
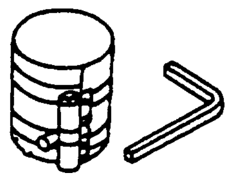
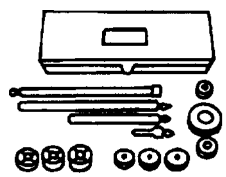
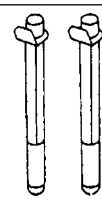
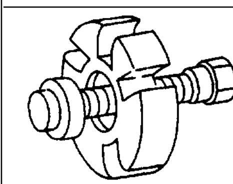
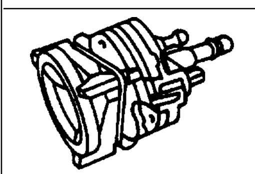
NOTE: Ford Power Products industrial engines are designed to perform with engine oils that are licensed by the American Petroleum Institute (API), and oils carrying the most current API classification should be used.

Engine – 4.2L

SPECIAL TOOLS

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Special Tool(s)	
 ST1385-A	Seal Remover T92C-6700-CH
 ST1378-A	Vibration Damper Remover Adapter T82L-6316-B
 ST1185-A	Impact Slide Hammer T50T-100-A
 ST1382-A	Rear Crankshaft Seal Remover T95P-6701-EH
 ST1327-A	Rear Main Seal Replacer T82L-6701-A
 ST1328-A	Front Crankcase Seal Installer/ Cover Aligner T88T-6701-A
 ST1379-A	Front Crankcase Seal Replacer T94P-6701-AH
Purchased From Local Tool Dealer	Pound/Inch Torque Wrench

Special Tool(s)	
 ST1428-A	Syncro Positioning Tool T89P-12200-A
 ST1383-A	Valve Spring Compressor T81P-6513-A
	Piston Ring Compressor D81L-6002-C or Equivalent
 ST1381-A	Camshaft Bearing Set T65L-6250-A
 ST1337-A	Connecting Rod Guide Tool T93P-6136-A
 ST1286-A	Crankshaft Damper Remover T58P-6316-D
 ST1276-A	Cylinder Ridge Reamer T64L-6011-EA

DESCRIPTION AND OPERATION

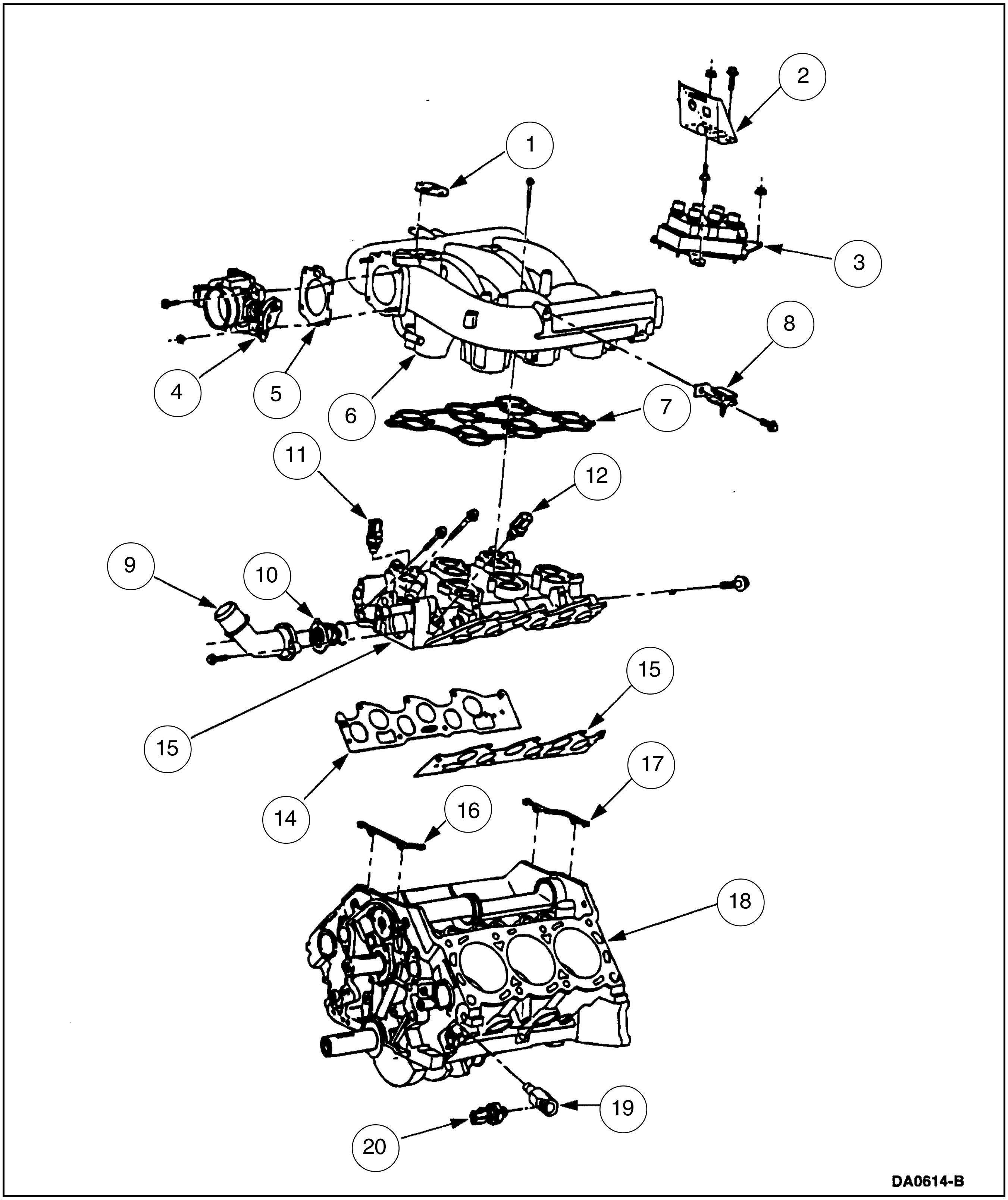
Engine

The 4.2L 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 tappets for automatic lash adjustment.
- Connecting rod parting faces that are unique with an interference fit.
- A balance shaft.

DESCRIPTION AND OPERATION (Continued)

Engine Disassembled View



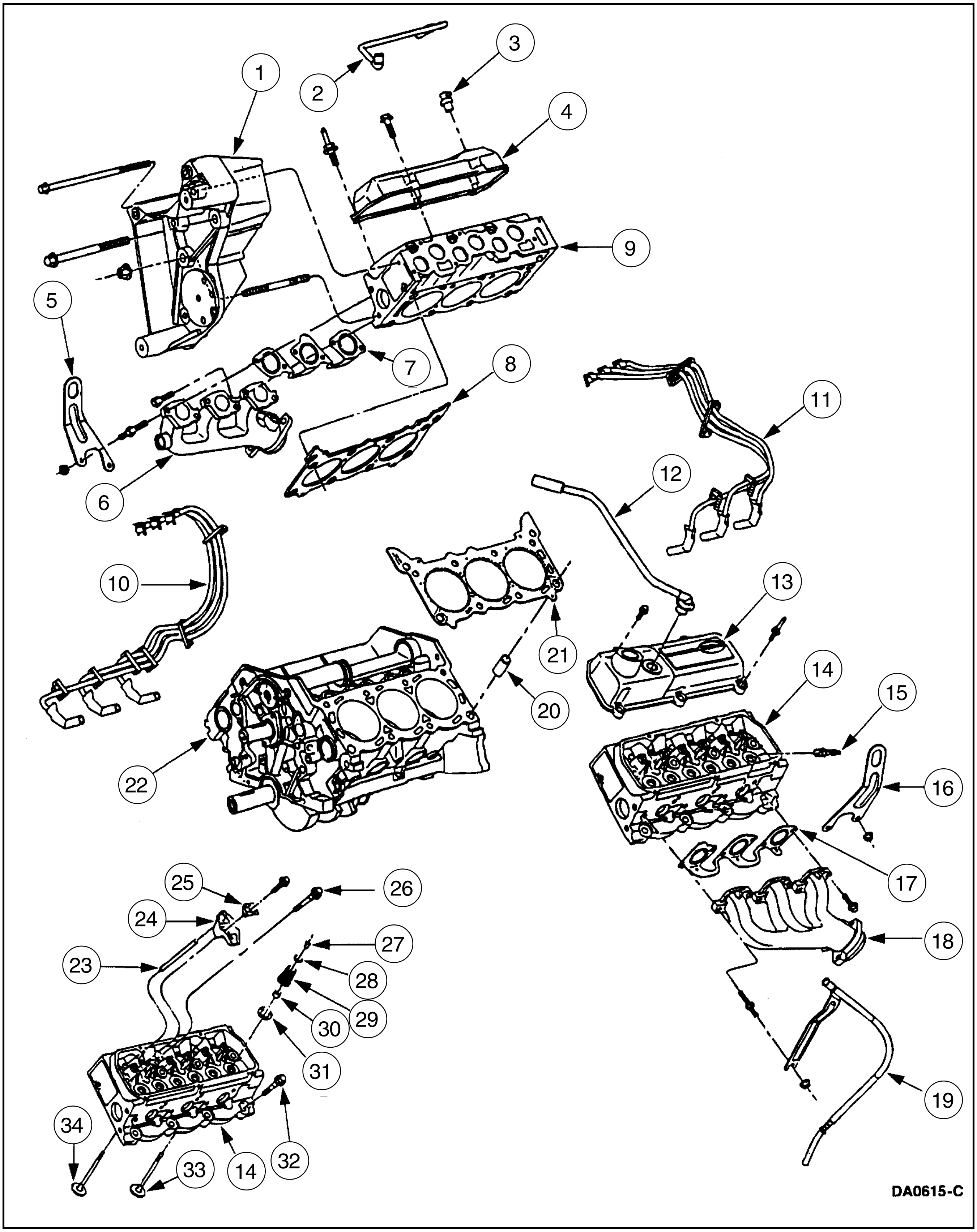
DESCRIPTION AND OPERATION (Continued)

Item	Part Number	Description
1	9F670	Idle Air Control Gasket
2	9728	Accelerator Cable Bracket
3	12029	Ignition Coil
4	9E926	Throttle Body
5	9E936	Throttle Body Gasket
6	9424	Intake Manifold (Upper)
7	9H486	Intake Manifold Upper Gasket
8	9736	Accelerator Cable Routing Clip
9	8594	Water Outlet Connection
10	8575	Water Thermostat
11	10884	Water Temperature Indicator Sender Unit

Item	Part Number	Description
12	12A648	Engine Coolant Temperature Sensor
13	9424	Intake Manifold (Lower)
14	9439	Intake Manifold Gasket (RH)
15	9439	Intake Manifold Gasket (LH)
16	9A424	Intake Manifold Seal Front
17	9A424	Intake Manifold Seal Rear
18	6010	Cylinder Block
19	9B339	Oil Pressure Sender Fitting
20	9278	Oil Pressure Sensor

DESCRIPTION AND OPERATION (Continued)

Engine Disassembled View (Continued)



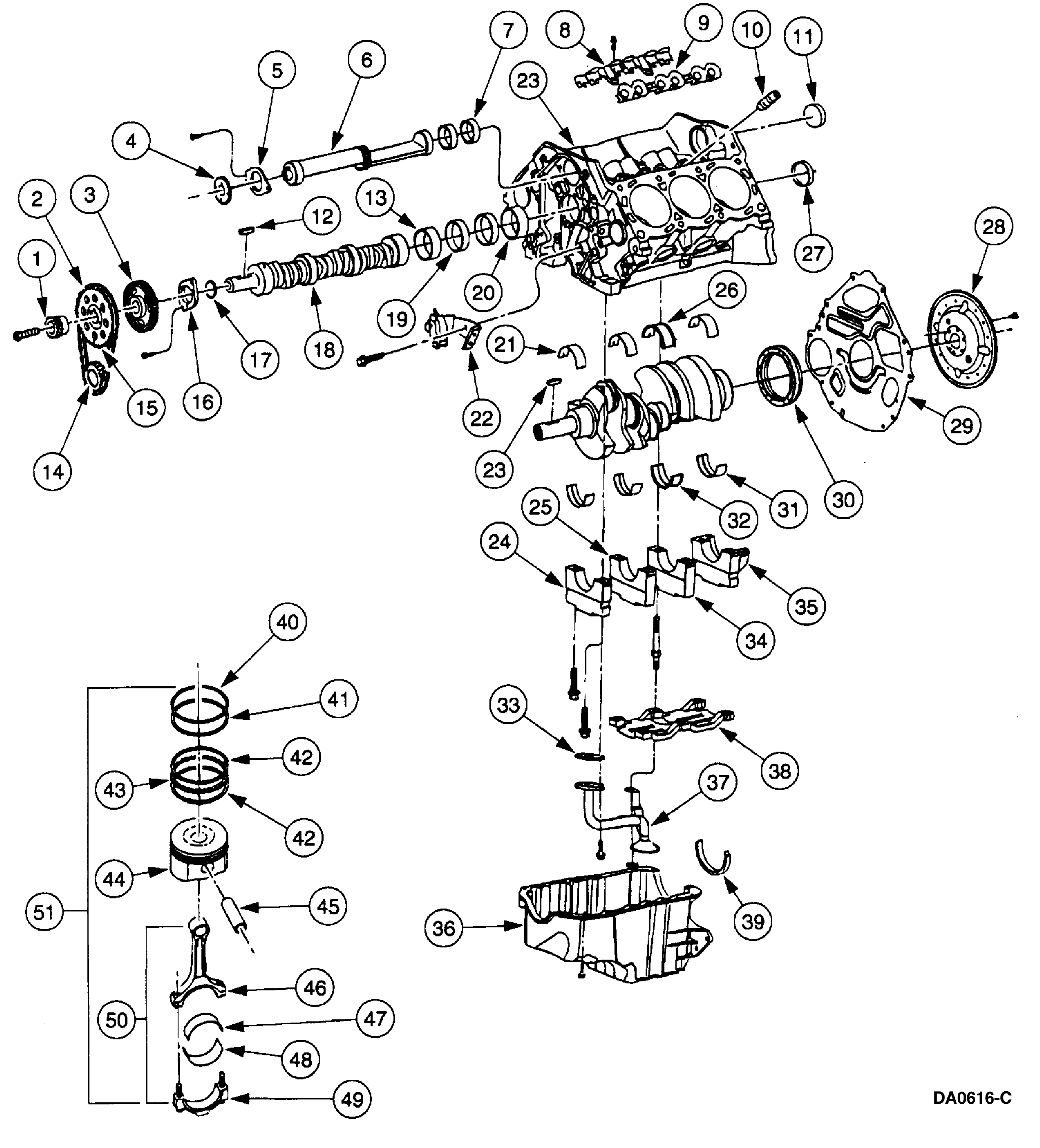
DESCRIPTION AND OPERATION (Continued)

Item	Part Number	Description
1	10039	Generator Bracket
2	6758	Crankcase Ventilation Tube
3	6A666	Positive Crankcase Ventilation Valve
4	6582	Valve Cover (RH)
5	17A084	Engine Lifting Eye
6	9430	Exhaust Manifold (RH)
7	9448	Exhaust Manifold Gasket (RH)
8	6051	Head Gasket (RH)
9	6049	Cylinder Head (RH)
10	12280	Ignition Wire and Bracket (RH)
11	12280	Ignition Wire and Bracket (LH)
12	6C324	Crankcase Vent Connector and Hose
13	6582	Valve Cover (LH)
14	6049	Cylinder Head (LH)
15	12405	Spark Plug (6 Req’d)
16	17A084	Engine Lifting Eye
17	9448	Exhaust Manifold Gasket (LH)
18	9430	Exhaust Manifold (LH)

Item	Part Number	Description
19	6754	Oil Level Indicator Tube
20	6A008	Cylinder Head to Block dowel (4 Req’d)
21	6051	Head Gasket (LH)
22	6010	Cylinder Block
23	6565	Push Rod (12 Req’d)
24	6564	Rocker Arm (12 Req’d)
25	6A528	Rocker Arm Seat (12 Req’d)
26	N807699	Rocker Arm Bolt (12 Req’d)
27	6518	Valve Spring Retainer Key (24 Req’d)
28	6514	Valve Spring Retainer (12 Req’d)
29	6513	Valve Spring (12 Req’d)
30	6571	Valve Stem Seal (12 Req’d)
31	6514	Valve Spring Retainer (12 Req’d)
32	N807324	Head Bolt (16 Req’d)
33	6507	Intake Valve (6 Req’d)
34	6505	Exhaust Valve (6 Req’d)

DESCRIPTION AND OPERATION (Continued)

Engine Disassembled View (Continued)



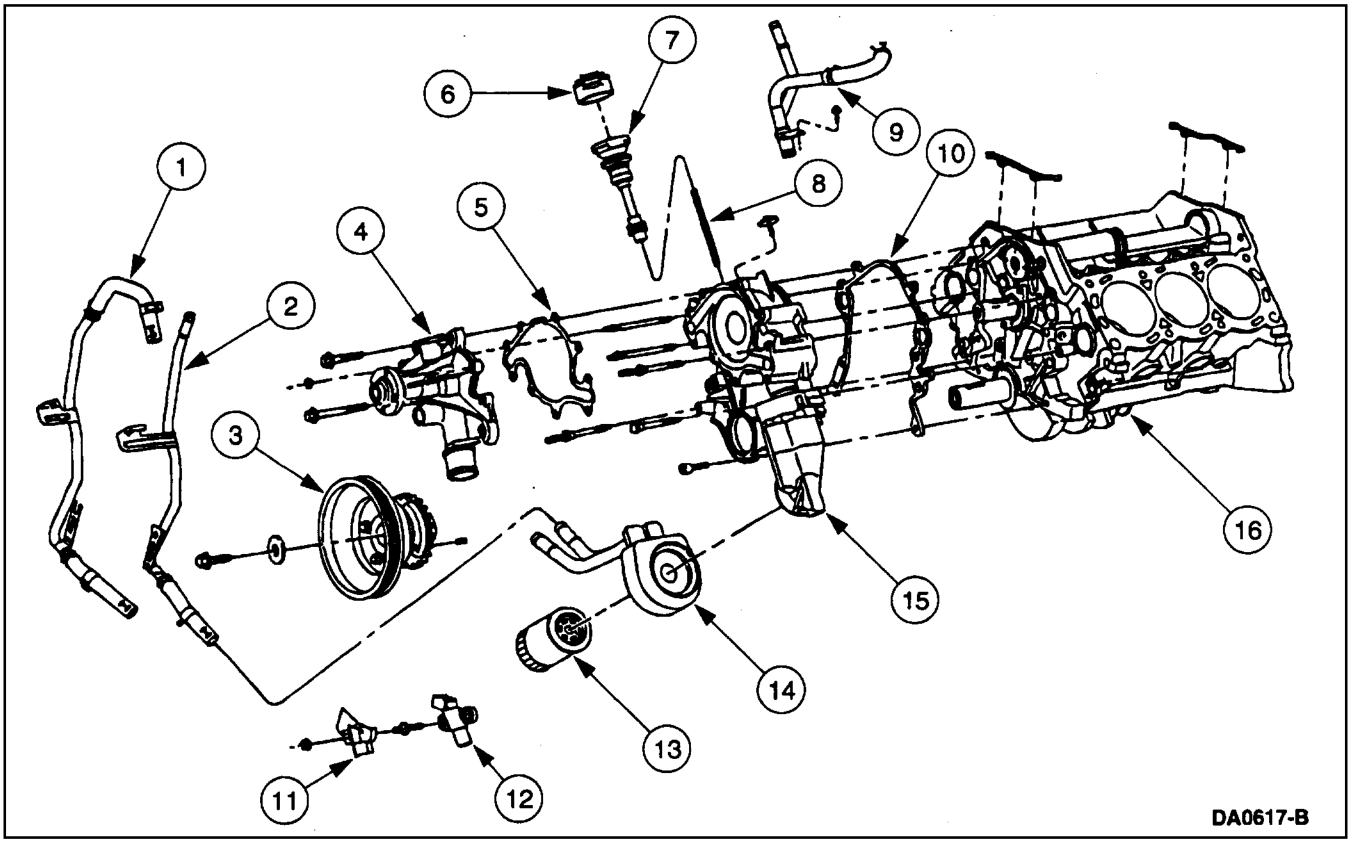
DESCRIPTION AND OPERATION (Continued)

Item	Part Number	Description
1	6255	Distributor Drive Gear
2	6288	Timing Chain/Belt
3	6A303	Engine Balance Shaft Drive Gear
4	6A304	Engine Balance Shaft Driven Gear
5	6C341	Balance Shaft Thrust Plate
6	6A311	Engine Dynamic Balance Shaft
7	6A333	Balance Shaft Front and Rear Bearing (2 Req'd)
8	6K564	Tappet Guide Plate and Retainer (RH)
9	6K564	Tappet Guide Plate and Retainer (LH)
10	6500	Valve Tappet (16 Req'd)
11	6A335	Balance Shaft Cover Plug
12	N805256	Woodruff Key
13	6261	Camshaft Front Bearing
14	6306	Crankshaft Sprocket
15	6256	Camshaft Sprocket
16	6269	Camshaft Thrust Plate
17	6265	Camshaft Sprocket Spacer
18	6262	Camshaft
19	6250	Camshaft Center Bearing (2 Req'd)
20	6263	Camshaft Rear Bearing
21	6333	Crankshaft Main Bearing (3 Req'd)
22	6284	Timing Chain Vibration Damper
23	388907	Woodruff Key
24	6329	Main Bearing Cap
25	6334	Main Bearing Cap
26	6337	Crankshaft Thrust Main Bearing

Item	Part Number	Description
27	6266	Camshaft Rear Bearing Cup Plug
28	6375	Flywheel
29	6A372	Engine Rear Plate
30	6701	Crankshaft Rear Oil Seal
31	6333	Crankshaft Main Bearing (3 Req'd)
32	6337	Crankshaft Thrust Main Bearing
33	6626	Oil Pump Inlet Tube Gasket
34	6327	Main Bearing Cap
35	6235	Rear Main Bearing Cap
36	6675	Oil Pan
37	6622	Oil Pump Screen Cover and Tube
38	6A835	Oil Pan Baffle Assy
39	6723	Oil Pan Rear Seal
40	6150	Piston Ring (6 Req'd)
41	6152	Piston Ring (6 Req'd)
42	6159	Piston Ring (6 Req'd)
43	6161	Piston Ring (6 Req'd)
44	6108	Piston (6 Req'd)
45	6135	Piston Pin (6 Req'd)
46	6200	Connecting Rod (6 Req'd)
47	6211	Connecting Rod Bearing (Upper) (6 Req'd)
48	6211	Connecting Rod Bearing (Lower) (6 Req'd)
49	6210	Connecting Rod Cap (6 (Req'd)
50	6200	Connecting Rod Assy (6 Req'd)
51	6100	Piston and Connecting Rod Assy (6 Req'd)

DESCRIPTION AND OPERATION (Continued)

Engine Disassembled View (Continued)

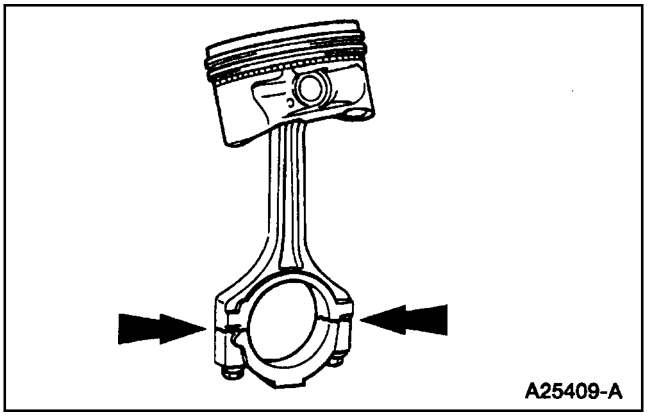


Item	Part Number	Description
1	6N867	Engine Oil Cooler Inlet Tube and Hose
2	6N866	Engine Oil Cooler Outlet Tube and Hose
3	6312	Crankshaft Pulley
4	8501	Water Pump
5	8507	Water Pump Housing Gasket
6	12A112	Camshaft Position Sensor
7	12A362	Camshaft Synchronizer
8	6A618	Oil Pump Intermediate Shaft

Item	Part Number	Description
9	18663	Heater Water Return Tube
10	6020	Engine Front Cover Gasket
11	6K342	Crankshaft Position Sensor Upper Shield
12	6C315	Crankshaft Position Sensor
13	6714	Oil Bypass Filter
14	6A642	Oil Cooler
15	6019	Engine Front Cover
16	6010	Cylinder Block

DESCRIPTION AND OPERATION (Continued)

The engine dynamic balance shaft (6A311) is driven by a camshaft gear and rotates in an opposite direction of the crankshaft (6303) to reduce vibration.



The large end of the connecting rod is mechanically split to produce a unique parting face. This produces a locking joint. Connecting rods (6200) and connecting rod caps are not interchangeable.

DIAGNOSIS AND TESTING

Engine

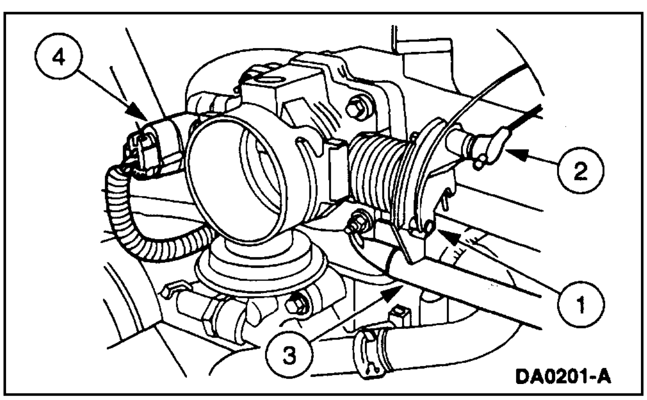
For basic engine mechanical concerns, refer to Section 01. For driveability concerns, refer to Ignition (Section 03).

ENGINE REPAIR

Intake Manifold – Upper

Removal

1. Remove the air cleaner assembly.
2. Remove the engine cover.
3. Disconnect the following at the throttle body:



   1 – Accelerator cable.

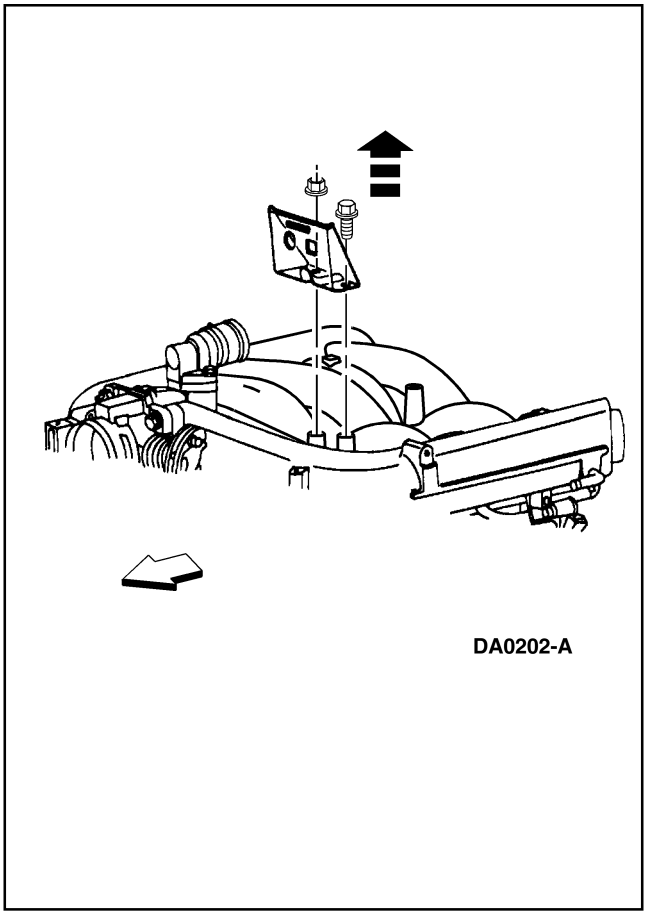
   2 – Speed control cable (if so equipped).

   3 – Vapor management hose for PCV system.

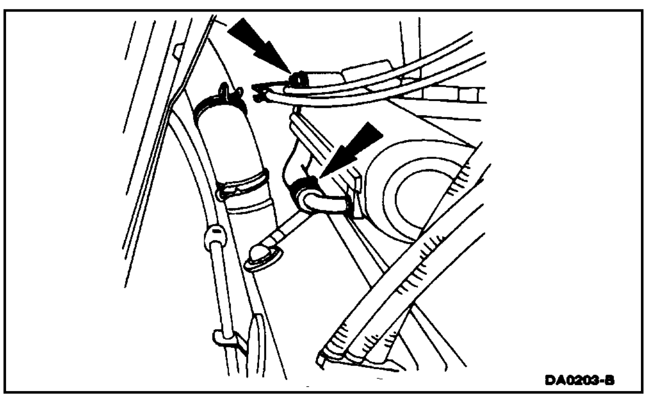
   4 – Wiring at the throttle position sensor.

   5 – Electronic Governor if so equipped.

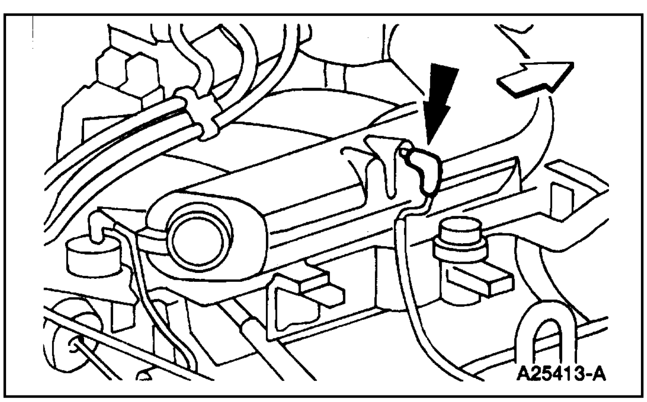
ENGINE REPAIR (Continued)



6. Remove the accelerator cable bracket if so equipped.

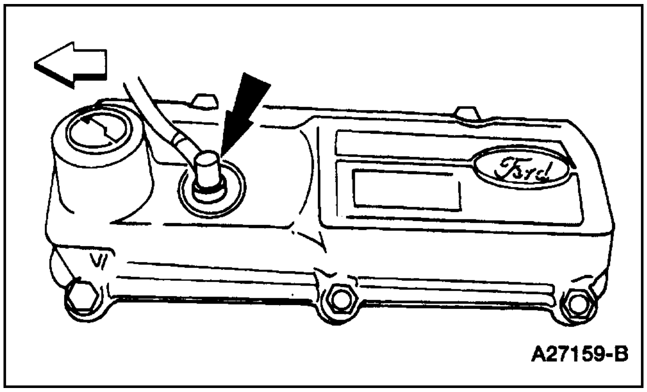


7. Remove the throttle cable/speed control routing clip retaining screw.

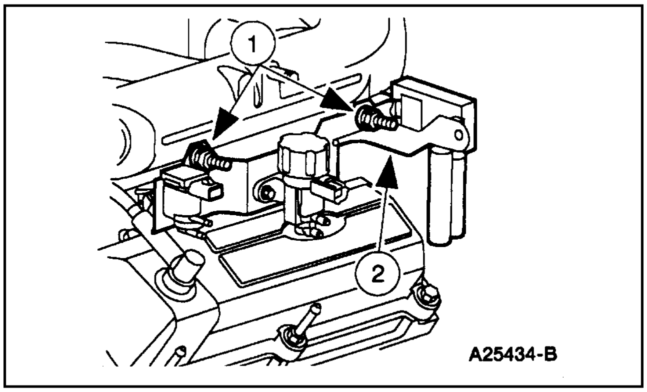


8. Disconnect the manifold vacuum connection.

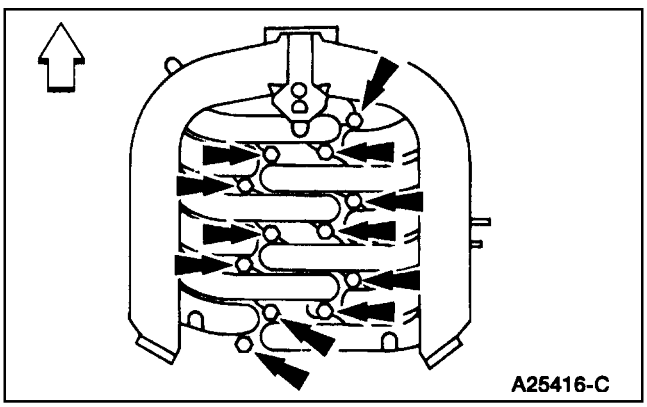
ENGINE REPAIR (Continued)



9. Remove the PCV valve.

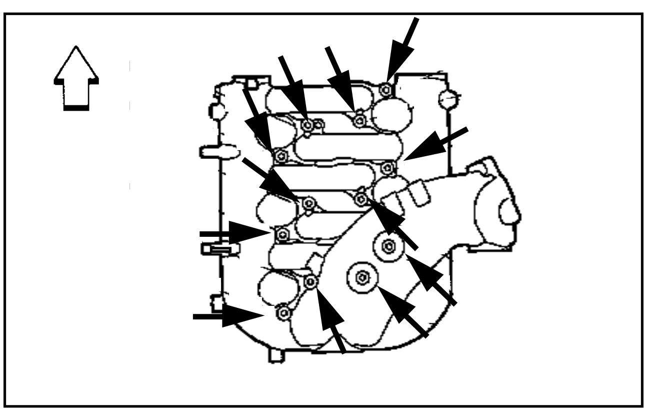


10. Remove the transmission dipstick tube routing bracket retaining nut and solenoid mounting bracket, if so equipped.



11. **NOTE**: Illustration shown is F-TYPE.

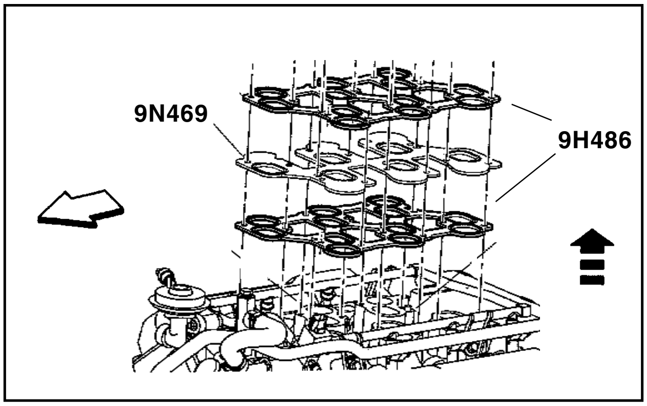
    Remove twelve bolts and the upper intake manifold (9424).



12. **NOTE**: Illustration shown is MUSTANG TYPE.

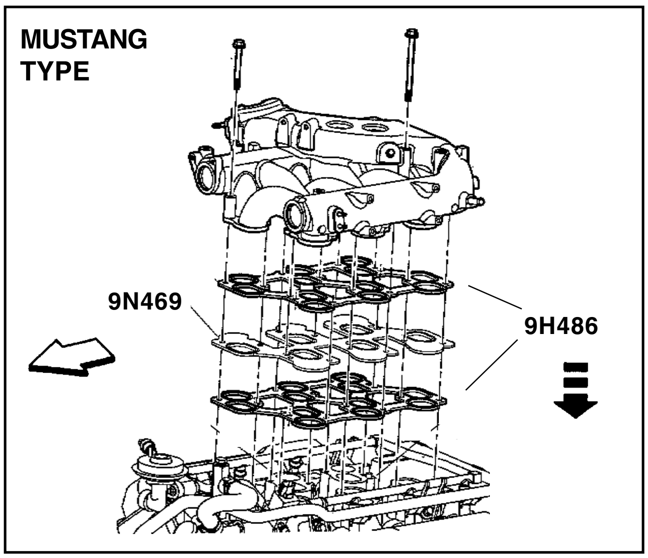
    Remove twelve bolts and the upper intake manifold (9424).

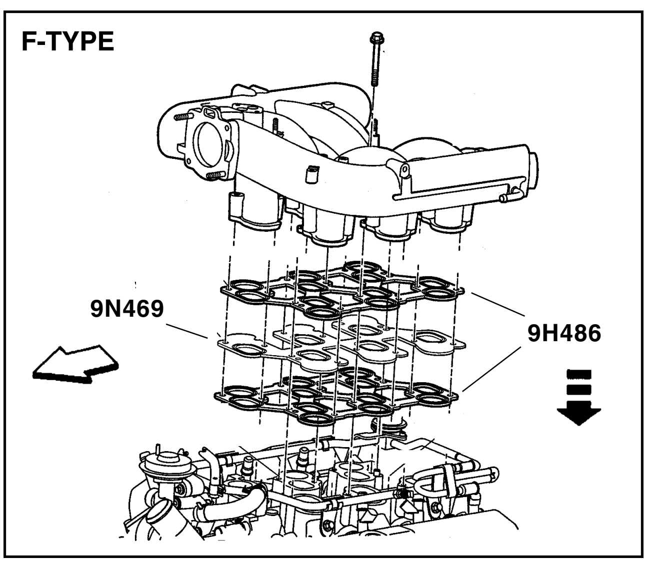
ENGINE REPAIR (Continued)



13. For both types of intake manifolds, remove and discard the two upper gaskets (9H486). Save and reuse spacer plate (9N469).

Installation of Upper Intake Manifold



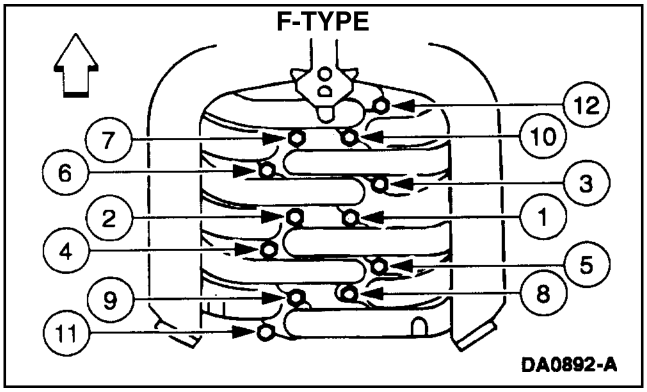


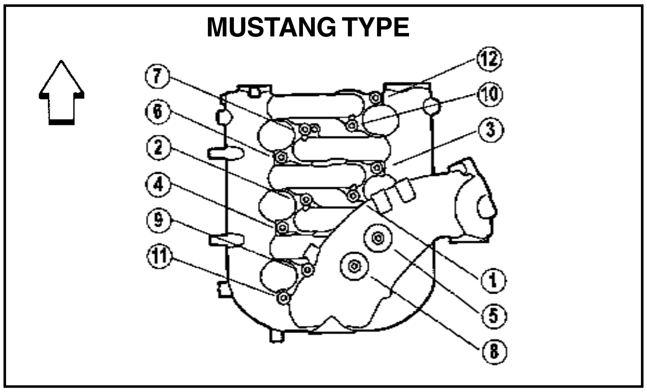
1. Follow the removal procedure in reverse order for both types of manifold (9424).

   NOTE: Install two new intake manifold upper gaskets (9H486) for both types of manifold.

2. Install first gasket to lower intake manifold (9J447).
3. Install spacer plate (9N469).
4. Install second upper intake manifold gasket (9H486).
5. Install upper intake manifold (9424).

ENGINE REPAIR (Continued)

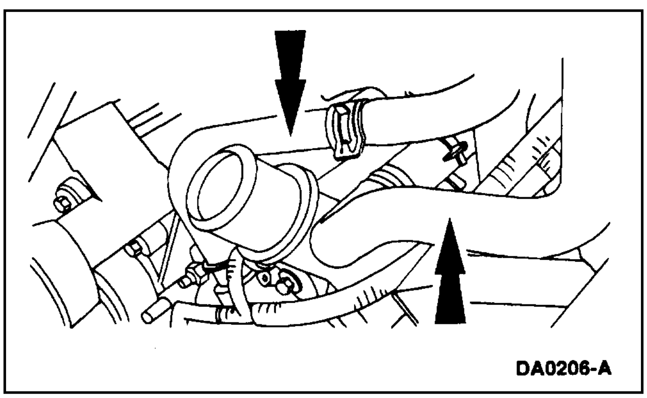




2. Tighten the upper intake manifold retaining bolts in three stages in the sequence shown, using the applicable illustration:
   - Stage 1: 6 Nm (53 lb/in)
   - Stage 2: 8-11.5 Nm (6-8 lb/ft)
   - Stage 3: Rotate 85°-95°

Intake Manifold – Lower

Removal



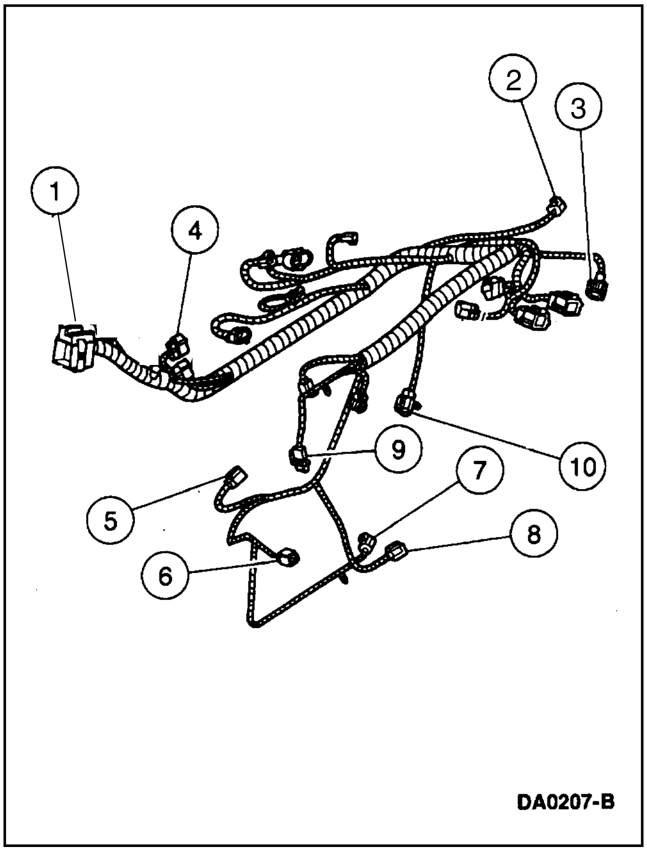
1. Remove the upper intake manifold. Refer to the procedure in this section.
2. Drain radiator and remove the radiator upper hose from the lower intake manifold.

ENGINE REPAIR (Continued)

3. Disconnect the coolant bypass hose and the heater hose.

4. **WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENTS. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND CAN BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.**

   Disconnect the fuel line. Refer to Section 04.



5. Disconnect the following electrical connectors:

   1 – 42 pin connector.

   2 – Camshaft Position Sensor (CMP).

   3 – Cylinder head temp sensor.

   4 – Crankshaft position sensor (CKP).

   5 – Oil pressure switch.

   6 – Heated oxygen (HO2S) sensor (LH).

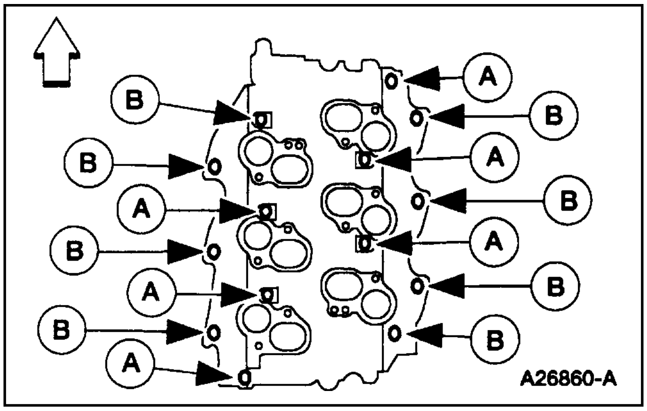
   7 – Manifold absolute pressure sensor (MAP).

   8 – Idle air control motor (IAC).

   9 – Intake air temperature (IAT).

   10 – Throttle position sensor (TPS).

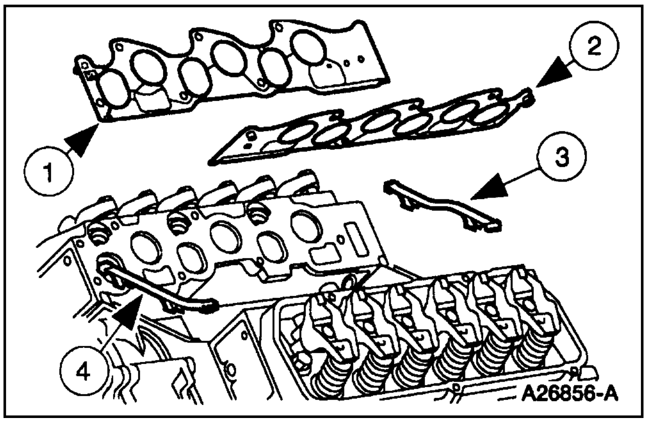
ENGINE REPAIR (Continued)



6. **NOTE:** Lower intake manifold bolts are torque-to-yield. They must be discarded and replaced with new bolts.

   NOTE: The fuel charging components and engine wiring harness are removed with the lower intake manifold.

   Remove the fourteen lower intake manifold bolts (A) and (B) and discard.

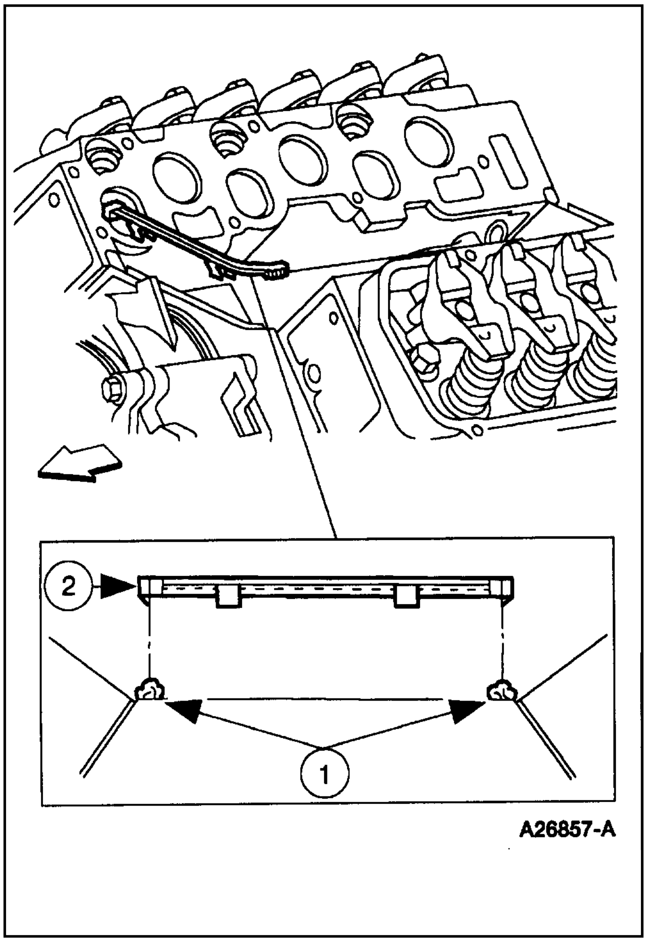


7. Remove and discard the lower intake manifold sealing components.

Item	Part Number	Description
1	9439	Intake Manifold Gasket (LH)
2	9439	Intake Manifold Gasket (RH)
3	–	Intake Manifold Rear End Seal (Part of 9439)
4	–	Intake Manifold Front End Seal (Part of 9439)

ENGINE REPAIR (Continued)

Installation of Lower Intake Manifold



CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

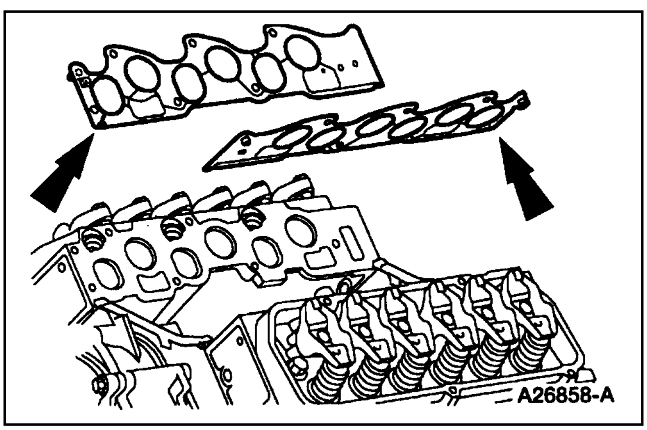
NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

1. Install the lower intake manifold front and rear end seals.

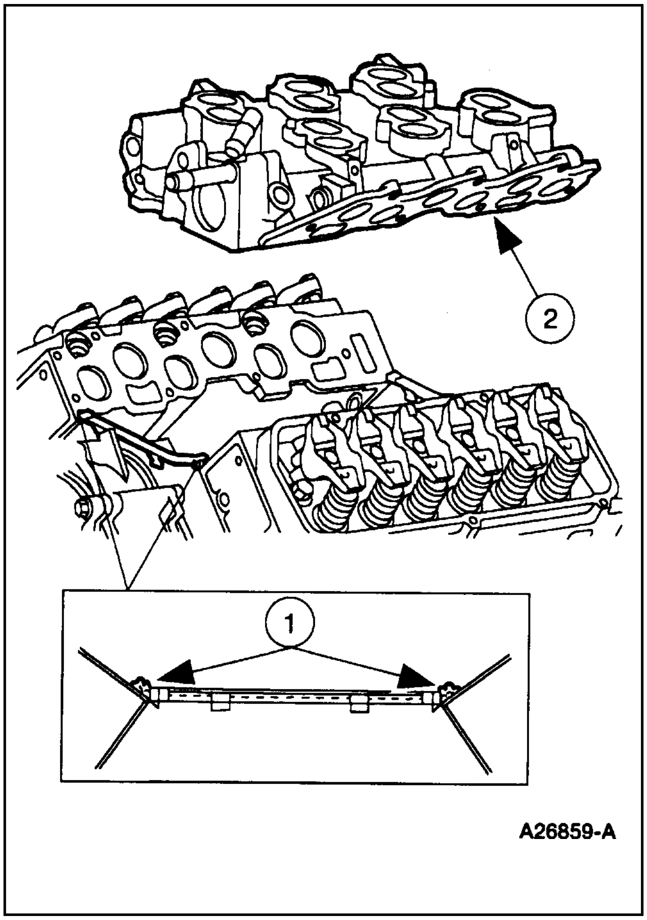
   1– Apply a bead of sealant to the intake manifold front and rear end seal mounting points as indicated.

   2 – Install the lower intake manifold front and rear end seals.



2. Install the intake manifold gaskets (9439).

ENGINE REPAIR (Continued)



CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

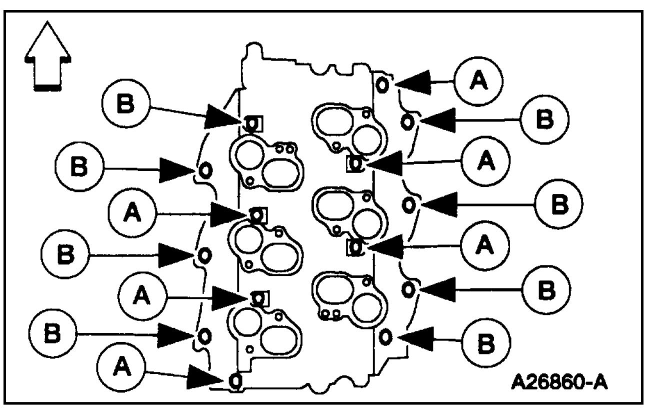
- Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

- Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

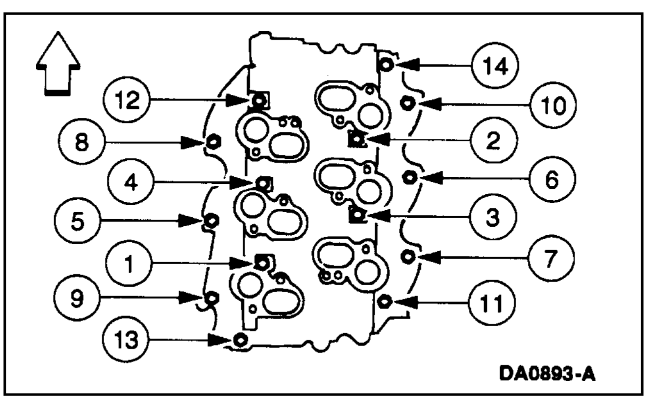
3. Apply a bead of sealant to the intake manifold front and rear end seal mounting at the points as indicated.

    - Position the lower intake manifold.



4. **NOTE:** Lower intake manifold bolts are torque-to-yield. They must be discarded and replaced.

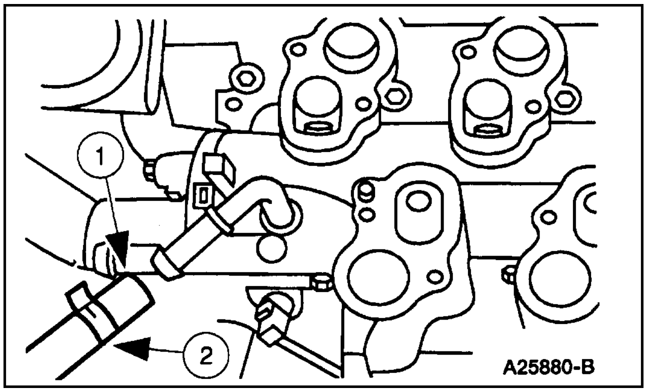
    Install six new (A) long lower intake manifold bolts and the eight new (B) short lower intake manifold bolts.



5. Tighten the lower intake manifold bolts in two stages in the sequence shown:

    - Stage 1: 5 Nm (44 lb/in).
    - Stage 2: 8-11.5 Nm (71-101 lb/in).

ENGINE REPAIR (Continued)



6. Connect the water pump bypass hose.

   1 – Position the water pump bypass hose.

   2 – Position the hose clamp.

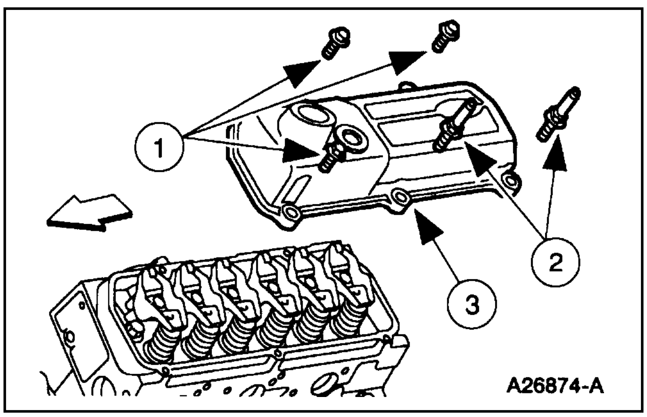
7. Connect the fuel line. Refer to Section 04.

8. Install the upper radiator hose to the lower intake manifold.

9. Connect the electrical harness.

10. Install the upper intake manifold. Refer to the procedure in this section.

Cylinder Head Removal



1. Remove the upper and lower intake manifolds. Refer to the procedures in this section.

2. Remove the valve cover (6582).

   • Remove the ignition coil pack (if necessary). Refer to procedures in Section 3.

   1 – Remove the three valve cover bolts.

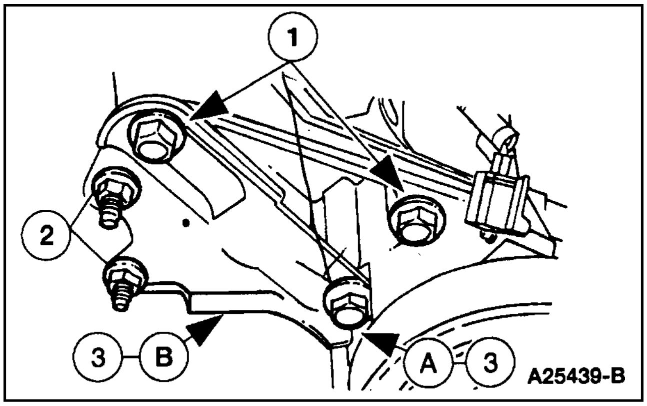
   2 – Remove the two valve cover stud bolts.

   3 – Remove the valve cover.

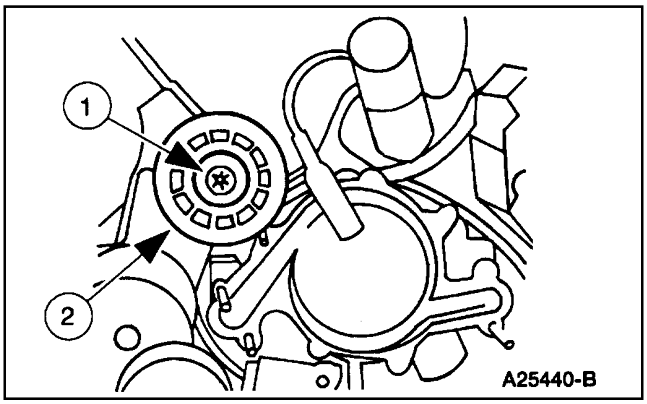
3. Remove the exhaust manifold (9430). Refer to the procedure in this section.

4. If removing the LH cylinder head (6049), remove and support the power steering pump when applicable.

ENGINE REPAIR (Continued)



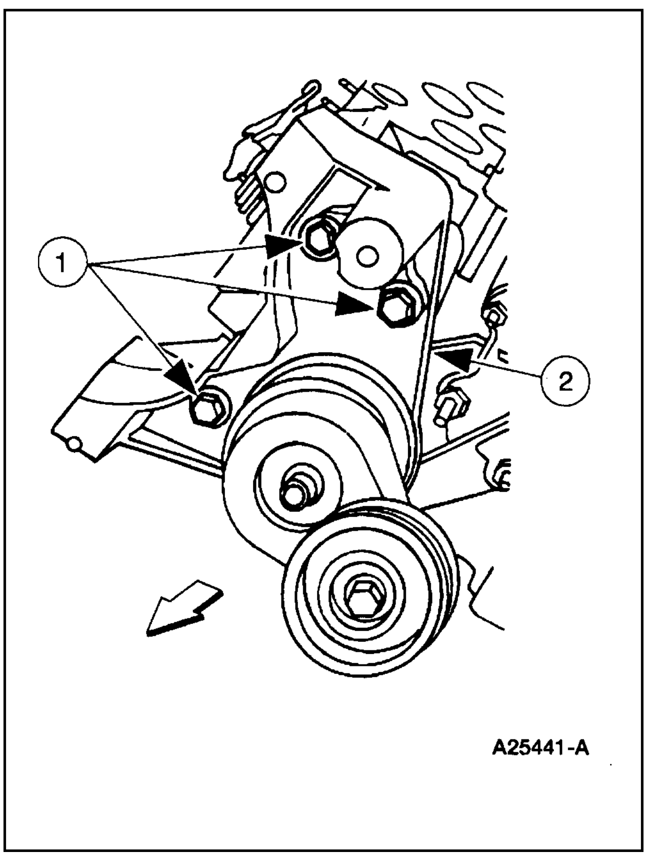
5. Remove the 3 idler pulley bracket bolts.
6. If removing the RH cylinder head, remove the generator (GEN) (10346). Refer to Section 06.



7. If removing the RH cylinder head, remove the idler pulley.

   1 – Remove the bolt.

   2 – Remove the idler pulley.

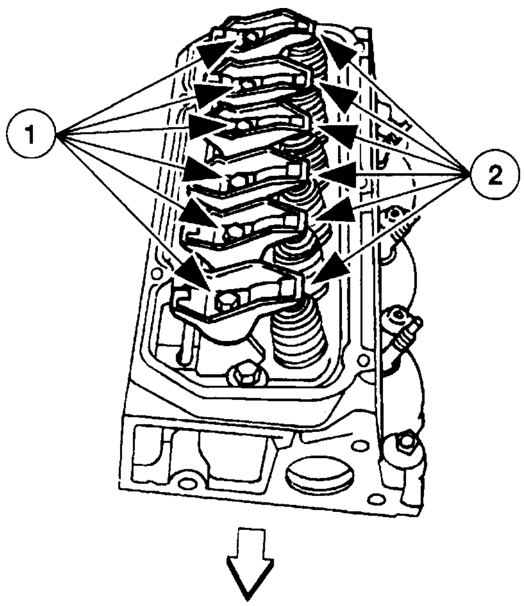


8. If removing the RH cylinder head, remove the generator bracket.

   1 – Remove the three bolts.

   2 – Remove the generator bracket.

ENGINE REPAIR (Continued)



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

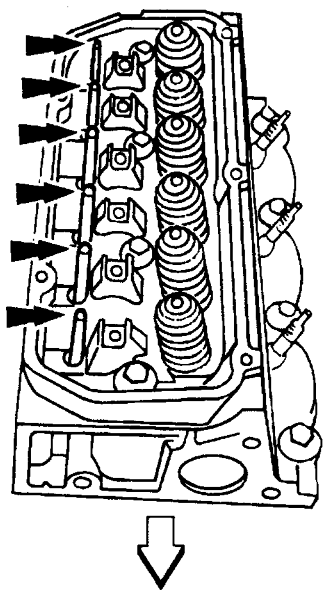
9. Remove the six rocker arms (6564).

   1 – Remove the six bolts.

   2 – Remove the six rocker arms.

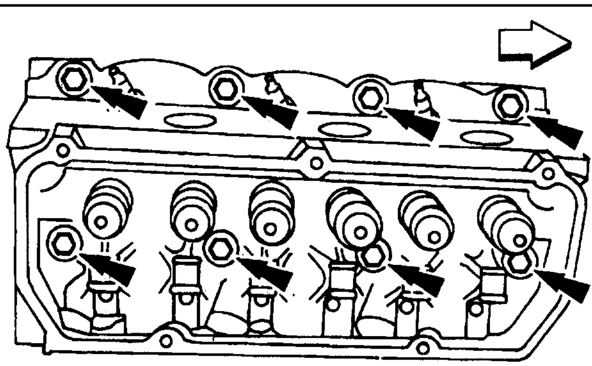
NOTE: Refer to Section 05-12 for cylinder head temperature sensor removal and installation if needed.

ENGINE REPAIR (Continued)



A25443-A

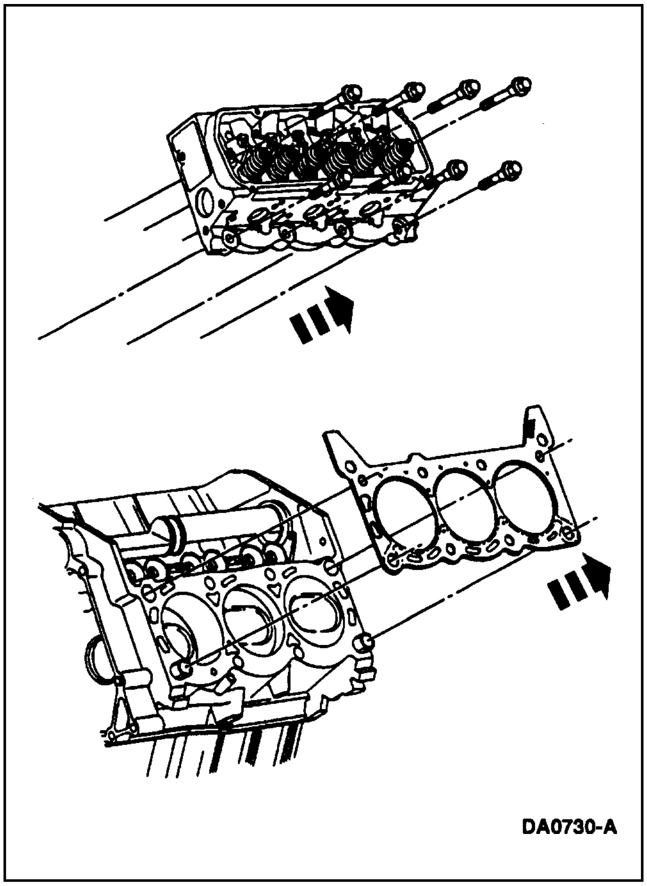
10. Remove the six push rods (6565).



A25444-A

11. Remove and discard the eight cylinder head bolts.

ENGINE REPAIR (Continued)

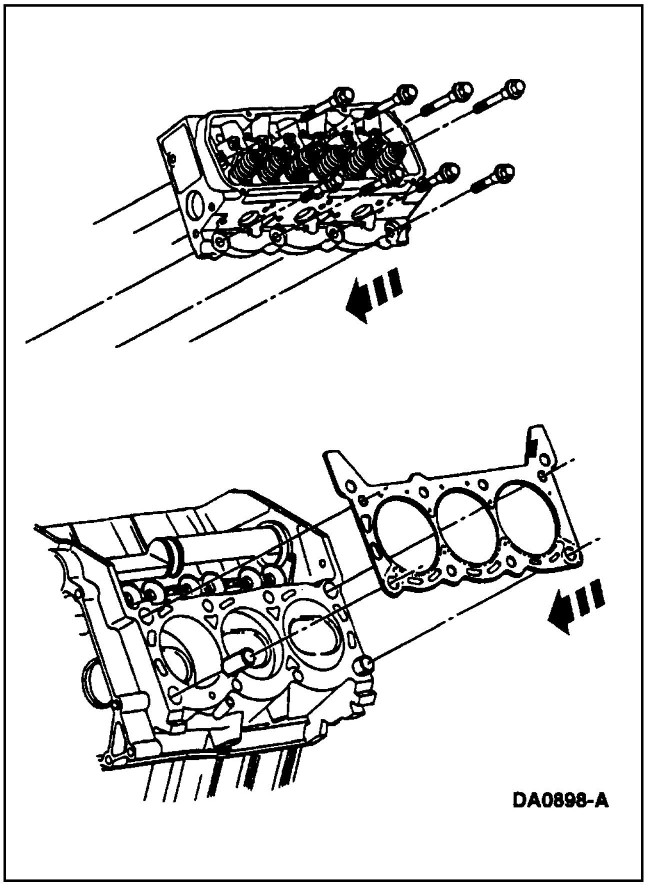


12. Remove the cylinder head and the head gasket (6051). Discard the head gasket and head bolts.

ENGINE REPAIR (Continued)

Cylinder Head

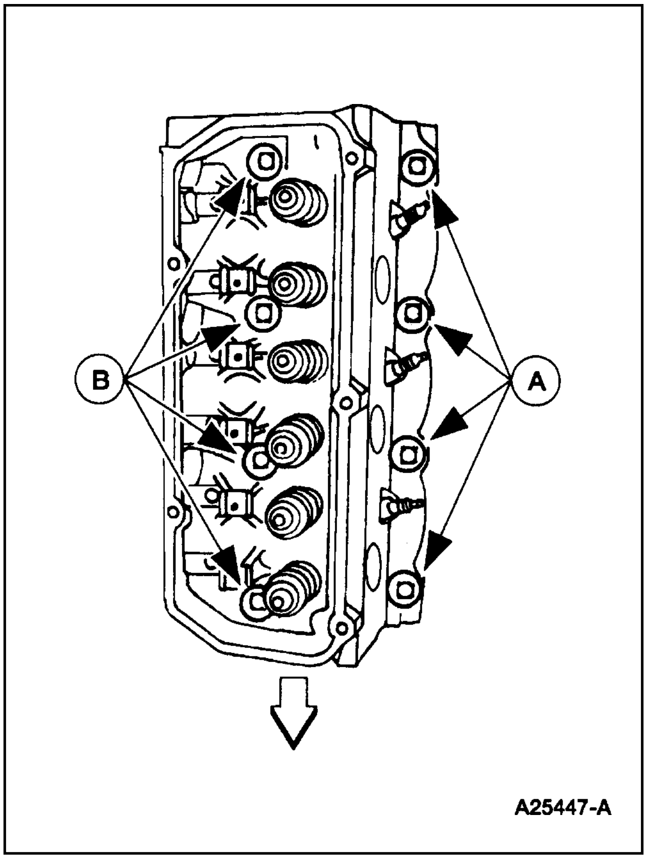
Installation



WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENTS. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND CAN BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

1. Install a new head gasket on the cylinder blocks (6010) with the small hole to the front of the engine and position the cylinder head.

ENGINE REPAIR (Continued)

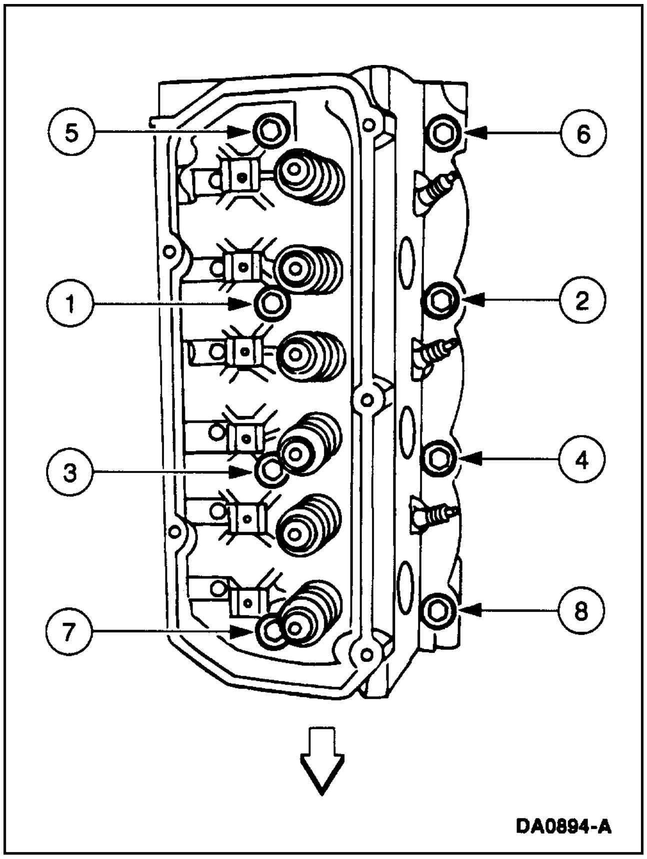


2. **CAUTION: Head bolts are torque to yield. To obtain proper torque specification always use new cylinder head bolts, otherwise may cause engine failure.**

   NOTE: Lubricate the new cylinder head bolts with engine oil prior to installation.

   Install the four new (A) short cylinder head bolts and the four new (B) long cylinder head bolts.

ENGINE REPAIR (Continued)



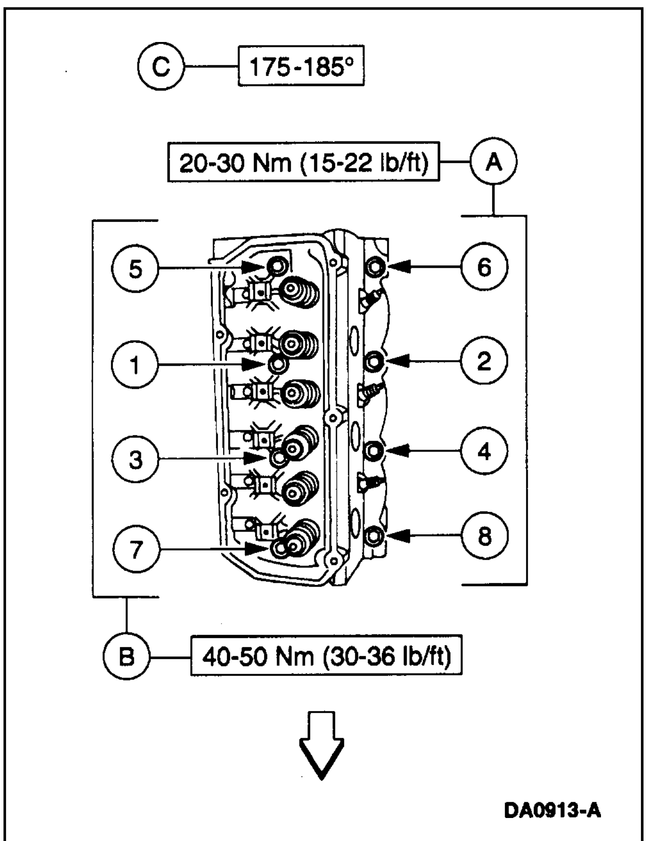
3. **NOTE:** Make sure to tighten the cylinder head bolts in three steps, using two operations. The head bolts are to be tighten following the next 3 steps. When this operation is complete the 3 steps in sequence #4 must be followed.

   Tighten the cylinder head bolts in three stages in the sequence shown:

   • Stage 1: 20 Nm (14 lb/ft).

   • Stage 2: 40 Nm (29 lb/ft).

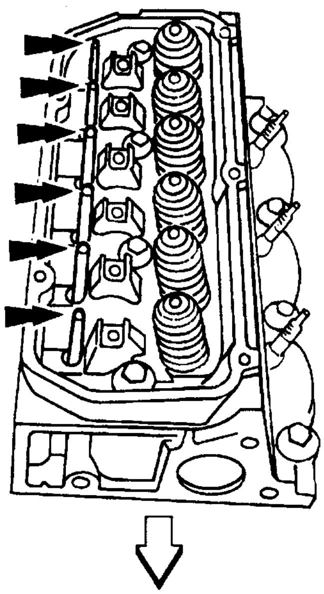
   • Stage 3: 50 Nm (36 lb/ft).



4. **CAUTION: Do not loosen all of the cylinder head bolts at one time. Each cylinder head bolt must be loosened and the final tightening completed prior to working on the next bolt in the sequence.**

   In the sequence shown, loosen the cylinder head bolt three turns, then tighten the (A) short cylinder head bolt or (B) long cylinder head bolt to the specification indicated, and then further tighten the cylinder head bolt to the (C) degrees indicated.

ENGINE REPAIR (Continued)



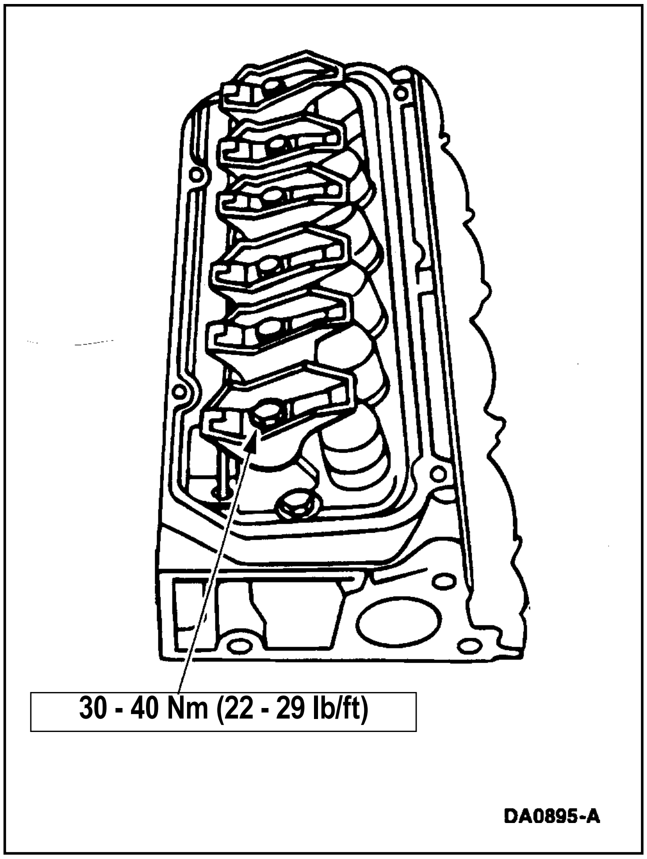
A25443-A

NOTE: Refer to location note made during removal and make sure components are installed in the correct location.

5. **NOTE:** Lubricate the push rods with engine oil prior to installation.

   Install the six push rods.

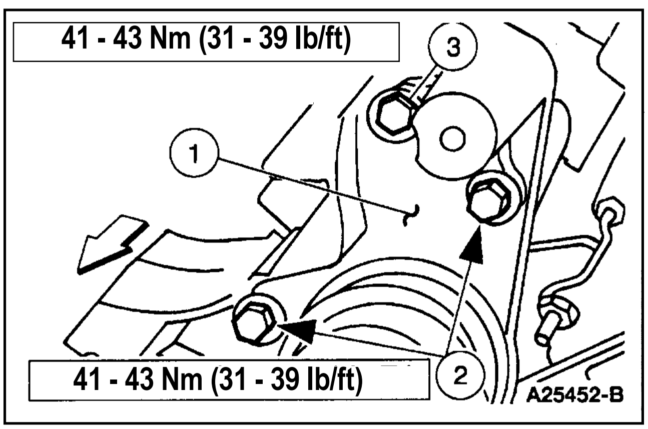
ENGINE REPAIR (Continued)



6. Install the six rocker arms.

   1 – Position the six rocker arms.

   2 – Install the six bolts.



7. If valve train components have been replaced, inspect the valve clearance.

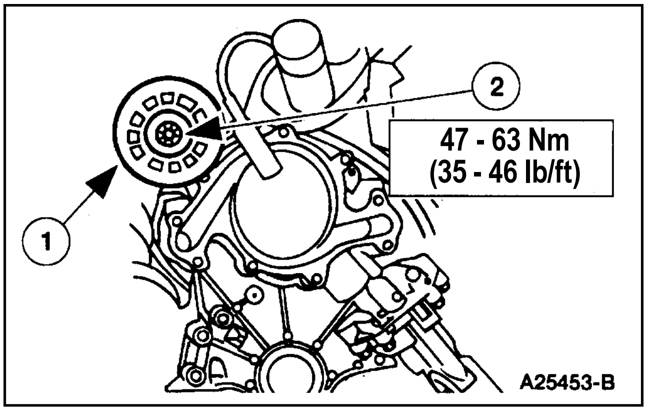
8. If installing the RH cylinder head, install the generator bracket.

   1 – Position the generator bracket.

   2 – Install the two long bolts.

   3 – Install the short bolt.

ENGINE REPAIR (Continued)



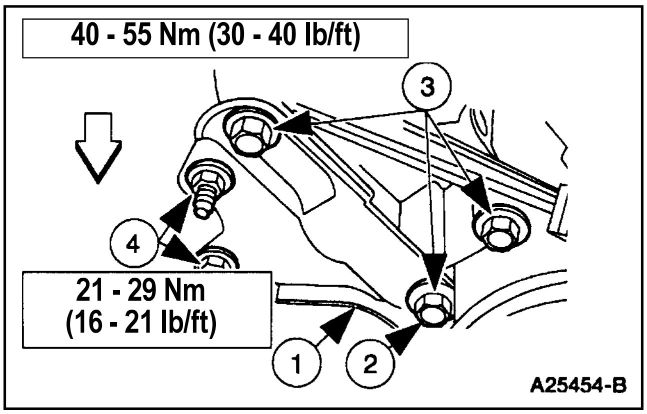
9. If installing the RH cylinder head, install the idler pulley.

   1 – Position the idler pulley.

   2 – Install the bolt.

10. If installing the RH cylinder head, install the generator.

11. Install the ignition coil pack (if necessary). Refer to procedures in Section 3. Torque bolts to 5-6 Nm (48 in/lbs).



12. If installing the LH cylinder head, install idler pulley bracket.

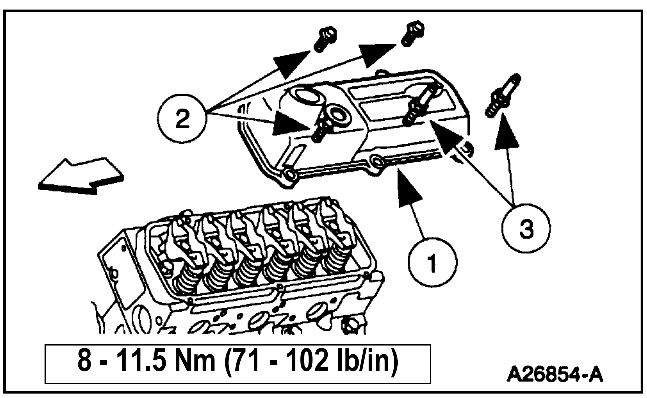
   1 – Position the idler pulley bracket.

   2 – Start the bracket bolts.

   3 – Install the three idler pulley bracket bolts.

13. Install idler pulley. Refer to Section 02-72.

14. Install the exhaust manifold. Refer to the procedure in this section.



15. Inspect the LH valve cover gasket for damage. Replace if necessary.

   1 – Position the LH valve cover.

   2 – Install the three bolts.

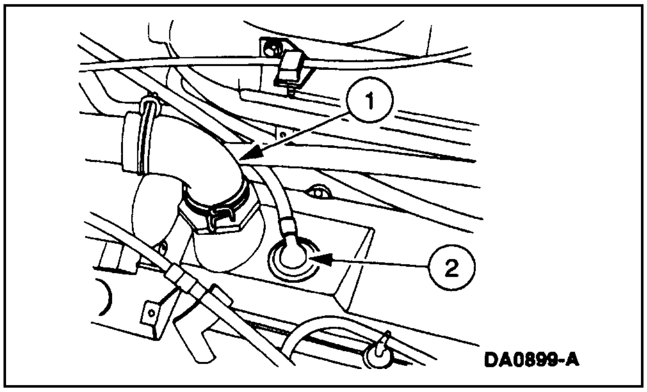
   3 – Install the two stud bolts.

16. Install the lower intake manifold. Refer to the procedure in this section.

ENGINE REPAIR (Continued)

Valve Cover – LH

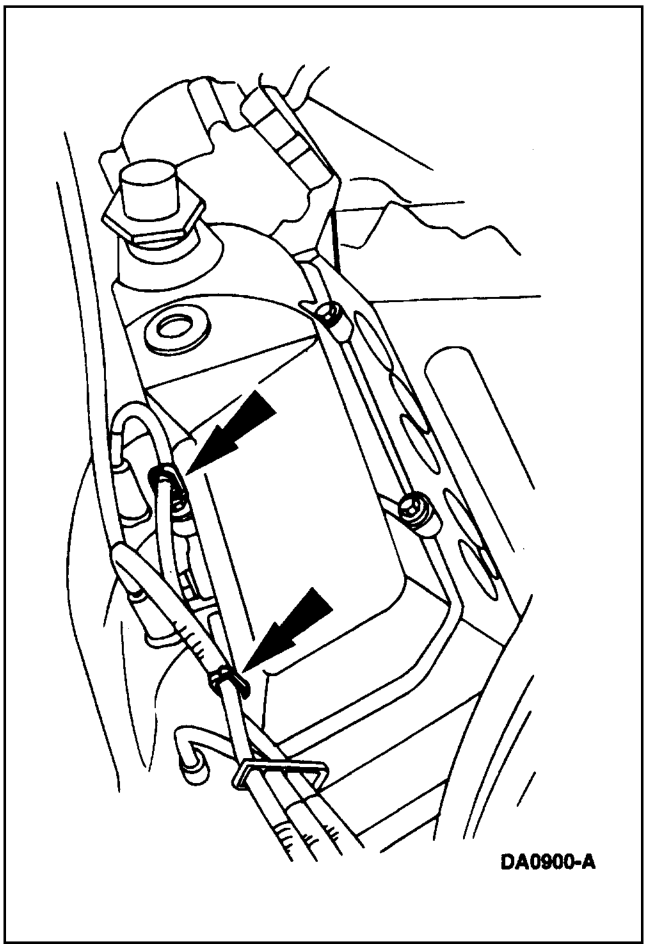
Removal



1. Disconnect the following:

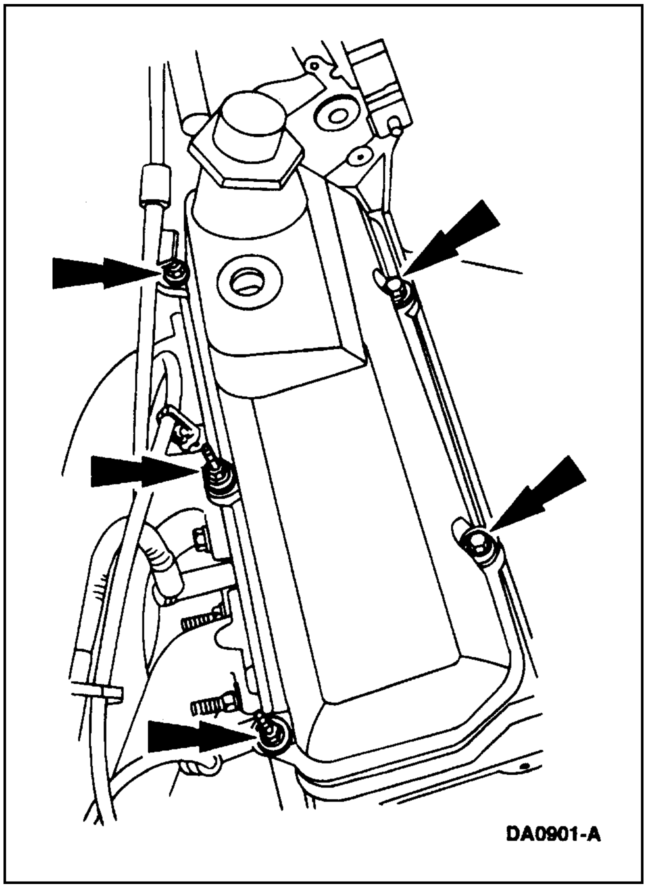
   1 – Oil filler extension tube if equipped.

   2 – PCV breather tube.



2. Disengage the spark plug routing clips at the valve cover studs.

ENGINE REPAIR (Continued)

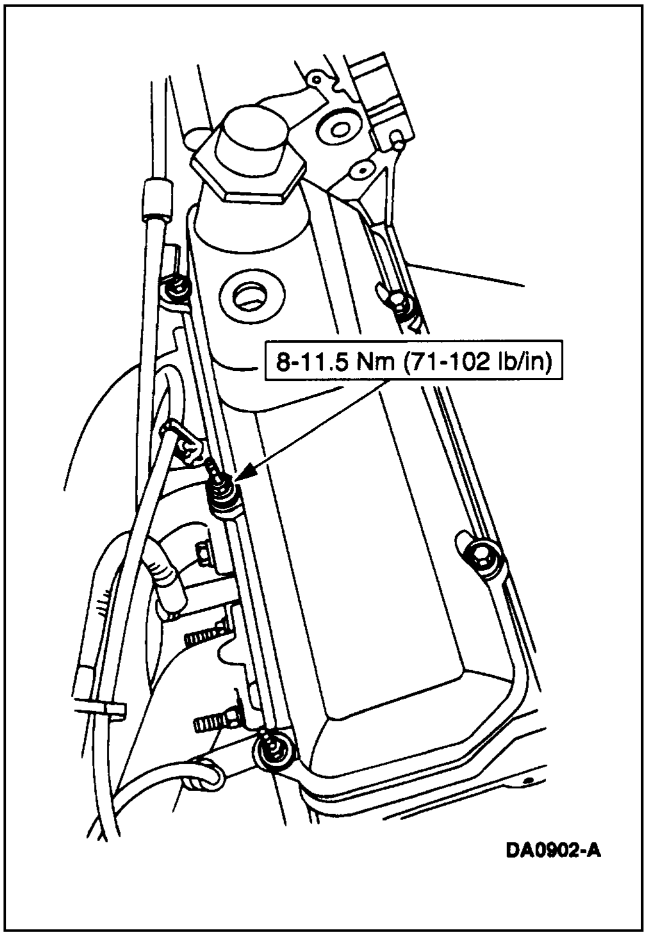


3. Remove the valve cover bolts and the valve cover.
4. Inspect the valve cover gasket. Replace if necessary.

ENGINE REPAIR (Continued)

Valve Cover – LH

Installation

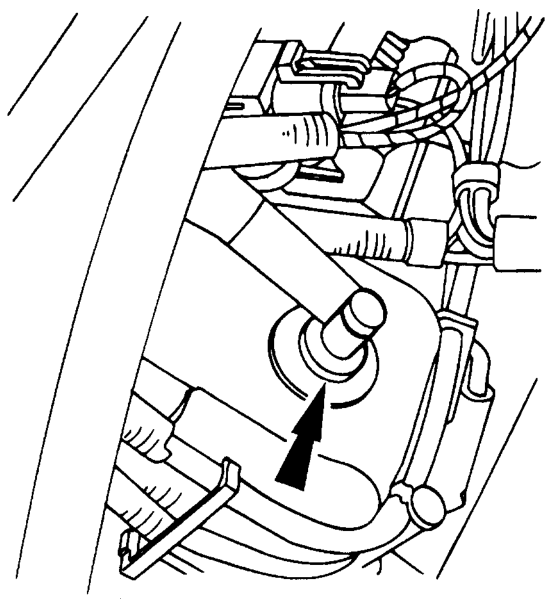


1. Follow the removal procedure in reverse order.

ENGINE REPAIR (Continued)

Valve Cover – RH

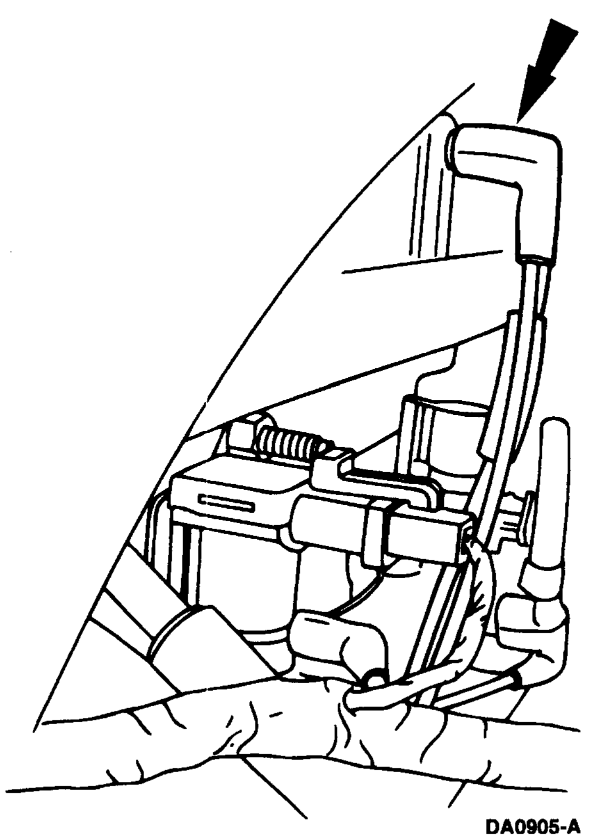
Removal



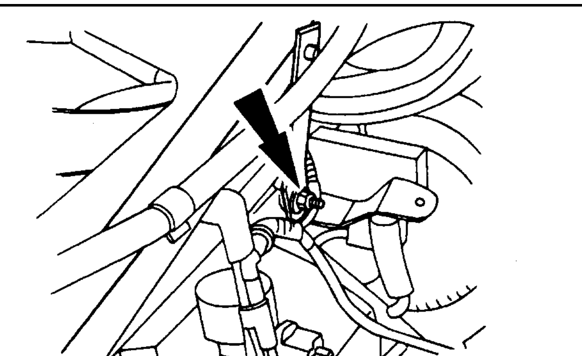
DA0904-A

1. Pull the PCV valve out of the valve cover.

ENGINE REPAIR (Continued)

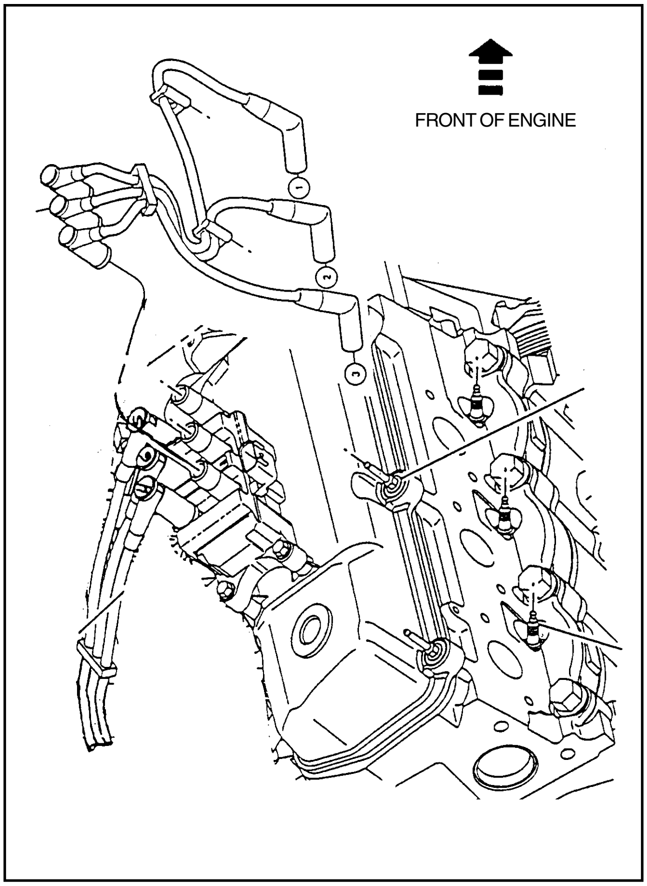

DA0905-A

2. Disconnect the vacuum supply line at the intake manifold.


DA0906-A

3. Remove the transmission support bracket retaining nut and pull the bracket away from the stud if equipped.

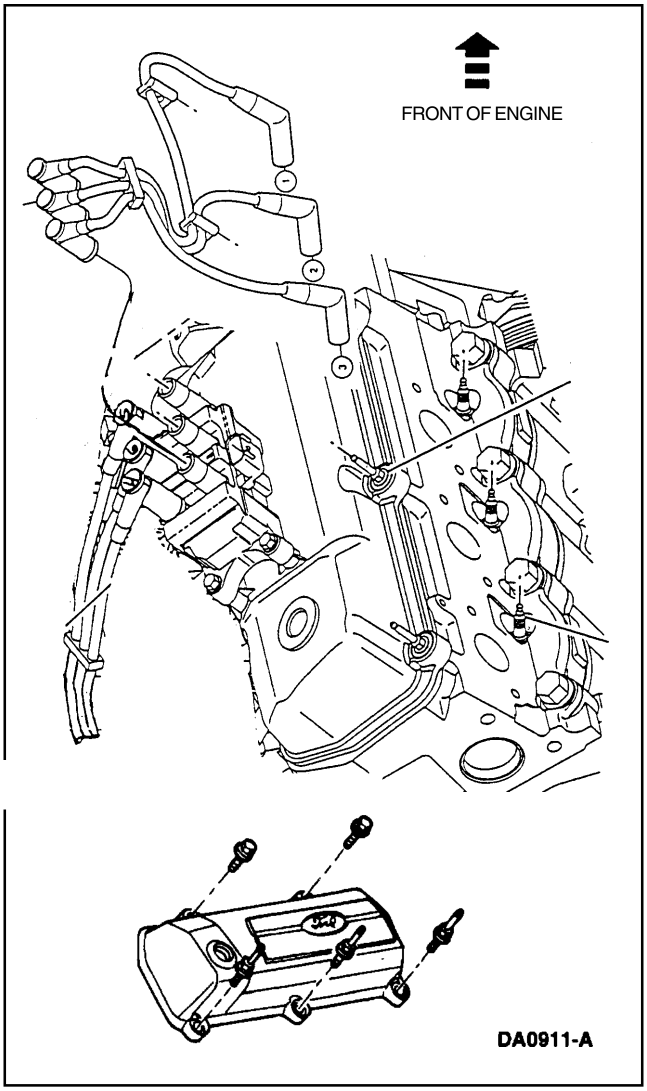
ENGINE REPAIR (Continued)



4. Remove the spark plug routing clips at the valve cover studs.

5. Remove the ignition coil pack. Refer to procedures in Section 3.

ENGINE REPAIR (Continued)

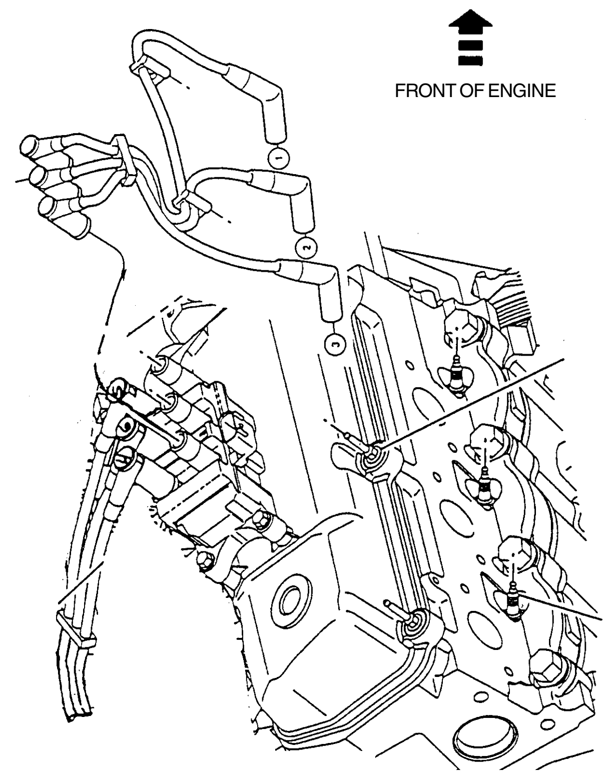


6. Remove the retaining bolts and the valve cover. The gasket is removed with the cover.

ENGINE REPAIR (Continued)

Valve Cover – RH

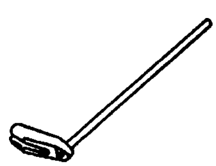
Installation



1. Install the valve cover. Make sure the gasket is serviceable. Replace if necessary. Follow the removal procedure in reverse order. Torque 8-12 Nm (71-106 lb/in) (5 bolts).
2. Install the ignition coil pack. Refer to procedures in Section 3. Torque to 5-6 Nm (48 lb/in) (3 bolts).

Valve Spring and Valve Spring Retainer

Special Tool(s)

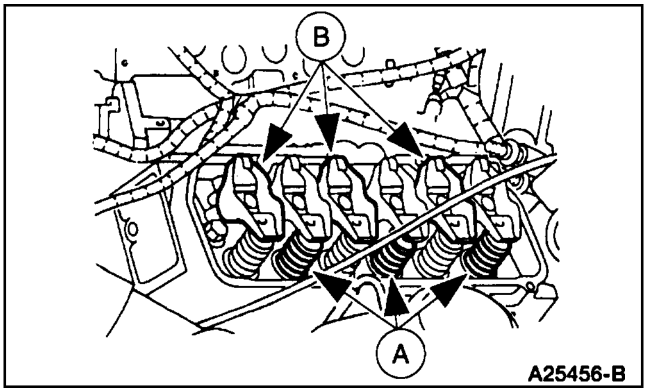
 ST1383-A	Valve Spring Compressor T81P-6513-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Removal.

1. Remove the valve cover. Refer to the procedure in this section.

ENGINE REPAIR (Continued)



2. Rotate the crankshaft (6303) until the piston (6108) for the valve being worked on is at the top of its stroke with both the (A) intake valve (6507) and the (B) exhaust valve (6505) closed.

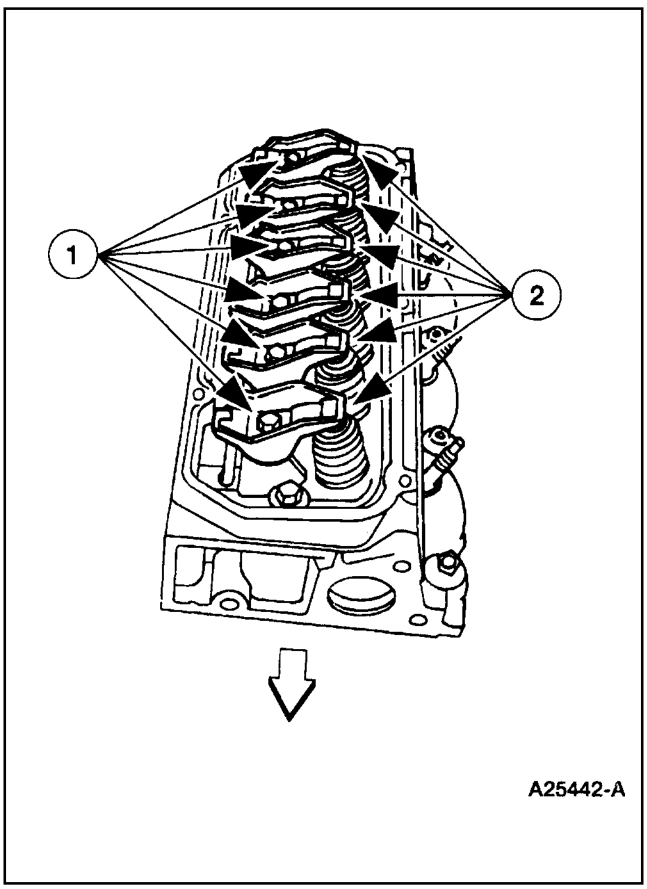
3. Hold the valve in the cylinder head.

   • Remove the spark plug, if necessary.

   • Apply a minimum of 965 kPa (140 psi) of compressed air to the cylinder to hold valve.

NOTE: If the components are to be reinstalled, they must be installed in the same position. Mark the components for location.

CAUTION: If a valve drops into the cylinder, remove the cylinder head. Refer to the procedure in this section.

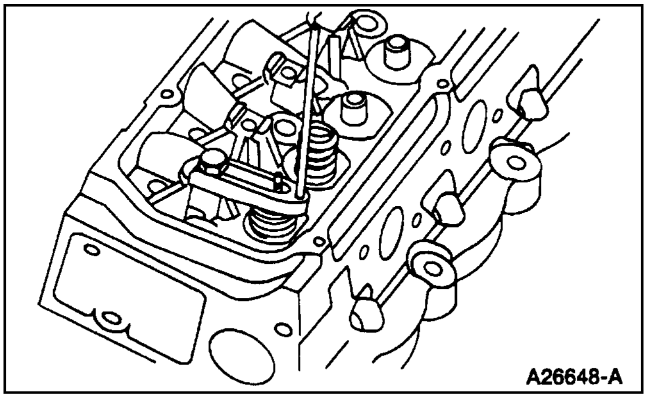


4. Remove the rocker arms.

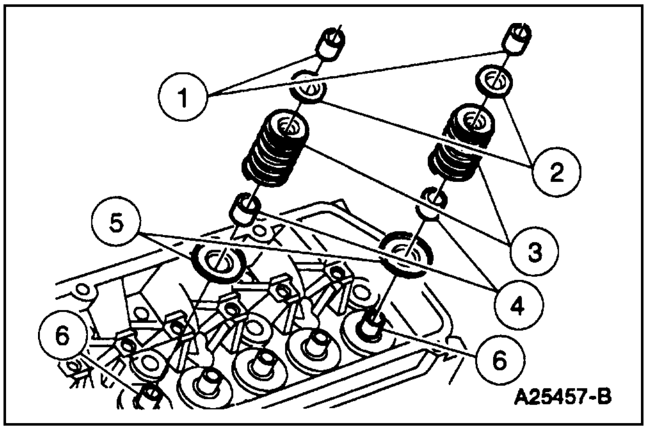
   1 – Remove the bolts.

   2 – Remove the rocker arms.

ENGINE REPAIR (Continued)



5. Use Valve Spring Compressor to compress the valve springs.



6. Remove the following:

   1– Remove the valve spring retainer key (6518).

   2 – Remove the valve spring retainer (6514).

   3 – Remove the valve spring (6513).

   4 – Remove and discard the valve stem seal (6571).

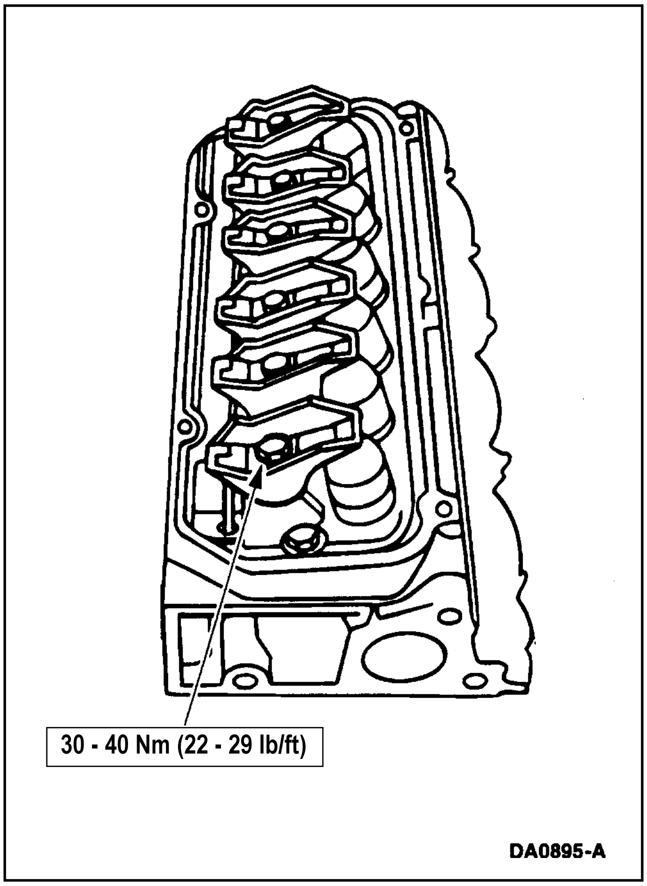
   5 – Remove the valve spring seat.

   6 – Secure the valve to keep it from dropping.

7. Inspect the components, replace if necessary. Refer to Section 01.

ENGINE REPAIR (Continued)

Installation



1. **NOTE:** Components removed should be marked for location. Make sure components are installed in the correct location.

   NOTE: Lubricate parts with engine oil prior to assembly.

   Follow the removal procedure in reverse order.

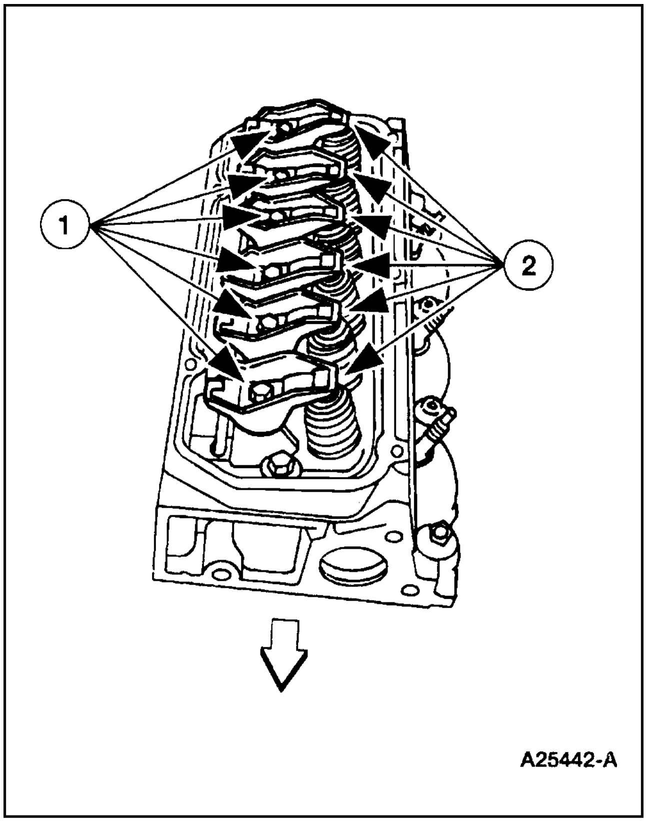
Valve Tappet

Removal

NOTE: If removing more than one valve tappet (6500), mark components removed for proper location.

1. Remove the upper and lower intake manifolds. Refer to the procedure in this section.
2. Remove the valve cover. Refer to the procedure in this section.

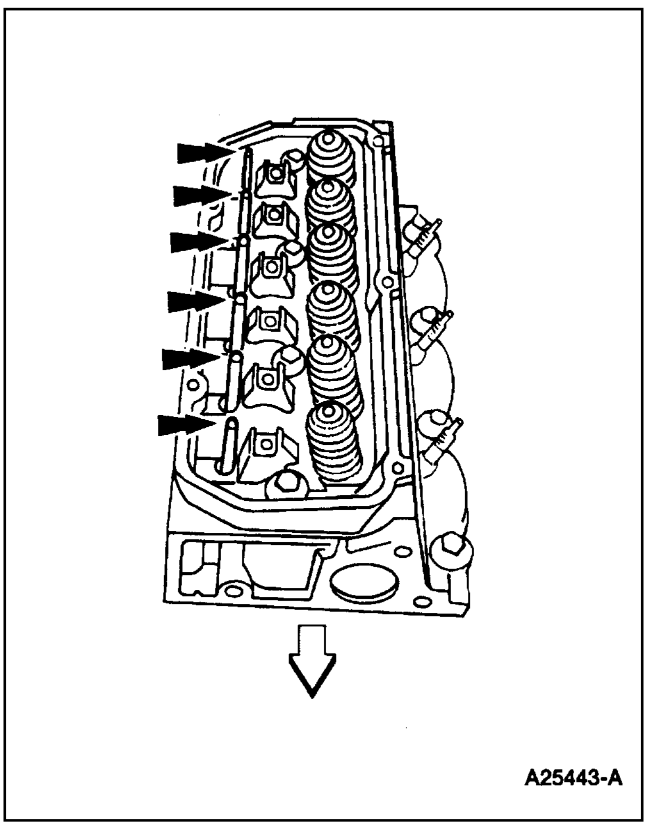
ENGINE REPAIR (Continued)



3. Remove the rocker arms.

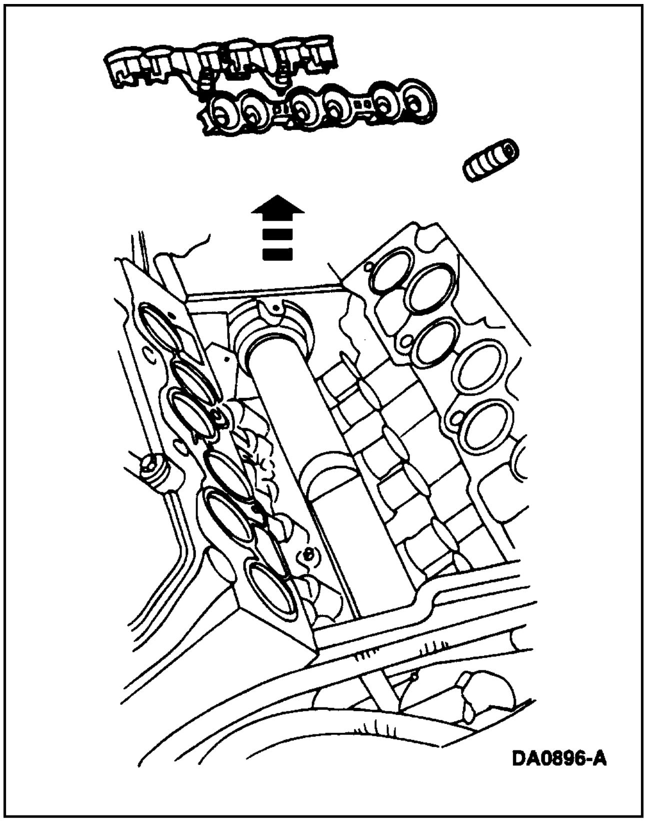
   1 – Remove the bolts.

   2 – Remove the rocker arms.



4. Remove the push rods.

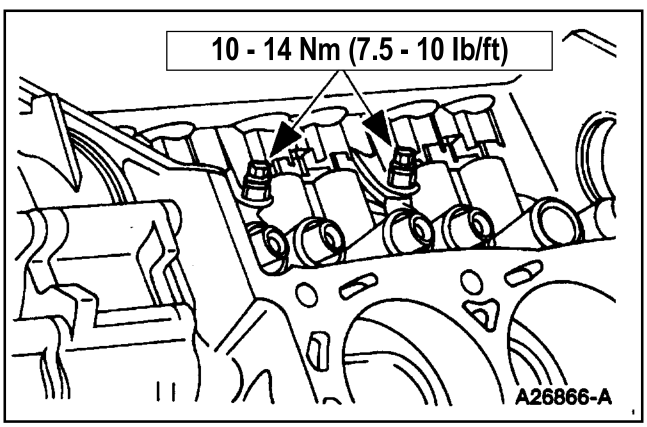
ENGINE REPAIR (Continued)



5. Remove the valve tappet guide and valve tappet.

Valve Tappet

Installation

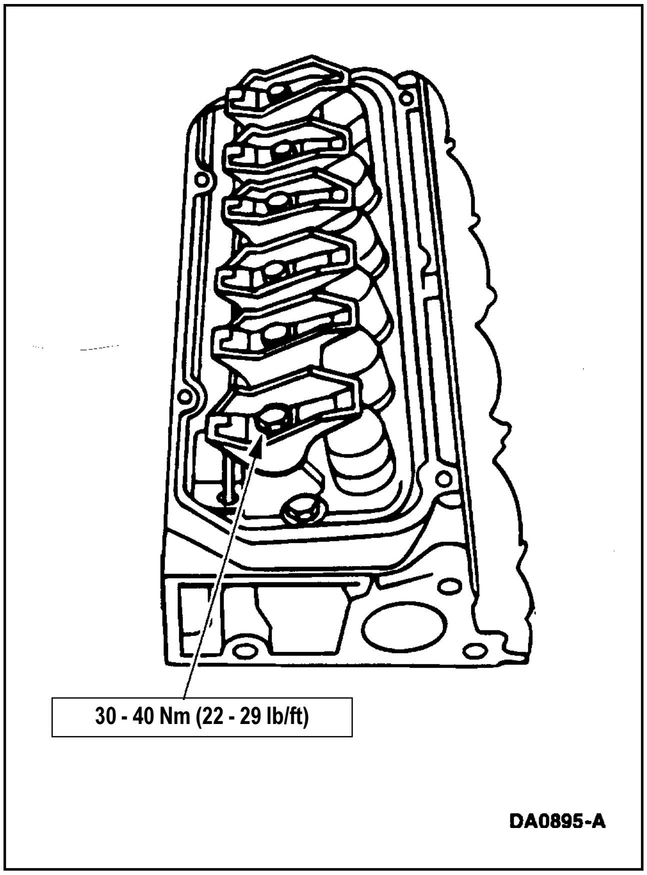


1. **NOTE:** Components removed should be marked for location. Make sure components are installed in the correct location.

   NOTE: Lubricate the valve tappet with engine oil before installing.

   Follow the removal procedure in reverse order.

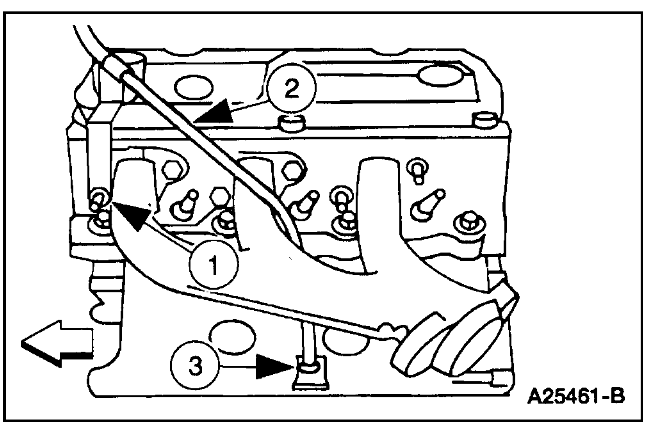
ENGINE REPAIR (Continued)



2. Install push rods.
3. Install rocker arms and bolts.
4. Install valve cover and gasket.
5. Install upper and lower intake manifolds.

Exhaust Manifold – LH

Removal



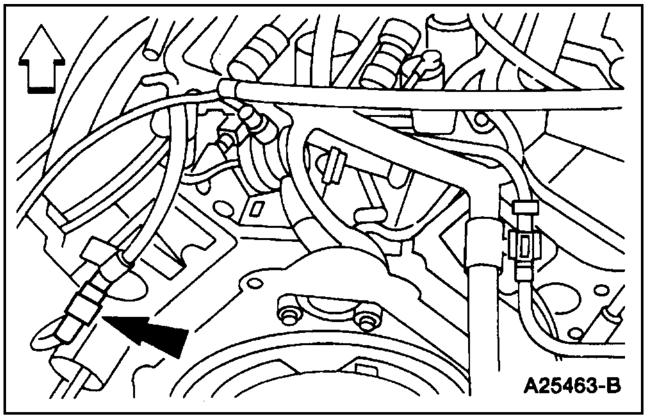
1. Remove the oil level indicator tube (6754).

   1– Remove the oil level indicator tube bracket nut.

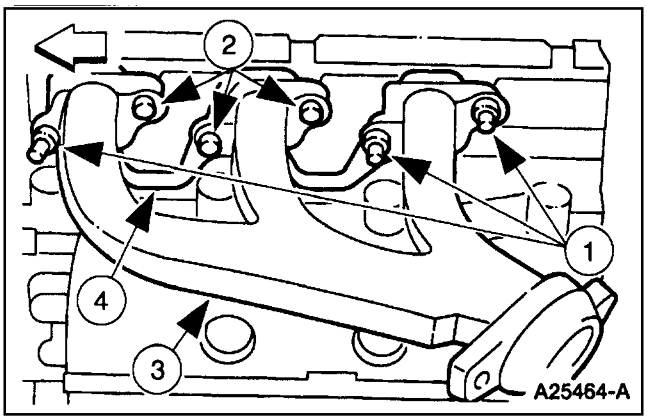
   2 – Remove the oil level indicator tube.

   3 – Remove and discard the oil level indicator tube O-ring.

ENGINE REPAIR (Continued)



2. Disconnect the LH heated oxygen sensor (HO2S) electrical connector if so equipped.



3. Remove the LH exhaust manifold and the LH exhaust manifold gasket (9448).

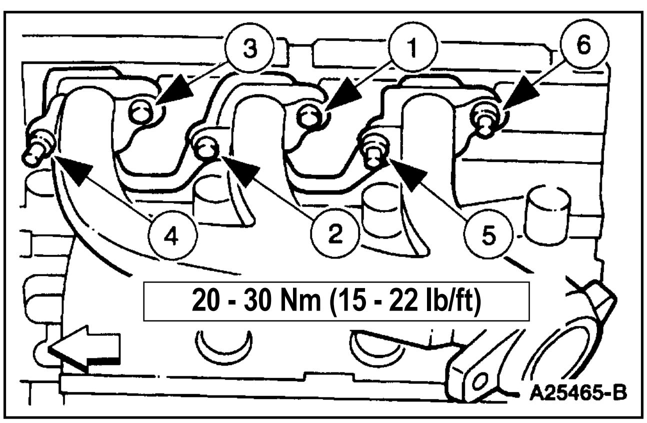
   1– Remove the three LH exhaust manifold stud bolts.

   2 – Remove the three LH exhaust manifold bolts.

   3 – Remove the LH exhaust manifold.

   4 – Remove and discard the LH exhaust manifold gasket.

Installation of Exhaust Manifold – LH



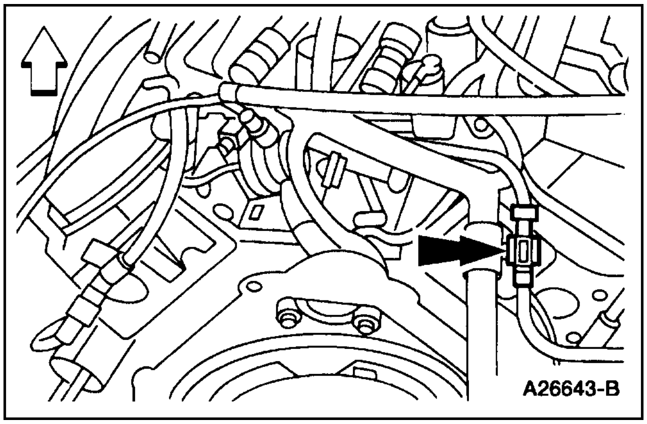
1. **NOTE:** Tighten in the sequence shown.

   Follow the removal procedure in reverse order.

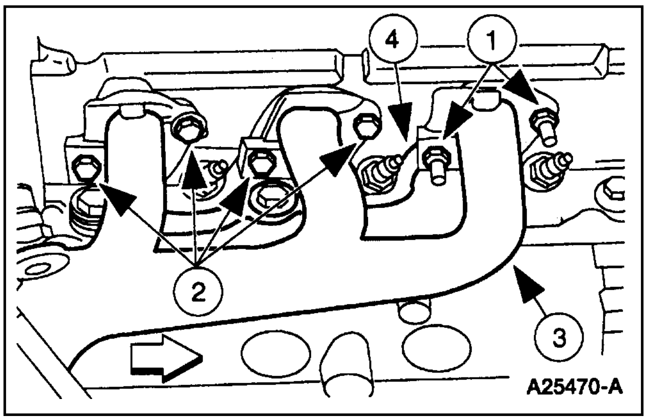
ENGINE REPAIR (Continued)

Exhaust Manifold – RH

Removal



1. Disconnect the RH heated oxygen sensor (HO2S) electrical connector if so equipped.



2. Remove the RH exhaust manifold and the RH exhaust manifold gasket.

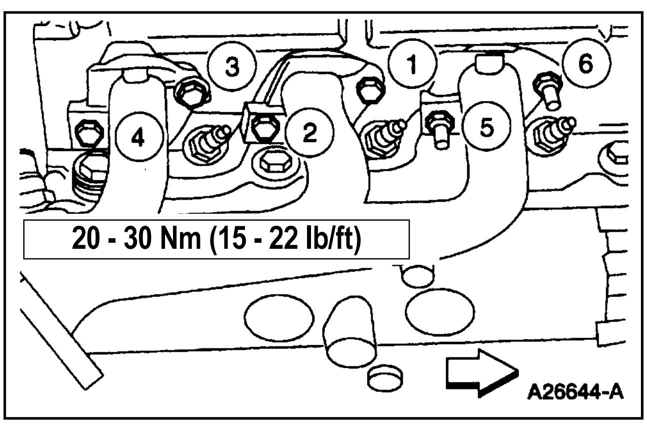
   1– Remove the two RH exhaust manifold stud bolts.

   2 – Remove the four RH exhaust manifold bolts.

   3 – Remove the RH exhaust manifold.

   4 – Remove and discard the RH exhaust manifold gasket.

Installation

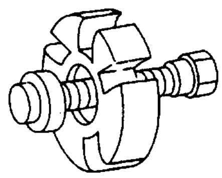
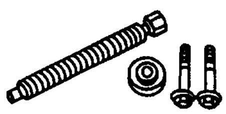


1. **NOTE:** Tighten in the sequence shown.

   Follow the removal procedure in reverse order.

ENGINE REPAIR (Continued)

Special Tool(s)

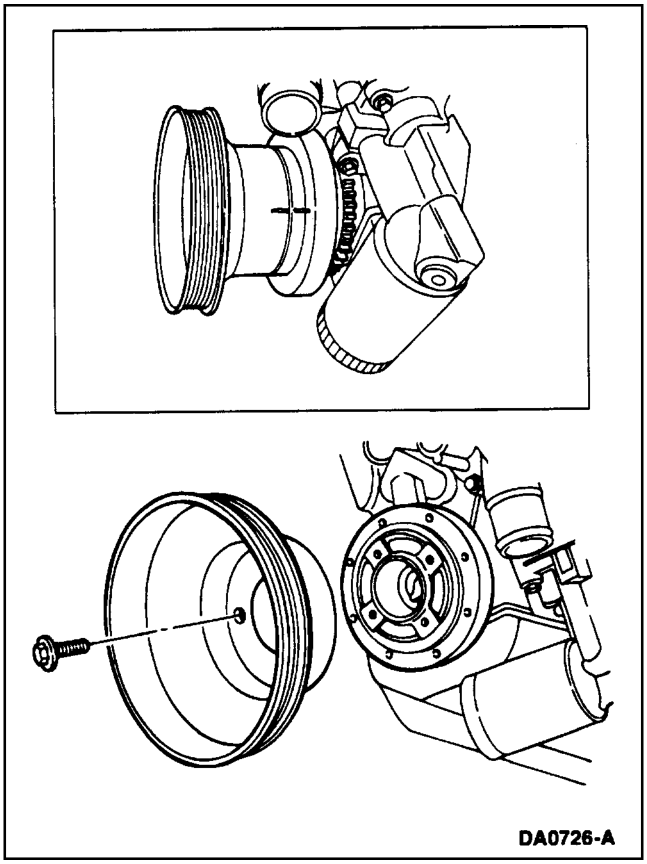
 ST1286-A	Crankshaft Damper Remover T58P-6316-D
 ST1378-A	Vibration Damper Remover Adapter T82L-6316-B

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Removal of Crankcase Damper

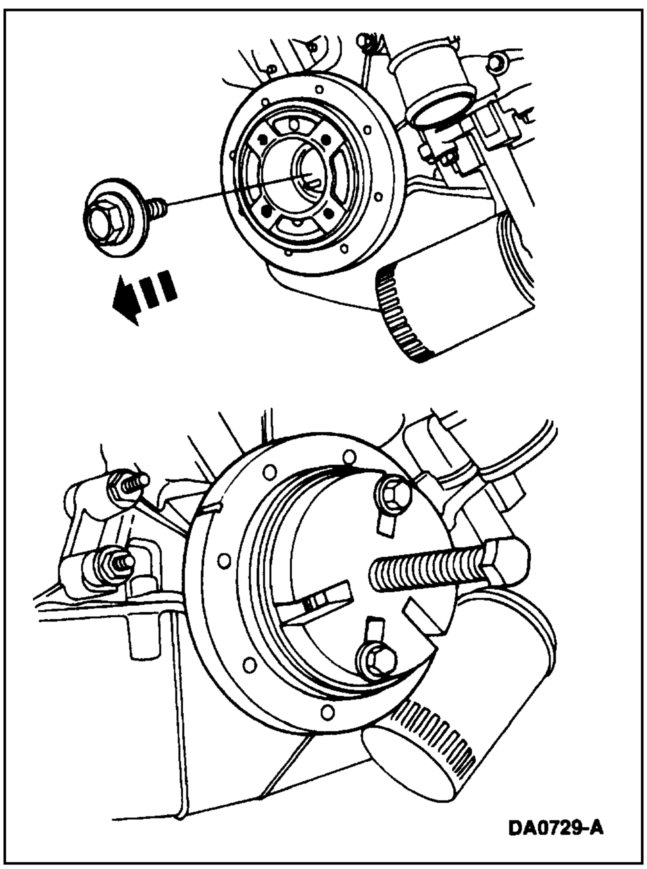
1. Remove the drive belt, if necessary.
2. Remove the fan and shroud.
3. Raise and support the vehicle when applicable.

ENGINE REPAIR (Continued)



4. **NOTE:** Mark the crankshaft pulley and damper position.

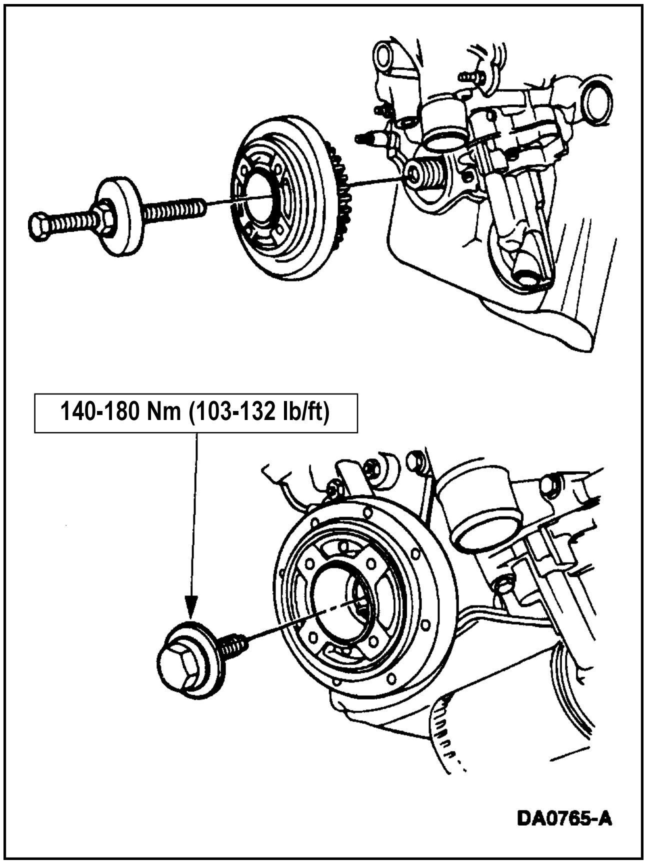
   Remove the crankshaft pulley.



5. Remove the crankshaft damper. A puller will be needed.

ENGINE REPAIR (Continued)

Installation



CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

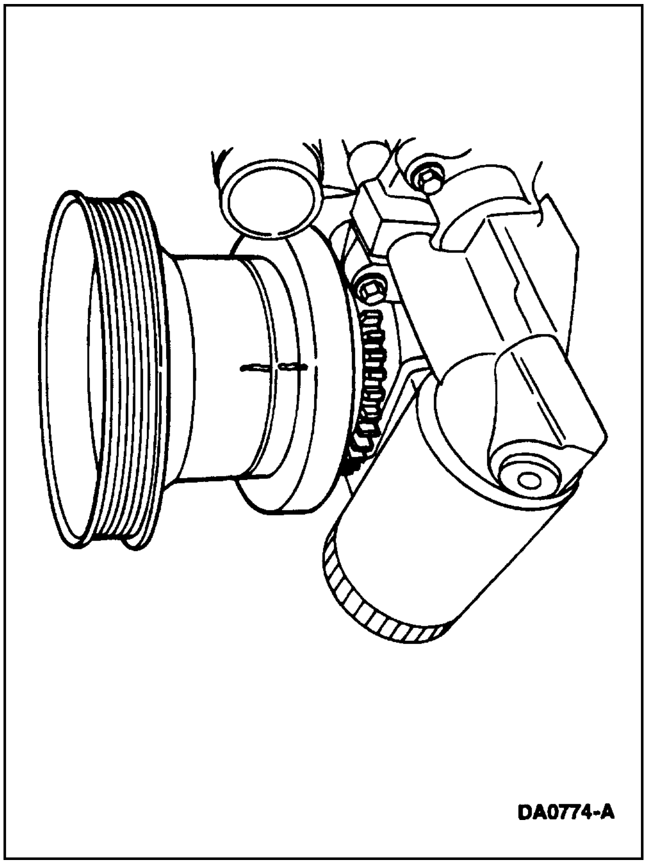
NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

1. Apply a bead of sealant to the keyway in the crankshaft damper and use Vibration Damper Installer Adapter to install the crankshaft damper.

   • Use Silicone Gasket and Sealant F6AZ-19562-A or equivalent meeting Ford specification WSE-M4G323-A6.

ENGINE REPAIR (Continued)



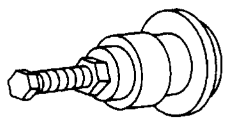
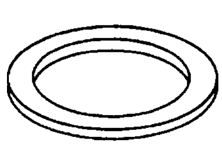
2. **NOTE:** Crankshaft pulley position on the crankshaft damper was marked before removal. Return it to the same position and install the crankshaft pulley.

3. Install the fan blade assembly.

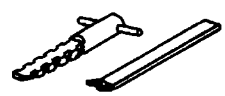
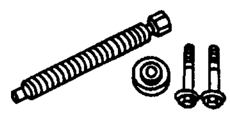
ENGINE REPAIR (Continued)

Crankcase Front Oil Seal

Special Tool(s)

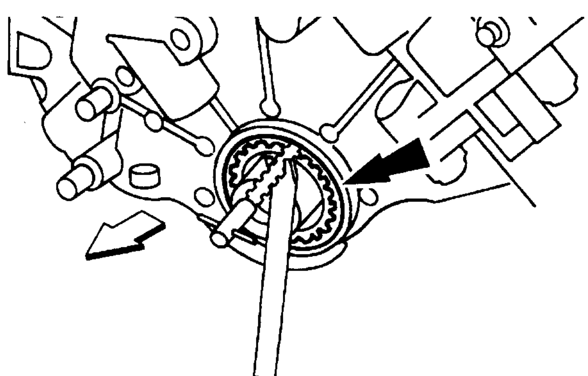
 ST1328-A	Front Crankcase Seal Installer/ Cover Aligner T88T-6701-A
 ST1379-A	Front Crankcase Seal Replacer T94P-6701-AH

Special Tool(s)

 ST1385-A	Seal Remover T92C-6700-CH
 ST1378-A	Vibration Damper Remover Adapter T82L-6316-B

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Removal of Front Crankshaft Oil Seal



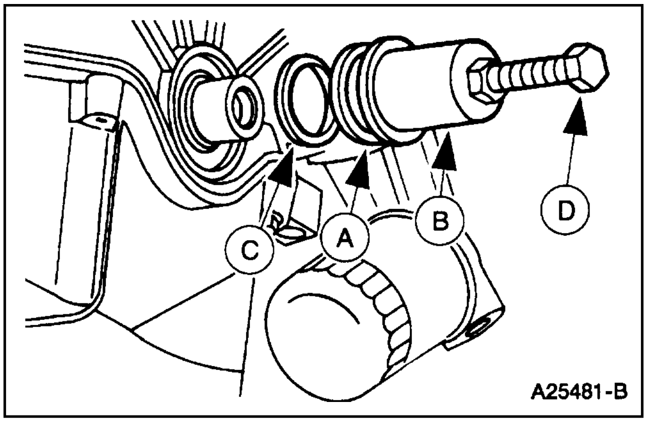
A25480-A

1. Remove the crankshaft damper. Refer to the procedure in this Section.
2. Use Seal Remover to remove the crankshaft front oil seal. Discard the seal.

Installation of Front Crankshaft Oil Seal

1. Inspect the crankshaft damper and engine front cover for damage that might cause the front crankshaft oil seal to fail.

ENGINE REPAIR (Continued)



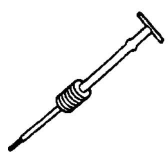
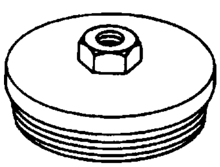
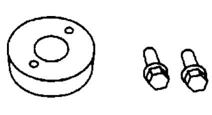
2. **NOTE:** Lubricate parts with engine oil before assembly.

   Use the (A) Front Crankshaft Seal Replacer (spacer), (B) Front Crankshaft Seal Installer/ Cover Aligner and (D) Vibration Damper Remover Adapter to install the (C) front crankshaft oil seal.

3. Install the crankshaft damper. Refer to the procedure in this section.

Crankshaft Rear Oil Seal

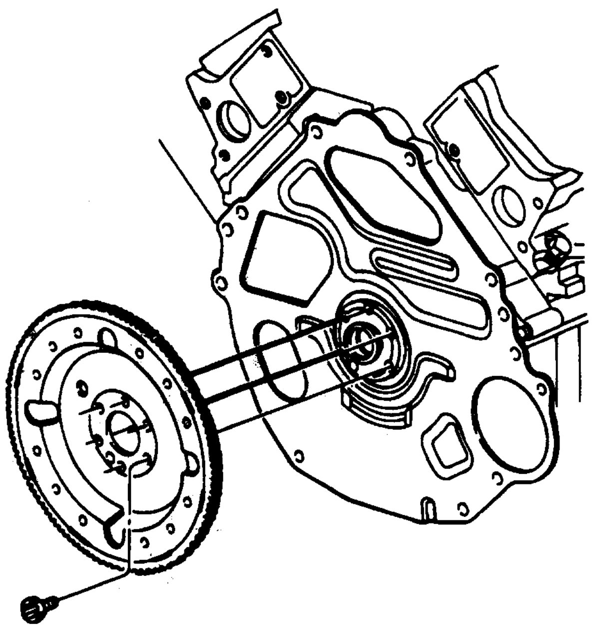
Special Tool(s)

 ST1185-A	Impact Slide Hammer T50T-100-A
 ST1382-A	Rear Crankshaft Seal Remover T95P-6701-EH
 ST1327-A	Rear Main Seal Replacer T82L-6701-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

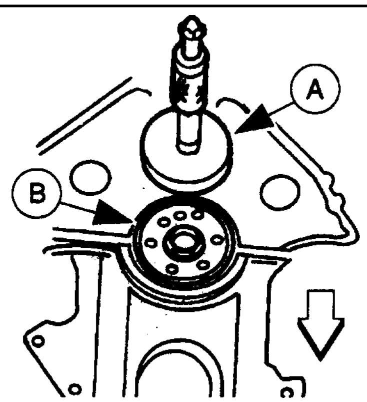
ENGINE REPAIR (Continued)

Removal of Rear Crankshaft Oil Seal



DA0978-A

2. Remove the flywheel (6375).

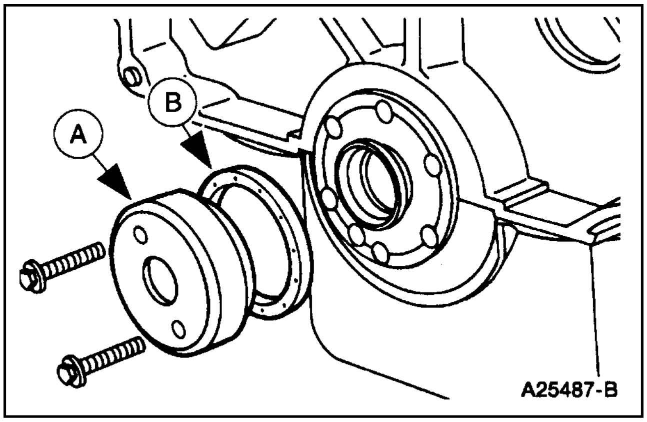


A25486-A

3. Use (A) Rear Crankshaft Seal Remover and Impact Slide hammer to remove the (B) crankshaft rear oil seal.

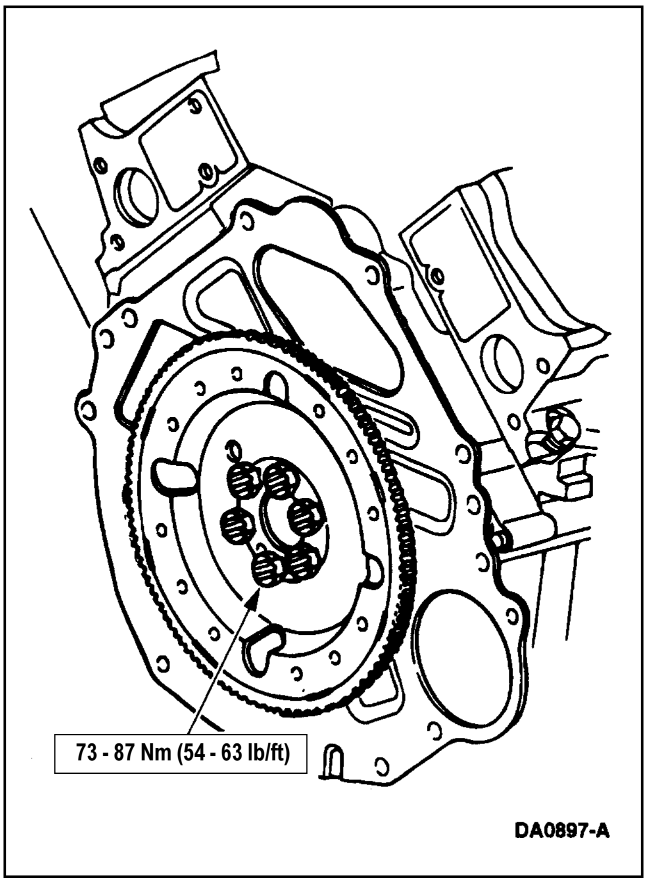
ENGINE REPAIR (Continued)

Installation of Rear Crankshaft Oil Seal



1. **NOTE:** Lubricate the crankshaft rear oil seal lips with engine oil prior to installation.

   Use (A) Rear Main Seal Replacer to install the (B) crankshaft rear oil seal.

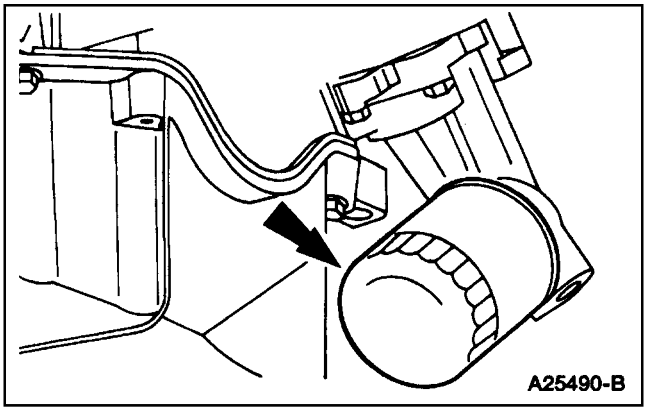


2. Install the flywheel.

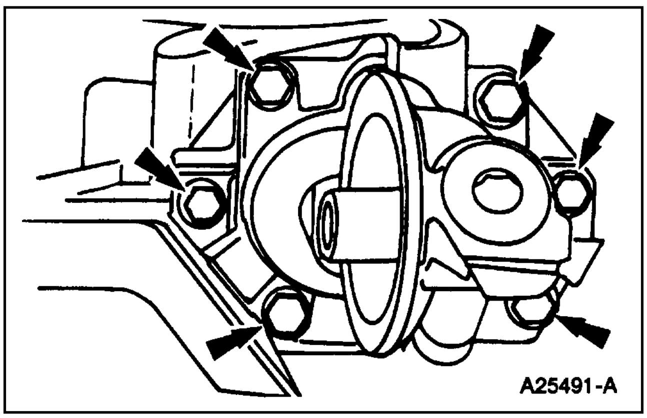
ENGINE REPAIR (Continued)

Oil Pump

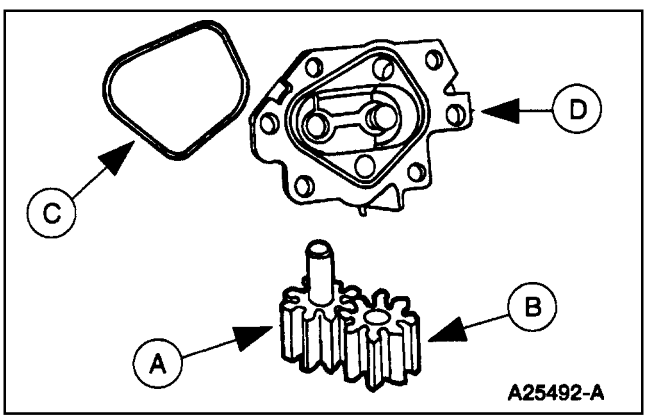
Removal



1. Remove the oil bypass filter (6714).



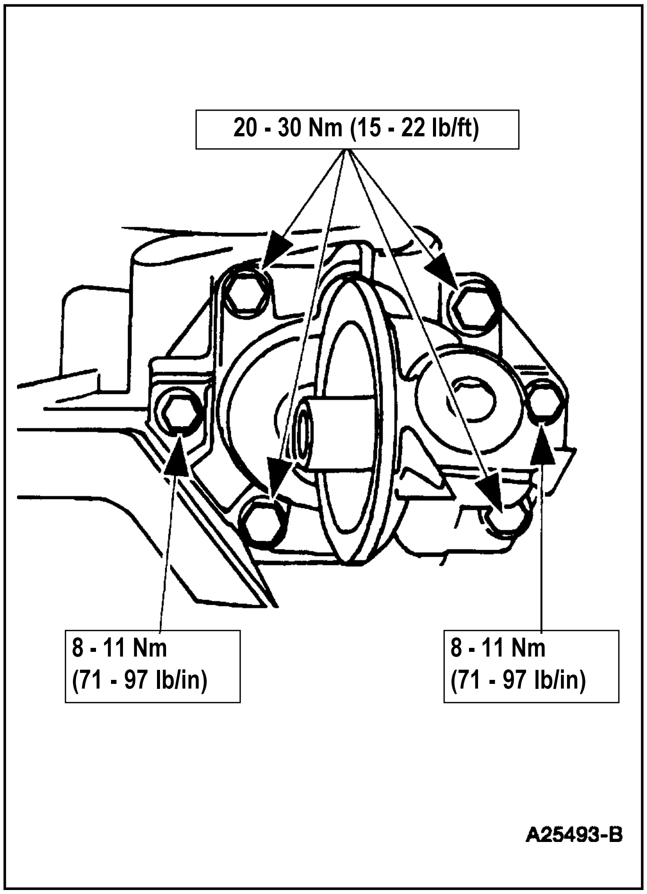
2. Remove the six oil pump bolts.



3. Remove the (A) oil pump drive gear, (B) oil pump driven gear, (C) oil pump O-ring and (D) oil pump and filter body (6603). Discard the (C) oil pump O-ring.

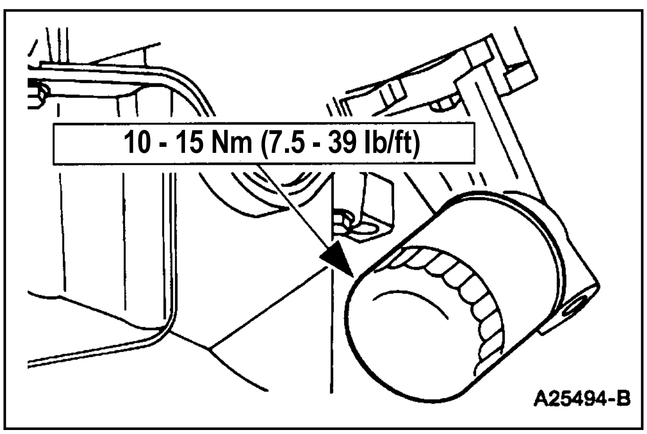
ENGINE REPAIR (Continued)

Installation of Oil Pump



1. **NOTE:** Lubricate parts with engine oil before assembly.

   Follow the removal procedure in reverse order.



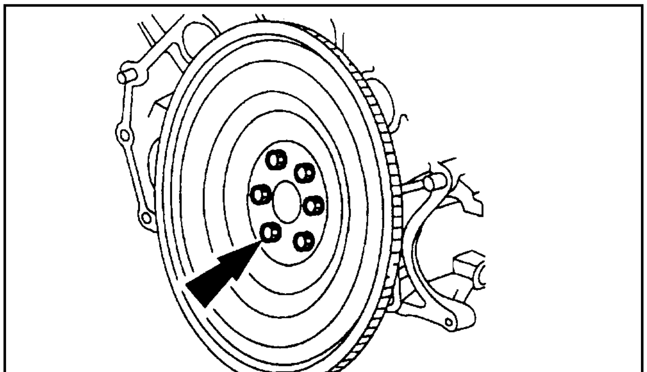
NOTE: If new oil filter is used, fill filter with fresh oil before installation to help prevent oil starvation to bearings.

1. Install oil filter using clean motor oil on mating gasket and tighten to specification.

ENGINE REPAIR (Continued)

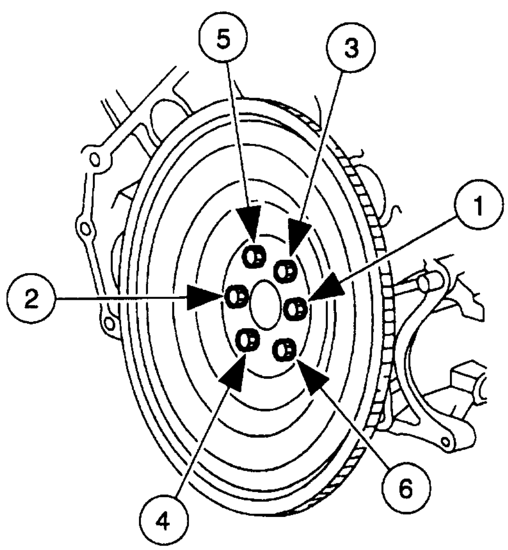
Flywheel

Removal


A26925-A

1. Remove the transmission or P.T.O.
2. Remove the six flywheel bolts.

Installation of Flywheel



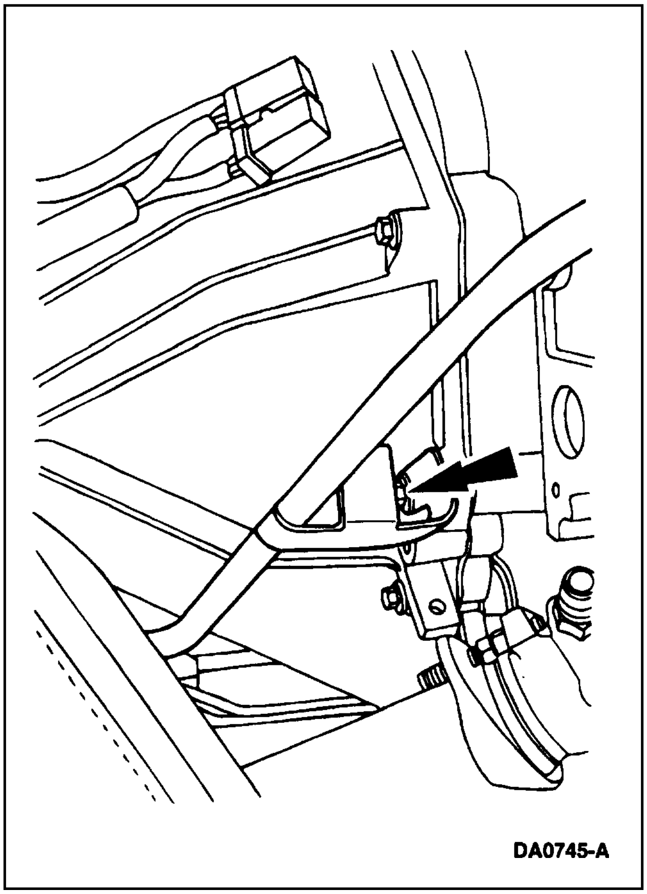
A26926-A

1. Position the flywheel on the crankshaft and install the retaining bolts.
2. Install the transmission or P.T.O.

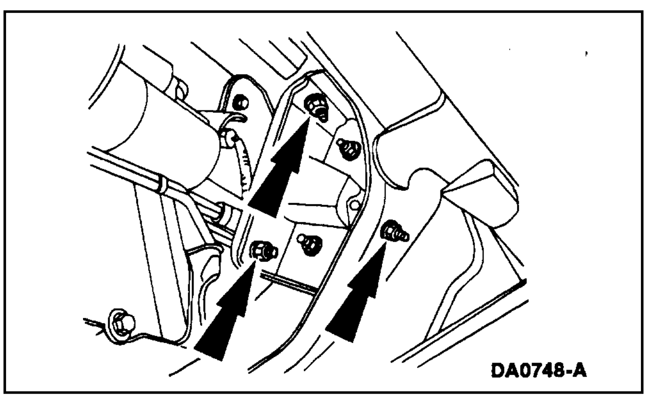
ENGINE REPAIR (Continued)

Oil Pan

Removal

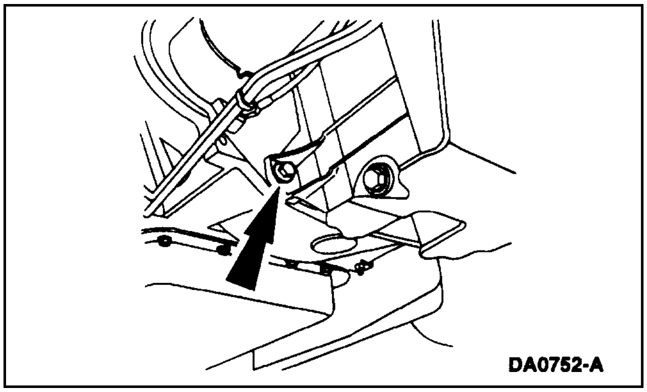


1. Disconnect the battery ground cable.
2. Remove the fan shroud and fan.
3. Remove the bolt retaining the dipstick tube support bracket to the transmission converter housing.
4. Drain the oil pan.

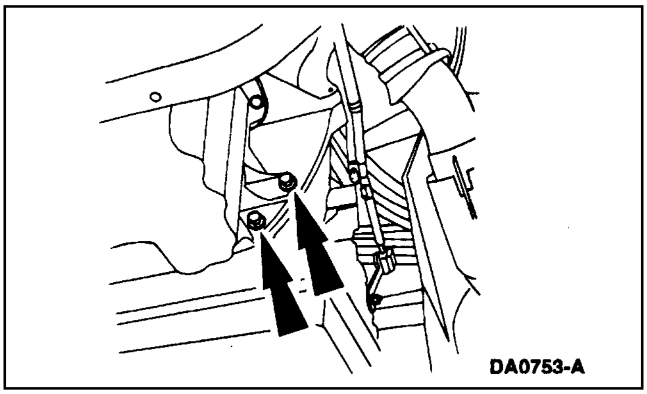


5. Remove the engine mount retaining nuts (right side shown, left side similar).

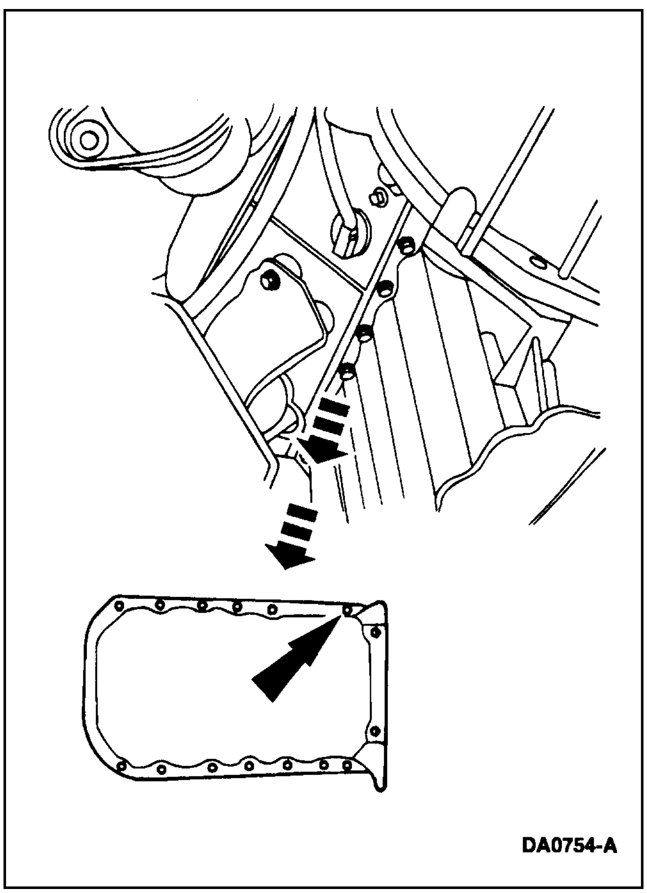
ENGINE REPAIR (Continued)



6. Remove the bolt retaining the oil pan to the right side of the transmission converter housing or SAE housing.



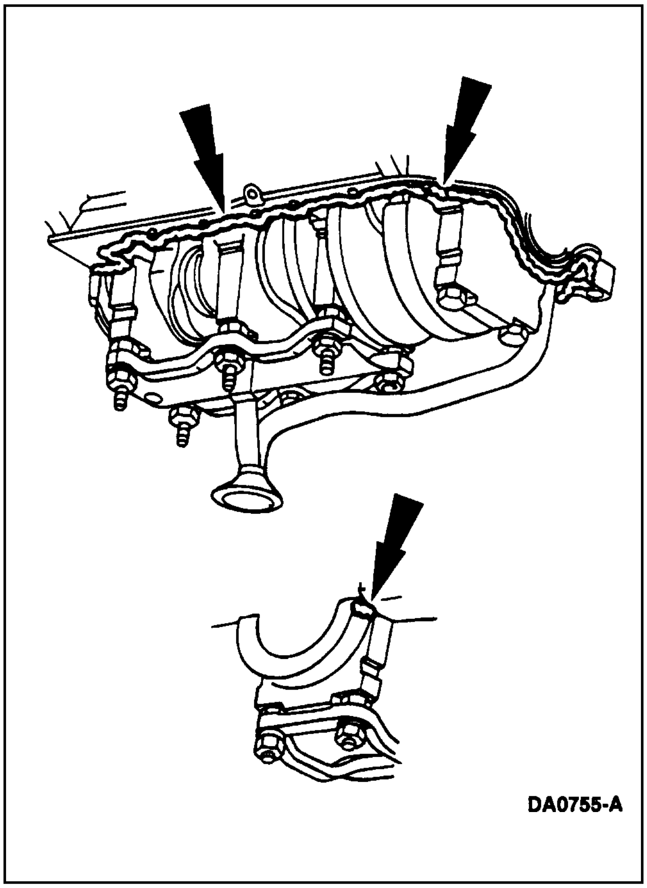
7. Remove the bolts retaining the oil pan to the left side of the transmission converter housing.



8. Remove the remaining retaining bolts and the oil pan. Remove and discard the oil pan seal.

ENGINE REPAIR (Continued)

Installation of Oil Pan



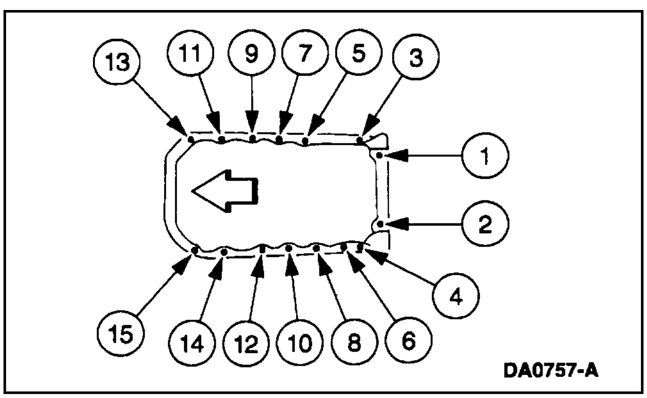
⚠ CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

1. Clean mating surfaces on the oil pan and the cylinder block.
2. Apply a bead of Silicone Gasket and Sealant as shown in the illustration.
3. Follow removal procedure in reverse order.



4. Tighten the oil pan retaining bolt in two stages in the sequence shown.

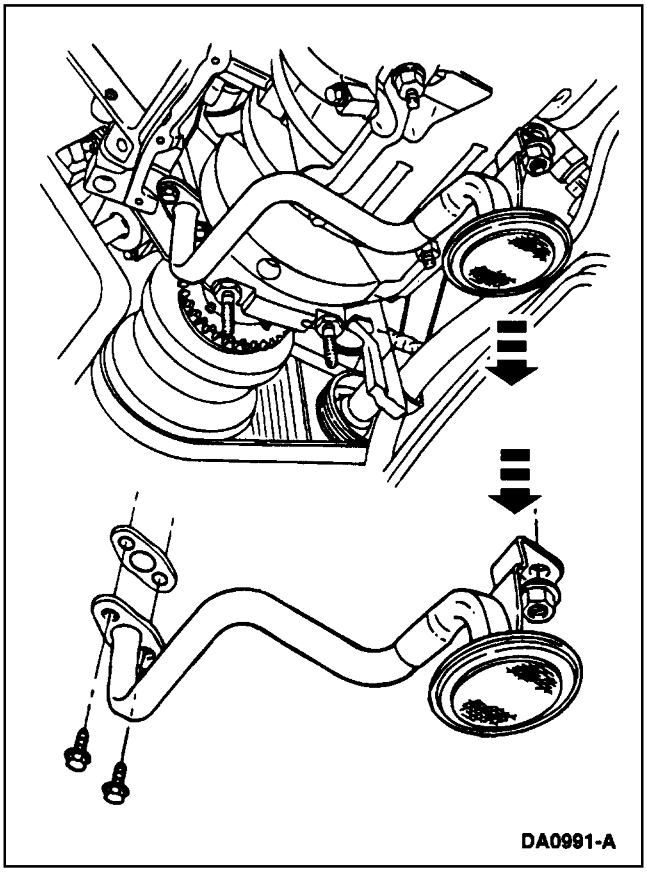
    • Stage 1: 4-5 Nm (35-44 lb/in).

    • Stage 2: 9-12 Nm (79-106 lb/in).

ENGINE REPAIR (Continued)

Oil Pump Screen Cover and Tube

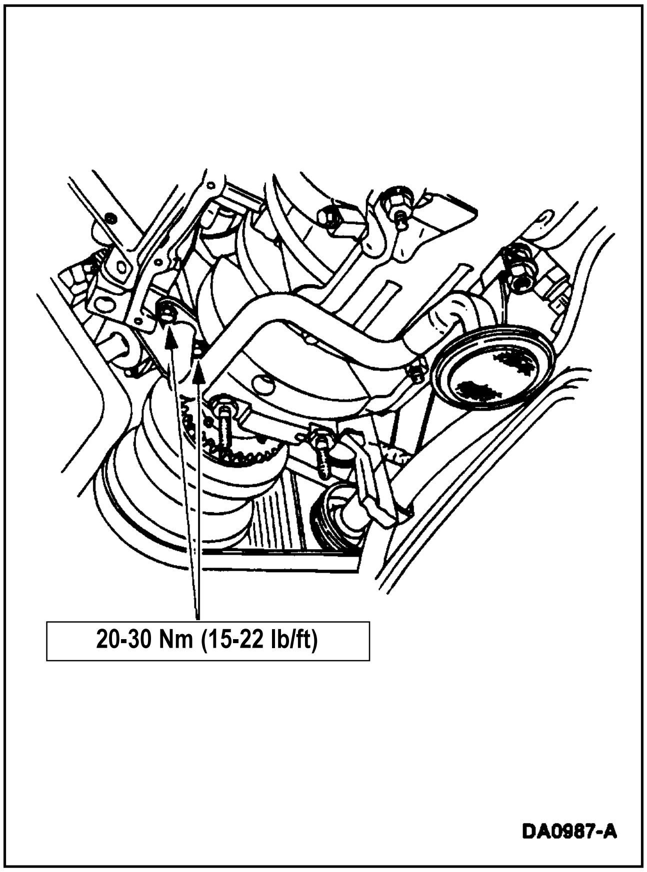
Removal



1. Remove the oil pan. Refer to the procedure in this Section.
2. Remove the retaining bolts and the oil pump screen cover and tube. Discard the gasket.

ENGINE REPAIR (Continued)

Installation of Oil Pump Screen Cover and Tube



1. Install the oil pump screen cover and tube. Use a new gasket.
2. Install the oil pan. Refer to the procedure in this section.

Crankshaft Main/Piston Rod Bearings

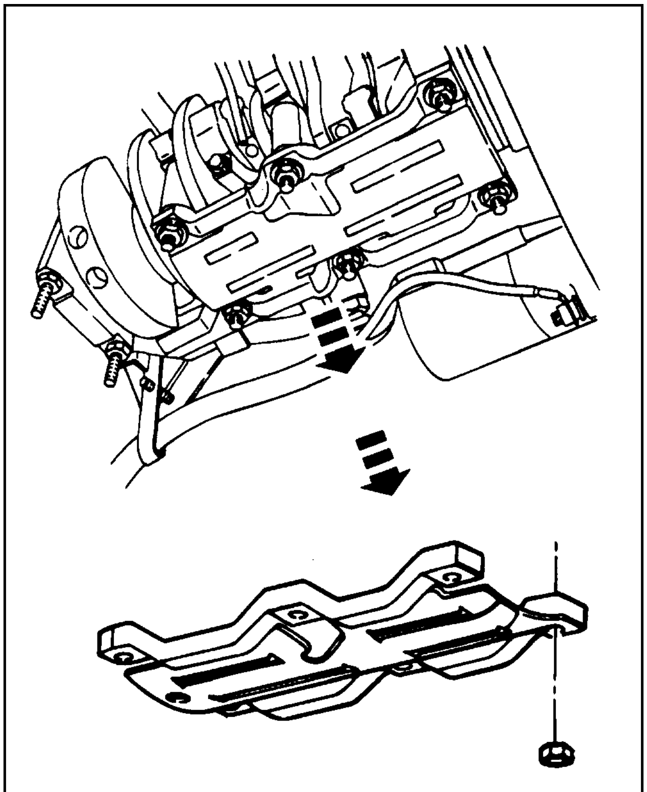
Removal

1. **CAUTION: The cylinder heads must be removed prior to removal of the oil baffle assembly. Failure to observe this caution can result in severe engine damage.**

   Remove the cylinder heads. Refer to the procedure in this Section.

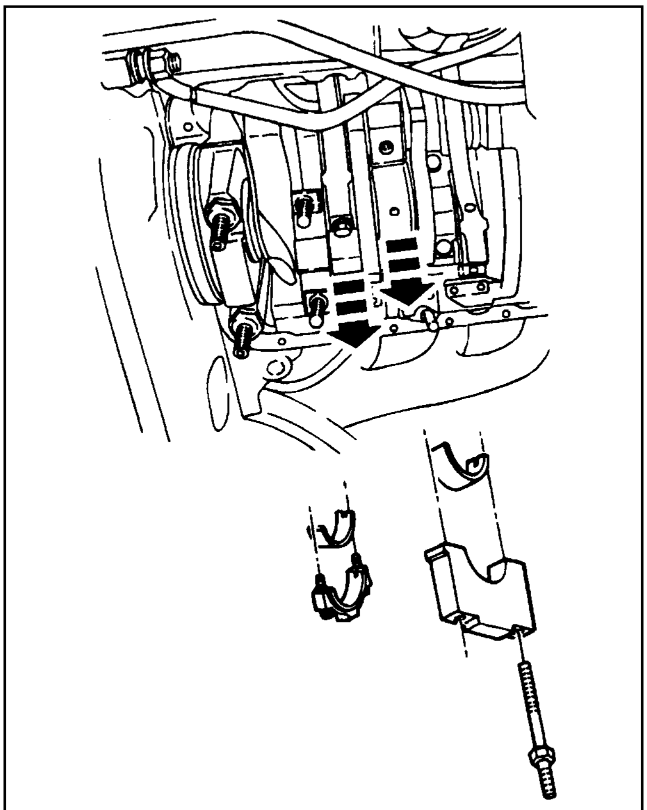
2. Remove the oil pan. Refer to the procedure in this Section.
3. Remove the oil pump screen cover and tube. Refer to the procedure in this Section.

ENGINE REPAIR (Continued)



DA0882-A

4. Remove the oil baffle assembly.



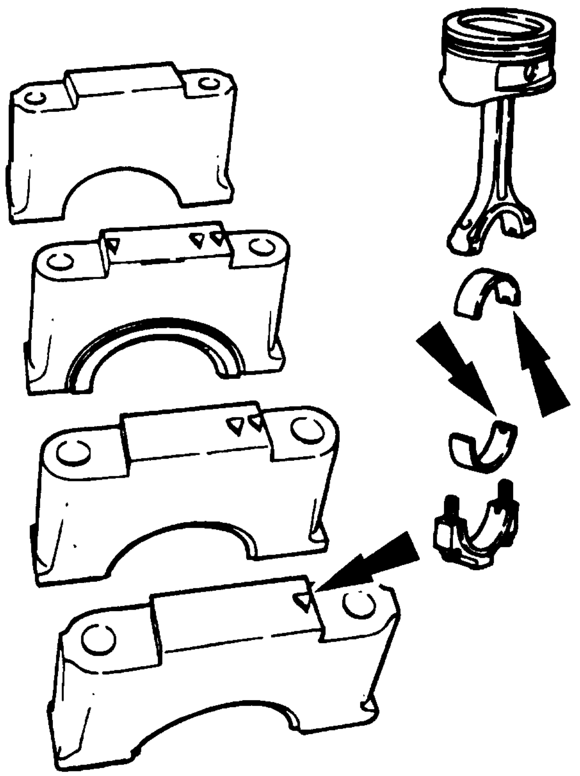
DA0883-A

5. Remove the main bearing cap or piston rod cap. Rotate the crankshaft, as required, to access the rod caps. To check main or rod bearing clearances, refer to Section 01.

CAUTION: Discard all main and rod bolts and replace. Bolts are torque to yield. The use of used bolts may result in improper torque setting and could cause engine failure.

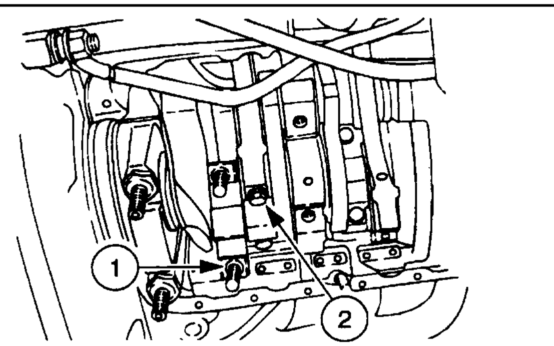
ENGINE REPAIR (Continued)

Installation of Crankshaft Main/Piston Rod Bearings



DA0885-A

1. On a main bearing cap, locate the arrows that indicate the cap location and direction of installation. On a rod cap, locate the bearing insert notches which must align when the cap is installed.



DA0886-A

2. Install the main bearing cap or rod cap, as required.

   1 – Tighten the main bearing cap retaining bolts in two stages:

   • 50 Nm (37 lb/ft).

   • 115-125 degrees.

   2 – Tighten the rod cap bolts retaining bolts in three stages:

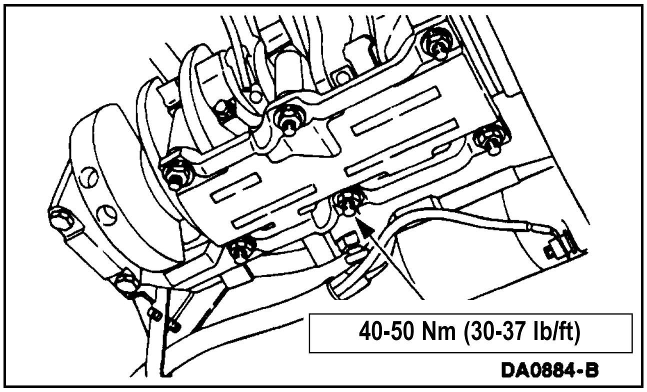
   • 20-25 Nm (15-18 lb/ft).

   • 40-45 Nm (29-33 lb/ft).

   • 90-120 degrees.

CAUTION: All main and rod bolts are torque-to-yield. Discard and replace. The use of used bolts could cause engine failure.

ENGINE REPAIR (Continued)



3. Install the oil baffle assembly.
4. Install oil pump screen cover and tube. Refer to this Section.
5. Install oil pan. Refer to this Section.

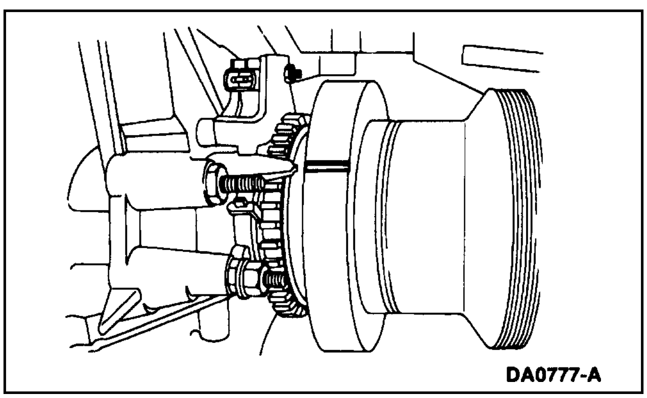
NOTE: Always use new cylinder head bolts.

6. Install cylinder heads. Refer to this Section.

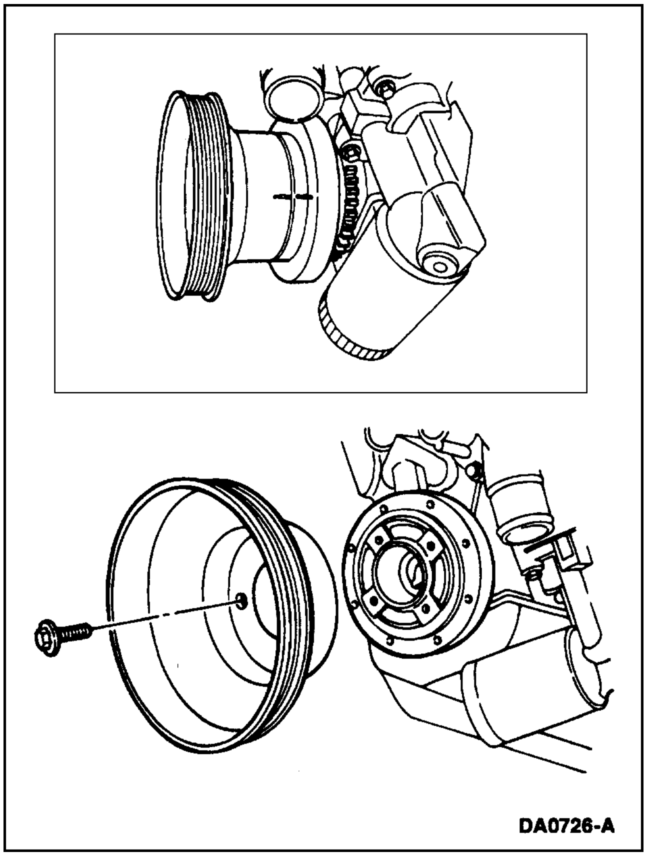
Engine Front Cover

Removal

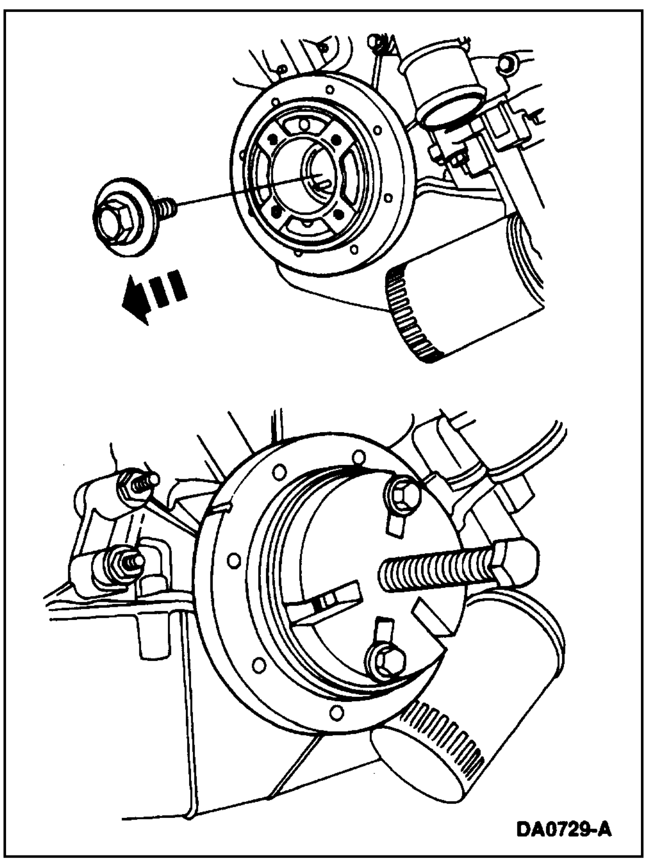
1. Disconnect the battery ground cable. Drain coolant from radiator.
2. Remove the water pump. Refer to this Section.
3. Rotate the crankshaft until the damper timing mark aligns with the top dead center indicator.



ENGINE REPAIR (Continued)

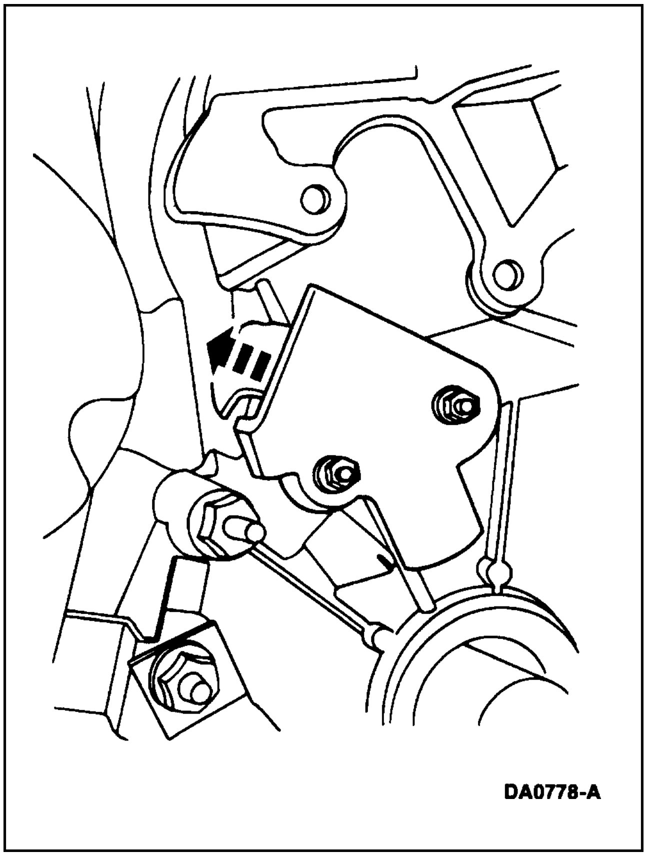


5. Mark the crankshaft damper and pulley for alignment reference. Remove the crankshaft pulley.



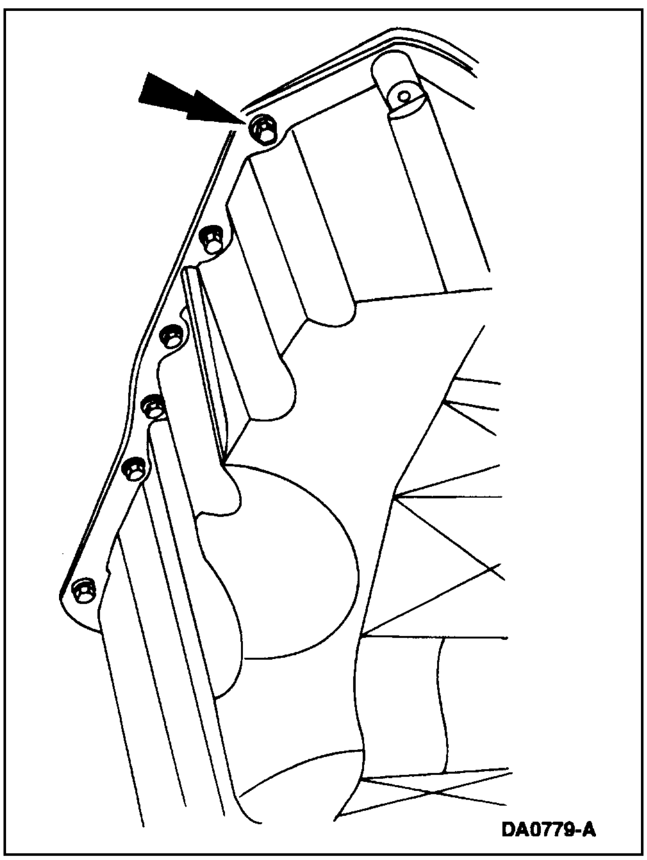
6. Remove the crankshaft damper. A puller will be needed.

ENGINE REPAIR (Continued)



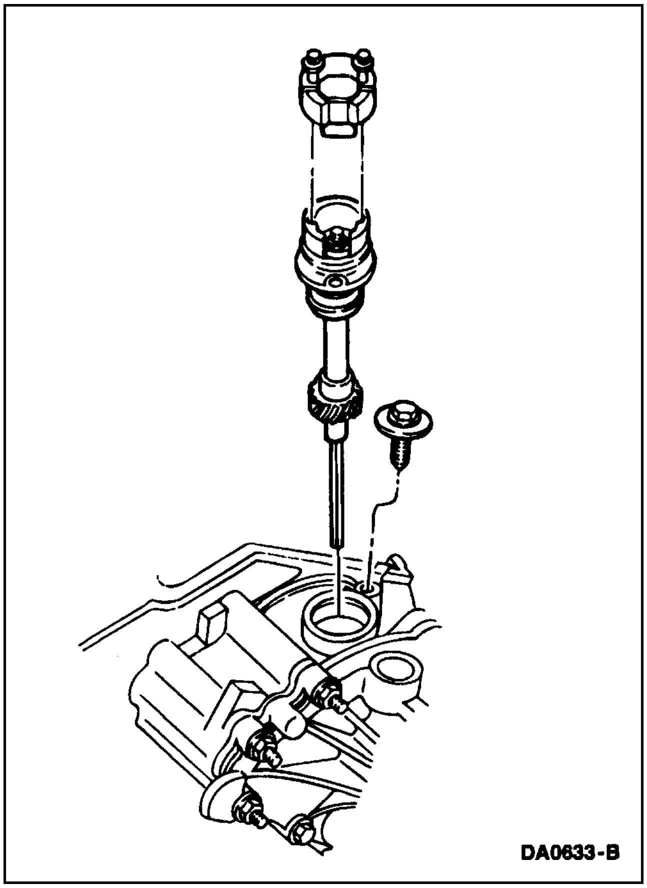
7. Disconnect the wiring at the crankshaft position sensor.

8. Remove crankshaft position sensor (CKP).



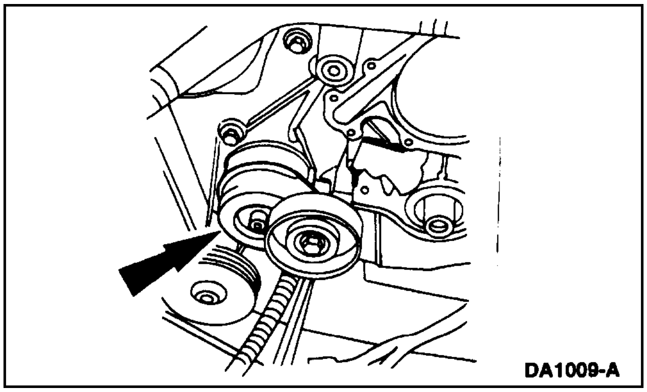
9. At the front of the oil pan, remove a retaining bolt from the left and right side of the oil pan.

ENGINE REPAIR (Continued)



10. Disconnect the wiring at the camshaft synchronizer.
11. Remove the two screws (6B288) from stator assy. and remove stator assy. (6B288).
12. Index shaft by marking synchronizer housing to front cover.
13. Remove retaining bolt (N808826).
14. Remove chamshaft synchronizer assembly.
15. Remove the accessory drive belt idler pulley.

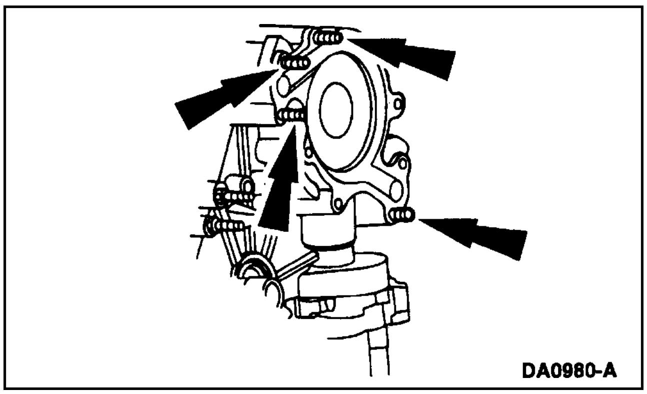
ENGINE REPAIR (Continued)



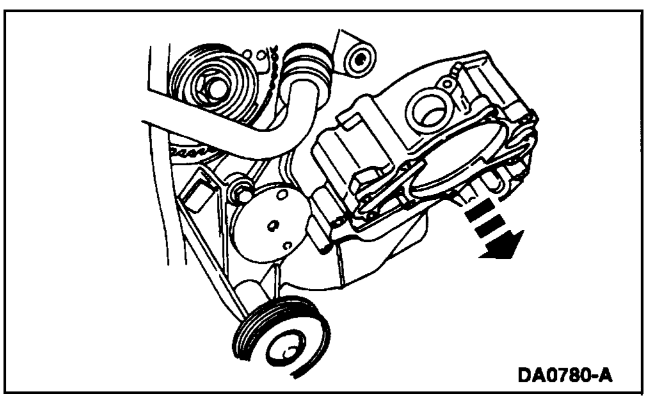
16. Remove the accessory drive belt tensioner.

    NOTE: For ease of handling, remove oil filter.

    NOTE: If new front cover is being installed, remove oil filter and pump from cover. Refer to this Section.



17. Remove the water pump mounting studs. Discard the studs.



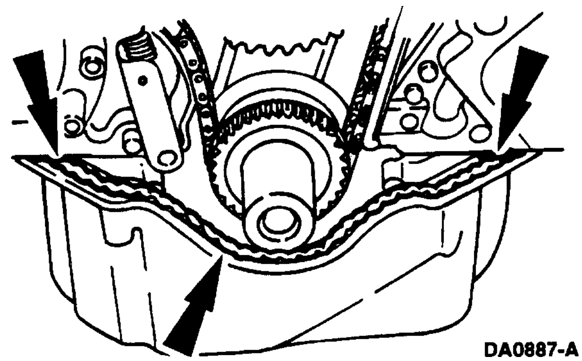
18. Remove the engine front cover (6019) and the engine front cover gasket (6020). discard the gasket.

19. **NOTE:** When cleaning, use care to prevent debris from falling into the oil pan.

    Clean the mating surfaces on the oil pan and the cylinder block. Use Metal parts Cleaner F4AZ-19A536-RA or equivalent meeting Ford specifications WSE-M5B292-A.

ENGINE REPAIR (Continued)

Installation of Engine Front Cover


DA0887-A

⚠ CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

1. Apply a bead of Silicone Gasket and Sealant at the oil pan to block seam.

2. Install the engine front cover gasket.

3. Apply a second bead of sealant along the edge of the engine front cover gasket at the oil pan to block seam.

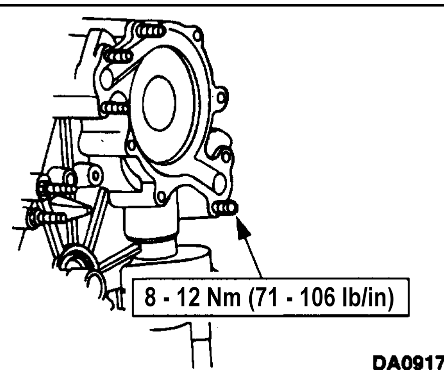
4. Apply a bead of sealant on the oil pan flange.

5. Install the front cover. Position the lower edge of the cover on the oil pan and tip upward into position.

   NOTE: If new front cover was used, reinstall oil pump and filter. Refer to this Section.

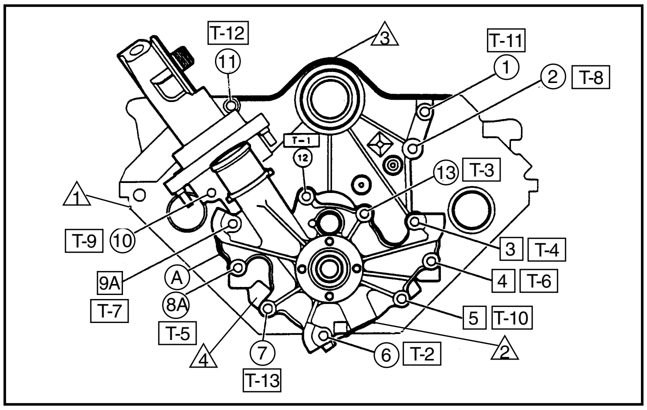
6. Install the new water pump studs. The correct stud will be supplied with pre-applied Loctite ®

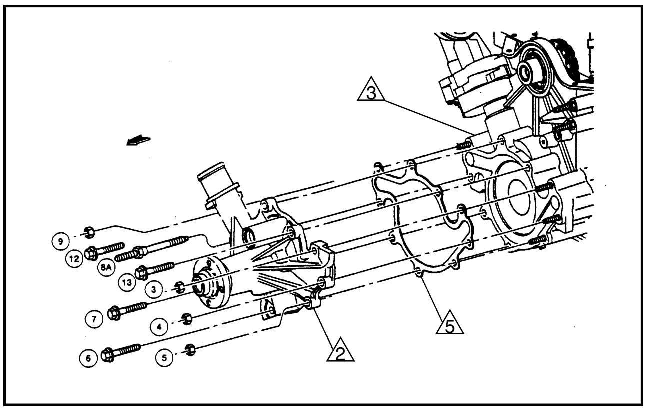
   NOTE: Make sure the Loctite ® end of the stud is installed in the engine. Refer to this Section.



DA0917-A

ENGINE REPAIR (Continued)





3. Water Pump assembly

   Torque Specs:
   ◯ Bolt #1,2,6,7,8A,10,11,12 & 13 = 20-30 Nm (15-22 lb/ft).
   ☐ Stud #3, 4, 5 & 9A = 6-8 Nm.
   1 - Install studs torque to 6-8 Nm.
   2 - Install front cover gasket (-6020-).
   3 - Install front cover & oil pump assy. (-6F008-).
   4 - Install water pump gasket (-8507-).
   5 - Install water pump assy. (-8501-).
   6 - Install remaining fasteners.
   7 - Torque all bolts and nuts to 20-30 Nm (15-22 lb/ft) making sure to follow the sequence as shown above.

NOTE: T-# Indicates the torque sequence order.

1 Cylinder Block Assy.

2 Water Pump Assy. (8501).

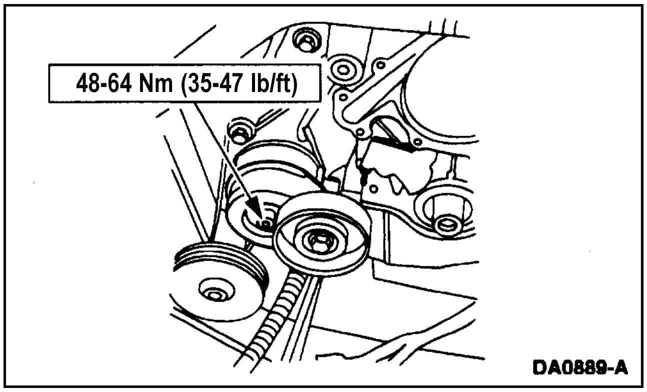
3 Front Cover & Oil Pump Assy. (6F008).

4 Wire Retention Hole.

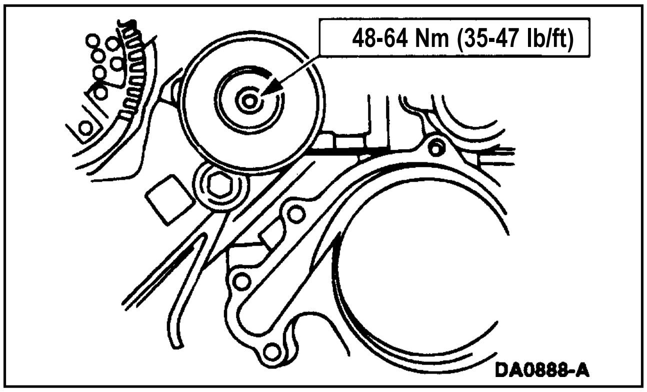
5 Water Pump Gasket (8507).

4.2L ENGINE APPLICATIONS						
HOLE NO.	W/P	F/C	PART NO.	PART NAME	DESCRIPTION	HEX SIZE
1.		X	N805112	Stud Bolt	M8 X 1.25 X 98	(15mm Hex)
2.		X	N805112	Stud Bold	M8 X 1.25 X 98	(15mm Hex)
3.	X		N805757	Stud	M8 x 1.25 X 137	(N/A)
4.	X		N804853	Stud	M8 X 1.25 X 156	(N/A)
5.	X		N805757	Stud	M8 X 1.25 X 137	(N/A)
6.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
7.	X		N808217	Bolt	M8 X 1.25 X 117.5	(10mm Hex)
8.	X		N804852	Stud Bolt	M8 X 1.25 X 160.3	(15mm Hex)
9.	X		N804853	Stud	M8 X 1.25 X 156	(N/A)
10.		X	N804839	Bolt	M8 X 1.25 X 105	(10mm Hex)
11.		X	W701885	Socket Head Cap Screw	M8 X 1.25 X 19.5	(N/A)
12.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
13.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
3,4,5,9	X		N804745	Nut	M8 X 1.25	(15mm Hex)

ENGINE REPAIR (Continued)

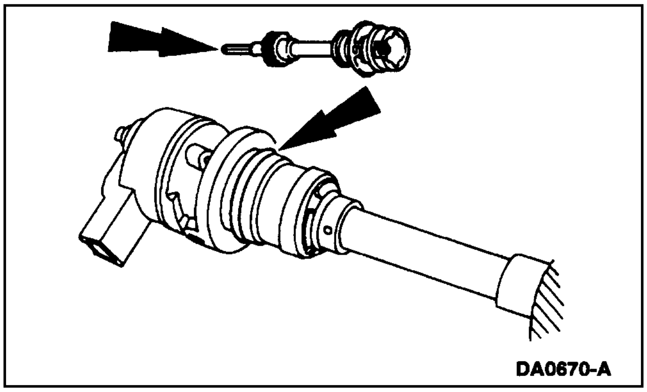


4. Install the accessory drive belt tensioner.

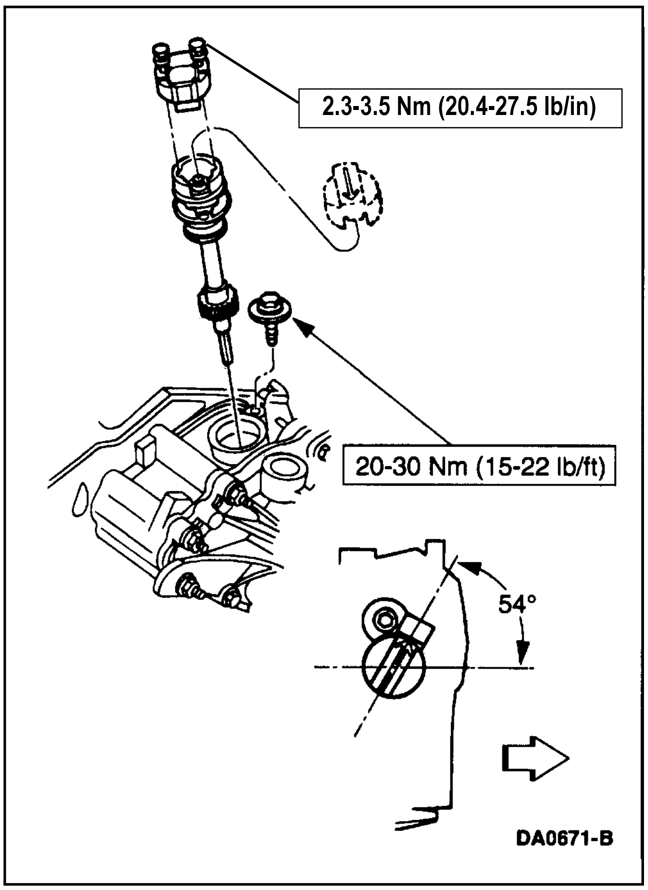


5. Install the accessory drive belt idler pulley.

ENGINE REPAIR (Continued)



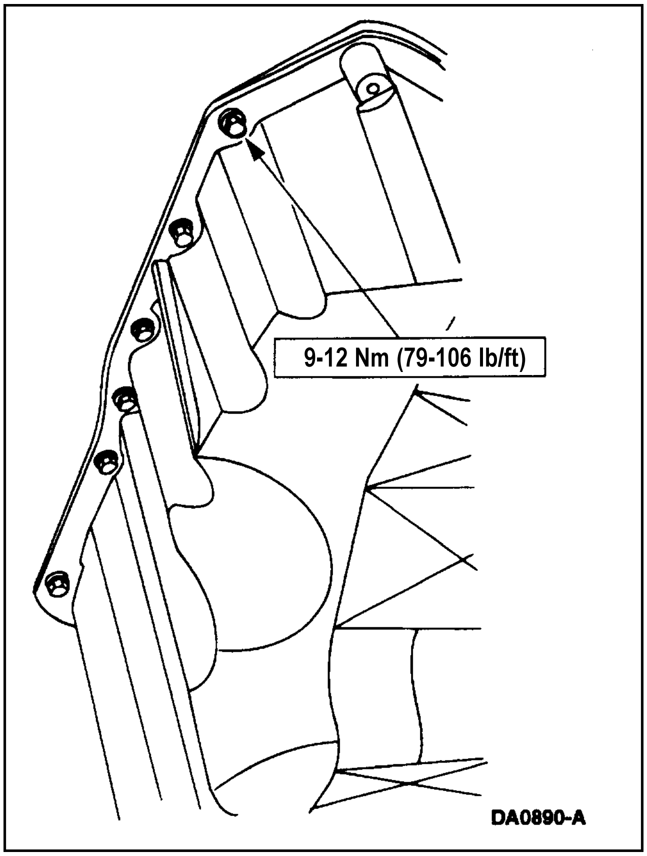
6. Install a new O-ring on the synchronizer and make sure the oil pump intermediate shaft is installed with the lock ring into the synchronizer.



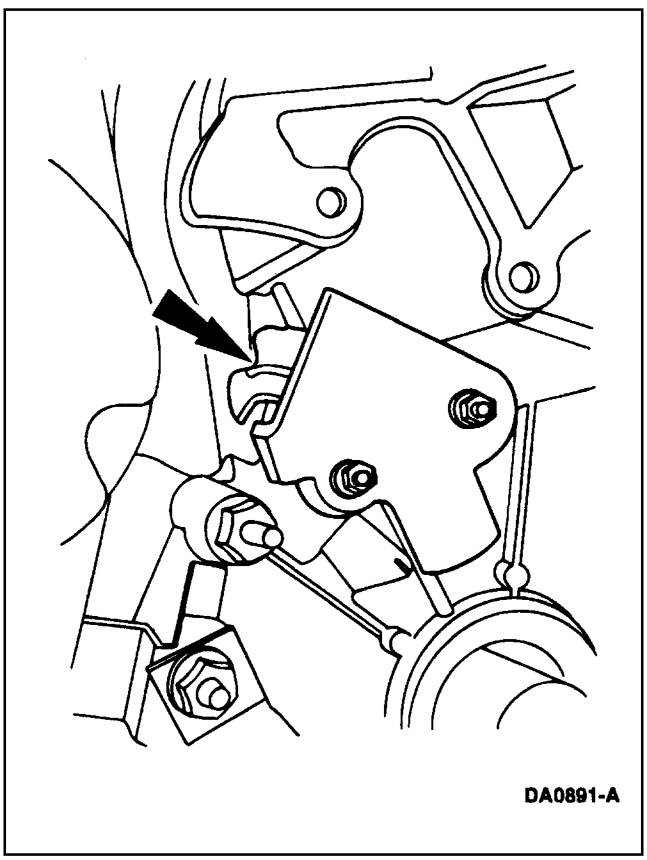
7. **NOTE:** The arrow on the alignment tool must point as shown in the illustration. Make sure piston number one is at top dead center on intake stroke.

   Install the synchronizer, remove the alignment tool and install the camshaft position sensor.

ENGINE REPAIR (Continued)



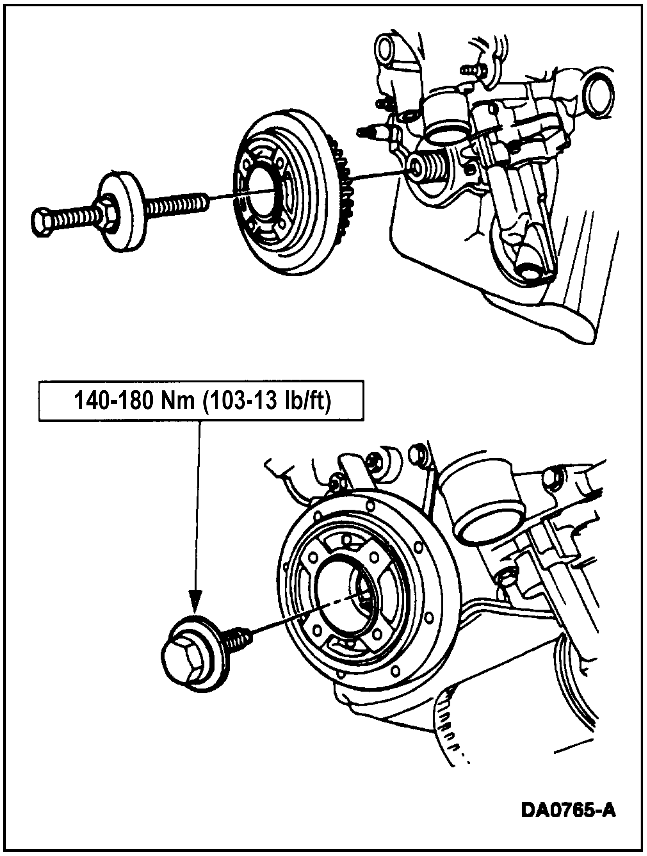
8. Install the oil pan retaining bolts.



9. Install crankshaft position sensor (CKP).
   • Torque hold down bolts to Nm (lb/in).

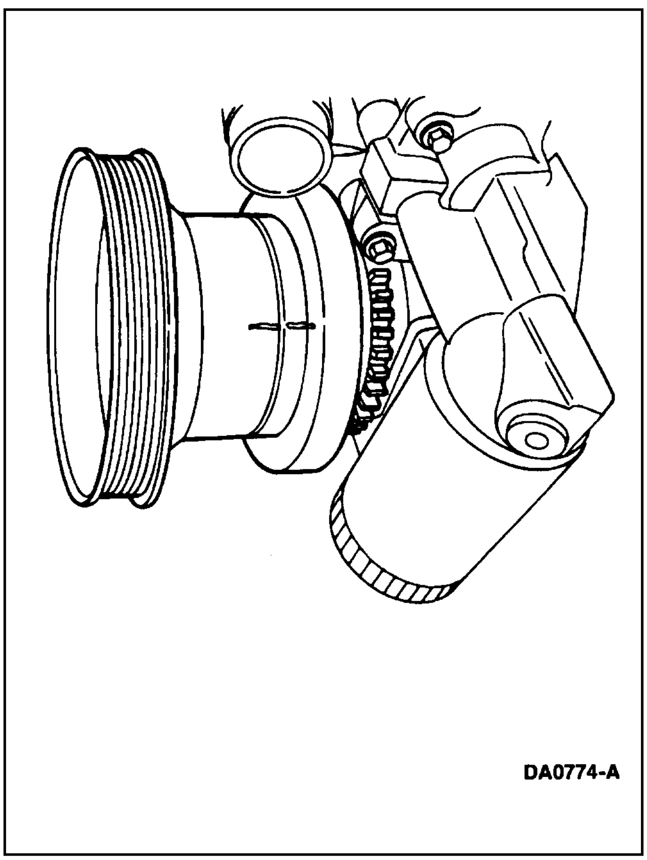
10. Connect the wiring at the CKP.

ENGINE REPAIR (Continued)



11. Install the crankshaft damper.

    • An installation tool will be required. Refer to Special Tools at front of this section.



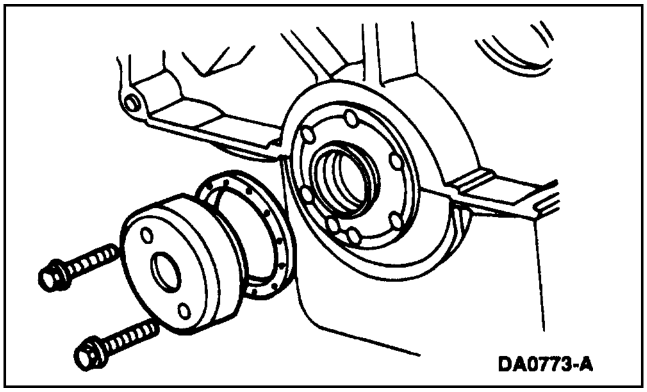
12. Align the crankshaft pulley and install the retaining bolts.

13. Install the water pump, refer to the procedure in this section.

ENGINE REPAIR (Continued)

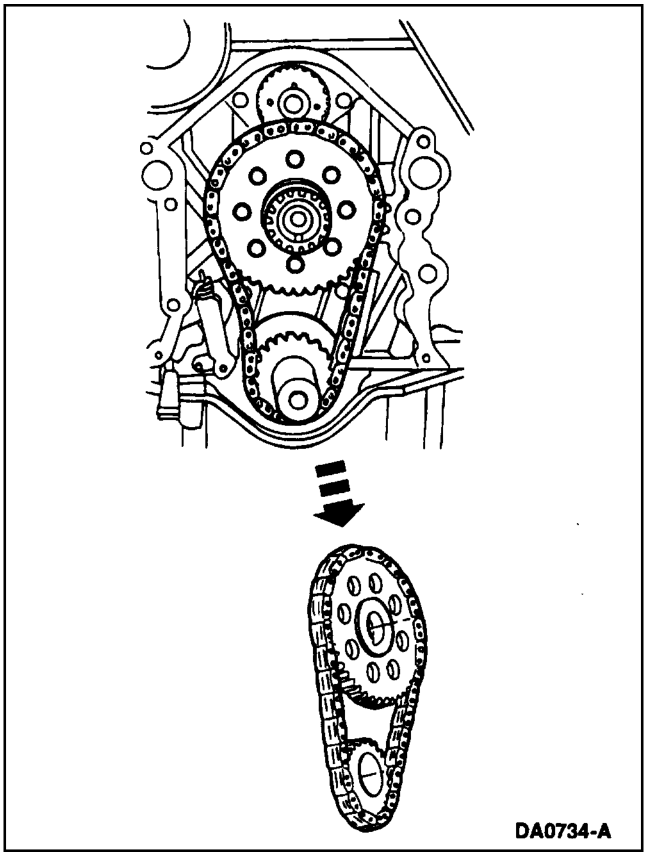
Timing Chain/Balance Shaft

Removal

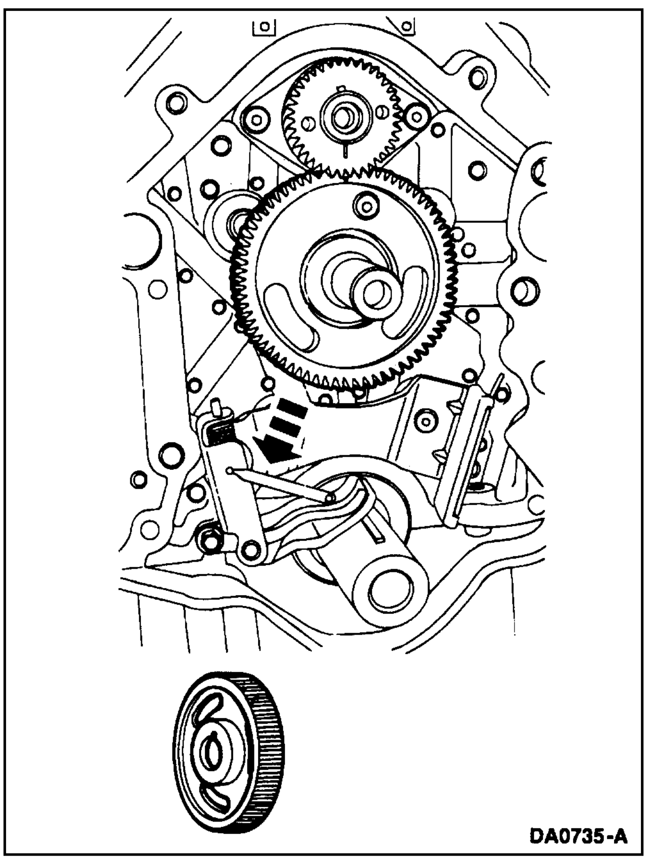


1. Remove the front cover. Refer to the procedure in this section.
2. Remove the synchronizer drive gear.

ENGINE REPAIR (Continued)



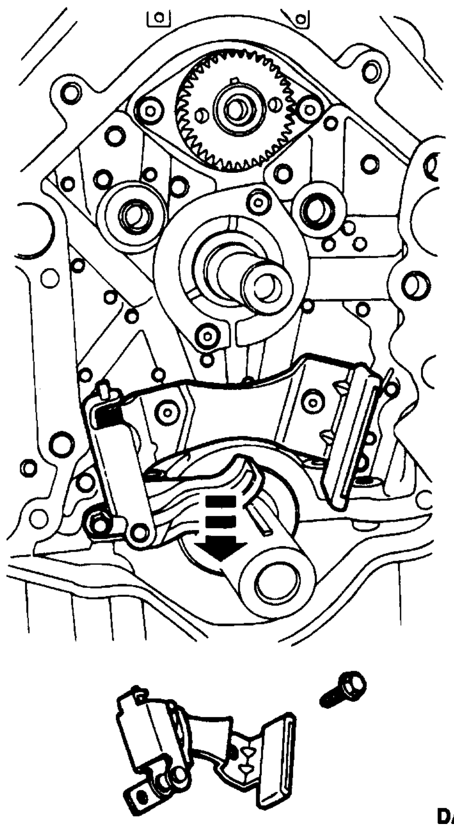
3. Remove the crankshaft sprocket, camshaft sprocket and timing chain as an assembly.



4. **CAUTION: Use care when removing balance shaft as not to bump or score balance shaft bearings. May cause balance shaft failure.**

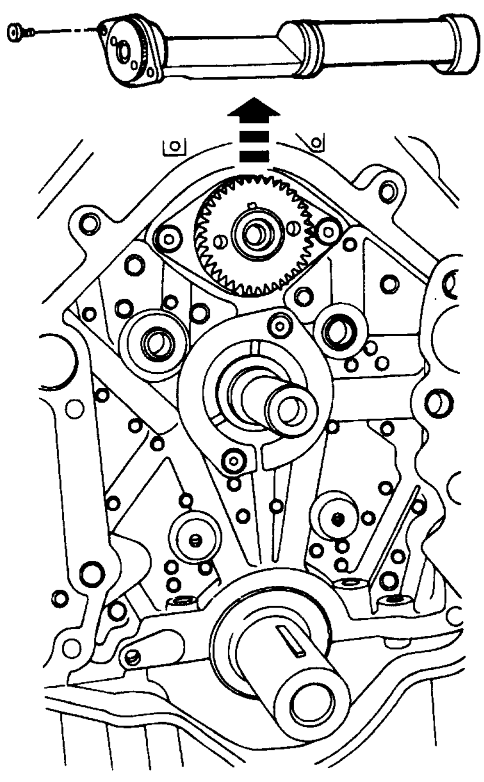
   Remove the balance shaft drive gear.

ENGINE REPAIR (Continued)



DA0736-A

5. Remove the timing chain vibration damper.

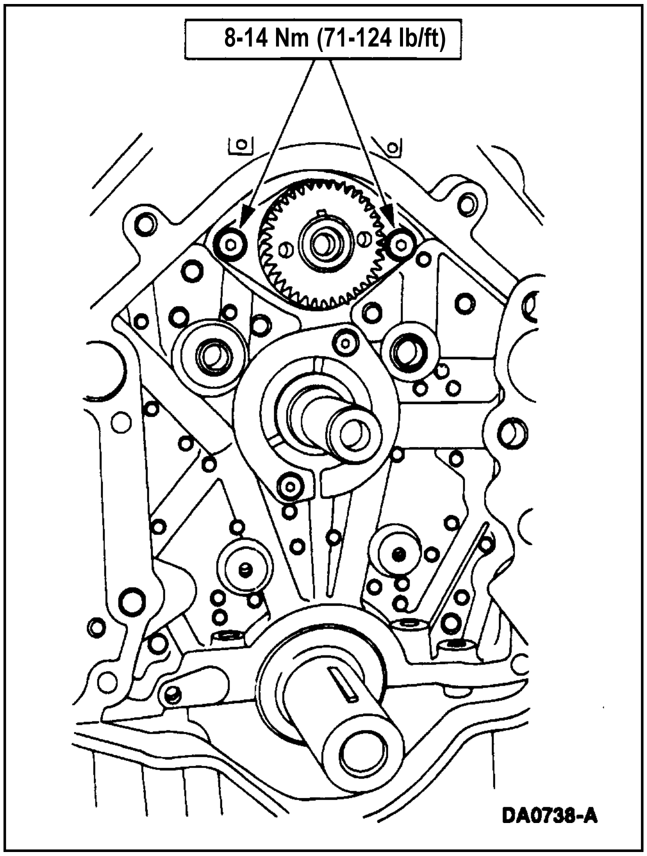


DA0737-A

6. Remove the thrust plate retaining screws and the balance shaft.

ENGINE REPAIR (Continued)

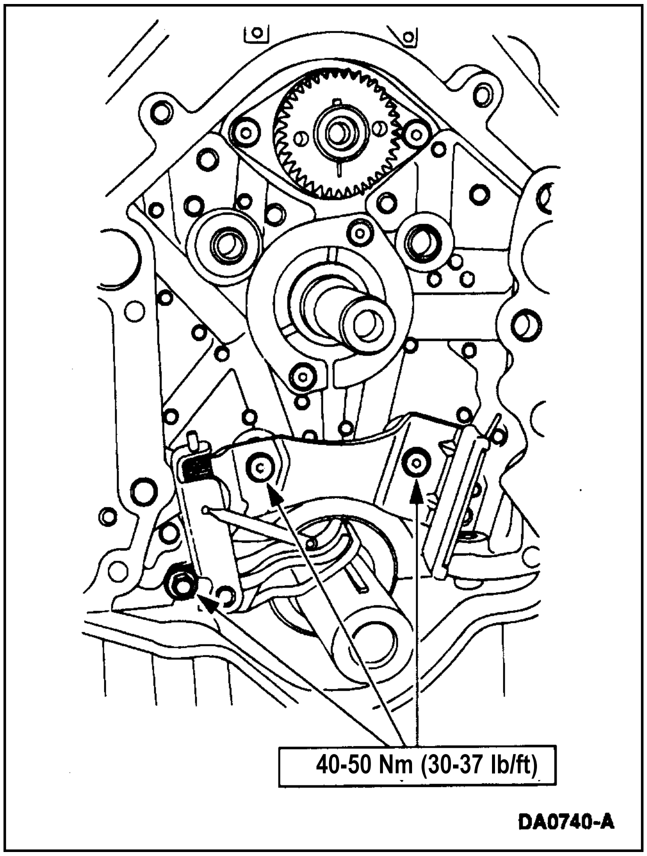
Installation



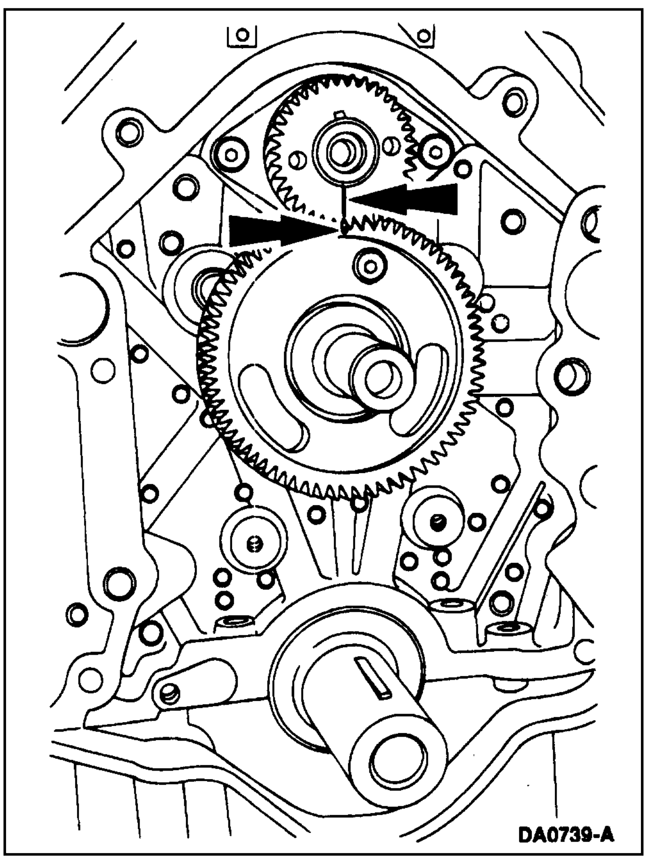
1. **CAUTION: Use care when removing balance shaft as not to bump or score balance shaft bearings. May cause balance shaft failure.**

   Lubricate the balance shaft bearings with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A and install the balance shaft.

ENGINE REPAIR (Continued)



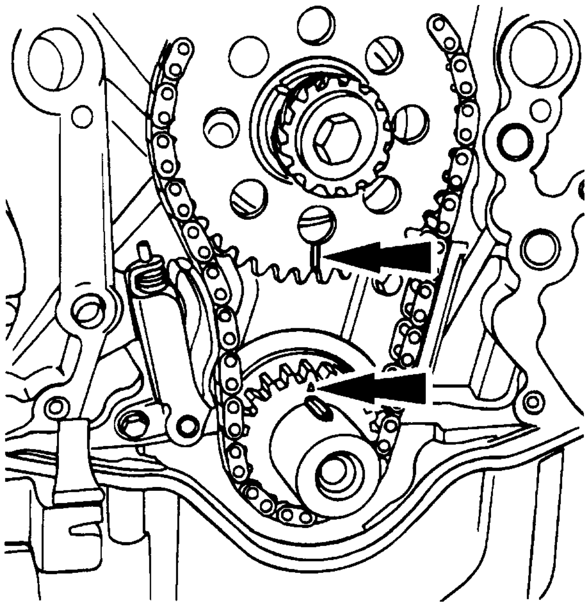
2. Install the timing chain vibration damper.



3. Install the balance shaft drive gear.

   - The timing marks on the drive and driven gear must align.

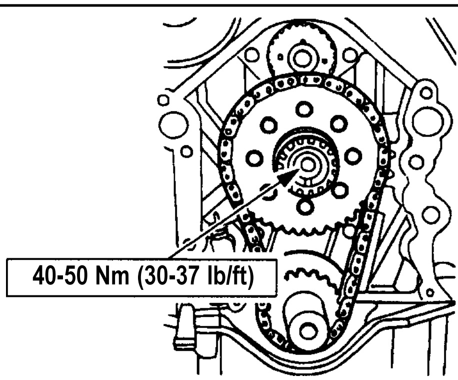
ENGINE REPAIR (Continued)



DA0741-A

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

   • Timing marks on the gears and keyways on the shafts must align.



DA0742-A

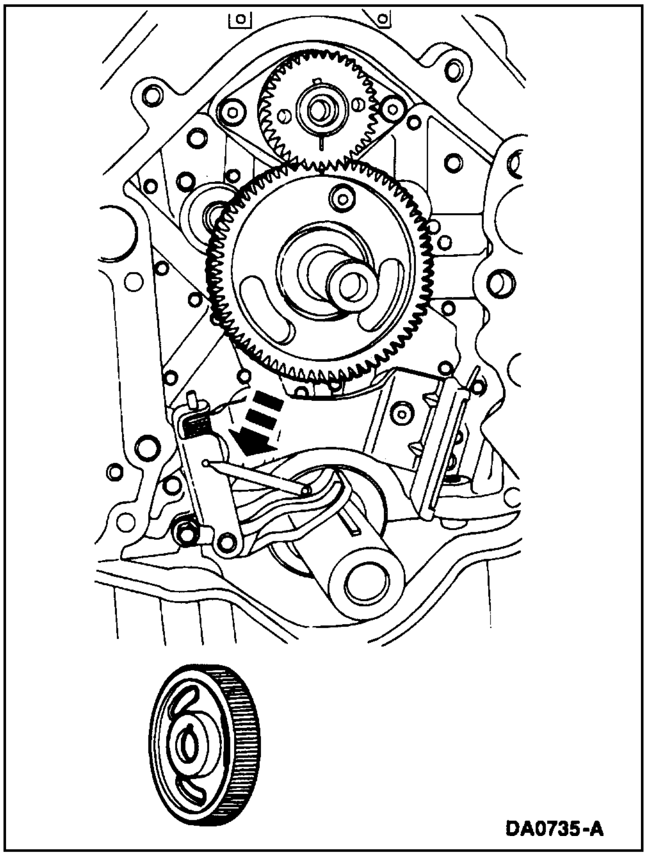
5. Install the synchronizer drive gear.

6. Install the front cover. Refer to the procedure in this section.

ENGINE REPAIR (Continued)

Camshaft

Removal



1. Remove the following components. Refer to the procedures in this section.

   • Upper and lower intake manifolds.

   • Valve covers.

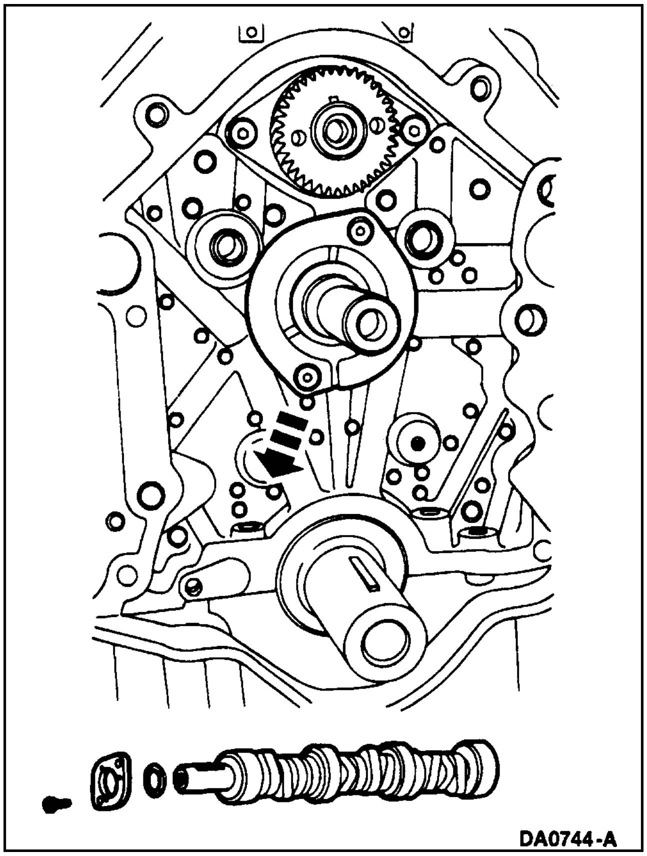
   • Push rods, tappet guides and tappets.

   • Front cover.

   • Timing chain and sprockets.

2. Remove the balance shaft drive gear.

ENGINE REPAIR (Continued)

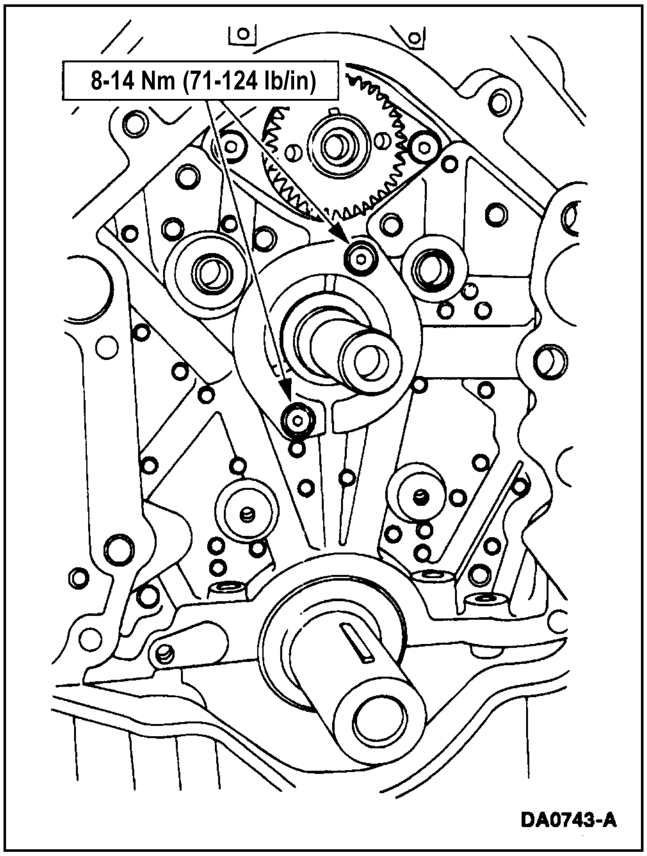


3. ⚠ **CAUTION: Use care when removing cam as not to bump or score cam bearings. May cause cam bearing failure.**

   Remove the thrust plate retaining screws and the camshaft.

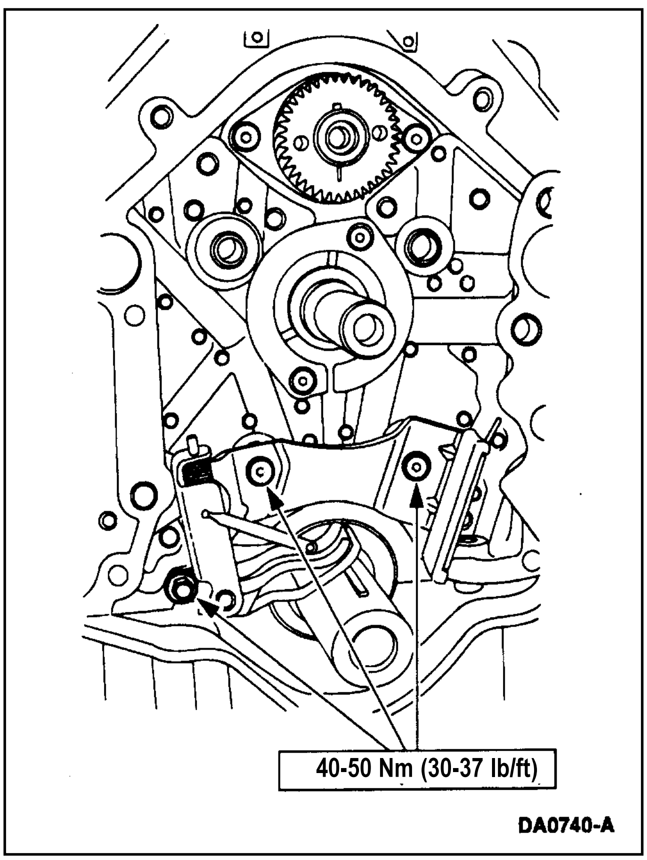
ENGINE REPAIR (Continued)

Installation



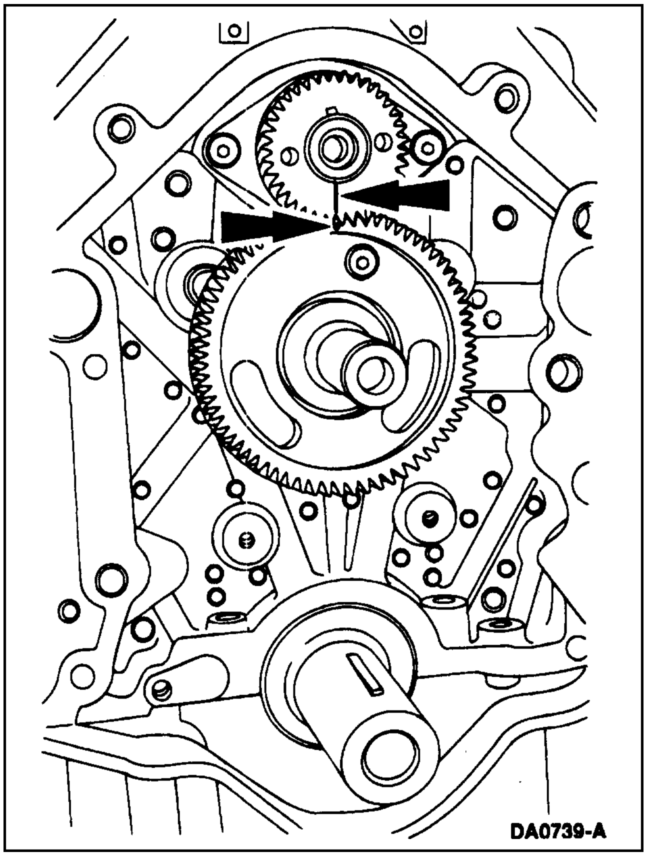
1. **CAUTION: Use care when removing cam as not to bump or score cam bearings. May cause cam bearing failure.**

   Lubricate the camshaft bearings, lobes and journals with Engine Assembly Lubrication D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A. Install the camshaft.



2. Install the timing chain vibration damper.

ENGINE REPAIR (Continued)



3. Install the balance shaft drive gear.
   - The timing marks on the drive gear and driven gear must align.
4. Install the following components. Refer to the procedures in this section.
   - Timing chain.
   - Front cover.
   - Tappets, tappet guides and push rods.
   - Valve covers.
   - Lower and upper intake manifolds.

REMOVAL

Engine

Special Tool(s)

 ST1377-A	Engine Lifting Bracket 014-00730 or Equivalent

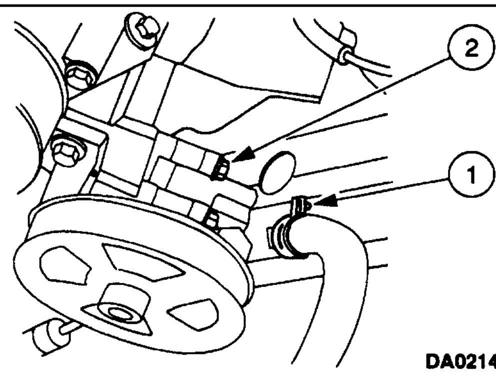
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Removal of Engine

1. Disconnect the battery gound cable.
2. Remove the retaining bolt and the lower core support.
3. Remove the routing bracket retaining bolt and the engine oil dipstick tube.
4. Remove the upper intake manifold. Refer to Intake Manifold – Upper this section.
5. Remove the lower intake manifold. Refer to Intake Manifold – Lower this section.
6. Remove the accessory drive belt.
7. Set the power steering pump aside if equipped.

   1 – Disconnect the low-pressure line at the power steering pump.

   2 – Remove the pump retaining bolts.



DA0214-A

8. Set the radiator lower hose aside.

   1 – Cut the clamp.

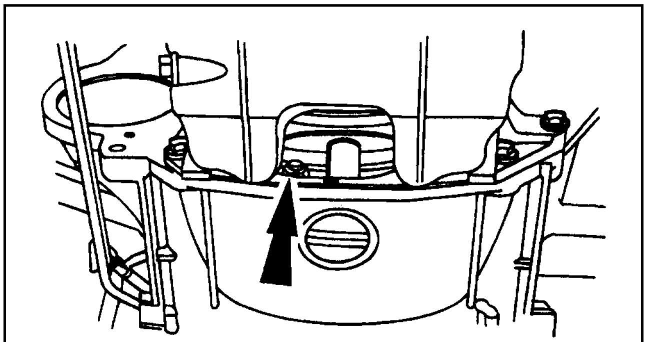
   2 – Disconnect the hose at the water pump.

REMOVAL (Continued)

9. Drain the engine oil.

   WARNING: PROTECT ENVIRONMENT. IT IS ILLEGAL TO POLLUTE DRAINS, WATER COURSES OR SOIL. USE AUTHORIZED FACILITY FOR DISPOSAL. IF IN DOUBT, CONTACT YOUR LOCAL AUTHORITY FOR ADVICE.

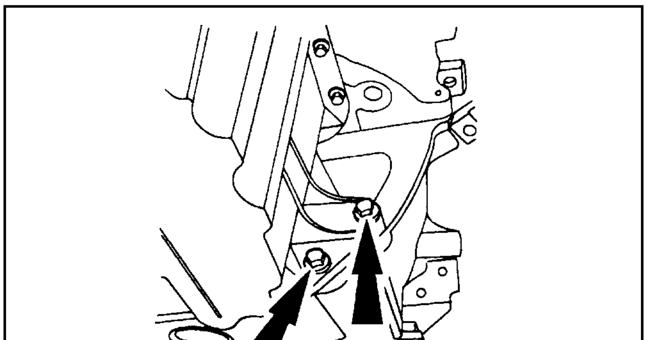
10. Remove the starter.



DA0915-A

11. Remove the torque converter access cover and the torque converter retaining nuts. Rotate the crankshaft to access the retaining nuts.

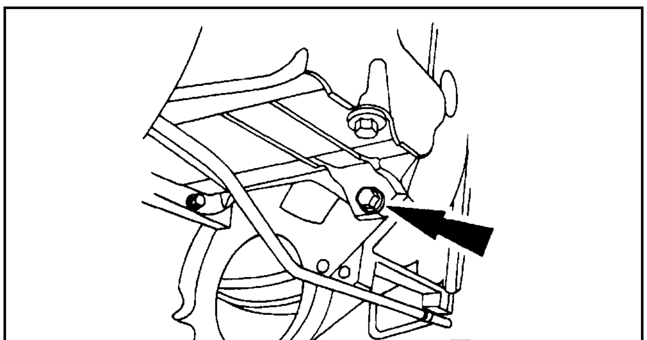
   • Remove PTO if equipped.



DA0218-A

12. Remove the engine oil pan-to-transmission retaining bolts on the left side.

   NOTE: Remove SAE housing and adaptor plate if equipped.



DA0219-A

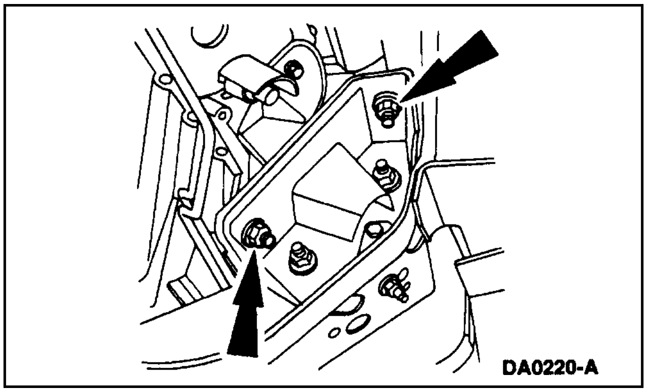
13. Remove the engine oil pan-to-transmission retaining bolts on the right side.

   • See note in Step 12 above.

14. Remove the nuts retaining the exhaust pipe at the exhaust manifolds.

15. Remove the shift cable routing bracket retaining bolt (if so equipped).

REMOVAL (Continued)



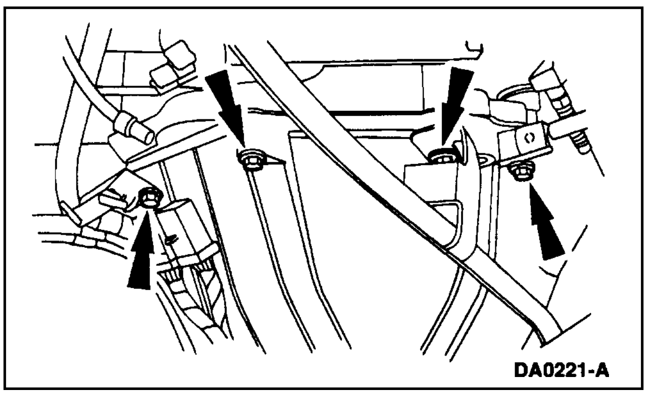
16. Remove the engine mount retaining nuts. (Left side shown).
17. Install the engine lifting equipment.
18. Remove the transmission dipstick tube for automatic transmissions.

    1 – Position the drain pan.

    2 – Remove the transmission-to-engine retaining bolt at the dipstick tube bracket.

    3 – Remove the tube.

    4 – Discard the O-ring.

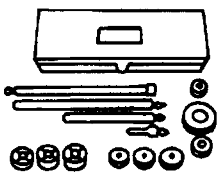
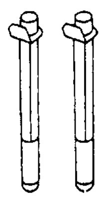
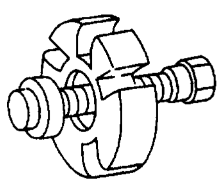
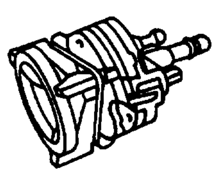


19. Remove the transmission-to-engine retaining bolts.
20. Remove the engine.

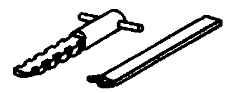
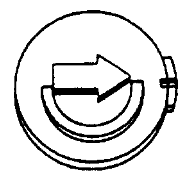
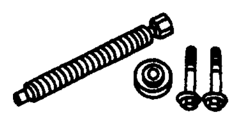
DISASSEMBLY

Engine

Special Tool(s)

 ST1381-A	Camshaft Bearing Set T65L-6250-A
 ST1337-A	Connecting Rod Guide Tool T93P-6136-A
 ST1286-A	Crankshaft Damper Remover T58P-6316-D
 ST1276-A	Cylinder Ridge Reamer T64L-6011-EA

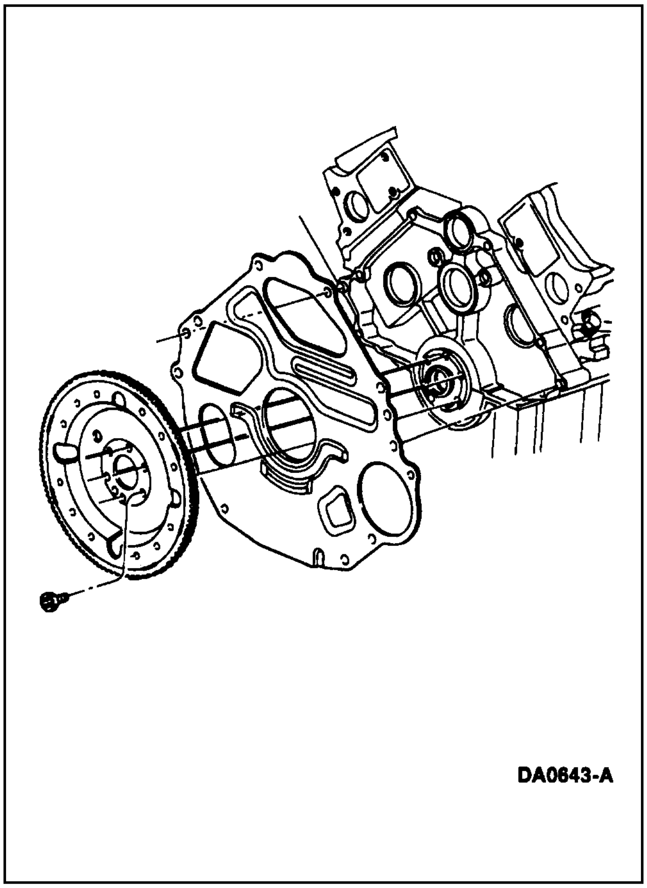
Special Tool(s)

 ST1385-A	Seal Remover T92c-6700-CH
 ST1428-A	Syncro Positioning Tool T89P-12200-A
 ST1378-A	Vibration Damper Remover Adapter T82L-6316-B

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

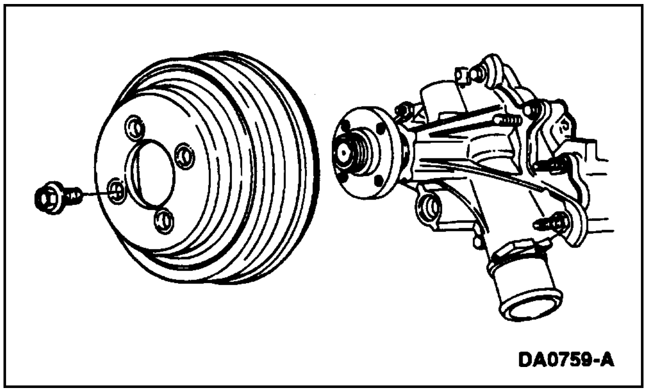
DISASSEMBLY (Continued)

Gears

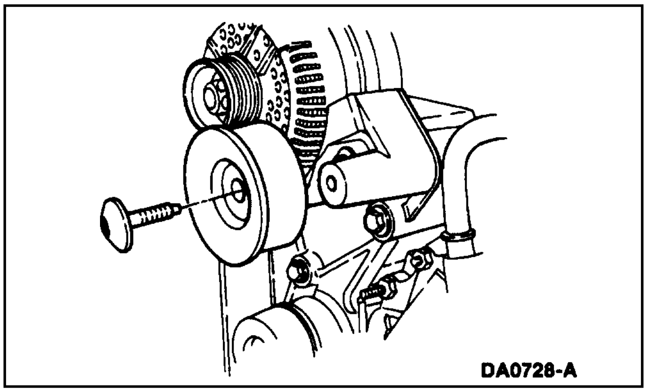


1. Remove the flywheel and rear cover plate and mount the engine (6007) on a suitable workstand.

DISASSEMBLY (Continued)

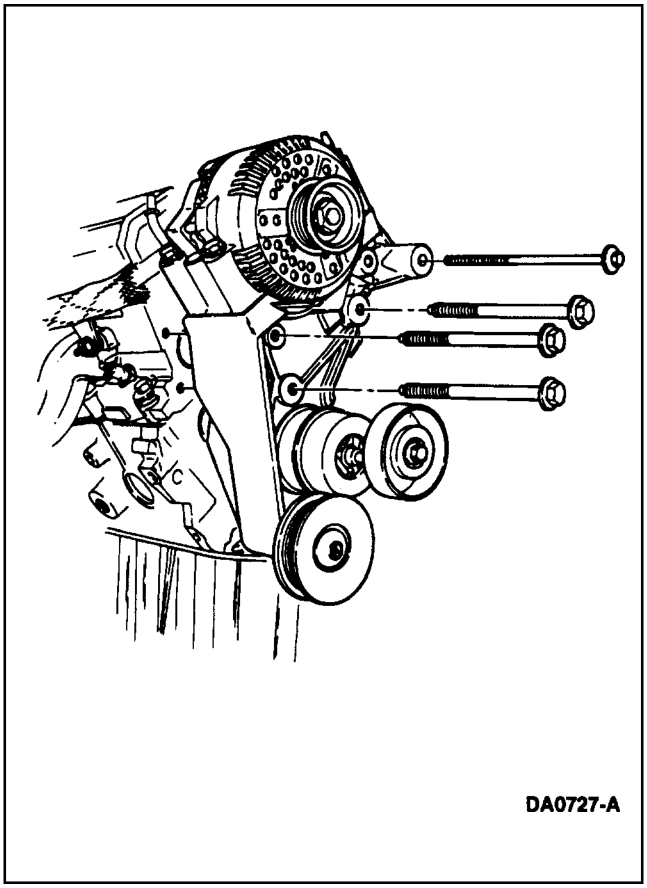


2. Remove the water pump pulley (8509).



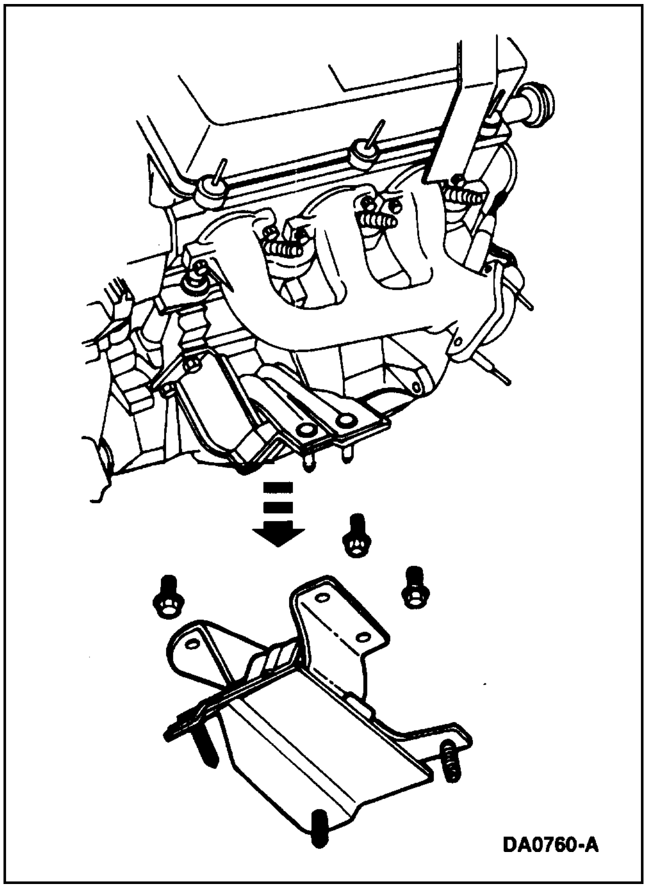
3. Remove the drive belt idler pulley (8678).

DISASSEMBLY (Continued)

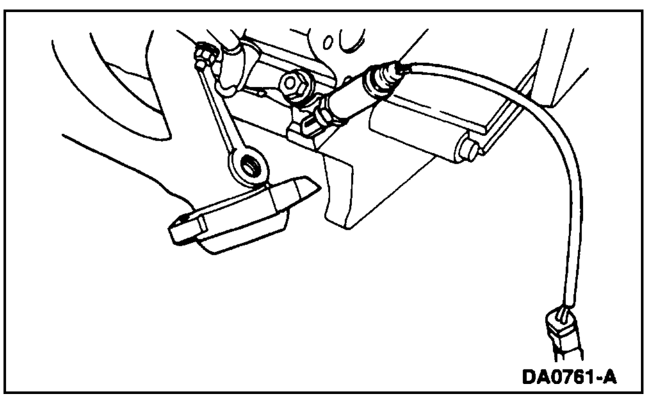


4. Remove the generator mounting bracket.

DISASSEMBLY (Continued)

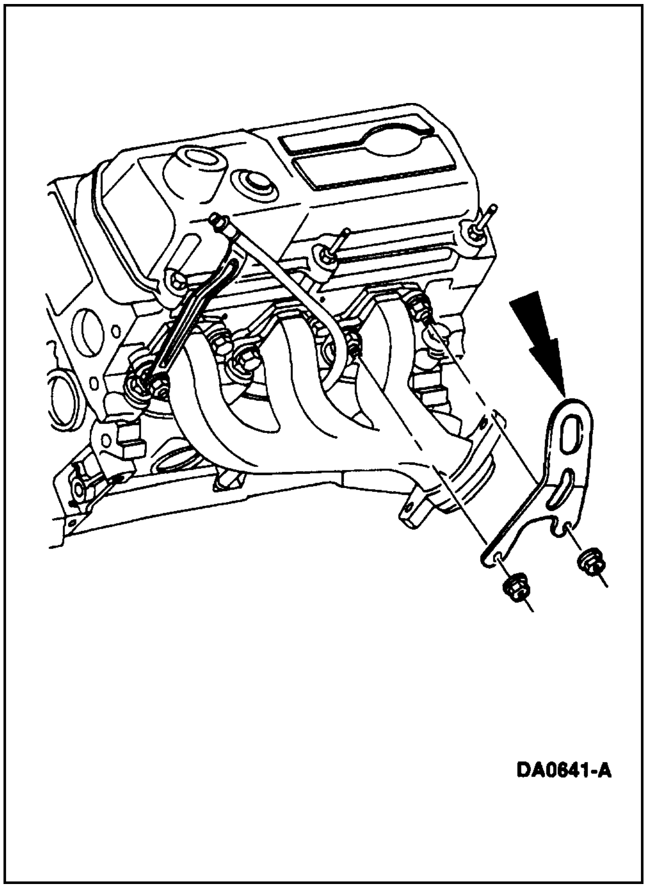


5. Remove the engine mounts.

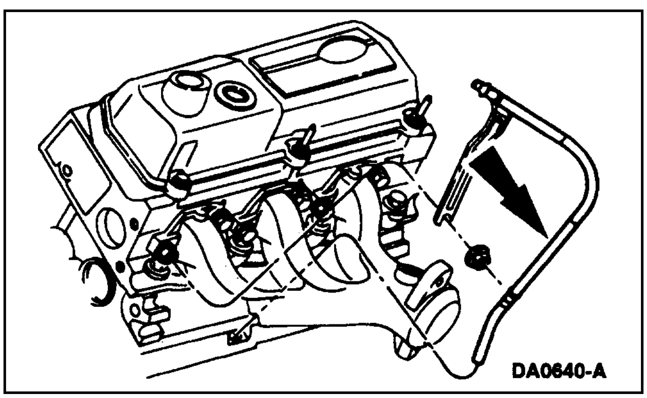


6. Remove the heated exhaust gas oxygen (HO2S) sensors (left side shown; right side similar).

DISASSEMBLY (Continued)

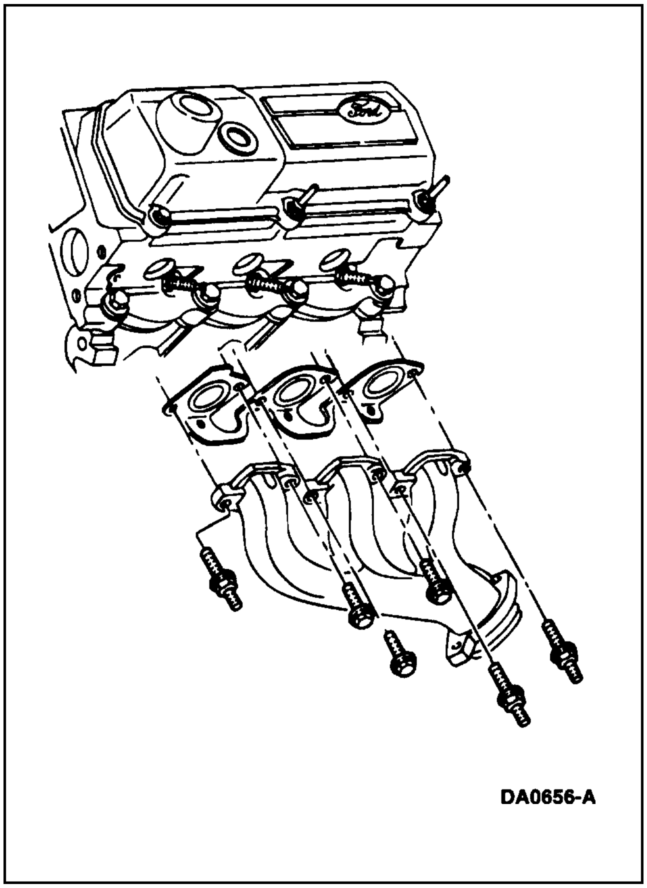


7. Remove the engine lifting eyes (left side shown; right side similar).

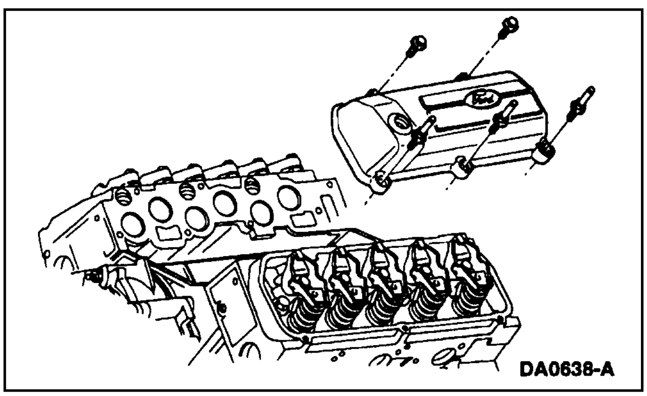


8. Remove the oil level indicator tube.

DISASSEMBLY (Continued)

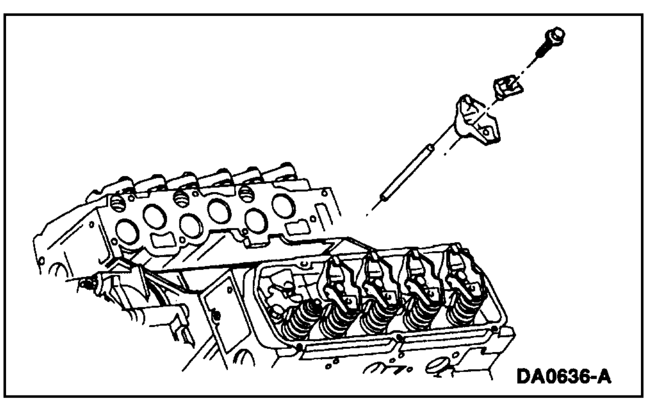


9. Remove the exhaust manifolds (left side shown; right side similar). Discard the gaskets. Same procedure for optional center dump exhaust manifolds.



10. Remove the valve covers (left side shown; right side similar).

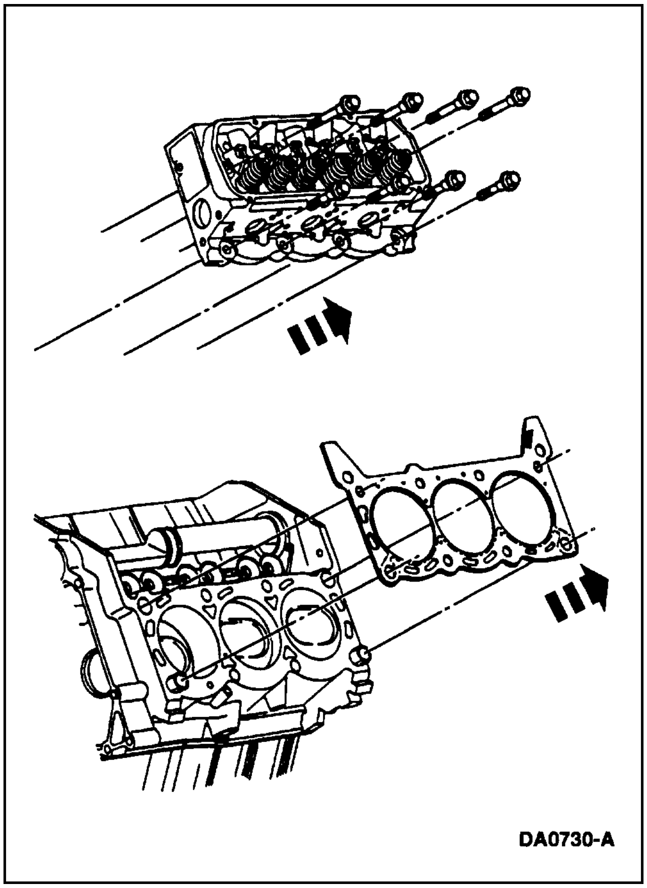
    NOTE: Remove the ignition coil pack (if necessary). Refer to Section 3.



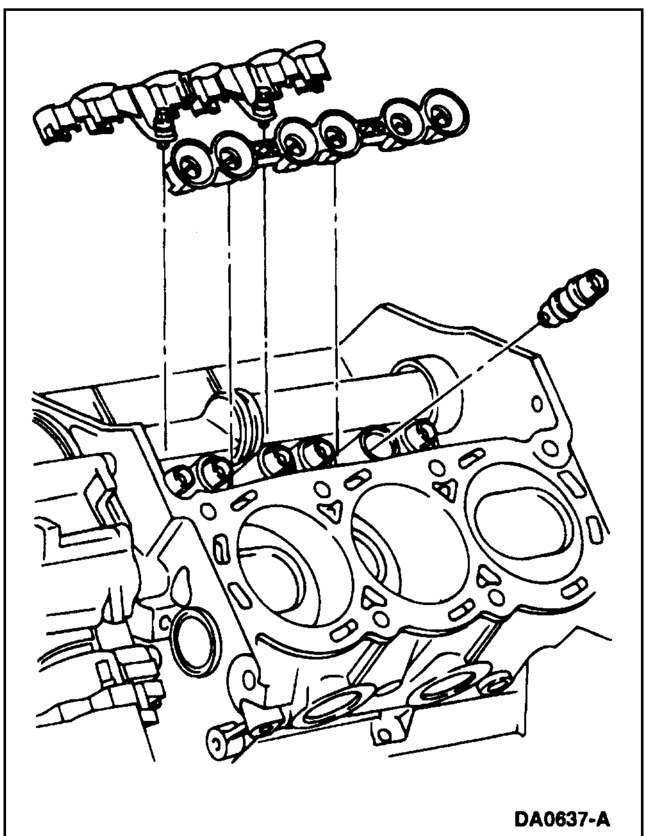
11. **NOTE:** The location of each rocker arm seat, rocker arm and pushrod should be identified. When the engine is assembled, each component should be installed in its original position.

    Remove the rocker arms, rocker arm seats and push rods.

DISASSEMBLY (Continued)



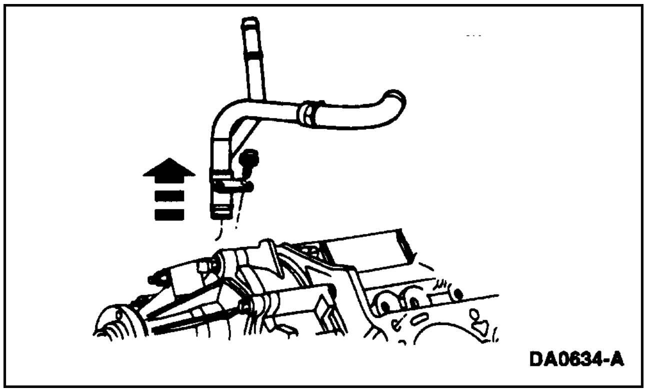
12. Remove the cylinder heads and head gaskets (left side shown; right side similar). Discard the head gaskets and bolts.



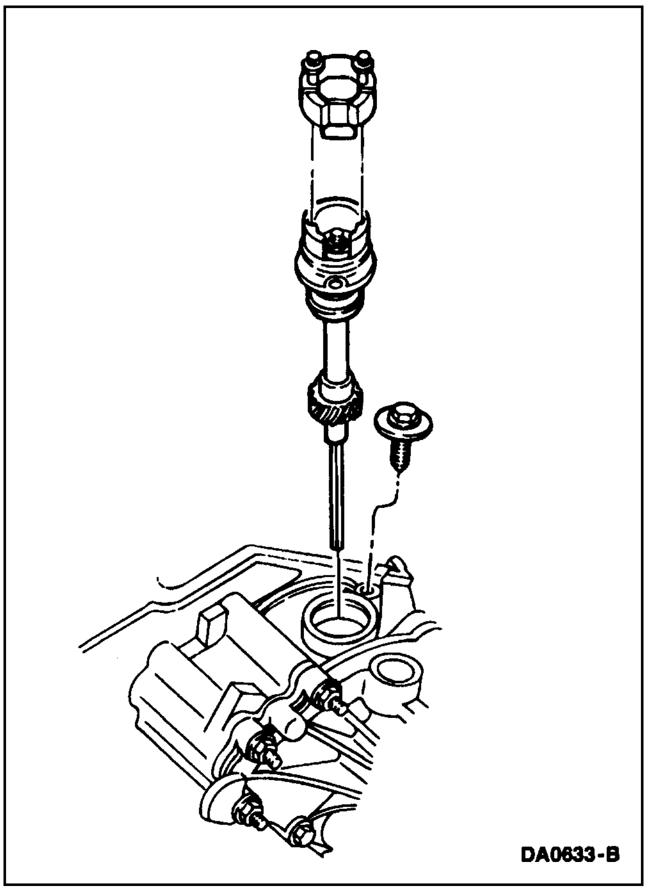
13. **NOTE:** Identify the location of each valve tappet. When the engine is assembled, make sure each valve tappet is installed in its original position.

    Remove the tappet guides and valve tappets.

DISASSEMBLY (Continued)

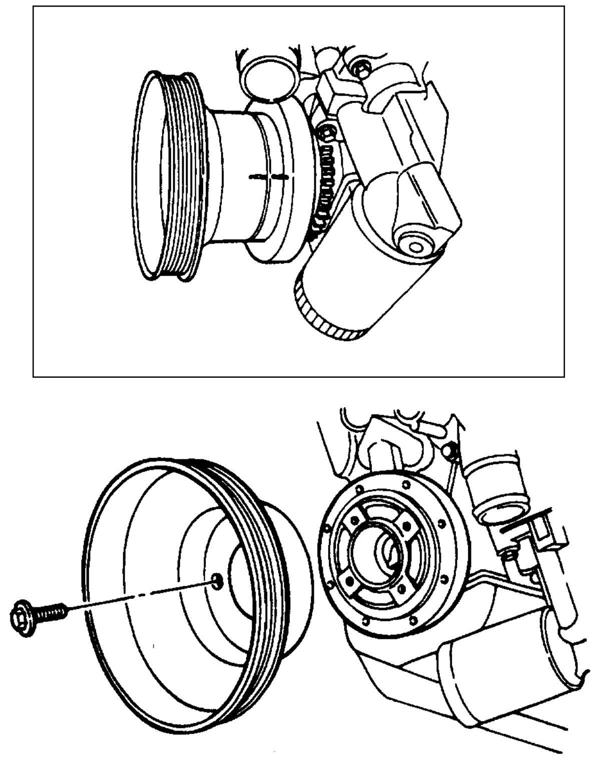


14. Remove the heater outlet water tube.



15. Remove the crankshaft synchronizer.

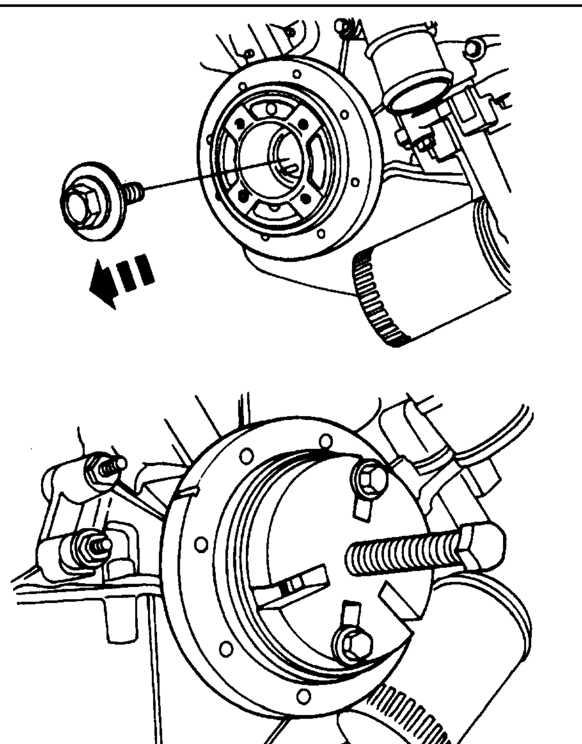
DISASSEMBLY (Continued)



DA0726-A

16. **NOTE:** The crankshaft pulley (6312) and damper are a balanced assembly. Mark the components for alignment before removal.

    Remove the crankshaft pulley.

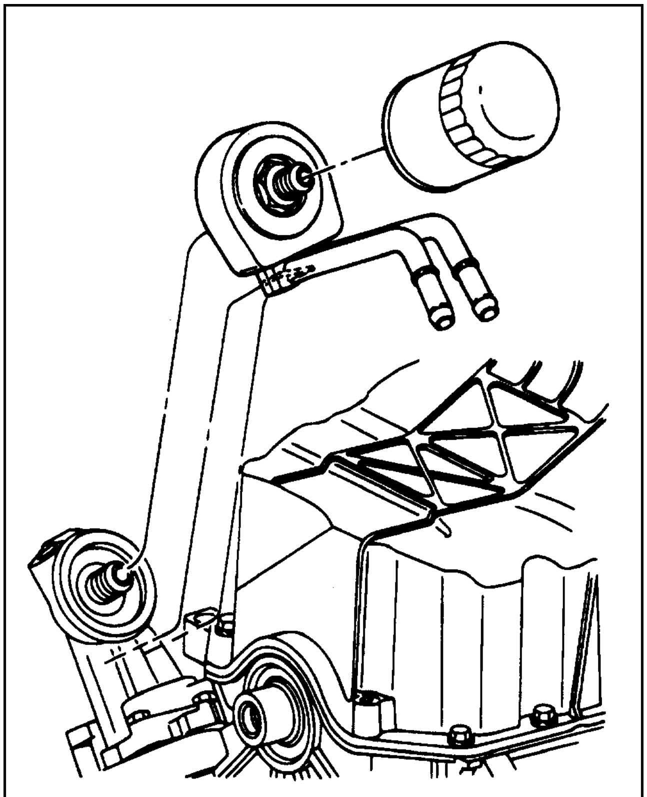


DA0729-A

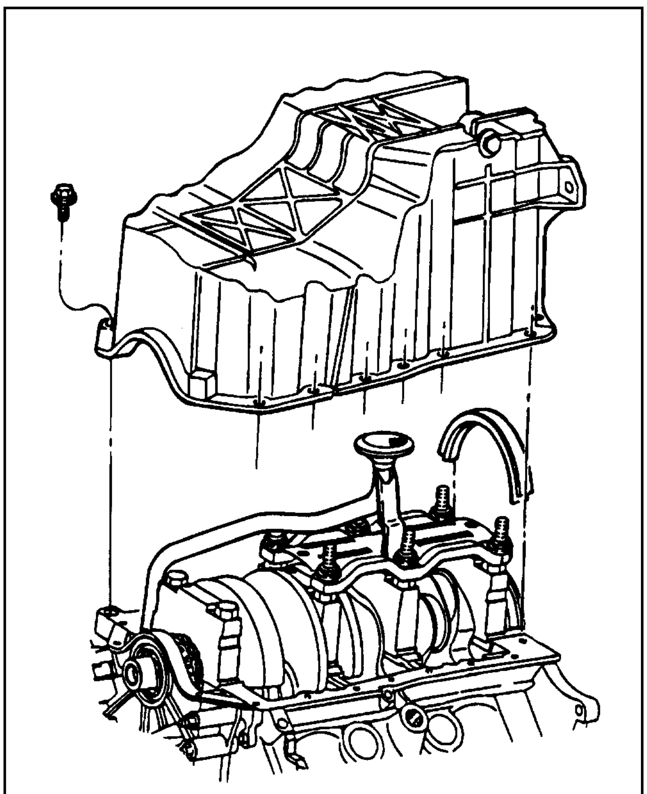
17. Remove the retaining bolt and the crankshaft damper.

    - A puller will be needed to remove the damper from the crankshaft.

DISASSEMBLY (Continued)

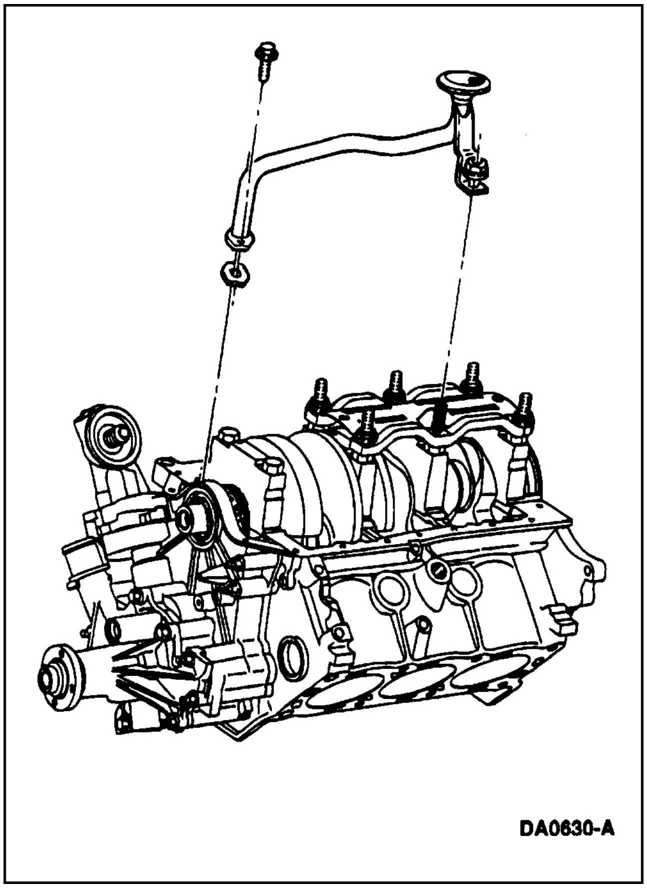

DA0632-A

18. Remove the oil bypass filter and the engine oil cooler (6A642) (if so equipped).

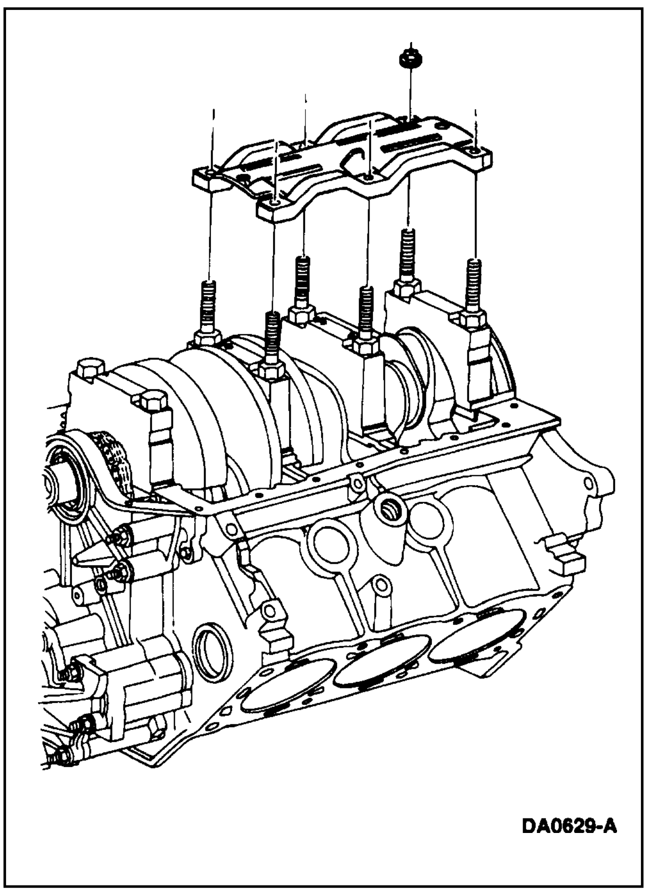

DA0631-A

19. Remove the oil pan (6675) and the oil pan rear seal.

DISASSEMBLY (Continued)



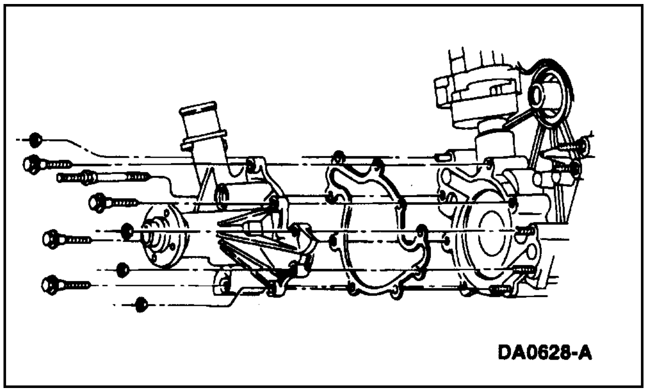
20. Remove the oil pump screen cover and tube (6622). Discard the oil pan gasket (6710).



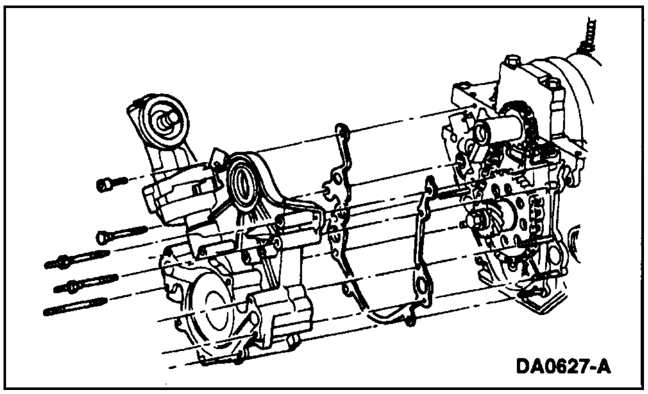
21. **CAUTION: Before this step is started, both cylinder heads must be removed to prevent lower block from distorting.**

    Remove the oil pan baffle.

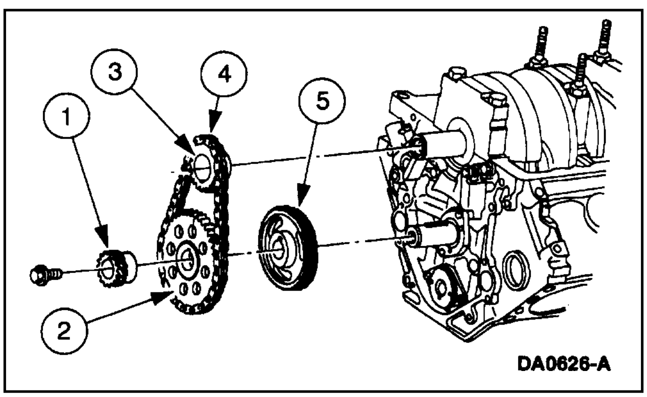
DISASSEMBLY (Continued)



22. Remove the water pump (8501).



23. Remove the engine front cover. Discard the gasket.



24. Remove the following:

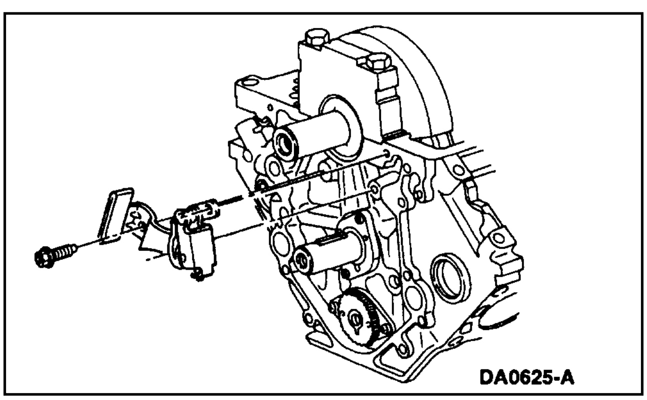
    1 – Synchronizer drive gear.

    2 – Camshaft sprocket.

    3 – Crankshaft sprocket.

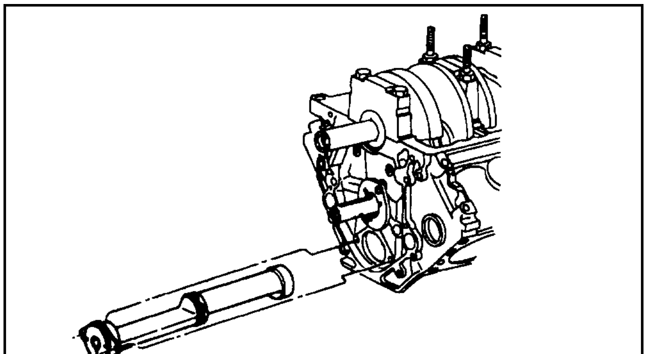
    4 – Timing chain.

    5 – Balance shaft drive gear.



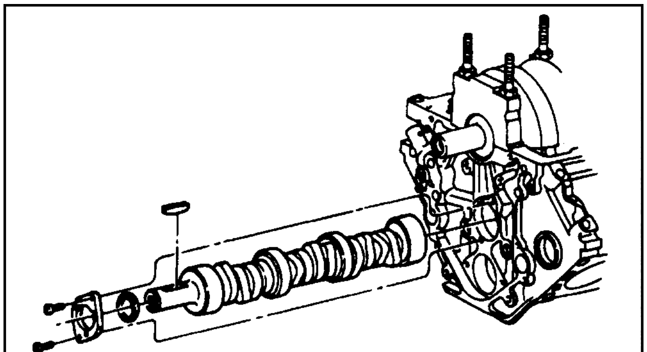
25. Remove the timing chain vibration damper.

DISASSEMBLY (Continued)



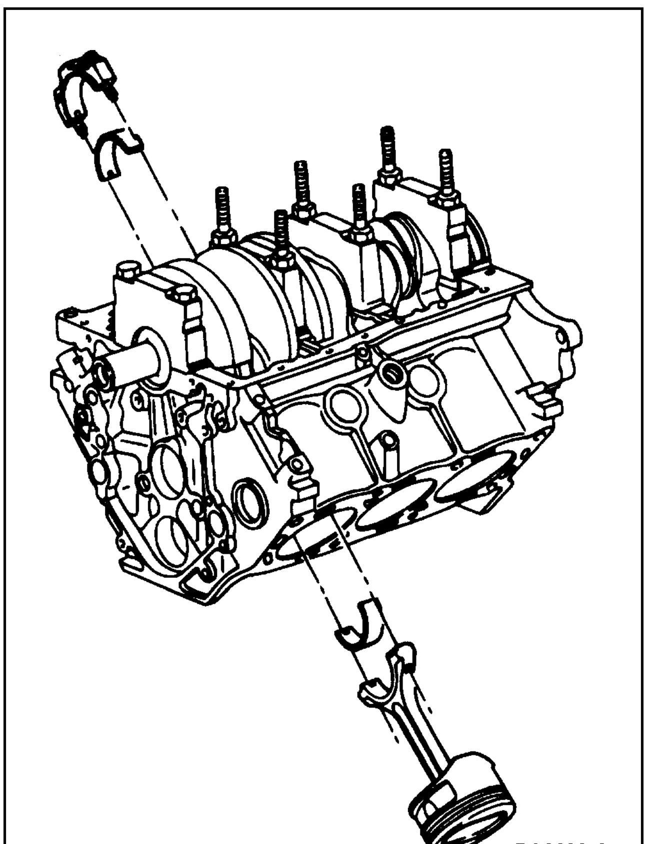
DA0624-A

26. Remove the balance shaft.



DA0623-A

27. Remove the camshaft.

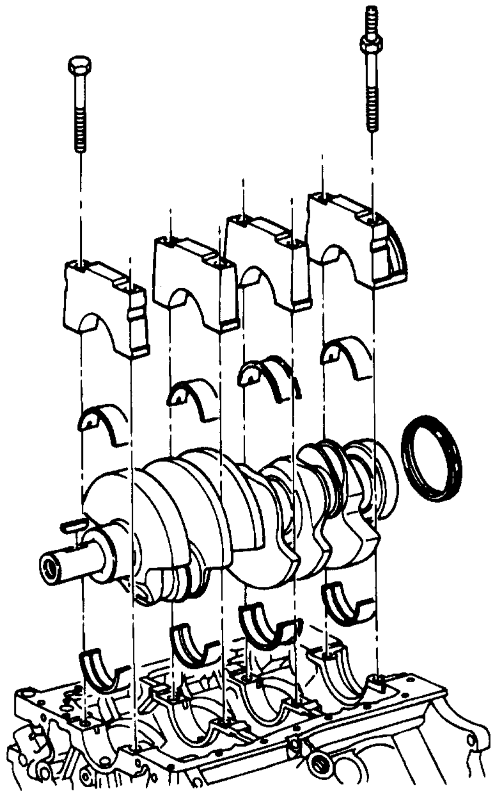


DA0622-A

28. **NOTE:** Mark the location of each piston, connecting rod bearing (6211) and connecting rod cap. When the engine is assembled, each component should be installed in its original position. Discard all bolts and replace with now bolts.

    Inspect the top of each cylinder bore and, if necessary, remove the ridge or carbon deposits. Remove the pistons.

DISASSEMBLY (Continued)



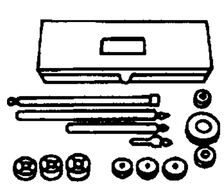
DA0621-A

29. Remove the crankshaft and main bearings. Discard the crankshaft rear oil seal (6701) and all bolts and replace with new bolts and oil seal.

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES

Cylinder Blocks

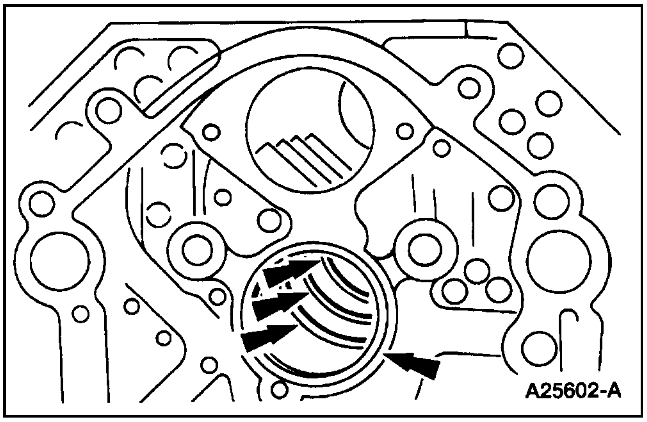
Special Tool(s)

 ST1381-A	Camshaft Bearing Set T65L-6250-A

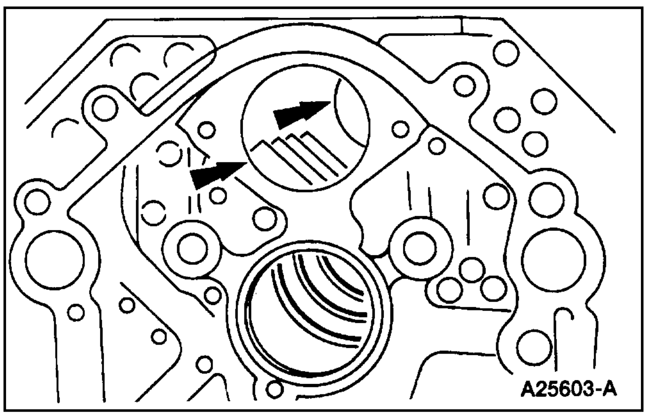
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)

Disassembly



1. Use the Camshaft Bearing Set to remove the four camshaft bearings.



2. Use the Camshaft Bearing Set to remove the two engine dynamic balance shaft bearings.

3. If so equipped, remove the block heater.

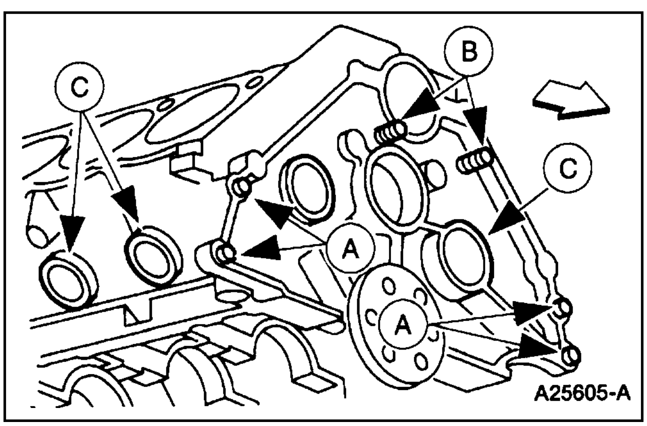
4. **NOTE:** For cleaning purposes, plugs should be removed.

   If necessary, remove plugs and dowels:

   • Cylinder block dowels (A).

   • Oil gallery plugs (B).

   • Water jacket plugs (C).

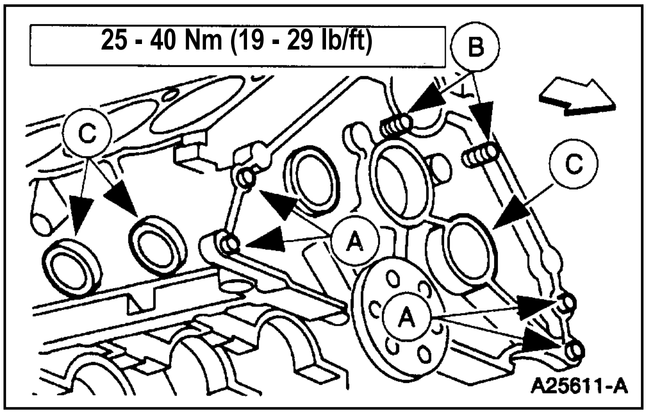


DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)

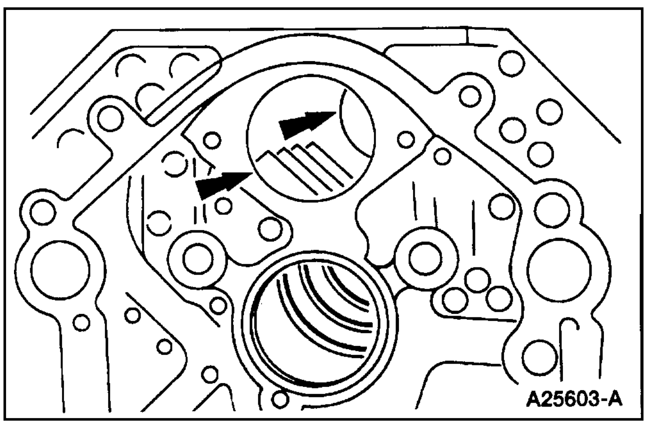
Assembly

NOTE: Moving components must be lubricated with engine oil before assembly.

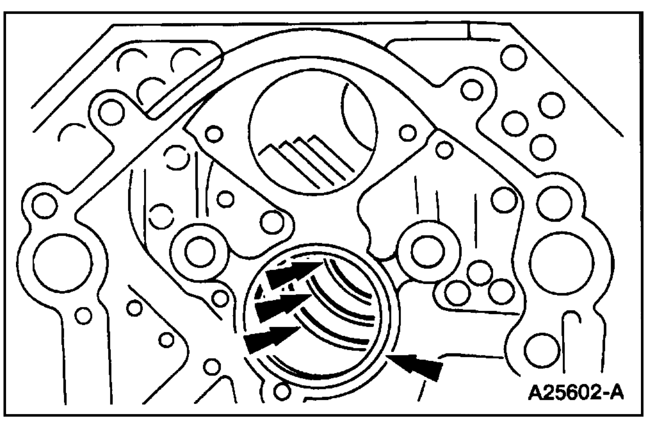
NOTE: Components with oil holes must be properly aligned with oil feed holes.



1. If necessary, install plugs and dowels:
   - Cylinder block dowels (A).
   - Oil gallery plugs (B).
   - Water jacket plugs (C).
2. If so equipped, install the block heater.

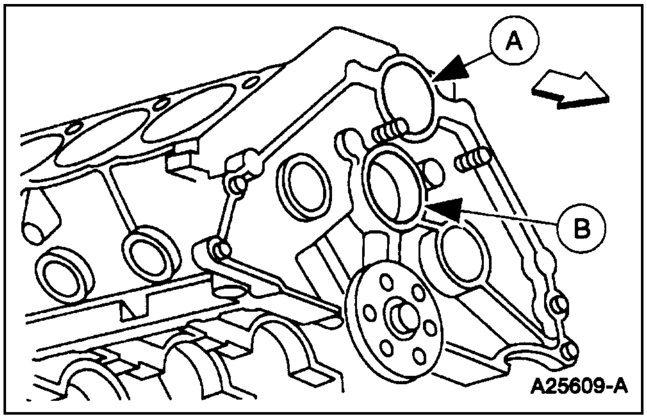


3. Use the Camshaft Bearing Set to install the two dynamic balance shaft bearings.



4. Use the Camshaft Bearing Set to install the four camshaft bearings.

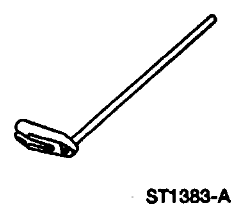
DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)



5. Install the (A) engine dynamic balance shaft bearing cover and the (B) camshaft bearing cover.

Cylinder Head

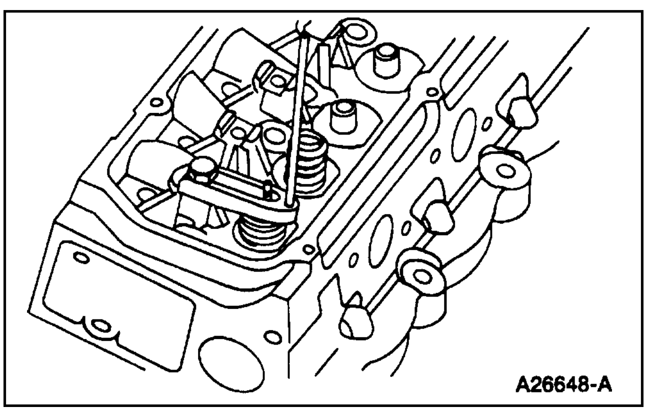
Special Tool(s)

	Valve Spring Compressor T81P-6513-A

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

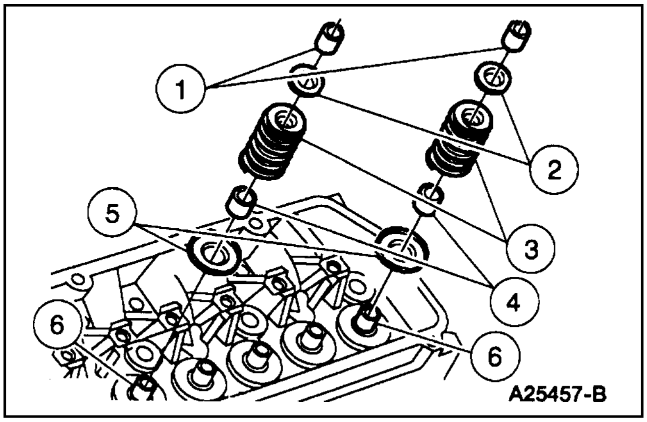
NOTE: If components are to be installed, they must be installed in the same positions. Mark components removed for correct location.

Disassembly of Cylinder Head



1. Remove the spark plugs (12405).
2. Use Valve Spring Compressor to compress the valve springs.

DISASSEMBLY AND ASSEMBLY OF SUBASSEMBLIES (Continued)



3. Remove the following:

   1 – Remove the valve spring retainer key.

   2 – Remove the valve spring retainer.

   3 – Remove the valve spring.

   4 – Remove and discard the valve stem seal.

   5 – Remove the valve spring seat.

   6 – Remove the valve.

Assembly of Cylinder Head

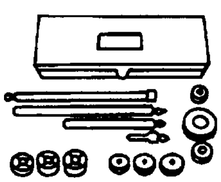
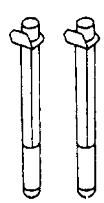
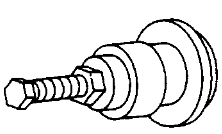
1. **NOTE:** Lubricate parts with engine oil before installing.

   Follow the disassembly procedure in reverse order.

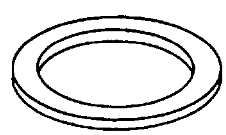
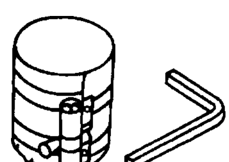
ASSEMBLY

Engine

Special Tool(s)

 ST1381-A	Camshaft Bearing Set T65L-6250-A
 ST1337-A	Connecting Rod Guide T93P-6136-A
 ST1328-A	Front Crankshaft Seal Installer/Aligner T88T-6701-A

Special Tool(s)

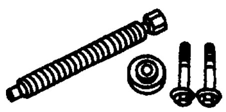
 ST1379-A	Front Crankshaft Seal Replacer T94P-6701-AH
	Piston Ring Compressor D81L-6002-C or Equivalent

(Continued)

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

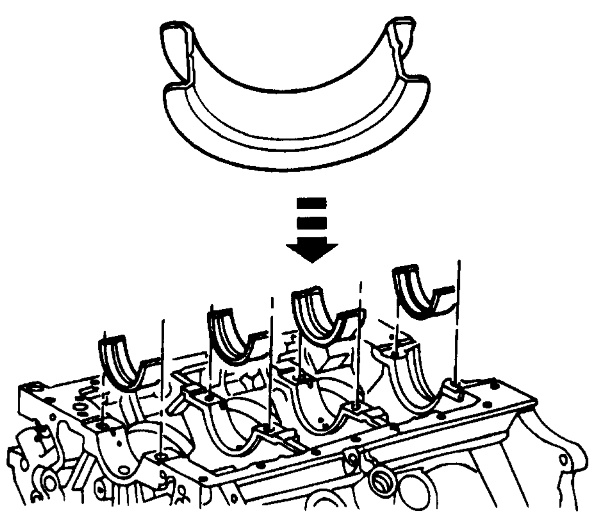
DISASSEMBLY (Continued)

Special Tool(s)

 ST1327-A	Rear Main Seal Replacer T82L-6701-A
 ST1378-A	Vibration Damper Remover Adapter T82L-6316-B

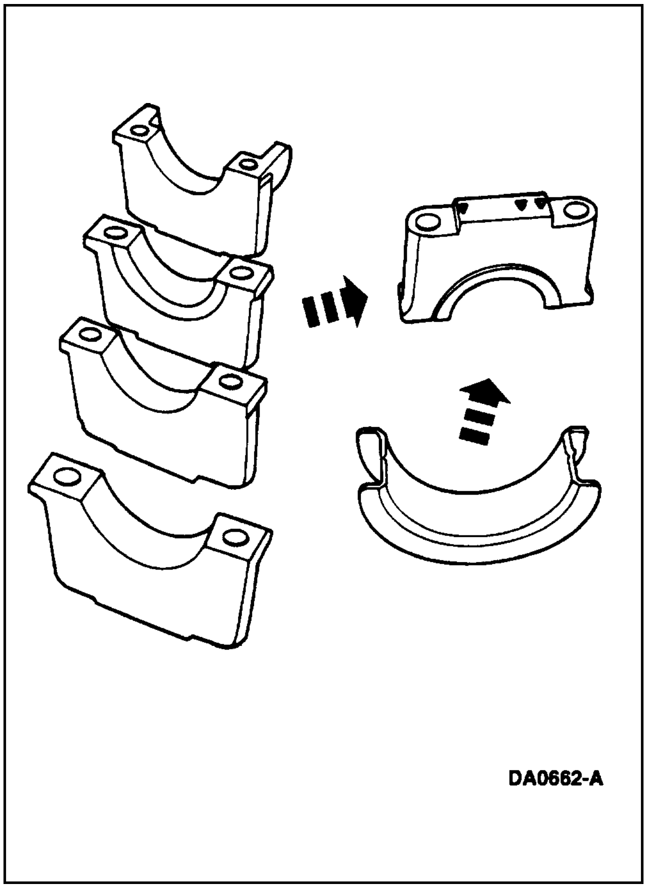
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Assembly of Engine

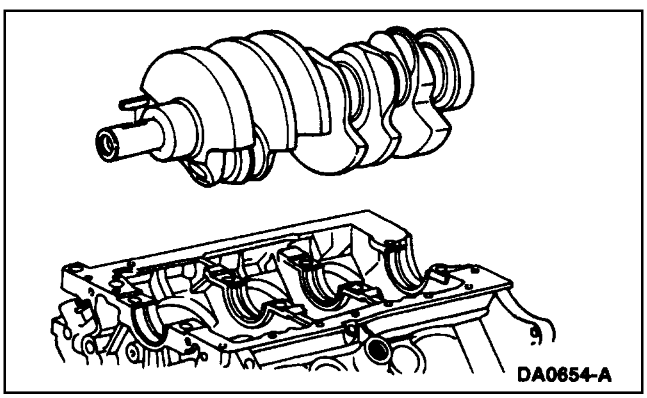

DA0661-A

1. Install the upper crankshaft main bearings (6333) in the cylinder block.
   - The third bearing from the front of the engine is the thrust bearing.

ASSEMBLY (Continued)

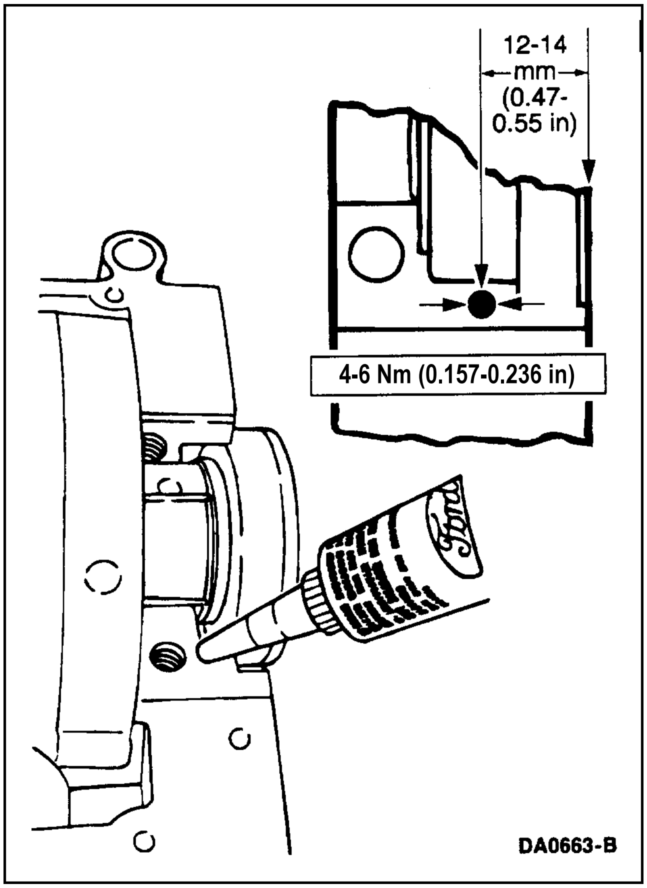


2. Install the lower crankshaft main bearings in the bearing caps.
   - The third bearing from the front of the engine is the thrust bearing.



3. Install the crankshaft.
   - Lubricate the main bearings and crankshaft journals with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.
   - Make sure the Woodruff key is installed in the end of the crankshaft.

ASSEMBLY (Continued)



CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

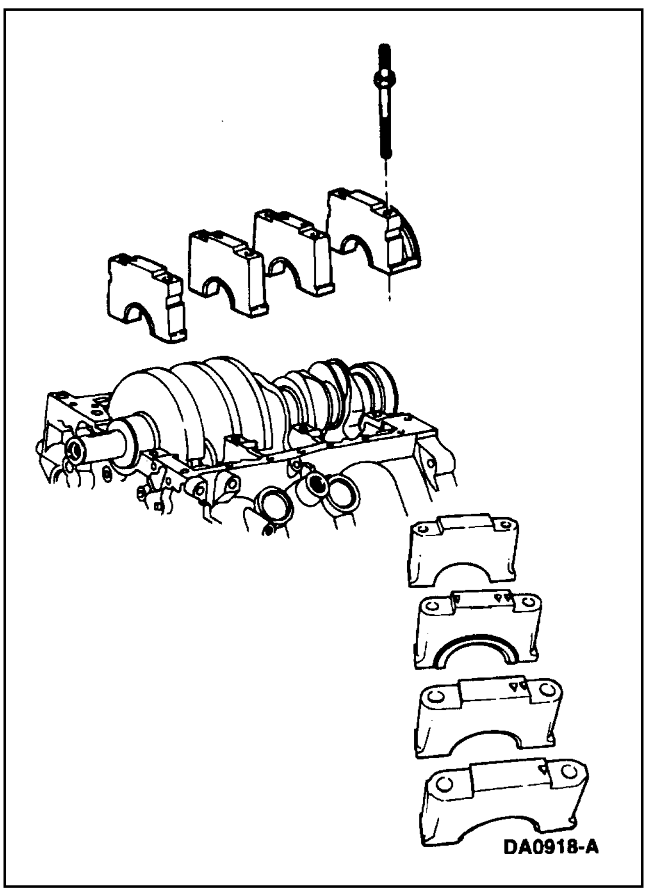
• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

4. Clean the mating surfaces on the rear main bearing cap and the cylinder block.

    • Apply a small amount of Silicone Gasket and Sealant in the location shown in the illustration.



5. Install the main bearing caps.

    1 – Arrows on the bearing caps indicate installation direction and location.

    2 – Tighten the main cap retaining bolts (two) and stud bolts (six) in two stages:

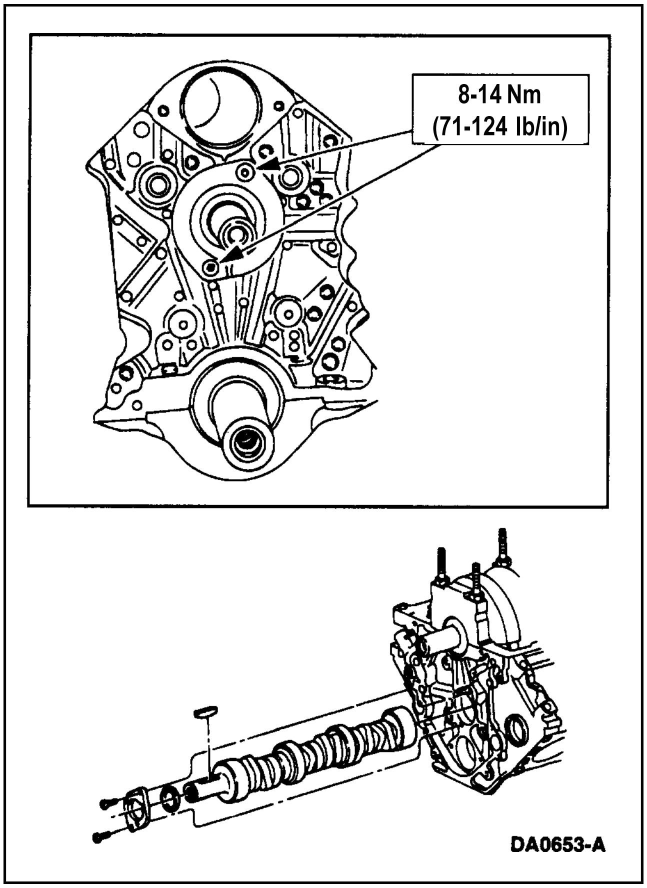
    • Stage 1: 50 Nm (37 lb/ft).

    • Stage 2: 115-125 degrees.

NOTE: Main cap retaining bolts and stud bolts are torque-to-yield. Discard and replace with new.

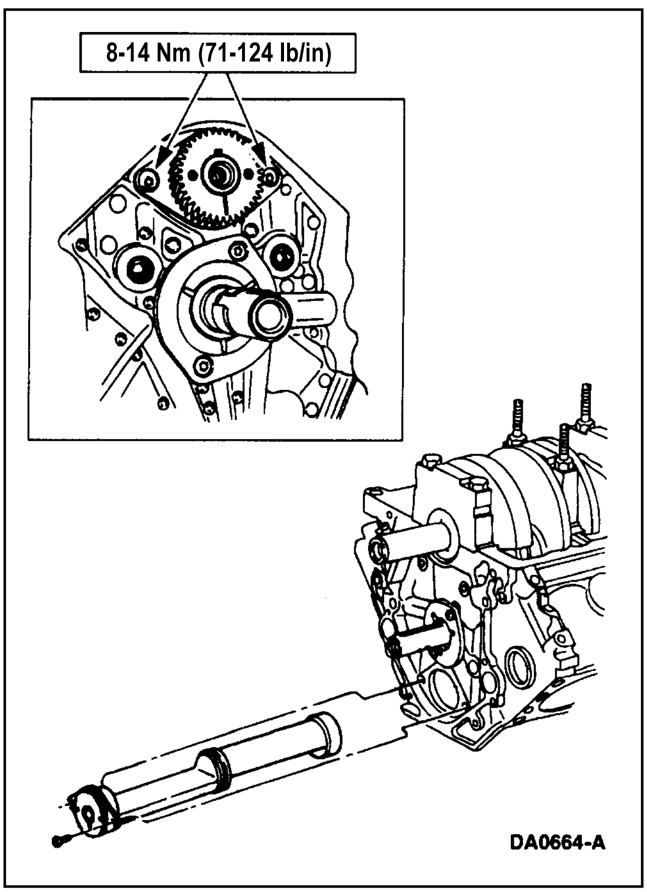
• Refer to this Section for installation procedures.

ASSEMBLY (Continued)



6. **CAUTION: Use extreme care installing camshaft to prevent scoring or scuffing cam bearings. May cause bearing failure.**

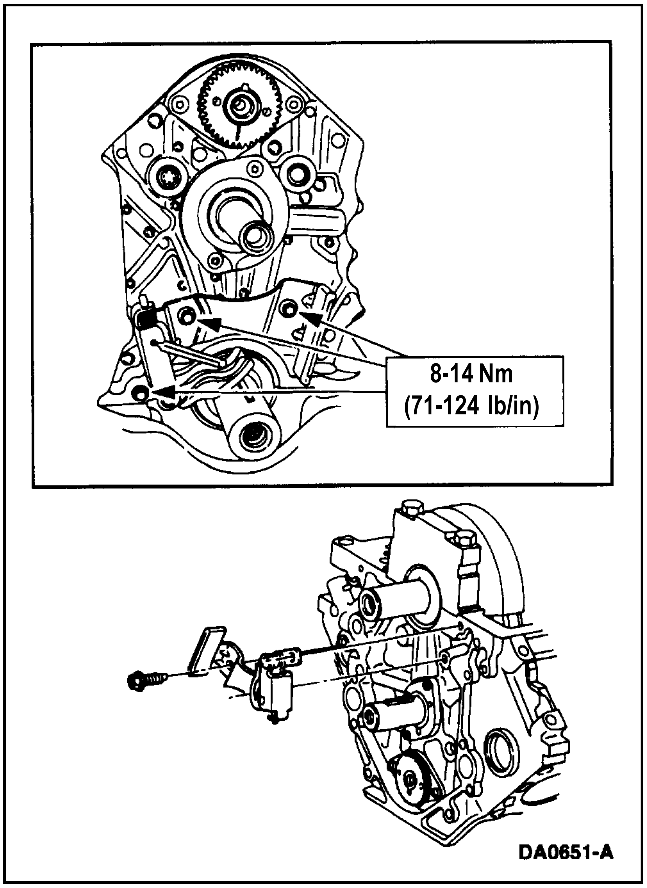
   - Lubricate the camshaft.
   - Lubricate the camshaft bearings, lobes and journals with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.
   - Install the camshaft and tighten (2) bolts to specification.



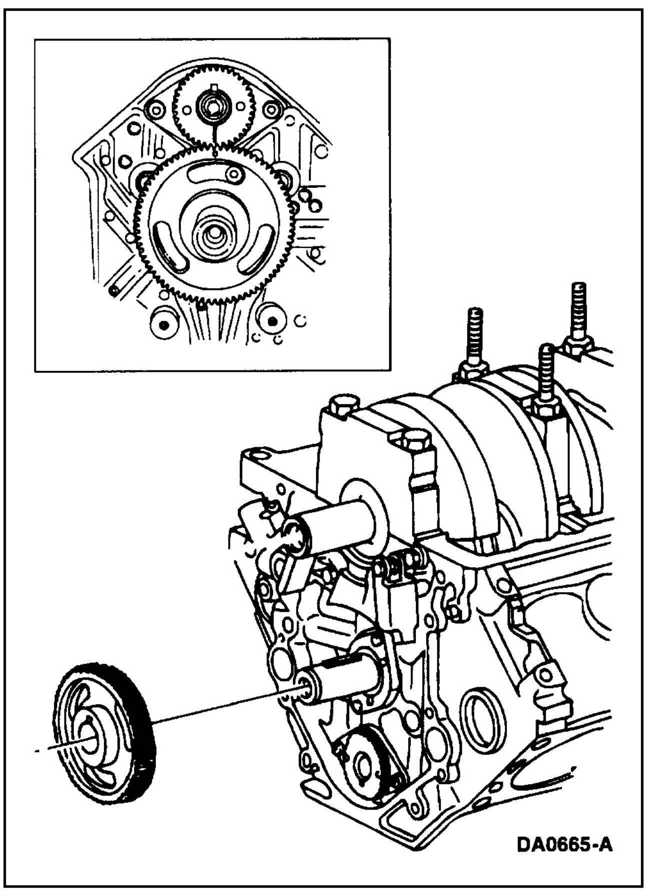
7. **CAUTION: Use extreme care installing balance shaft to prevent scoring or scuffing balance shaft bearings. May cause bearing failure.**

   - Lubricate the balance shaft bearings with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.
   - Install the balance shaft and tighten (2) bolts to specification.

ASSEMBLY (Continued)



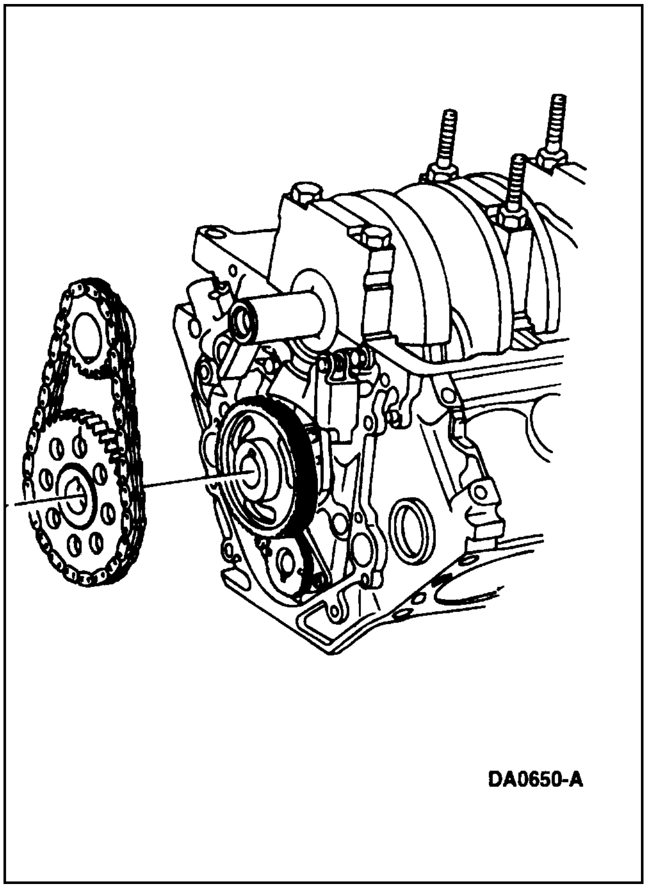
8. Install the timing chain vibration damper.



9. Install the balance shaft drive gear.

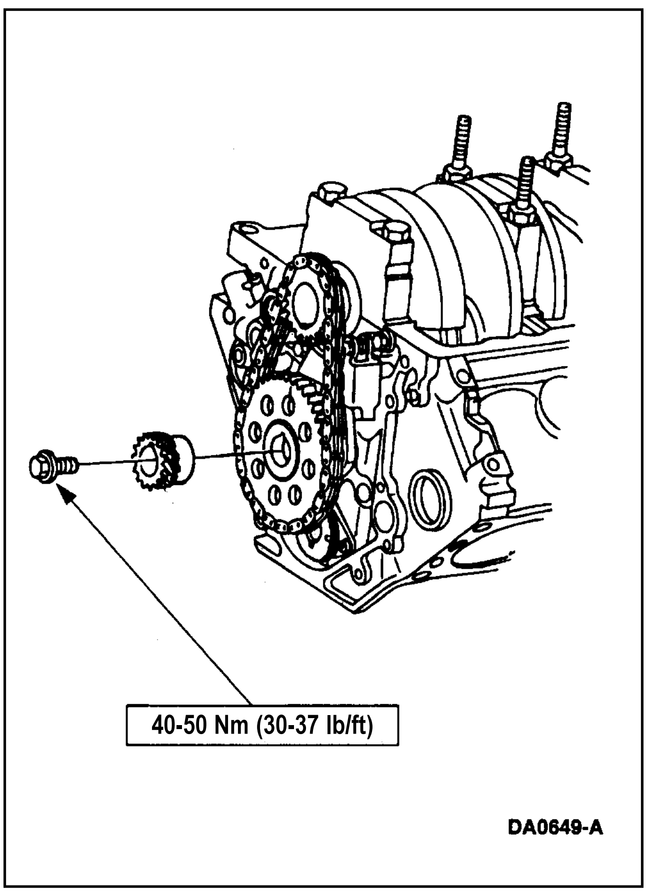
   • Timing marks on the drive and driven gear must align.

ASSEMBLY (Continued)



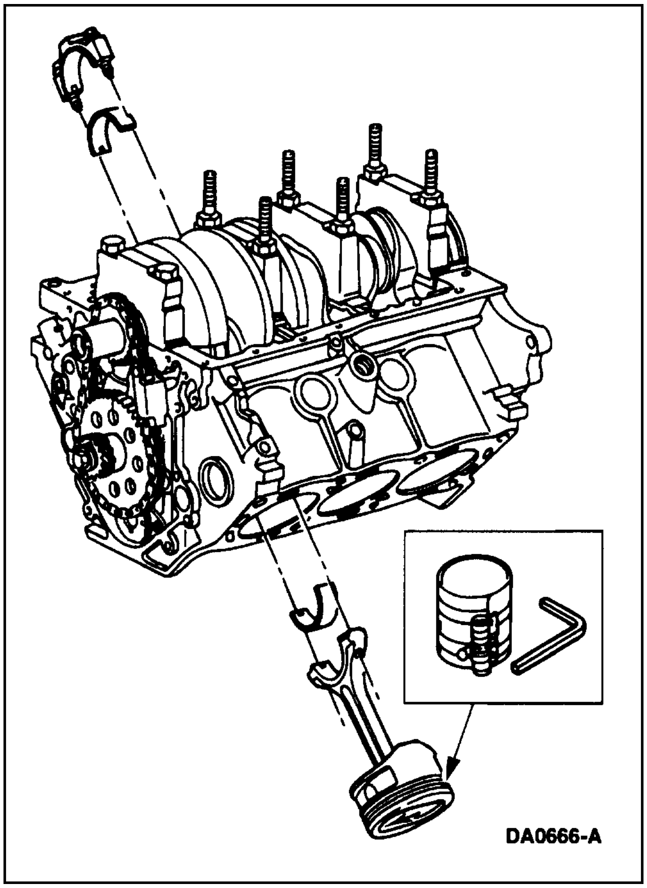
10. Install the crankshaft sprocket, camshaft sprocket and timing chain as an assembly.

    • Timing marks on gears and keyways on shafts must align.



11. Install the synchronizer drive gear.

ASSEMBLY (Continued)

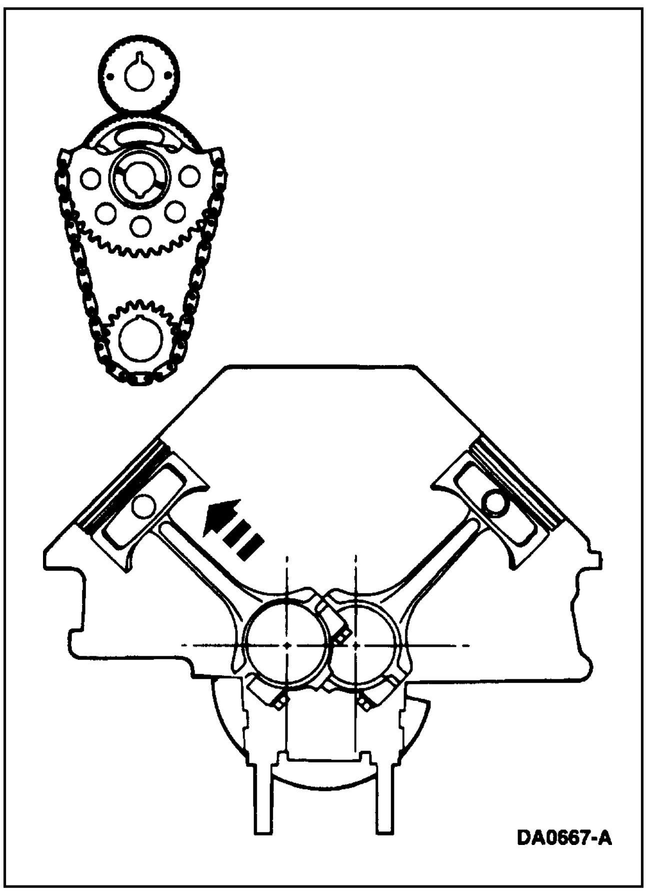


12. Install the bearing in the piston connecting rod and rod cap.

    - Lubricate the connecting rod bearings and crankshaft journals with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.
    - Lubricate the cylinder walls with clean engine oil and install the pistons. The arrow on the top of the piston must face the front of the engine and the notches in the bearing shells must align.
    - Install connecting rod caps.

NOTE: Bolts are torque-to-yield. Discard and replace with new.

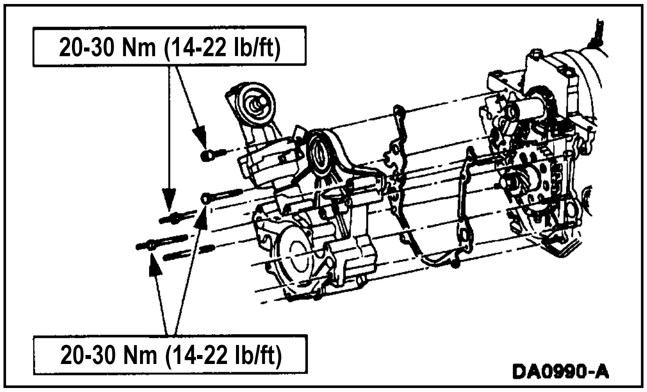
- Refer to this Section for installation procedures.



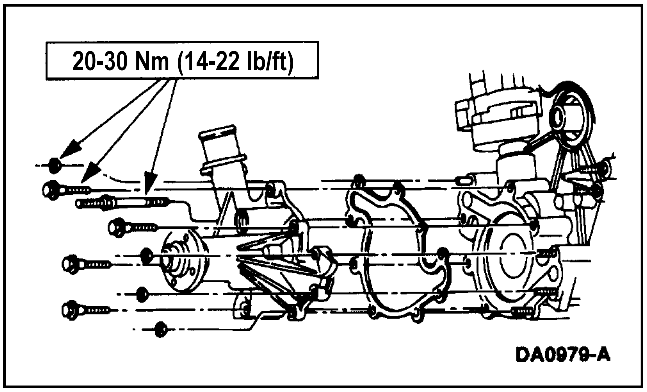
13. **NOTE:** All timing marks must be aligned with the number one piston at TDC.

    Turn the crankshaft to position the number one piston at top dead center (TDC). After setting at (TDC) the crankshaft must not be turned until camshaft synchronizer is installed.

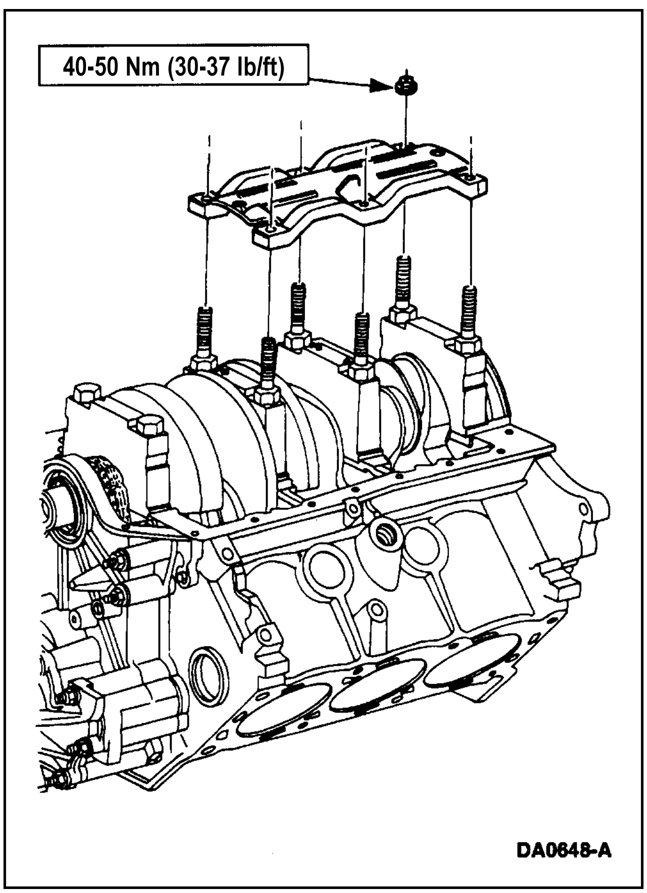
ASSEMBLY (Continued)



14. Install the engine front cover.
    - Use a new gasket.

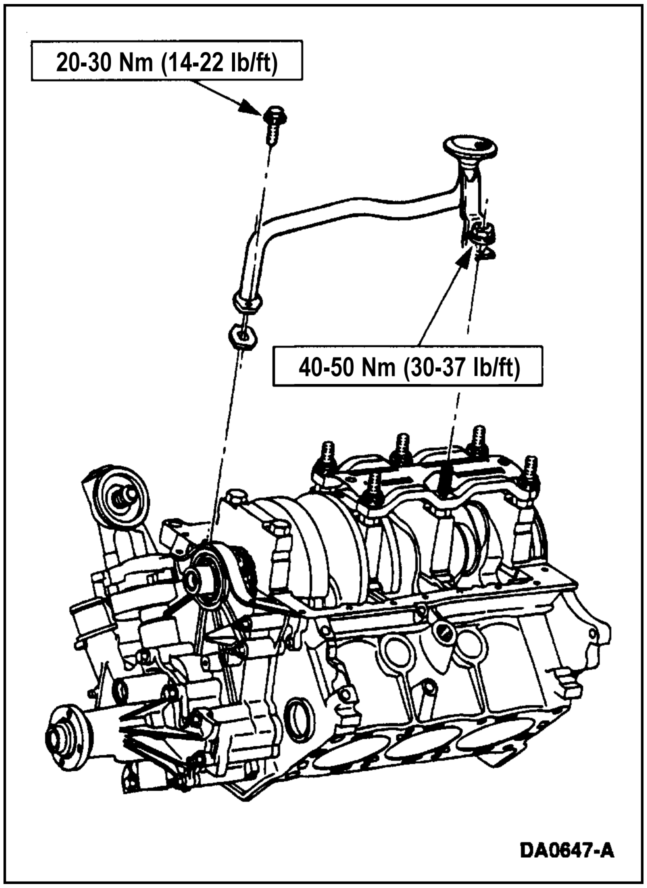


15. Install the water pump.
    - Use a new gasket.



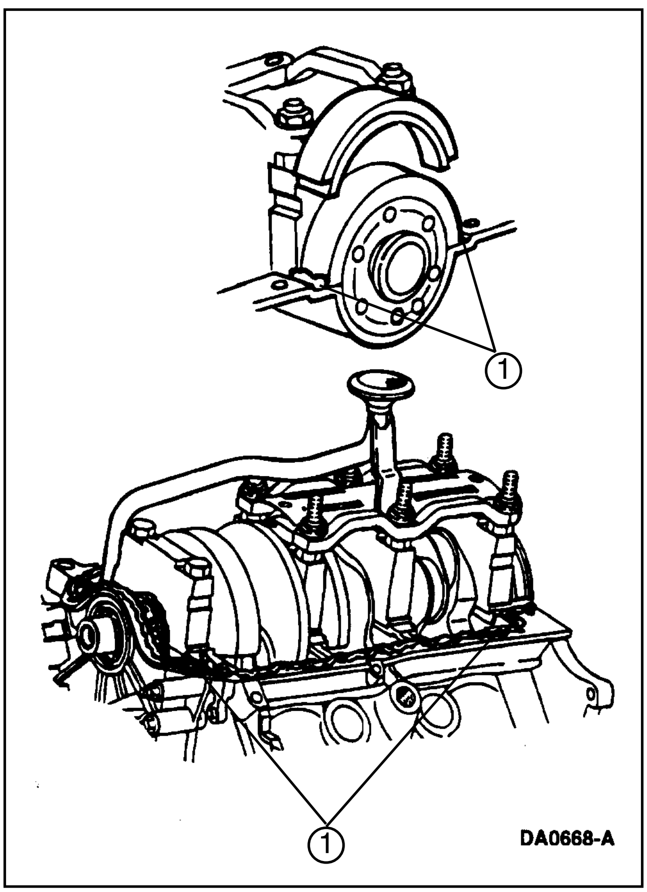
16. Install the oil baffle assembly.

ASSEMBLY (Continued)



17. Install the oil pump screen cover and tube.

    • Use a new gasket.



CAUTION: Mating parts must make contact to each other within 4 minutes and connecting bolts must be torqued within 15 minutes after applying sealant. Failure to follow this procedure can cause future oil leakage.

• Use silicone gasket and sealant F6AZ-19562-AA or equivalent meeting Ford specification WSE-M4G323-A6.

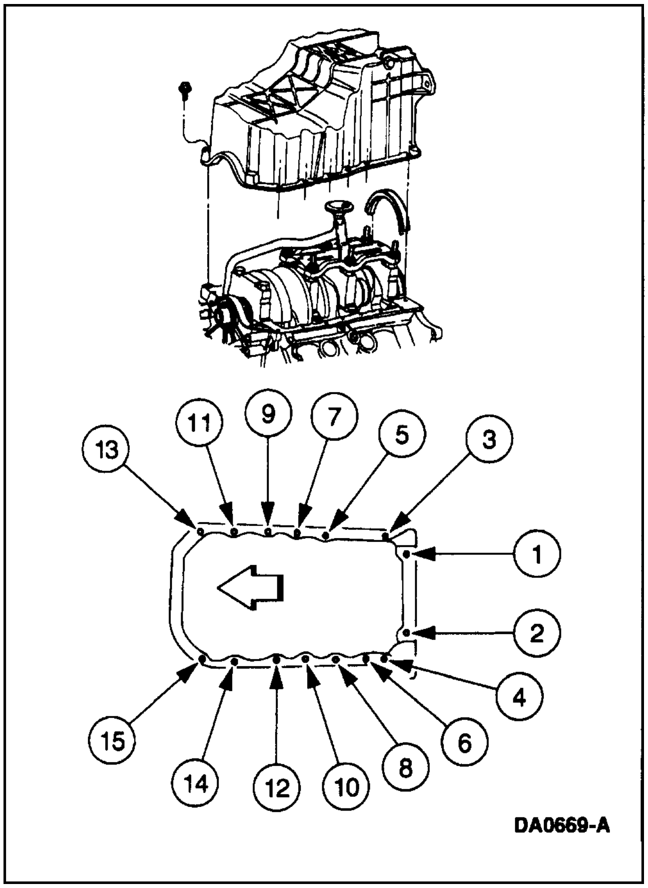
NOTE: Sealant must be removed and area cleaned with solvant if above instructions are not followed.

• Use metal surface cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

18. Clean mating surfaces on oil pan and cylinder block. Use Metal Parts Cleaner F4AZ-19A536-RA or equivalent meeting Ford specification WSE-M5B292-A.

    • Apply a bead of Silicone Gasket and Sealant at position 1 as shown in the illustration. Apply a bead along engine block the entire surface where oil pan mates to block and at each end of crank oil pan seal.

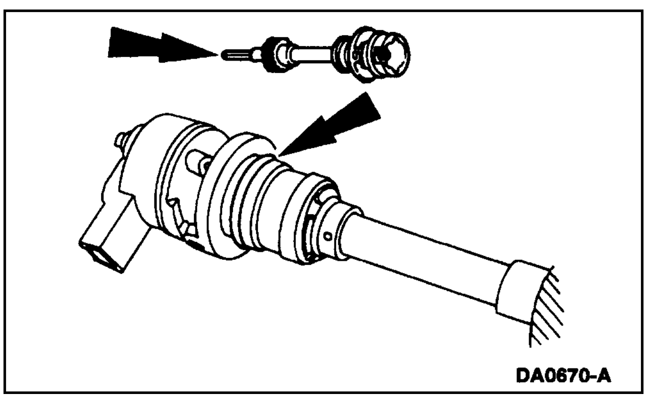
ASSEMBLY (Continued)



19. Install the rear seal and oil pan.

    1 – Tighten the oil pan retaining bolts in two stages in the sequence shown.

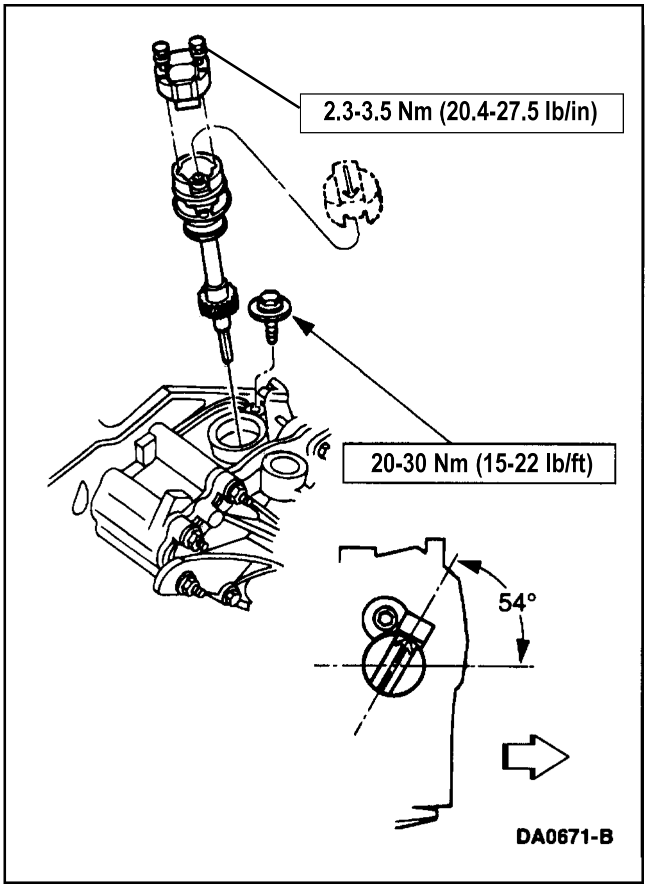
    - Stage 1: 4-5 Nm (36-44 lb/in).
    - Stage 2: 9-12 Nm (80-106 lb/in).



20. Install a new "O"-ring on the synchronizer and make sure the oil pump intermediate shaft is installed with the lock ring into the synchronizer.

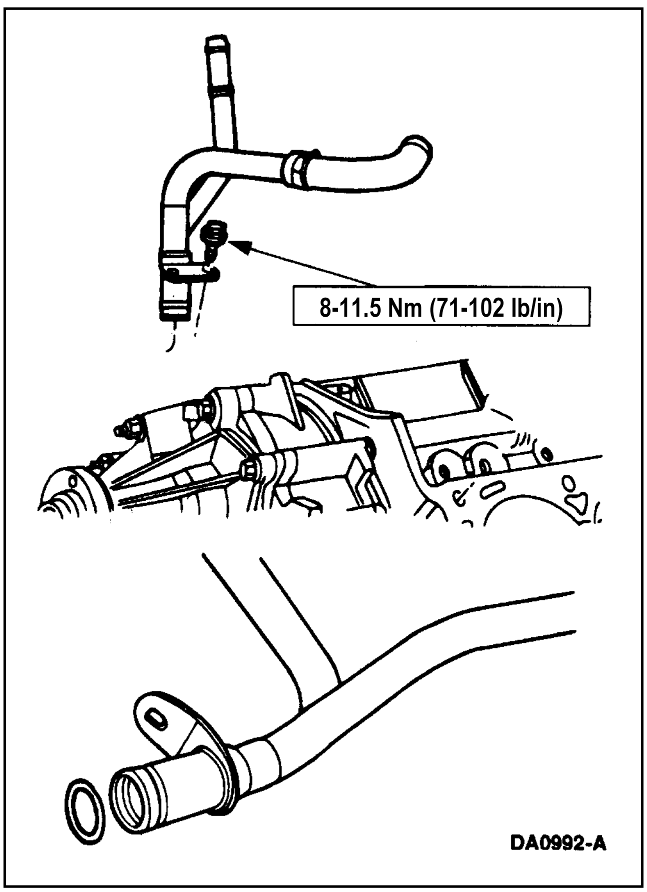
    - Lubricate "O"-ring with WSE-M2C908-A oil prior to installation.

ASSEMBLY (Continued)



21. **NOTE:** The arrow on the alignment tool must point as shown in the illustration. Make sure piston number one is at top dead center on intake stroke.

    Install the synchronizer, remove the alignment tool and install the camshaft position sensor.

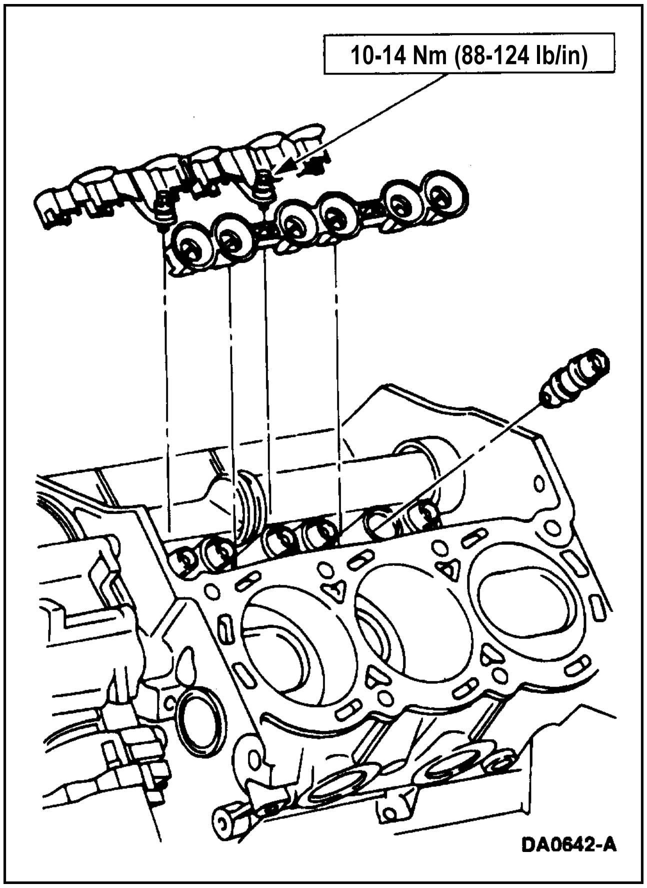


22. Install the coolant water heater outlet tube assembly (refer to cooling system Section 05 of auxiliary system section).

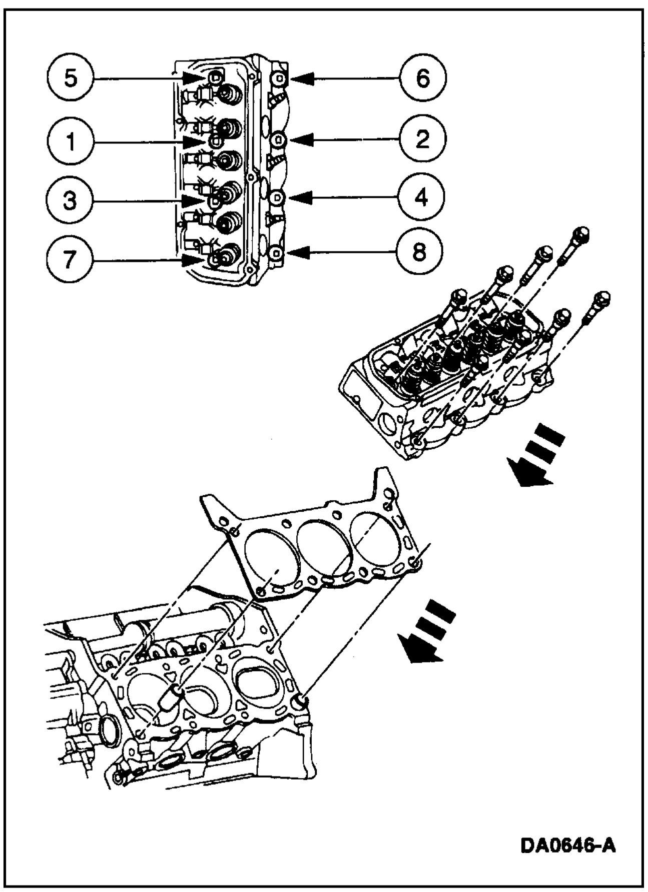
    • Use a new O-ring.

    • Lubricate "O"-ring with WSE-M2C908-A oil prior to installation.

ASSEMBLY (Continued)



23. Install the valve tappets and tappet guides.
    - Lubricate the tappet bore and tappet roller with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.



24. Install the cylinder heads.

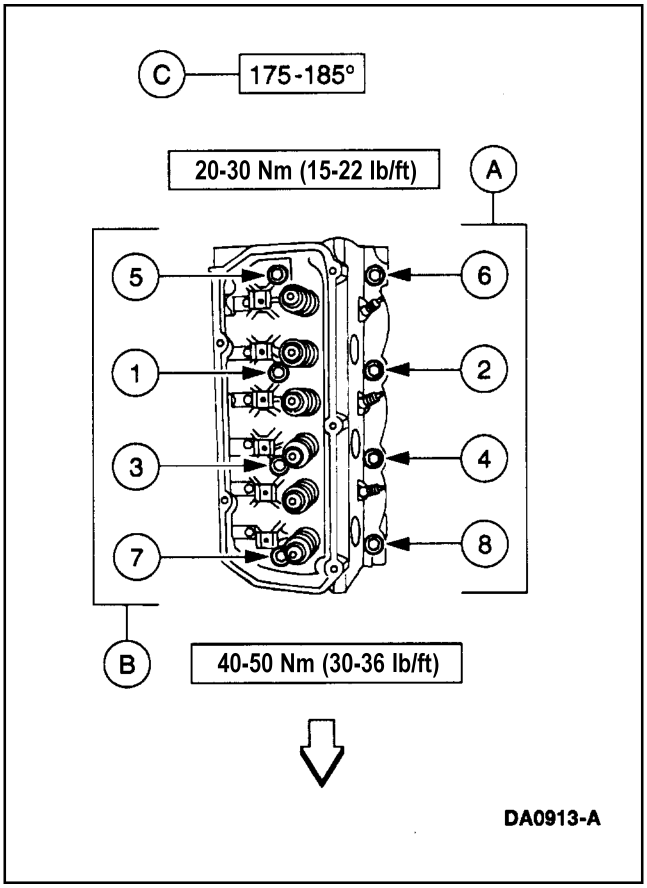
    1 – Use new gaskets and cylinder head bolts.

    2 – Tighten the cylinder head bolts in three stages in the sequence shown:

    - Stage 1: 20 Nm (14 lb/ft).
    - Stage 2: 40 Nm (29 lb/ft).
    - Stage 3: 50 Nm (36 lb/ft).

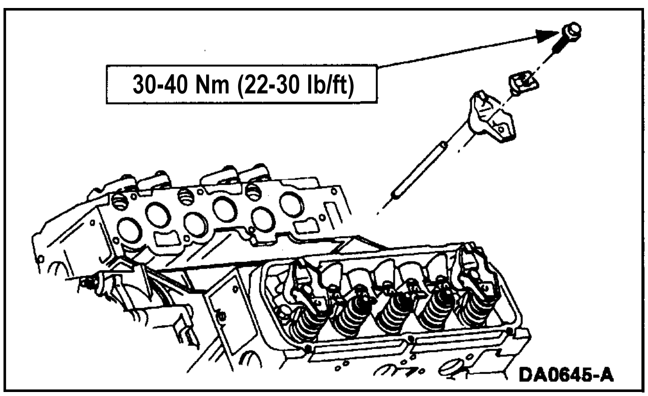
    3 – The bolts must be loosen and retighten. Following procedure in Step 25 next page.

ASSEMBLY (Continued)



25. **CAUTION: Do not loosen all of the cylinder head bolts at one time. Each cylinder head bolt must be loosened and the final tightening completed prior to working on the next bolt in the sequence.**

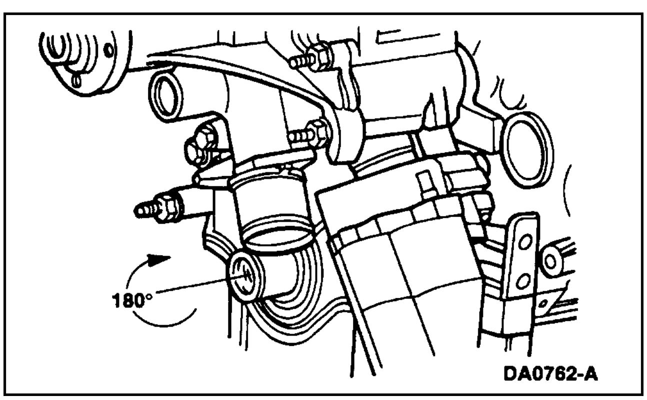
    In the sequence shown, loosen the cylinder head bolt three turns, then tighten the (A) short cylinder head bolt or (B) long cylinder head bolt to the specification indicated, and then further tighten the cylinder head bolt to the (C) degrees indicated.



26. Install the rocker arms, rocker arm seats and push rods in the following positions:

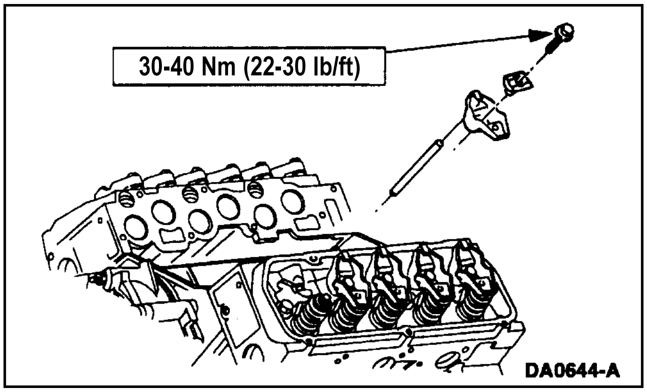
    1 – Lubricate the ends of the push rods and rocker arm seats with Engine Assembly Lubricant D9AZ-19579-D or equivalent meeting Ford specification ESR-M88C80-A.

    - Number 1 – intake and exhaust.
    - Number 2 – exhaust.
    - Number 3 – intake.
    - Number 4 – exhaust.
    - Number 6 – intake.

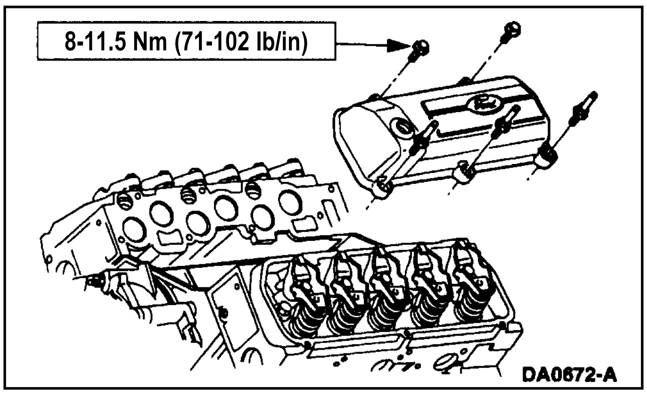


27. Rotate the crankshaft 180 degrees.

ASSEMBLY (Continued)

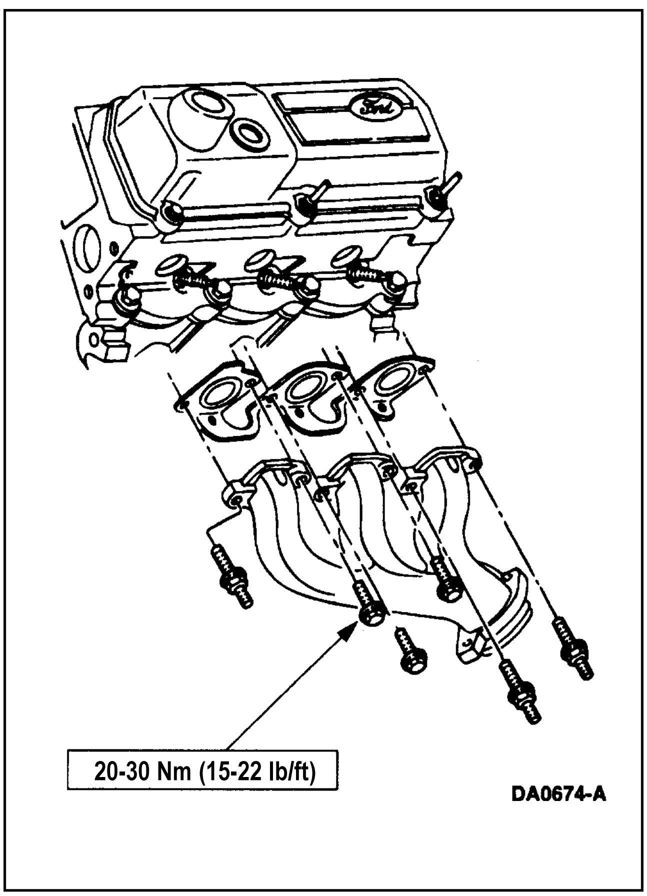


28. Install the remaining push rods, rocker arms and rocker arm seats.
    - Number 2 – intake.
    - Number 3 – exhaust.
    - Number 4 – intake.
    - Number 5 – intake and exhaust.
    - Number 6 – exhaust.



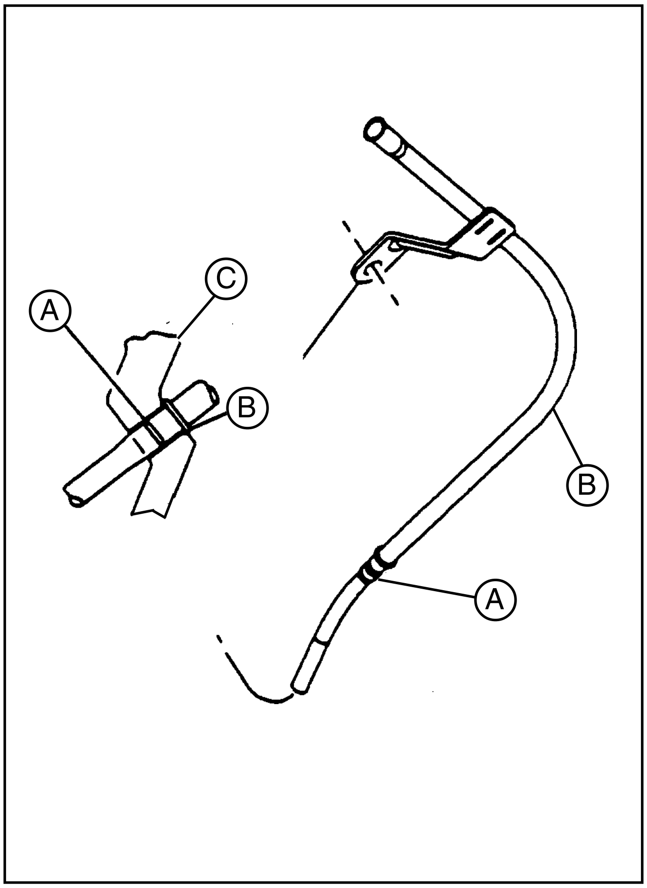
29. Install the valve covers.

    NOTE: Install the ignition coil pack (if necessary). Refer to Section 3. Torque 5-6 Nm (48 lb/in) (3 bolts).



30. Install the exhaust manifolds.
    - Use a new gasket.

ASSEMBLY (Continued)



31. Install the engine oil level indicator tube.

   • Use a new O-ring.

   (A) "O" Ring

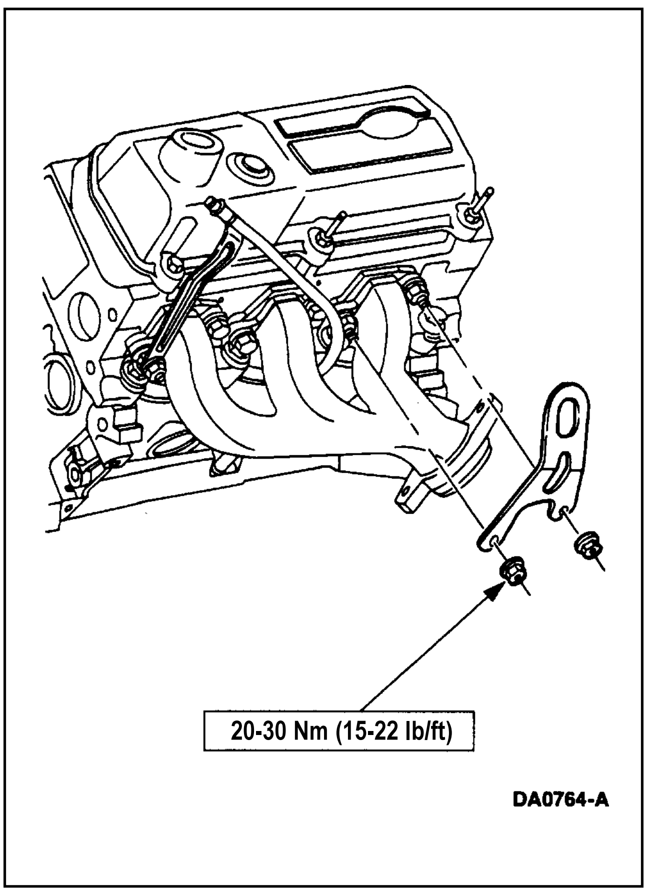
   (B) Tube Assy.

   (C) Cylinder Block

   1 – Lubricate "O" Ring with WSE-M2C908-A oil prior to installation.

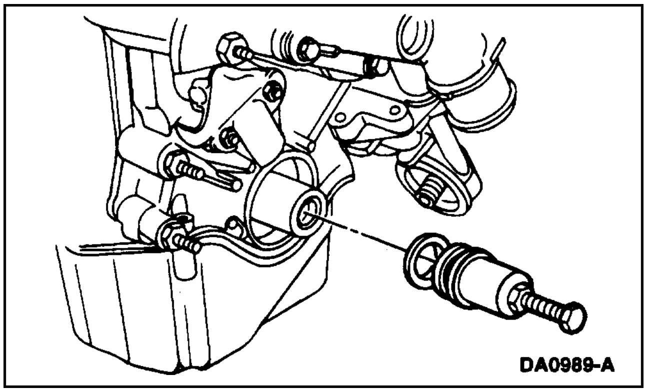
   2 – Tube must be seated within 2mm of engine block.

   3 – Install outboard of spark plug wires.

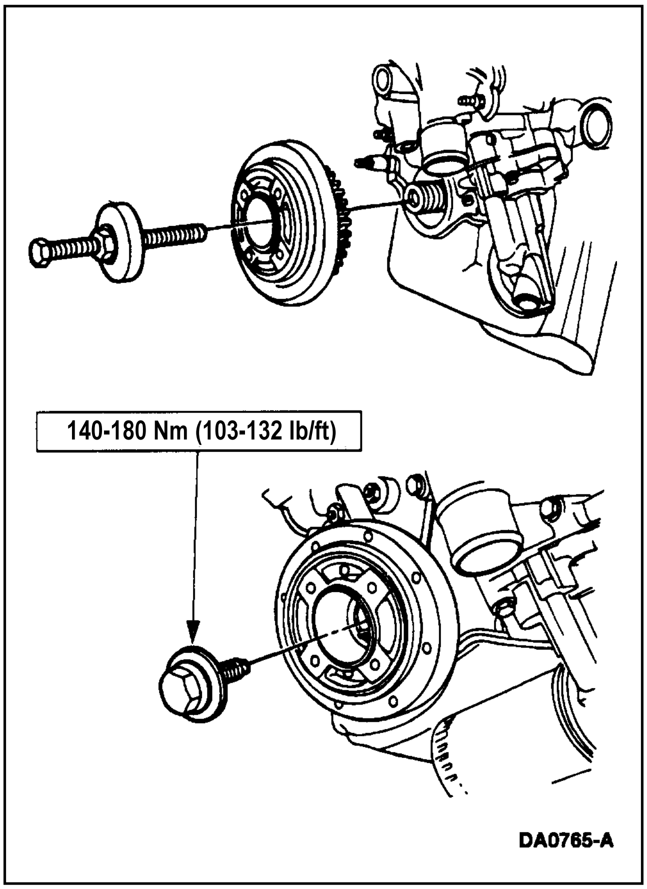


32. Install the engine lifting eyes (left side shown; right side similar).

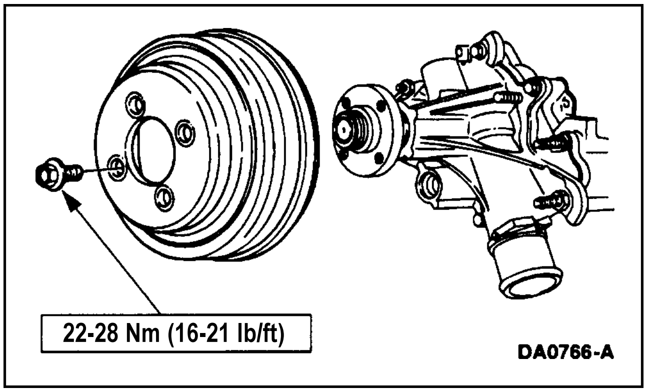
ASSEMBLY (Continued)



33. Install the crankshaft front seal (6700).
    - A seal installer will be needed.

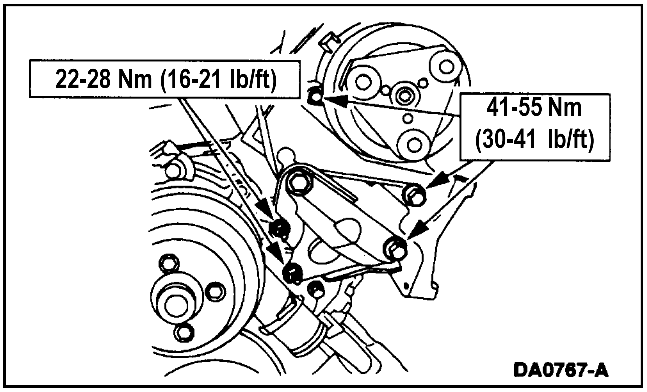


34. Install the crankshaft damper and the damper retaining bolt.
    - An installation tool will be required.

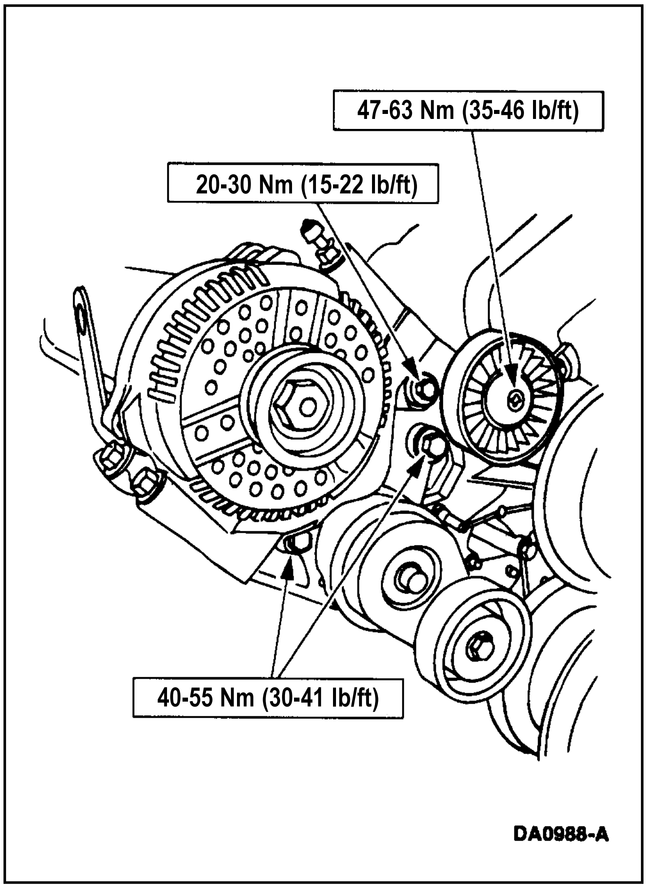


35. Install the water pump pulley.

ASSEMBLY (Continued)

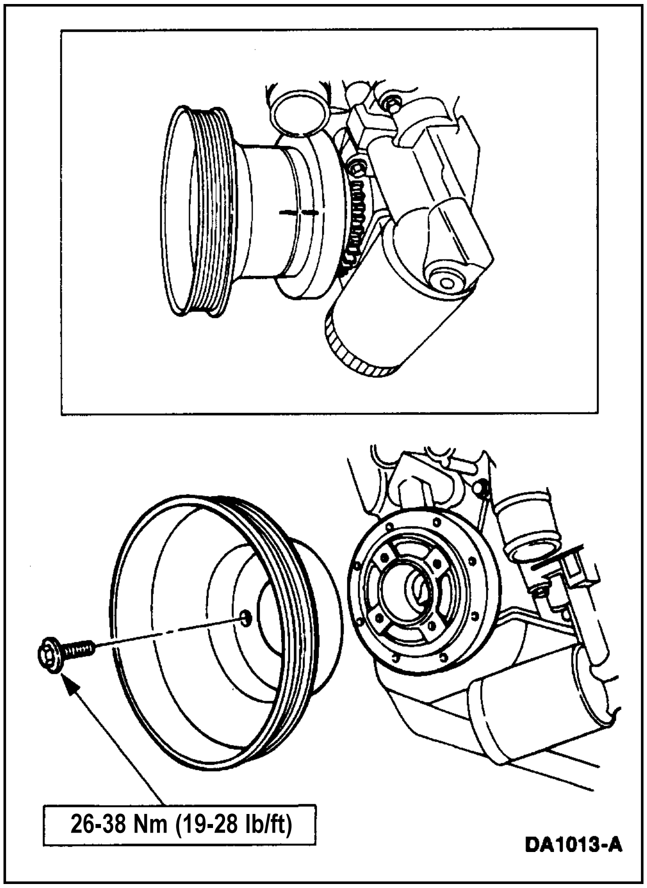


36. Install the idler pulley mounting and support brackets.

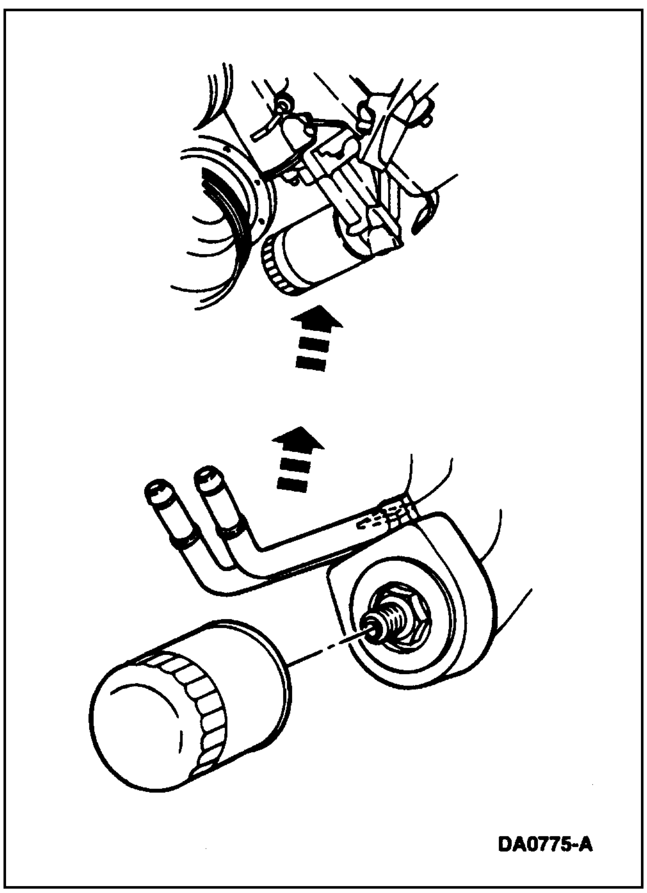


34. Install the generator mounting bracket and belt idler pulley.

ASSEMBLY (Continued)

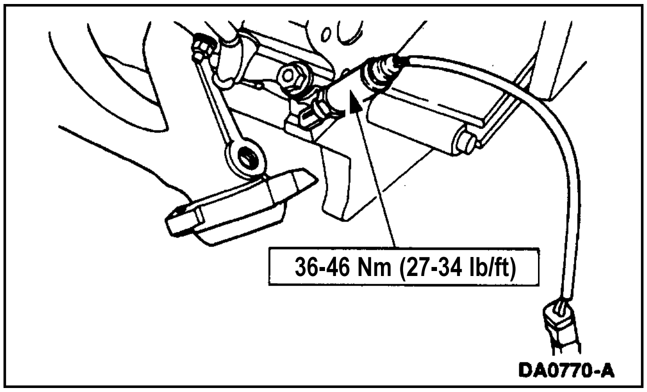


38. Align and install the crankshaft pulley.



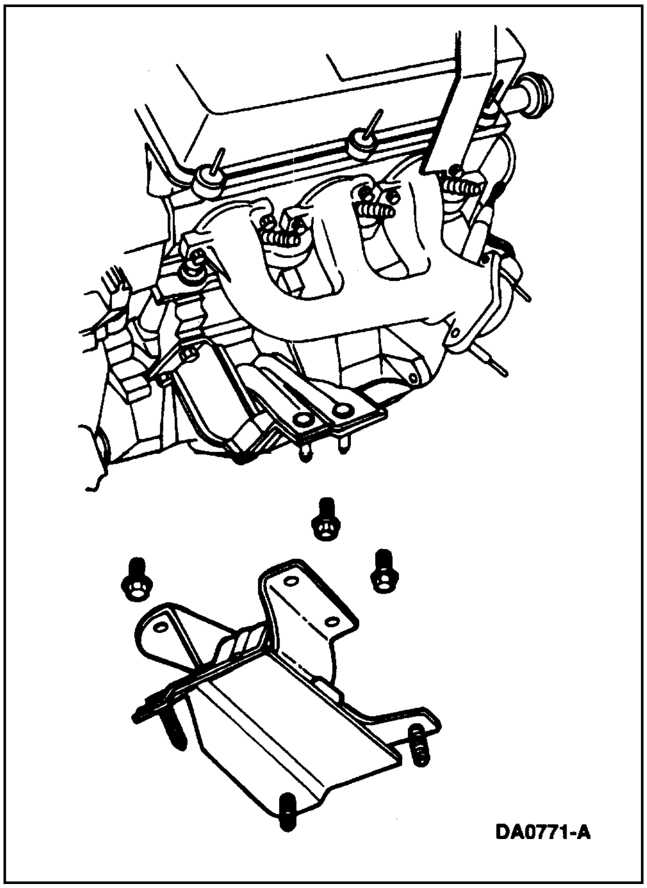
39. Install the oil bypass filter and engine oil cooler (if so equipped).

ASSEMBLY (Continued)



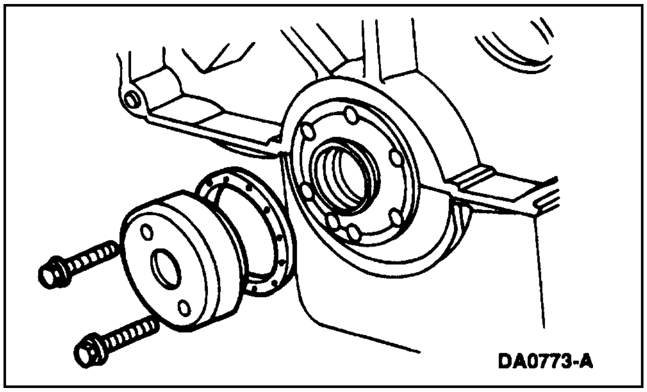
40. Install the exhaust gas oxygen (HO2S) sensors.

    NOTE: There may only be one HO2S sensor depending upon application.

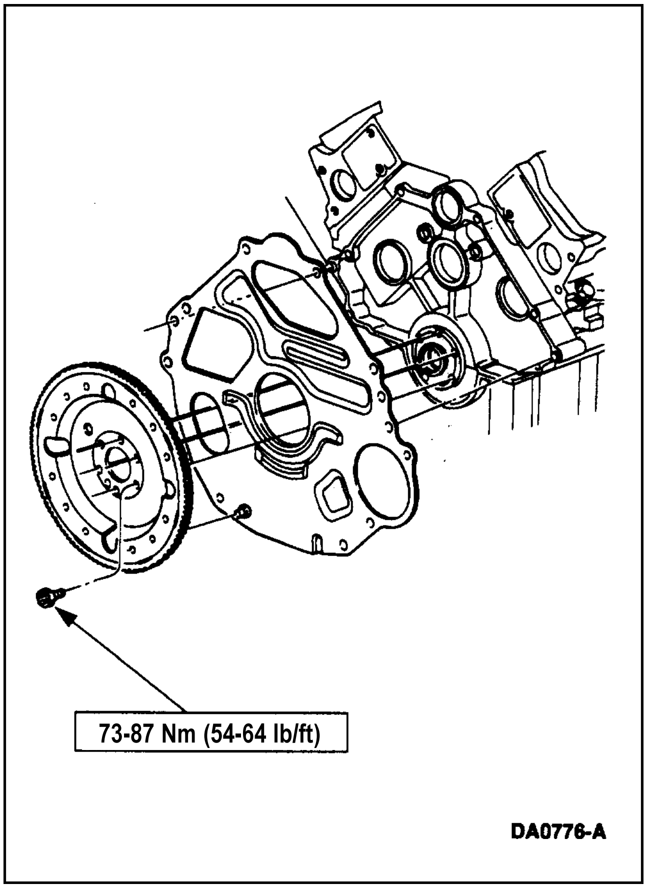


41. Install the engine mounts.

ASSEMBLY (Continued)



42. Remove the engine from the stand and install the rear oil seal.
    - A seal installer will be required.



43. Install the rear cover plate and flywheel.

INSTALLATION

Engine

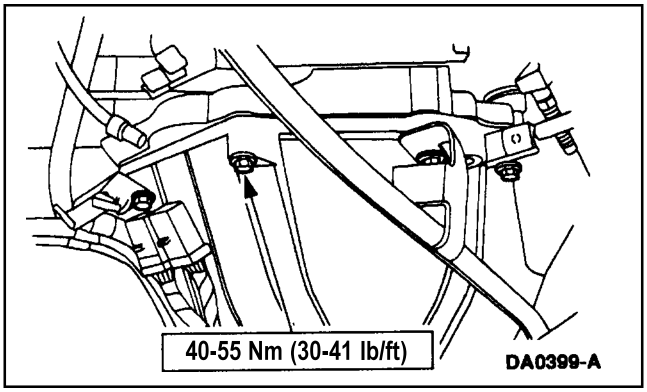
Special Tool(s)

 ST1377-A	Engine Lifting Bracket 014-00730 or Equivalent

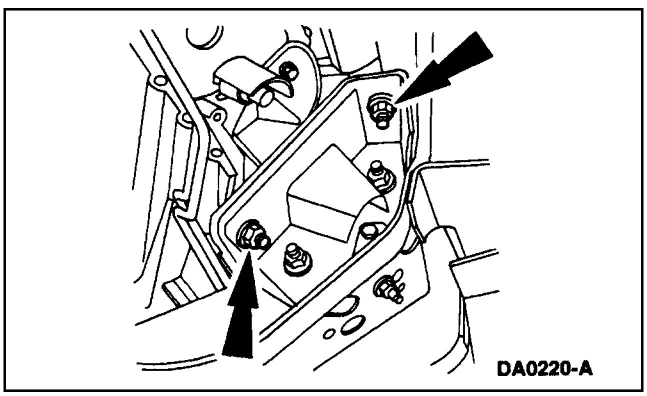
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Installation

1. Install the engine.



2. Install the transmission or PTO-to-engine retaining bolts, if so equipped.
3. Install the transmission dipstick tube. Use a new “O”-ring.
   - Lubricate “O”-ring with WSE-M2C908-A oil prior to installation.
4. Remove the engine lifting equipment.
5. Raise the vehicle.



6. Install the engine mount retaining nuts. (Left as shown).
7. Install the shift cable routing bracket retaining bolt, if so equipped.

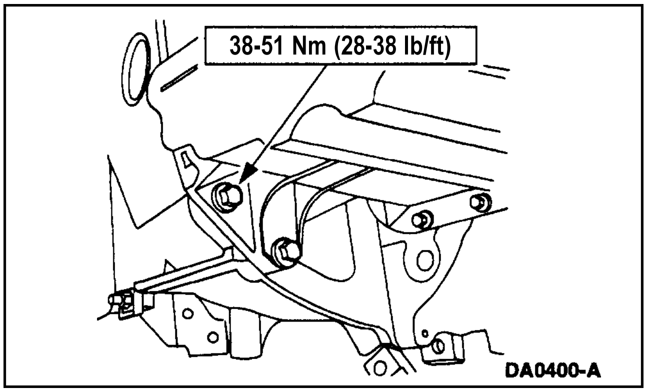
   1 – Position the wiring harness and engage the routing clips.

   2 – Connect the wiring at the daytime running lamp module, if so equipped.

   3 – Connect the wiring at the horn, if so equipped.

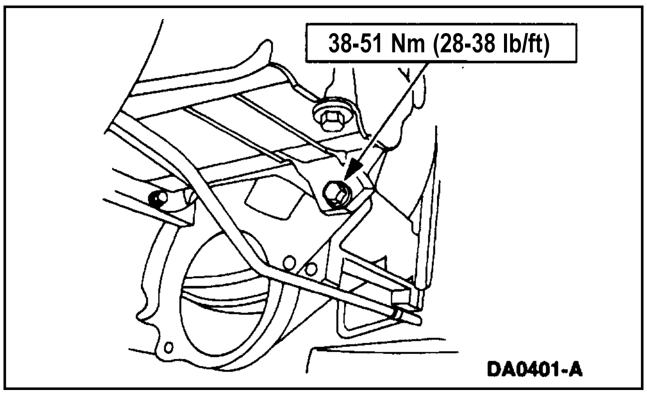
   4 – Connect the wiring at the front air bag sensor, if so equipped.

INSTALLATION (Continued)

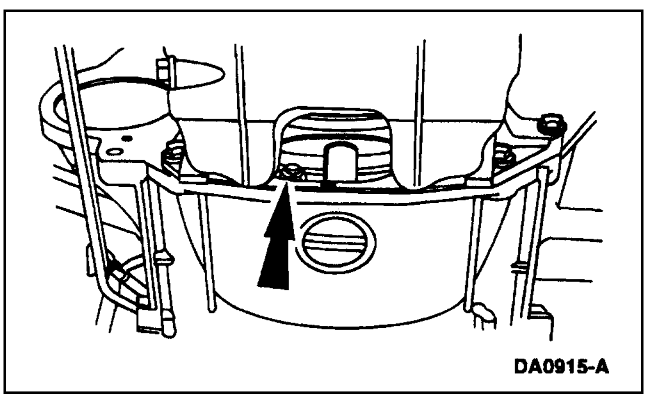


8. Install the engine oil pan to the transmission retaining bolts on the right side.

9. Install the nuts retaining the exhaust pipe at the exhaust manifolds.



10. Install the engine oil pan to the transmission retaining bolts on the left side.

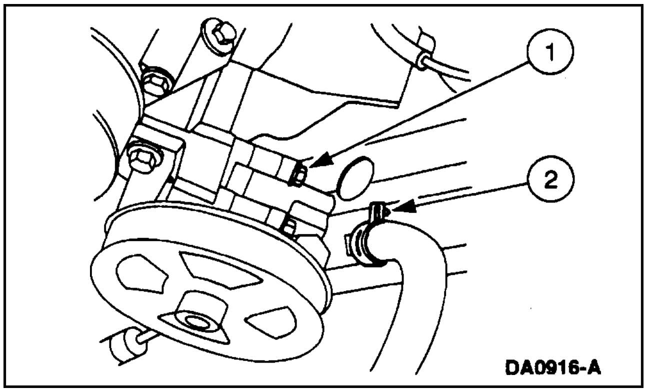


11. Install the (C) torque converter access cover and the (B) torque converter retaining nuts. Turn the (A) crankshaft to access the retaining nuts studs.

12. Install the starter.

13. Connect the radiator lower hose.

INSTALLATION (Continued)



14. Install the power steering pump, if so equipped.

    1 – Install the pump retaining bolts.

    2 – Connect the low-pressure line at the power steering pump.

    3 – Fill pump with appropriate fluid.

15. Install the accessory drive belt.
16. Install the lower intake manifold. Refer to Intake Manifold – Lower.
17. Install the upper intake manifold. Refer to Intake Manifold – Upper.
18. Install the routing bracket retaining bolt and the engine oil dipstick tube.
19. Add the correct amount of oil to the engine and the transmission.

SPECIFICATIONS

General Specifications

Item	Specification
Displacement (Liters)	4.2
Number of Cylinders	6
Bore mm (Inch)	96.8325 (3.81)
Stroke mm (Inch)	95 (3.74)
Spark Plug (Motorcraft):	
Gas AGSF-42 FCM	1.12mm (.044 in)
Dual Fuel AGSF-42 FCM	1.12mm (.044 in)
LPG & NG AGSF-42 FCM	1.12mm (.044 in)
Firing Order	1-4-2-5-3-6
Compression Ratio	9.17:1
Oil Capacity with Oil Filter – L (Qt) Oil Pressure (Hot 2500 RPM) Engine Oil XO-10W30-QSP or -DSP	5.7 (6.0) 5 qt. Pan + 1 qt. Filter 40-125 PSI ESE-M2C153-E

NOTE: Ford Power Products industrial engines are designed to perform with engine oils that are licensed by the American Petroleum Institute (API), and oils carrying the most current API classification should be used.

General Specifications

Item	Specification
Valve stem Diameter Exhaust mm (Inch)	8.682-8.662 (0.3418-0.3410)
Valve Spring Installed Length mm (Inch)	39.8-41.6 (1.566-1.637)
Valve Spring Free Length	
Intake mm (Inch)	50.5 (1.99)
Exhaust mm (Inch)	50.5 (1.99)
Valve Gap With Collapsed Tappet mm (Inch)	2.15-4.69 (0.08465-0.18465)
Camshaft Specifications	
Lobe Lift	
Intake mm (Inch)	6.22 (0.245)
Exhaust mm (Inch)	6.57 (0.259)
Lobe Wear Limit	
Intake mm (Inch)	0.127 (0.005)
Exhaust mm (Inch)	0.127 (0.005)

General Specifications

Item	Specification
Camshaft Specifications (Continued)	
End Play Wear Limit mm (Inch)	0.025-0.150 (0.001-0.006)
Journal-to-Bearing Clearance mm (Inch)	0.025-0.015 (0.001-0.0006)
Runout mm (Inch)	0.05 (0.002)
Journal Diameter mm (Inch)	52.108-52.082 (2.0515-2.0505)
Out-of-Round Limit mm (Inch)	0.025 (0.001)
Cylinder Block Specifications	
Head Gasket Surface Flatness per 0.08 (0.003) mm (Inch)	152.0 (6.00)
Cylinder Bore Diameter	
Standard mm (Inch)	96.80 (3.81)
Out-of-Round mm (Inch)	0.050 (0.002)
Taper Limit mm (Inch)	0.050 (0.002)
Crankshaft Specifications	
Main Journal Diameter	
Standard mm (Inch) (2.5182-2.5190)	63.983-64.003
0.25 mm (0.010 Inch) Undersize mm (Inch)	63.963-63.983 (2.5182-2.5190)
Out-of-Round Limit mm (Inch)	0.03 (0.0012)
Taper Limit mm (Inch)	0.016 (0.0006)
Runout mm (Inch)	0.05 (0.002)

(Continued)

SPECIFICATIONS (Continued)

General Specifications

Item	Specification
Connecting Rod Journal Diameter	
Standard mm (Inch)	58.682-58.702 (2.3103-2.3111)
0.25 mm (0.010 Inch) Undersize mm (Inch)	58.662-58.682 (2.3095-2.3103)
0.50 mm (0.020 Inch) Undersize mm (Inch)	58.632-58.652 (2.3083-2.3091)
Taper Limit mm (Inch)	0.016 (0.0006)
Out-of-Round Limit mm (Inch)	0.030 (0.0012)
Crankshaft Eng Play mm (Inch)	0.007-0.20 (0.00003-0.00787)
Connecting Rod Specifications	
Bend for Each 25 mm (1.97 Inches) mm (Inch)	0.04 (0.0015)
Side Clearance Maximum mm (Inch)	0.11-0.49 (0.0047-0.01929) 0.36 max (0.014 max)
Piston Specifications	
Piston Diameter	
Standard mm (Inch)	96.795 (3.81)
Piston-to-Bore Clearance mm (Inch)	0.018-0.044 (0.000709-0.00173)
Piston Ring to Land Clearnace mm (Inch)	0.030-0.080 (0.00122-0.00315)
Compression Ring mm (Inch)	1.54-1.52 top (0.060-0.059) 1.54-1.52 bottom (0.060-0.059)
Ring Gap	
Compression Ring mm (Inch)	0.25-0.41 (0.00098-0.00161) 0.38-0.64 (0.00149-0.0025)
Oil Ring mm (Inch)	0.15-165 (0.0059-0.0064)
Lubrication System Specifications	
Oil Pump	
Oil Pump Gear Radial Clearance (Idler and Drive) mm (Inch)	0.125-0.050 (0.0055-0.002)
Oil Pump Gear End Height (Extends Below Housing) mm (Inch)	0.085-0.010 (0.0033-0.0004)
Oil Capacity	
With Oil Filter L (Qt)	6.1-6.6 (6.5-7)
Without Oil Filter L (Qt)	5.8-6.1 (5)
Total (Dry Engine) L (Qt)	6.1-6.6 (6)

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
A/C Compressor Bracket-to-Cylinder Head Bolts	48	35	–
A/C Compressor Bracket-to-Cylinder Head Nut	48	35	–
A/C Compressor Bracket-to-Cylinder Stud Bolt	25	18	–
Accelerator Cable Bracket Nut and Bolt	8-11	6-8	–
Accelerator Cable Bracket-to-Intake Manifold Bolts	10	–	89
Accessory Drive Belt Tensioner Bolt	48-64	35-47	–
Accessory Drive Belt Idler Pulley Bolt	48-64	35-47	–
Battery Positive Cable Nut	9-12	7-8	–
Belt Idler Pulley Bolts	55	41	–
Belt Tensioner Bolt	55	40	–
Camshaft Position Sensor Bolts	3	–	27
Camshaft Position Sensor Drive Gear Bolt	40-50	30-36	–
Camshaft Synchronizer-to-Front-Cover Bolt	25	18	–
Camshaft Synchronizer Drive Gear-to-Camshaft	45	33	–
Camshaft Thrust Plate Bolts	8-14	–	71-124
Connecting Rod Bolts	Page 02-65		
Coolant Recovery Reservoir-to-Bracket Bolts	5	–	44
Coolant recover reservoir bracket-to-GOP bolts	9	–	80
Crankshaft Damper Bolt	140-180	103-132	–
Crankshaft Pulley Bolts	26-38	19-28	–
Cylinder Head Bolts[2]	Page 02-119		
Drive Belt Tensioner Bolts	25	18	–
Engine Coolant By-Pass Hose	8-11.5	–	71-102
Engine Exhaust Gas Oxygen (HO2S) Sensor	36-46	27-34	–
Engine Cylinder Head Temperature (ECHT) Sensor	9-11	–	80-95
Engine Dynamic Balance Shaft Thrust Plate Bolts	8-14	6-10	–
Engine Front Cover Bolt	20-30	14-22	–
Engine Front Cover Stud Bolt	20-30	15-22	–
Engine Front Cover Socket Head Cap Screw	20-30	15-22	–
Engine Lifting Eye Nuts	20-30	15-22	–
Engine Mount Through-Bolts	68-92	51-67	–

(Continued)

SPECIFICATIONS (Continued)

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Engine-to-Transmission Bolts	40	30	–
Exhaust Flange Nuts	40	30	–
Exhaust Manifold Bolts and Stud Bolts[2]	20-30	15-22	–
Exhaust Manifold-to-Cylinder Head Nuts	25	18	–
Exhaust Manifold Studs	8	–	71
Flywheel Bolts	73-87	54-63	–
Flywheel-to-Crankshaft Bolts	80	59	–
Front Cover-to-Cylinder Block Bolts	25	18	–
Fuel Injection Supply Manifold Bolts	8-11.5	–	70-102
Fuel Pressure Dampener Screws	3-4.5	2.5-3	–
Fuel Pressure Relief Valve	7	–	62
Fuel Pressure Relief Valve	7.75	5.5	–
Fuel Pressure Relief Valve	7.75	–	68.6
Fuel Pressure Relief Valve Cap	0.6	–	5
Fuel Supply Manifold Bolts	10	–	89
Generator Nuts and Bolts	20-30	15-22	–
Generator Positive Cable Nut	10	–	89
Generator Bracket Short Bolt	20-30	15-22	–
Generator Bracket Long Bolts	40-55	30-41	–
Generator Bracket-to-Cylinder Head Bolts	40	30	–
Generator Positive Cable Nut	10	_	89
Head Bolts[1]			
Heater Water Outlet Tube Bolt	8-11	6-8	–
Idler Bracket Bolt & Nuts	25	18	–
Idler Pulley	41-55	30-41	–
Idler Pulley – 4.2L	55	40	–
Idler Pulley Bolt	47-63	35-46	–
Ignition Coil Bolts (3)	5-6		48
Intake Manifold (Lower)	Page 02-20		
(Upper)	Page 02-16		
Main Bearing Brace Nuts	40-55	30-40	–
Main Bearing Cap Bolts	50	37	–

(Continued)

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Oil Bypass Filter	10-15	7.5-11	–
Oil Filter Adapter Bolts (8 mm)	20-30	15-22	–
Oil Filter Adapter Bolts (6 mm)	8-11	–	71-97
Oil Galley Plugs	25-40	19-29	–
Oil Level Indicator Tube Bracket Nut	20-30	15-22	–
Oil Level Indicator Tube-to-Cyl. Head Bolt	10	–	89
Oil Baffle Nuts	40-50	30-37	–
Oil Pan Drain Plug	26	19	–
Oil Pan to Cylinder Block Bolts	9-12	–	80-106
Oil Pan to Transmission	38-51	28-38	–
Oil Pickup Tube-to-Cyl. Block Bolts	25	18	–
Oil Pickup Tube-to-Oil Pan Baffle Nut	48	35	–
Oil Pressure Sensor	11-16	9-11	–
Oil Pump Screen Cover and Tube Bolts	20-30	15-22	–
Oil Pump Screen Cover and Tube Nut	40-50	30-37	–
Power Steering Pressure Tube to Pump Nut	40	30	–
Power Steering Pump Bolts	22-28	17-20	–
Power Steering Pump Bracket-to-Water	20	15	–
Power Steering Pump Bracket-to-Generator	20	15	–
Bracket Bolts			
Power Steering Reservoir Bolts	9-12	–	80-106
Radiator Fan Shroud-to-Radiator Bolts	9	–	80
Rocker Arm Bolts	30-40	22-29	–
Rod Cap Bolts	[1]	–	–
Spark Plugs	10-20	–	84-180
Synchronizer Drive Gear Bolt	40-50	30-37	–
Synchronizer Hold Down Bolt	20-30	15-22	–
Synchronizer Stator Asy. Screws	2.5-3.5	–	20.4-27.5
Tappet Guide Plate Bolts	10-14	7.5-10	–
Timing Chain Tensioner-to-Cyl. Block Bolts	12	9	–
Timing Chain Vibration Damper Bolts	8-14	–	71-124

(Continued)

SPECIFICATIONS (Continued)

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Throttle Body Nuts & Bolts	10	–	89
Torque Converter-to-Flywheel Nuts	36	27	–
Transmission-to-Engine Retaining Bolts	40-55	30-41	–
Valve Cover Bolts and Stud Bolts	8-11.5	–	71-102
Valve Cover-to-Cyl. (LH) & (RH)	10	–	89
Valve Cover-to-Cyl. Head Stud Bolt (LH) & (RH)	10	–	89
Water Outlet Tube-to-Front Water Pump Bolt	10	–	89
Water Pump Bolts	20-30	15-22	–
Water Pump Stud Bolt	8-12	–	71-106
Water Pump Nuts	20-30	15-22	–
Water Pump Pulley Bolts	22-28	16-21	–
Water Temperature Indicator Sender Unit	14-19	10-14	–
42 Pin Connector Bolt	10	–	89
42 Pin Connector Bracket Hold Down Bolt	4-5.6	-	35-50

1 Refer to the procedure for torque specification and sequence.

2 Refer to the procedure for the tightening sequence.

IGNITION INDEX

SUBJECT	PAGE

INTRODUCTION

COLOR ABBREVIATIONS

BL	**Blue**	**N**	**Natural**
BK	**Black**	**O**	**Orange**
BR	**Brown**	**PK**	**Pink**
DB	**Dark Blue**	**P**	**Purple**
DG	**Dark Green**	**R**	**Red**
GN	**Green**	**T**	**Tan**
GY	**Gray**	**W**	**White**
LB	**Light Blue**	**Y**	**Yellow**
LG	**Light Green**		

NOTE: Whenever a wire is labeled with two colors, the first color listed is the basic color of the wire, and the second color listed is the stripe marking of the wire.

How to Find Electrical Concerns

Troubleshooting Steps

These six steps present an orderly method of troubleshooting.

Step 1: Verify the concern.

- Operate the complete system to check the accuracy and completeness of the customer's complaint.

Step 2: Narrow the concern.

- Using a DVOM, narrow down the possible causes and locations of the concern to pinpoint the exact cause.
- Read the description about the components and study the wiring schematic. You should then know enough about the circuit operation to determine where to check for the trouble.

Step 3: Test the cause.

- Use electrical test procedures to find the specific cause of the symptoms.

Step 4: Verify the cause.

- Confirm that you have found the correct cause by connecting jumper wires and/or temporarily installing a known good component and operating the circuit.

Step 5: Make the repair.

- Repair or replace the inoperative component.

Step 6: Verify the repair.

- Operate the system as in Step 1 and check that your repair has removed all symptoms without creating any new symptoms.

Some engine circuits may need special test equipment and special procedures. See the Service Manual and other service books for details. You will find the circuits in this manual to be helpful with those special test procedures.

Troubleshooting Tools

Jumper Wire

This is a test lead used to connect two points of a circuit. A Jumper Wire can bypass an open in a wire to complete a circuit.

WARNING: NEVER USE A JUMPER WIRE ACROSS LOADS (MOTORS, ETC.) CONNECTED BETWEEN HOT AND GROUND. THIS DIRECT BATTERY SHORT MAY CAUSE INJURY OR FIRE.

Voltmeter

A DC Voltmeter measures circuit voltage. Connect negative (- or black) lead to ground, and positive (+ or red) lead to voltage measuring point.

Ohmmeter

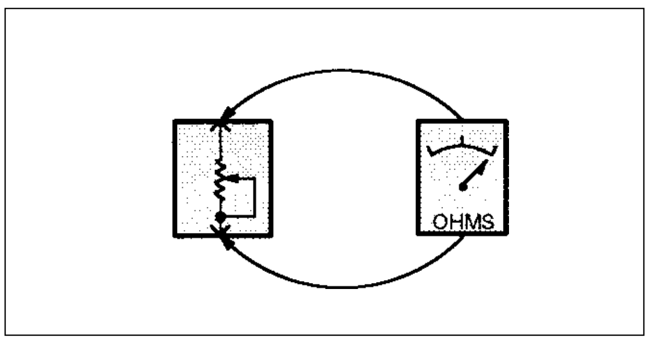


Figure 1 – Resistance Check

An Ohmmeter shows the resistance between two connected points (Figure 1).

INTRODUCTION (Continued)

Test Lamp

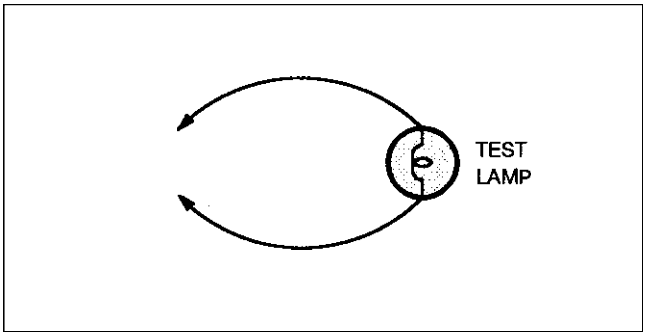


Figure 2 – Test Lamp

A Test Light is a 12-volt bulb with two test leads (Figure 2).

Uses: Voltage Check, Short Check.

Self-Powered Test Lamp

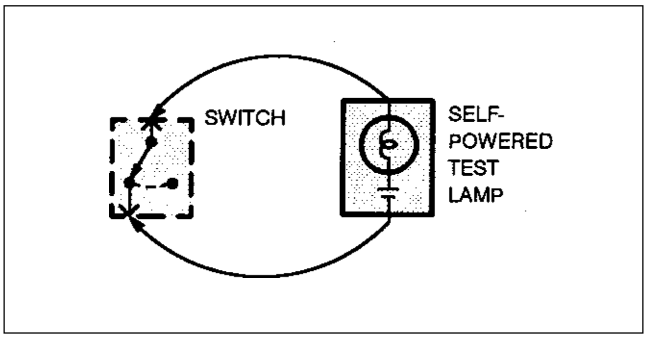


Figure 3 – Continuity Check

The Self-Powered Test Lamp is a bulb, battery and set of test leads wired in series (Figure 3). When connected to two points of a continuous circuit, the bulb glows.

Uses: Continuity Check, Ground Check.

⚠CAUTION: When using a self-powered test lamp or ohmmeter, be sure power is off in circuit during testing. Hot circuits can cause equipment damage and false readings.

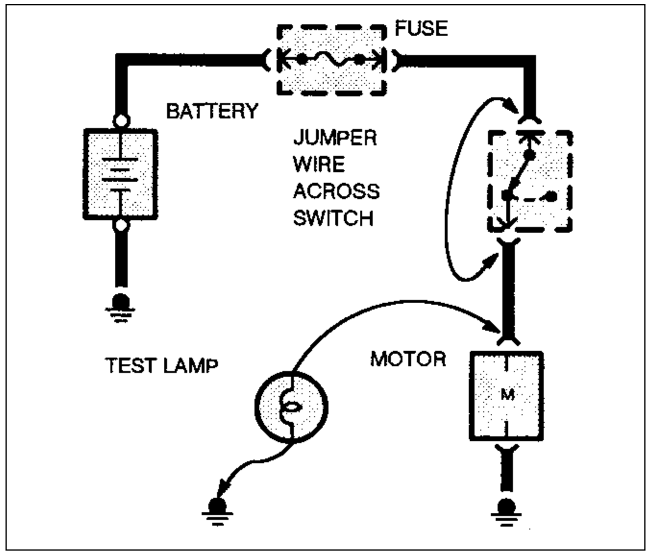


Figure 4 – Switch Circuit Check and Voltage Check

In an inoperative circuit with a switch in series with the load, jumper the terminals of the switch to power the load. If jumpering the terminals powers the circuit, the switch is inoperative (Figure 4).

Continuity Check (Locating open circuits)

Connect one lead of test lamp to a known good ground or the negative (-) battery terminal. Test for voltage by touching the other lead to the test point. The bulb goes on when the test point has voltage (Figure 4).

INTRODUCTION (Continued)

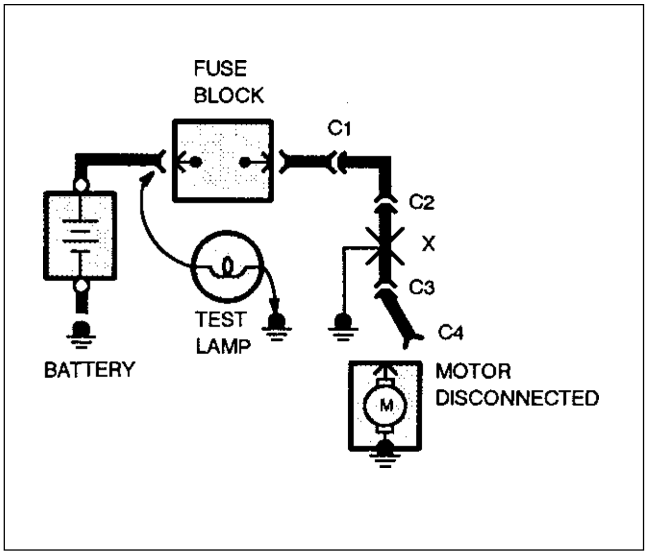


Figure 5 – Short Check

A fuse that repeatedly blows is usually caused by a short to ground. It's important to be able to locate such a short quickly (Figure 5).

1. Turn off everything powered through the fuse.

2. Disconnect other loads powered through the fuse:

   • Motors: disconnect motor connector (Connector C4 in Figure 5).

   • Lights; remove bulbs.

3. Turn the Ignition Switch to RUN (if necessary) to power fuse.

4. Connect one Test Lamp lead to the hot end of the blown fuse. Connect the other lead to ground. The bulb should glow, showing power to fuse. *(This step is just a check to be sure you have power to the circuit).*

5. Disconnect the test lamp lead that is connected to ground, and reconnect it to the load side of the fuse at the connector of the disconnected component. (In Figure 5, connect the test lamp lead to connector C4).

   • If the Test Lamp is off, the short is in the disconnected component.

   • If the Test Lamp goes on, the short is in the wiring. You must find the short by disconnecting the circuit connectors, one at a time, until the Test Lamp goes out. For example, in Figure 5 with a ground at X, the bulb goes out when C1 or C2 is disconnected, but not after disconnecting C3. This means the short is between C2 and C3.

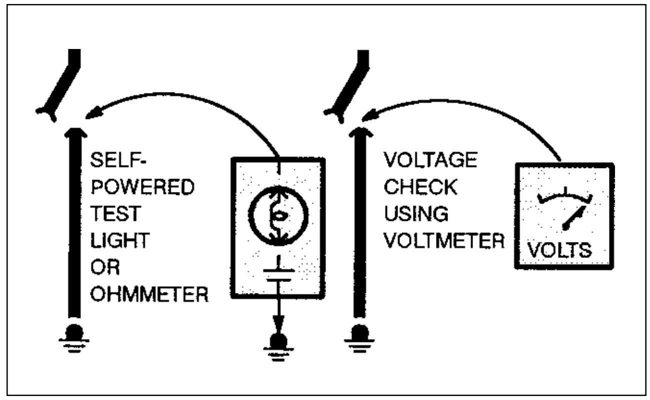


Figure 6 – Ground Check

Turn on power to the circuit. Perform a Voltage Check between the suspected inoperative ground and the frame. Any indicated voltage means that the ground is inoperative (Figure 6).

Turn off power to the circuit. Connect one lead of a Self-Powered Test Lamp or Ohmmeter to the wire in question and the other lead to a known ground. If the bulb glows, the circuit ground is OK (Figure 6).

The circuit schematics in this manual make it easy to identify common points in circuits. This knowledge can help narrow the concern to a specific area. For example, if several circuits fail at the same time, check for a common power or ground connection. If part of a circuit fails, check the connections between the part that works and the part that doesn't work.

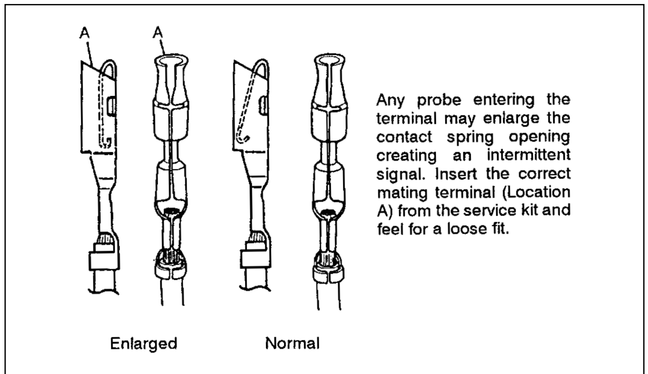
For example, if the low beam headlamps work, but the high beams and the indicator lamp don't work, then the power and ground paths must be good. Since the dimmer switch is the component that switches this power to the high beam lights and the indicator, it is most likely the cause of failure.

INTRODUCTION (Continued)

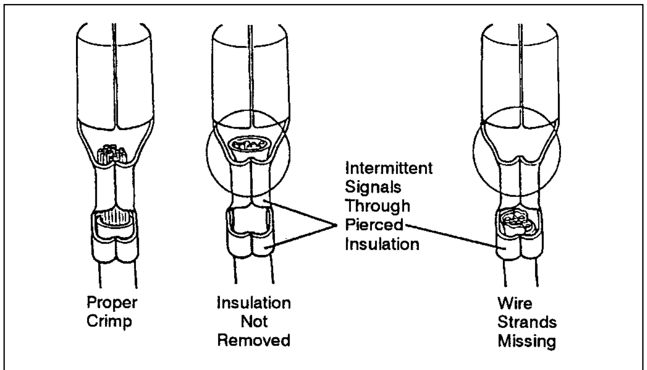
Troubleshooting Wiring Harness and Connector Hidden Concerns

The following illustrations are known examples of wiring harness, splices and connectors that will create intermittent electrical concerns. The concerns are hidden and can only be discovered by a physical evaluation as shown in each illustration.

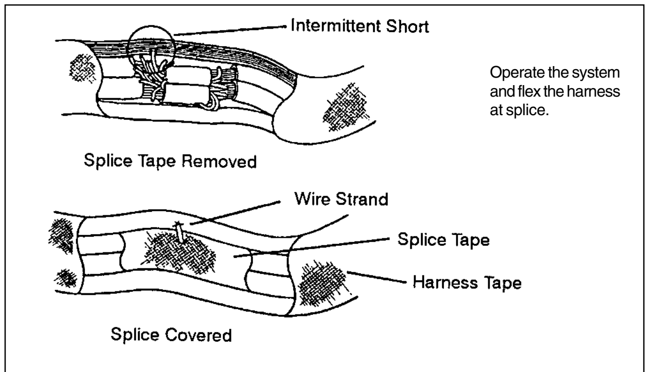
NOTE: When servicing gold plated terminals in a connector, only replace with gold plated terminals designed for that connector.



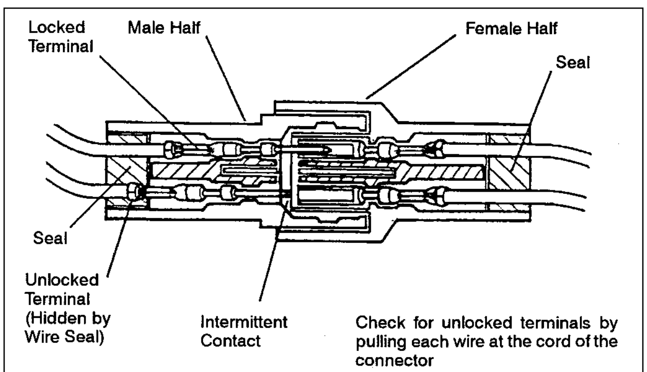
DEFORMED (ENLARGED) FEMALE TERMINALS



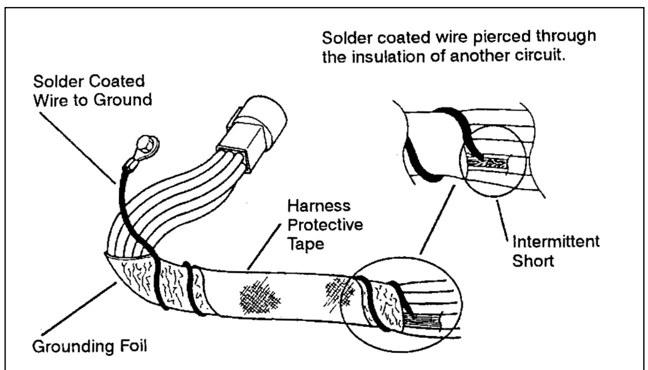
DEFECTIVE INSULATION STRIPPING



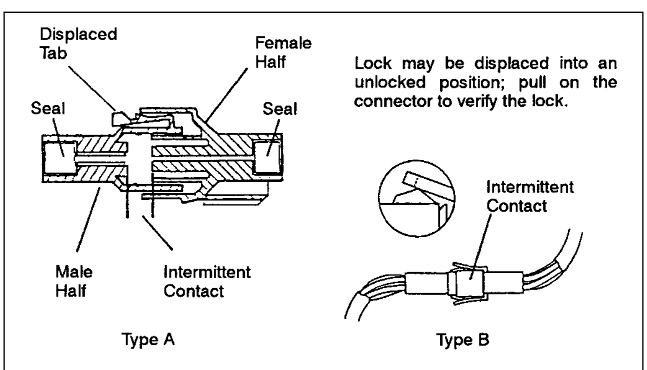
ELECTRICAL SHORT WITHIN THE HARNESS



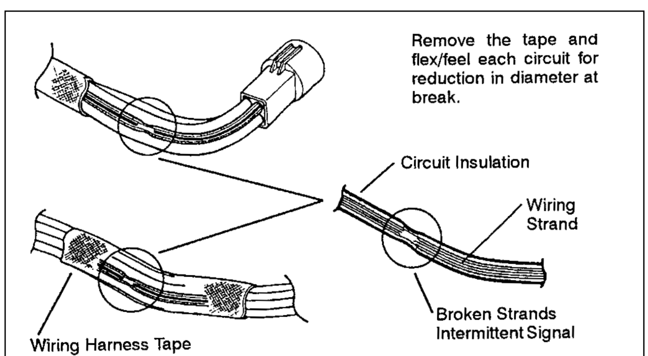
TERMINAL NOT PROPERLY SEATED



ELECTRICAL SHORT INSIDE THE HARNESS



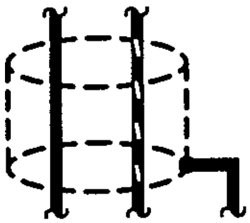
PARTIALLY MATED CONNECTORS



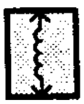
BROKEN WIRE STRANDS IN HARNESS

INTRODUCTION (Continued)

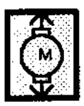
Electrical Symbols



SHIELD
WIRES ARE COVERED BY A SHIELD



FIELD COIL



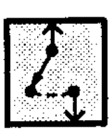
MOTOR

HEATING ELEMENT

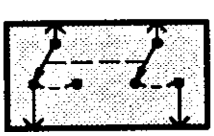
THERMISTOR

RHEOSTAT OR POTENTIOMETER

SOLENOID

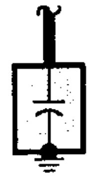


SWITCH

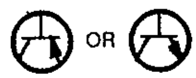


GANGED SWITCHES
CONTACTS MOVE AT THE SAME TIME

DIODES
CURRENT FLOWS IN DIRECTION OF ARROW ONLY



CAPACITOR

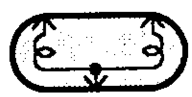


TRANSISTOR

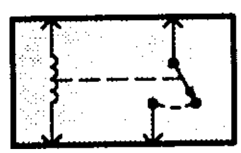
GAUGE

LIGHT EMITTING DIODE (LED)

LIGHT BULB



DUAL FILAMENT LIGHT BULB



RELAY
CONTACTS CHANGE POSITION WITH CURRENT THROUGH COIL

DESCRIPTION AND OPERATION (ECM)

WARNING: WHEN CARRYING OUT SERVICE OPERATIONS ON AN ENGINE EQUIPPED WITH DISTRIBUTORLESS IGNITION. FOLLOW ALL THE USUAL SAFETY MEASURES TO PREVENT THE POSSIBILITY OF ELECTRIC SHOCKS SHOULD BE FOLLOWED.

NOTE: High tension voltage produced by a distributorless ignition system is higher than for a conventional ignition system. It is in excess of 55,000 Volts.

Description

The ESG 642 engine uses a Distributorless Ignition System (DIS) to ignite the fuel/air mixture at the correct time and sequence based upon the input it receives. The brain of this system is an Engine Control Module (ECM). The ECM has the capability at the OEM option to protect the engine from over heating and low oil pressure. Inputs are sensors or switches that feed the ECM information. The ECM is used on EFI engines, and the ICM is used on carbureated engines.

- Engine Cylinder Head Temperature Sensor (CHT) Input.
- Camshaft Position Sensor (CMP) Input.
- Crankshaft Position Sensor (CKP) Input.
- Intake Air Temperature Sensor (IAT) Input.
- Heated Oxygen Sensor (H02S) Input.
- Manifold Absolute Pressure Sensor (MAP) Input.
- Throttle Position Sensor (TP Sensor) Input.
- Fuel Select Switch
- Manifold Skin Temperature (MST sensor)

From these inputs, the ECM computes spark strategy (spark advance) and fuel mixture (air/fuel) to obtain optimum engine performance for correct load conditions.

Operation

The engine control module needs the following information to calibrate the engine properly:

- Crankshaft position.
- Engine RPM.
- Engine temperature.
- Air temperature.
- Engine load and altitude.
- Fuel select switch.

The Manifold Absolute Pressure Sensor (MAP sensor):

- Monitors atmospheric pressure at start up to adjust timing for altitude.
- During operation monitors engine vacuum which is proportional to its load and adjust timing accordingly.

The throttle position sensor (TP sensor):

- Sends the engine control module a signal indicating the throttle plate angle.
- Is the main input to the engine control module from the driver.

The idle air control valve (IAC):

- Controls bypass air around the throttle plate at low speeds.
- Is controlled by the engine control module.

The camshaft position sensor (CMP sensor):

- Sends the engine control module a signal indicating camshaft position used for fuel synchronization.

The crankshaft position sensor (CKP sensor):

- Sends the engine control module a signal indicating crankshaft position.
- Is essential for calculating spark timing.

The intake air temperature sensor (IAT sensor):

- Sends the engine control module a signal indicating the temperature of the air entering the engine.
- Resistance decreases as temperature increases.

The heated oxygen sensor (HO2S):

- Has the ability to create a voltage signal dependent on exhaust oxygen content.
- Provides feedback information to the engine control module used to calculate fuel delivery.

The cylinder heat temperature (CHT sensor):

- Is mounted into the back of the cylinder head and is not connected to any coolant passages.
- Sends a signal to the engine control module indicating the cylinder head temperature.

The manifold skin temperature sensor (MST sensor):

- Sends the engine control module a signal indicating the temperature of the outer skin of the intake manifold.
- Resistance decreases as temperature increases.

DESCRIPTION AND OPERATION (ECM) (Continued)

The Fuel Select Switch

In the event that the engine is operated on alternate fuels such as natural gas, compressed natural gas (CNG), or liquefied petroleum gas (LPG), timing can be modified with a Fuel Select Switch.

NOTE: Fuel select switch is supplied by customer.

- Sends a signal to the ECM to adjust base timing for alternate fuel
- Is manually controlled.

With this system, the ECM monitors the engine load, speed, operating temperature, air intake temperature, oxygen in exhaust for emissions and throttle position and decides what degree of spark advance is correct for all of the operating conditions. Because timing is set for life inherently in the design of the engine, and there are no moving parts in the ignition system itself, no maintenance is required except for periodic spark plug checks. The system provides for fixed spark advance at start-up, for cold weather starting, and for "average value" default settings in case of component failure. Particular attention has been given to spark optimization for excellent fuel economy and power in the warm-up mode.

The spark plugs are paired so that one plug fires during the compression stroke and its companion plug fires during the exhaust stroke. The next time that coil is fired, the plug that was on exhaust will be on compression, and the one that was on compression will be on exhaust. The spark in the exhaust cylinder is wasted but little of the coil energy is lost.

Run Mode

The ECM interprets engine speed above 250 RPM as Run Mode.

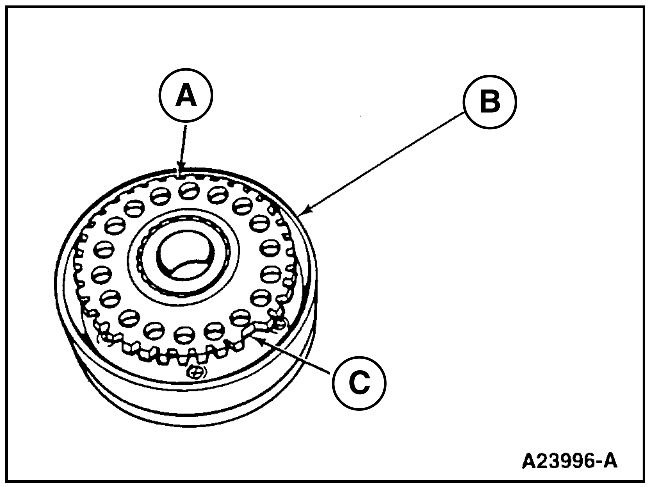
The Base Spark Advance (BSA) is calculated by the (ECM) module processing the engine speed and load plus sensors mentioned in operation of this section and Fuel Select Switch.

Inputs to the ECM Effecting the Ignition

The spark strategy is based on sensors and manifold vacuum input to the ECM module, which include the following inputs:

Crankshaft Position Sensor (CKP Sensor)

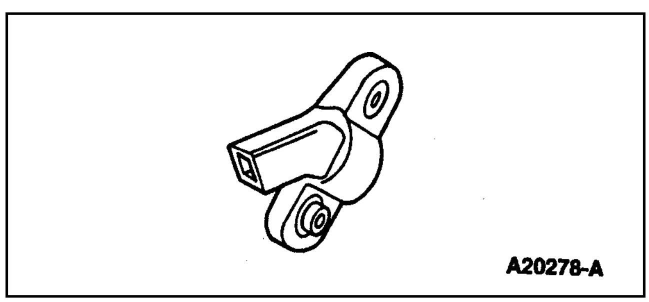
The CKP sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. By monitoring the crankshaft mounted pulse wheel A, the CKP is the primary sensor for ignition information to the ECM. The pulse wheel located behind the crankshaft pulley B, has a total of 35 teeth spaced 10 degrees apart with one empty space C for a missing tooth. An A/C voltage signal is generated which increases with engine rpm and provides engine speed and crankshaft position information to the ECM. By monitoring the pulse wheel, the CKP sensor signal indicates crankshaft position and speed information to the ECM. The CKP sensor is also able to identify piston travel in order to synchronize the ignition system and provide a way of tracking the angular position of the crankshaft relative to a fixed reference for the CKP sensor configuration.



A Pulse Wheel (Part Crankshaft Pulley).

B Crankshaft Damper (Face Down) 6312.

C Gap in Teeth (Provides position reference for number one piston

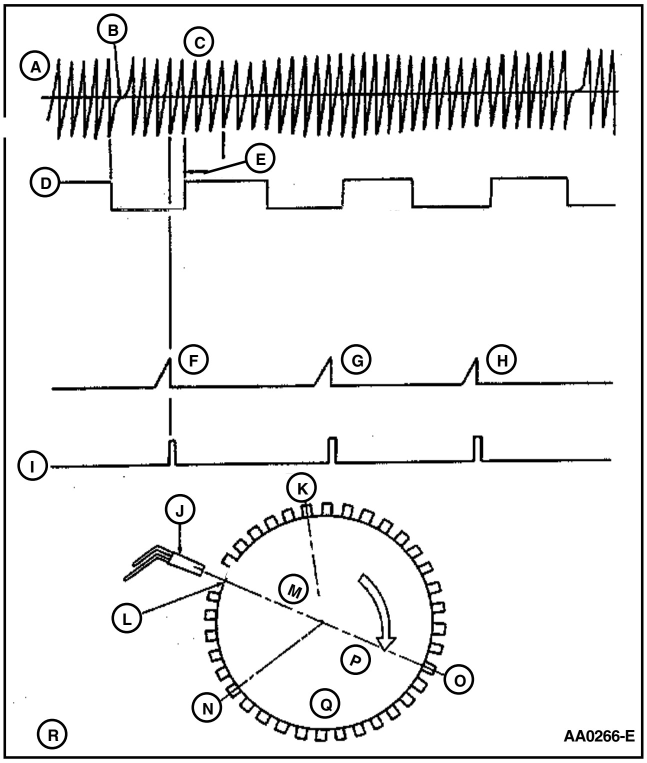


Crankshaft Position Sensor (CKP Sensor).

DESCRIPTION AND OPERATION (ECM) (Continued)

Cranking Mode

Cranking mode is the area of engine operating speed within which the ignition timing is at a static position. The static spark advance is fixed at 10 degrees BTDC up to 250 RPM.



- A CKP Sensor
- B Missing Tooth 60° BTDC
- C TDC
- D Spark
- E 10° BTDC
- F Coil 1
- G Coil 2
- H Coil 3
- I IDM
- J CKP Sensor
- K TDC 2 and 6
- L Missing Tooth
- M 60° BTDC
- N TDC 1 and 5
- O TDC 3 and 4
- P 1 and 5
- Q Crankshaft Wheel
- R **Note:** This diagram does not correlate to any timing marks that may be on the engine front cover or dampener.

Transient Mode

This function is to provide a limp in mode whenever certain components fail. The engine will run but at a set timing and batch fuel delivery. This mode will stay in effect until problem is corrected or ignition turned off and back on if an intermittent problem.

Overspeed Mode

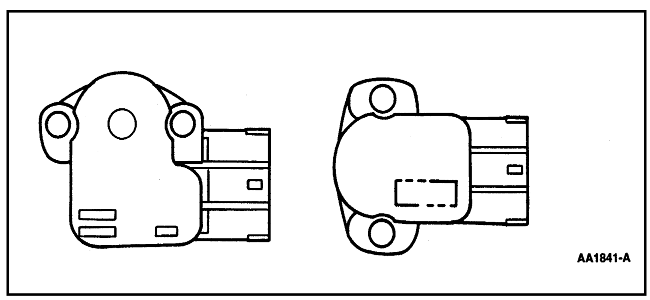
If the engine speed exceeds 4000 RPM the ignition and fuel are shut off. Ignition key must be recycled to restart engine.

Electronic Engine Controls

Refer to the Electronic Fuel Injection System Diagnostic Service Manual[1] FPP-194-306 or Section 08 of this manual.

Throttle Position Sensor (TP Sensor)

The throttle position (TP sensor) is a rotary potentiometer that provides a signal to the ECM that is linearly proportional to the throttle plate/shaft position. The sensor housing has a three-blade electrical connector that may be gold plated. The gold plating increases corrosion resistance on terminals and increases connector durability. The TP sensor is mounted on the throttle body. As the TP sensor is rotated by the throttle shaft, four operating conditions are determined by the ECM from the TP sensor. Those conditions are closed throttle (includes idle or deceleration), part throttle (includes cruise or moderate acceleration), wide open throttle (includes maximum acceleration), and throttle angle rate.



Typical TP Sensor.

ECM Replacement

Make sure correct program is installed before replacing ECM. To download or upload program for validation use interface cable.

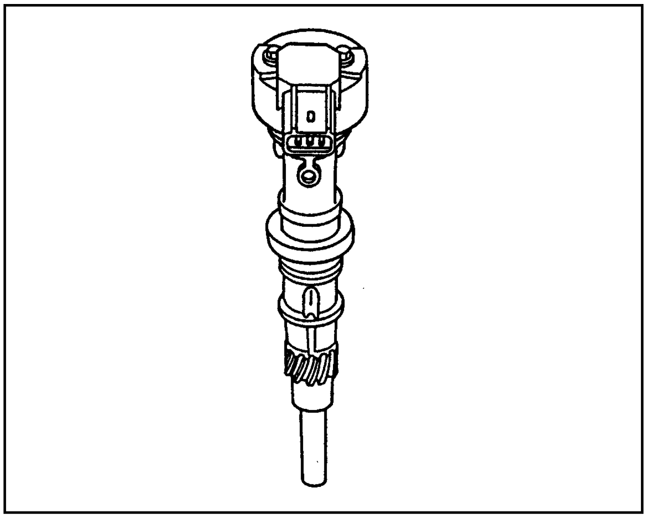
Installation of ECM/ICM

Refer to page 03-55 of this section.

DESCRIPTION AND OPERATION (ECM) (Continued)

Camshaft Position Sensor (CMP Sensor)

The CMP sensor detects the position of the camshaft and identifies when piston No. 1 is on its compression stroke. A signal is then sent to the engine control module (ECM) and used for synchronizing sequential fuel injection. The Input circuit to the ECM is referred to as the CMP input or circuit.



Typical Hall-Effect Sensor.

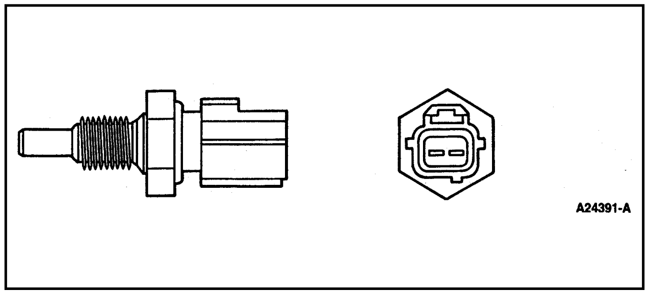
Cylinder Head Temperature Sensor (CHT Sensor)

The cylinder head temperature (CHT) sensor is a thermistor device in which resistance changes with temperature. The electrical resistance of a thermistor decreases as temperature increases, and increases as temperature decreases. The varying resistance affects the voltage drop across the sensor terminals and provides electrical signals to the ECM corresponding to temperature.

Thermistor-type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so that varying the resistance of the passive sensor causes a variation in total current flow.

Voltage that is dropped across a fixed resistor in series with the sensor resistor determines the voltage signal at the ECM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

The CHT sensor is installed in the aluminum cylinder head and measures the metal temperature. The CHT sensor communicates an overheating condition to the ECM. The ECM would then initiate a cooling strategy based on information from the CHT sensor. A cooling system failure such as low coolant or coolant loss could cause an overheating condition. As a result, damage to major engine components could occur. Using a CHT sensor and cooling strategy would prevent damage by allowing air cooling of the engine and limp home capability.



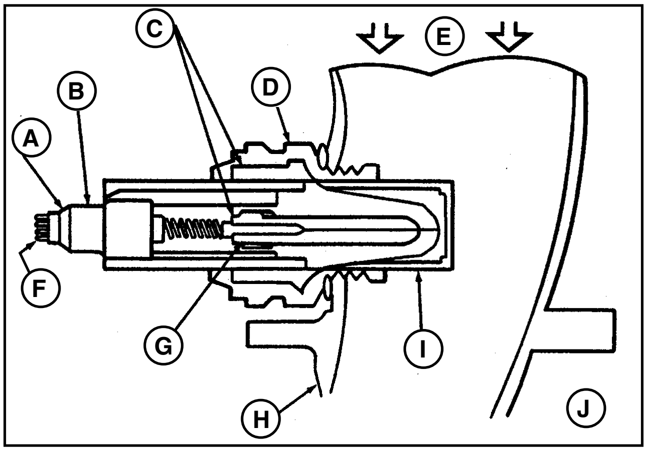
Cylinder Heat Temperature (CHT) Sensor.

Heated Oxygen Sensor (HO2S)

The heated oxygen sensor (HO2S) detects the presence of oxygen in the exhaust and provides a variable voltage according to the amount of oxygen detected. A high concentration of oxygen (lean air/fuel ratio) in the exhaust provides a low voltage signal less than 0.4 volt. A low concentration of oxygen (rich air/fuel ratio) produces a high voltage signal greater than 0.6 volt. The HO2S provides feedback to the ECM indicating air/fuel ratio in order to achieve a near stoichiometric air/fuel ratio of 14.7;1 during closed loop engine operation. The HO2S generates a voltage between 0.0 and 1.1 volts.

Embedded with the sensing element is the HO2S heater. The heating element heats the sensor to temperatures of 800°C (1400°F). At approximately 300°C (600°F) the engine can enter closed loop operation. The VPWR circuit supplies voltage to the heater and the ECM will complete the ground when the proper conditions occur. The 6 ohm heater design used by Ford Power Products is **not** interchangeable with new style 3.3 ohm new fast light off (FLO) HO2S heater.

DESCRIPTION AND OPERATION (ECM) (Continued)



Heated Oxygen Sensor (HO2S)

A Positive Elec Term
B Insulator
C Graphite Seal & Contact
D Housing
E Exhaust Gases
F Wire Terminals
G Heating Element
H Exhaust Manifold
I Shield
J 0.0-1.1 Volt Signal High Voltage - Over 0.6 (Rich)
Low Voltage - Under 0.4 (Lean)

Intake Air Temperature Sensor (IAT Sensor)

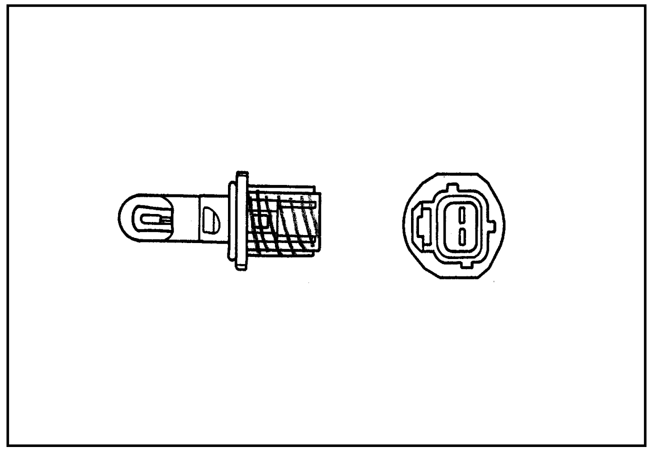
The IAT sensors are thermistor devices in which resistance changes with temperature. The electrical resistance of a thermistor decreases as the temperature increases, and increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor terminals and provides electrical signals to the ECM corresponding to temperature.

Thermistor-type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so that varying the resistance of the passive sensor causes a variation in total current flow.

Voltage that is dropped across a fixed resistor in a series with the sensor resistor determines the voltage signal at the ECM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

The IAT sensor provides air temperature information to the ECM. The ECM uses the air temperature information as a correction factor in the calculation of fuel, spark and mass air flow.

The IAT sensor provides a quicker temperature change response time than the CHT sensor.



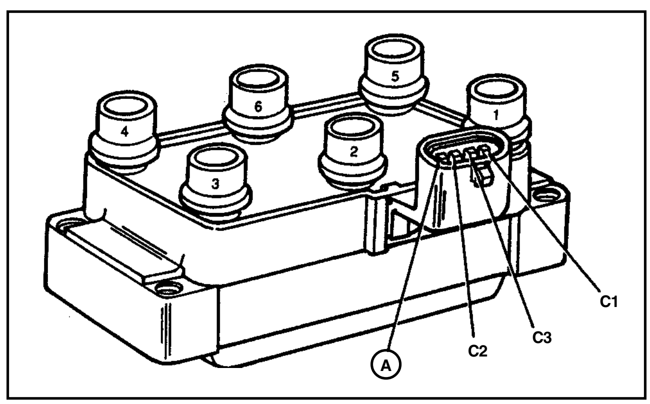
Intake Air Temperature (IAT)

Electronic Control Module (ECM) Outputs

Ignition Coil Pack

The coil is turned on (i.e. coil charging), then turned off by the ECM, thus firing two spark plugs at once. One is for the cylinder which is to be fired (on compression stroke) and the other goes to the mating cylinder which is on the exhaust stroke. The next time the coil is fired the situation is reversed. The next pair of spark plugs will fire according to the engine firing order, etc.

Ignition timing is adjusted constantly by the ECM module. Many factors, including all the sensor inputs, affect the final ignition setting.



A Coil Power B+ Volts
C1 Coil Pack #1
C2 Coil Pack #2
C3 Coil Pack #3

Firing Order: 1-4-2-5-3-6
Mating or Companion Cylinder: 1 & 5, 3 & 4, and 2 & 6.

DESCRIPTION AND OPERATION (ECM) (Continued)

Ignition Coil Pack Removal

1. Disconnect the wire harness connector (YU1L-12060-AA).
2. **CAUTION: Spark plug wires must be connected to the proper ignition coil terminal. Mark plug wire locations before removing them.**
3. Squeeze the locking tabs and remove each of the six ignition wires.
4. Remove the 3 mounting bolts and the coil pack.

Ignition Coil Pack Removal

1. Reverse removal procedures. Tighten the mounting nuts to 5-6 Nm (44-53 lb/in).
2. **CAUTION: Spark plug wires must be connected to the proper ignition coil terminal.**

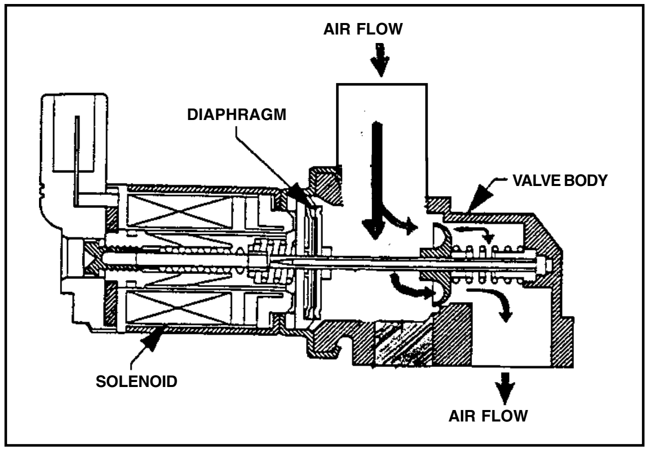
Engine Idle Speed

To control engine idle speed, some engines utilize an idle air control valve. This valve is attached to the intake manifold and controls airflow when engine is idling and throttle plate is closed.

With the intake mounted valve, air enters the intake through the valve behind the throttle plate.

The ECM controls idle speed by controlling the amount of bypassed air, this is done by changing the valve opening. Idle speed will be increased during cold engine warm-up.

IAC Motor



IAC DIAGNOSTICS

Condition	Possible Source	Action
• Idle Air Control (IAC) Circuit Malfunction.	• IAC circuit open. • IAC circuit short to PWR. • IAC circuit short to GND. • Damaged IAC valve. • Vacuum leak. • IAC valve stuck.	• CHECK IAC circuit. • REPLACE IAC. • CHECK engine for vacuum leaks. Refer to Section 01. • CLEAN or REPLACE as needed.
• Idle Air Control (IAC) Overspeed.	• IAC circuit short to GND. • Damaged IAC valve.	• CHECK IAC circuit.
• Idle Air Control (IAC) Underspeed.	• IAC circuit open. • IAC circuit short to PWR. • Air inlet is plugged. • Damaged IAC solenoid.	• CHECK IAC circuit. • Clean as needed. • REPLACE IAC.

Diagnosis Aids: The IAC solenoid resistance is from 6 to 13 ohms.
Disconnect IAC valve and look for no change in engine rpm as an indication of a stuck or damaged valve.

DESCRIPTION AND OPERATION IGNITION CONTROL MODULE (ICM)

Starting Mode

Module enters start mode at first application of power. No spark is applied for first turn of crankshaft. Timing is fixed at 10 degrees BTDC. Dwell is fixed at 10 degrees of crankshaft rotation. Start mode remains in effect until 10 turns of the crankshaft @ 500 rpm. If drops below 500 rpm at any time, turn counter is reset. Once 10 turns are made @ 500 rpm or greater, module is set to run mode. In transitioning to run mode, calculated timing values are ramped into system during approximately 3.5 revolutions to ensure transition. Dwell is determined with a base value plus a correction factor based on system voltage.

ECT Effects

Engine Coolant Temperature (ECT) is monitored and a correction factor is applied to engine timing based on one of three 1 X 8 tables. OCT1 selects which timing table will be used for correction.

IAT Effects

Intake Air Temperature (IAT) is monitored and a correction factor is applied to engine timing based on one of three 1 X 8 tables. OCT1 selects which timing table will be used for correction.

MAP Sensor Effects

The MAP signal is used by the ECM as an indication of engine load. This information is used to control spark advance and air/fuel ratio. The MAP signal is also used at KOEO to indicate barometric pressure. This information is used for altitude compensation when establishing spark advance and air/fuel ratio.

Overspeed Protection

Module contains an RPM limit that is set at 4000 RPM. Reaction is the module will be shut off, stalling the engine. Key must cycle from run to off to start in order to restart engine. Note: this strategy must be compatible with governor controllers.

Engine Protection

Reaction for overtemp (based on ECT or CHT input) and low oil pressure (based on oil pressure switch input) the module will be shut off, stalling the engine. Key must cycle from run to off to start in order to restart engine. Engine protection becomes active after 240 crankshaft revolutions and when 800 rpm is exceeded. The purpose of having to meet these conditions provides an opportunity for the engine to restart if the failure still exists which caused the engine to stall. Over temperature reaction is experienced when temperature reaches 250°F. Low oil pressure reaction is experienced when oil pressure drops below 6 psi +/- 1.5 psi. Oil pressure switch position is normally open when engine is off. This is the same strategy that is in the ECM.

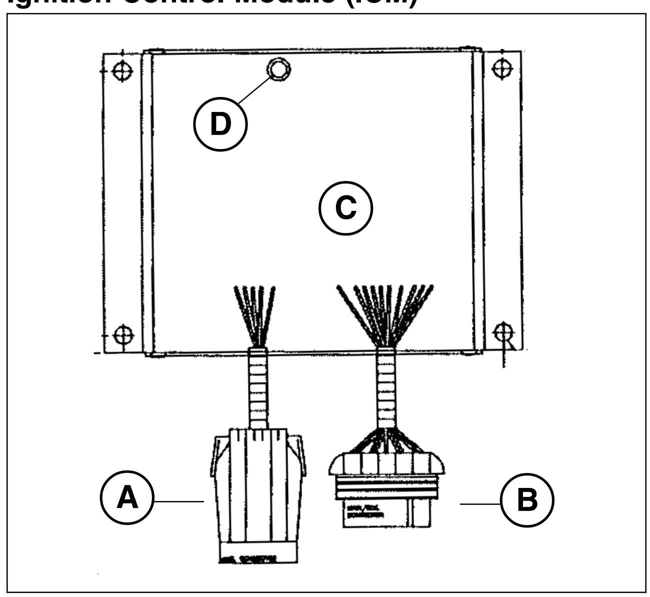
Starter Lockout

Starter lockout relay control open drain (switch to ground). Activated once engine is in the run mode and has reached 600 RPM. Will not allow start until ignition voltage to module is switched off and back on.

Tachometer Output

Tachometer output will be from auxiliary output #2, which is accessed through the five pin connector terminal E. The pulses per revolution will be determined by the number of cylinders the ICM will control. The four cylinder ICM will output 2 pulses per revolution, the six cylinder ICM output 3 pulses per revolution, the eight cylinder output 4 pulses per revolution, and the ten cylinder 5 pulses per revolution. The intention of this is to allow for use of a conventional tachometer from this output.

Ignition Control Module (ICM)



A 5 Pin Auxiliary Connector (Round)

B 10 Pin Main Connector (Oblong)

C Ignition Control Module

D Vacuum Port (5/32" I.D.) MAP Sensor

DESCRIPTION AND OPERATION (ICM) (Continued)

TABLE 1: Input/Output Function

I/O		Description
I	Battery Power (Vgt +V) Main Pin G	ICM supply voltage. Operational range is 6-24v. Ignition supply voltage is monitored and a correction factor is applied to assure proper dwell period.
I	Power Ground Main Pin H	Main ground circuit.
I	Crankshaft position sensor Main Pins A-B	Indicates crankshaft position and engine RPM.
O	Coil Drivers main Pins C-J-K	Controls switching of coils.
I	Octane select 1 (analog) States = Open, Ground, or V+ Main Pin F	The OCT1 input is used to select one of three timing maps and can be globally modified using OCT2. The following inputs are used for fuel selection: Open = Gasoline, Grounded = LPG, 12V = NG.
I	Octane select 2 (analog) Stages = Open, Ground, or V+ Main Pin E	The OCT2 input selects a constant to be added or subtracted from entire ignition timing map. The following inputs are used for ignition map modification: Open = no action, Grounded = subtract 3 degrees from table, 12V = add 5 degrees to table.
I	Engine Coolant Temperature or Cylinder Head Temperature Sensor (analog). Main Pin D	Used to indicate an overheated condition. ICM responds with engine protection function (stalls engine). Also used to modify timing when higher than normal coolant temperatures are experienced.
I	Oil pressure input (digital) States = open, ground Aux. Pin C	Used to indicate a low oil pressure condition. ICM responds with engine protection function (stalls engine). The oil pressure switch is normally open when engine is off or the oil pressure is low (6 psi +/- 1.5).
I	Aux. input #1 (analog) States = Ground, V+, or float Aux. Pin A	Undefined. Possible use could be an application select if ICM is to contain multiple calibrations (example 1.3L, 2.0L, 2.5L, 4.2L).
I	Aux. input #2 (analog) Aux. Pin B	Defined as Intake Air Temperature (IAT) input. To control ignition timing based on intake temperature. Need to determine location of sensor in intake air stream.
O	Aux. output #1 (open drain) Aux. Pin D	Starter lockout relay control energizes relay which opens starter solenoid circuit once engine is in run mode and has reached 600 RPM. This will also not allow a re-start until ignition voltage to module is switched off and back on. Same strategy as in ECM.
O	Aux. output #2 (open drain) Aux. Pin E	Tachometer signal on all application (relay control). Possible uses for output is tach signal, relay control, malfunction indicator lamp. Could flash MIL to indicate source of problem.

I / O = Input / Output.

DESCRIPTION AND OPERATION (ICM) (Continued)

HARNESS CONNECTOR PINOUT DESCRIPTION

TABLE 2: ICM Deluxe Pinout

Main Connector (10 Pin) Terminals				
I/O	**Conn**	**Pin**	**Description**	**4.2L Deluxe**
I	Main	A	Crank + (signal input)	X
I	Main	B	Crank - / ECT – (signal return)	X
I	Main	C	Coil 3 driver – cyl >>	2 + 6
I	Main	D	ECT + (signal input)	X
I	Main	E	OCT2 select input – Ground, V+, or float. Selects constant added or subtracted from timing.	X
I	Main	F	OCT1 select input – Ground, V+, or float. Selects from 3 fuel tables.	X
I	Main	G	Vigt +V supply voltage. Operational range 6 - 24V.	X
I	Main	H	Power ground	X
O	Main	J	Coil 1 driver – cyl >>	1 + 5
O	Main	K	Coil 2 driver – cyl >>	3 + 4
Auxiliary Connector (5 Pin) Terminals				
I	Aux	A	Aux input #1 (digital) – Ground, +V, or float. Undefined.	X
I	Aux	B	Aux input #2 (analog) – Defined as IAT. To control ignition timing based on intake temperature.	X
I	Aux	C	Oil pressure input – Switched to open. Reaction is stall engine.	X
O	Aux	D	Aux output #1 (open drain) – Starter lockout relay control.	X
O	Aux	E	Aux output #2 (open drain) – Tach signal or relay control.	X

I / O = Input / Output

DESCRIPTION AND OPERATION (ICM) (Continued)

OCTANE SELECT OPERATION

OCT1: Used to select ignition table for fuel type. Input can be V+, ground, or open. Fuel choices are LPG, Natural Gas. The ICM Deluxe is backwards compatible with ICM Basic.

OCT2: Used to choose constant to add or subtract from selected timing table.

TABLE 3: Operation of ICM- Deluxe Platform

Normal Operation			
Fuel	**OCT1 Circuit 674 (BR-W)**	**OCT2 Circuit 72 (Y-BK)**	**Timing Effect**
Gasoline	Open	Open	Base Gasoline
LPG	Ground	Open	Base LPG
NG	12V	Open	Base NG
To Globally Modify Ignition Timing Table			
		OCT2 Circuit 72 (Y-BK)	**Timing Effect**
		Open	No Effect on Base Timing
		Ground	Retard 3 Degrees Globally
		12V	Advance 5 Degrees Globally

DISTRIBUTORLESS IGNITION SYSTEM DESCRIPTION AND OPERATION

Service Adjustments And Checks

1. Each 400 hours of engine operation remove the spark plugs and clean and adjust the electrode.

2. Clean and visually check spark plug high tension leads, check for secure fit, and replace if necessary.

Diagnostic Equipment

To accurately diagnose DIS, certain diagnostic equipment and tools are required. In addition, the suggested diagnostic equipment may make the job easier and more convenient.

Prior to diagnosing DIS, obtain the following test equipment or equivalent.

• Spark tester, neon bulb type (Champion CT-436).

There is no need to disconnect a plug wire; just place this spark tester on a spark plug wire to determine if spark is being provided to the plug. This is especially useful for those hard-to-reach plug wires.

NOTE: When using the spark plug firing indicator, place the grooved end as close as possible to the plug boot. Very weak or no flashing may be caused by a fouled plug.

• Spark tester, gap type (special service tool D81P-6666-A).

Connect this gap type spark tester between any spark plug wire and engine ground to instantly determine if spark is being provided to the plug. A spark plug with a broken side electrode is not sufficient to check for spark and may lead to incorrect results.

• Volt-ohmmeter (Rotunda 014-00575).

A volt-ohmmeter is essential for gathering system operating data during diagnosis, testing, and engine servicing procedures. This digital volt ohmmeter (DVOM) can also be used for general purpose electrical troubleshooting on conventional starting and charging systems.

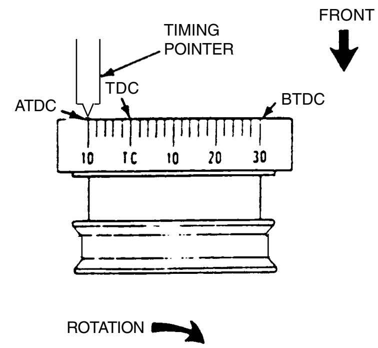
• 12-volt timing light (Rotunda Model Number 164-R0257).

This timing light uses an inductive pickup for convenience and safety on 12 volt systems, and suitable for DIS ignitions.

Ignition Timing Check

Base timing cannot be checked. It is constantly being adjusted electronically. To check timing, FPP engineers must be contacted for further instructions.

NOTE: When instructed to check, point timing light on crankshaft pulley and note degree BTDC that pointer is in alignment with.



CRANKSHAFT TIMING MARKS

CAUTION: There should be no wires spliced to the main wire harness for source of power or RPM signal unless pre-approved by Ford Power Products. Altering of wire harness may cause lack of power, no start, or erratic running.

NOTE: Do not use an incandescent test lamp to check CKPS- or CKPS+ circuits. The lamp will prevent the circuit from operating.

PRELIMINARY CHECKS

Before using this section, perform the MIL DTC Retrieval Procedure and verify all of the following items:

- The engine control module (ECM) and the malfunction indicator lamp are operating correctly.

- There are no DTC(s) stored.

Verify the customer complaint and refer to the appropriate symptom chart. Perform the procedure included in the symptom chart.

Visual/Physical Check

Several of the symptom procedures call for a careful visual/physical check. This can often lead to repairing a problem without performing unnecessary steps. Use the following guidelines when performing a visual/physical check:

Inspect unit for modifications or aftermarket equipment that can contribute to symptom, verify that all electrical and mechanical loads or accessory equipment is “OFF” or disconnected before performing diagnosis.

- Inspect engine fluids for correct levels and evidence of leaks.

- Inspect vacuum hoses for damage, leaks, cracks, kinks and proper routing, inspect intake manifold sealing surface for a possible vacuum leak.

- Inspect PCV valve for proper installation and operation.

- Inspect all wires and harnesses for proper connections and routing, bent or broken connector pins, burned, chafed, or pinched wires, corrosion, and verify harness grounds are clean and tight.

- Inspect engine control module (ECM), sensors and actuators for physical damage.

- Inspect ECM grounds for cleanliness, tightness and proper location.

- Inspect fuel system for adequate fuel level, and fuel quality (concerns such as proper octane, contamination, winter/summer blend).

- Inspect intake air system and air filter for restrictions.

Intermittent Problems

Important: An intermittent problem may or may not turn on the malfunction indicator lamp (MIL) or store a DTC. Do not use the Diagnostic Trouble Code (DTC) charts for intermittent problems. The fault must be present to locate the problem. MIL and DTC information is found in Section 08 of this manual.

Most intermittent problems are caused by faulty electrical connections or wiring. Perform a careful visual/physical check for the following conditions:

- Poor mating of the connector halves or a terminal not fully seated in the connector (backed out).

- Improperly formed or damaged terminals.

- Improper contact tension. All connector terminals in the problem circuit should be carefully checked.

- Poor terminal-to-wire connections. This requires removing the terminal from the connector body to check.

- Improperly installed aftermarket equipment or accessories.

Operate the engine with accessories “OFF” and a suitable multimeter connected to the suspected circuit. An abnormal voltage when the malfunction occurs is a good indication that there is a fault in the circuit being monitored.

To check ECM for loss of diagnostic code memory, disconnect the MAP sensor connector and idle the engine until the MIL illuminates. Perform MIL DTC Retrieval Procedure. DTC 14 should be stored and kept in memory when the ignition is turned “OFF”. If not, the ECM is faulty. When this test is completed, make sure that you clear DTC 14 from memory. An intermittent MIL with no stored DTC(s) may be caused by the following:

- DIS ignition coil shorted to ground and arcing at ignition wires or plugs.

- MIL circuit to ECM shorted to ground.

- Poor ECM grounds.

- Keep alive memory wire doesn’t have a constant 12V.

HARD START SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Engine cranks, but does not start for a long time. Does eventually run, or may start but immediately stalls.				
1	Was a visual/physical check performed?		Go to Step 2	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure. Ignition "ON", engine not running, short STI connector to ground. (Purple and white wire). Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	Check cylinder head temperature sensor (CHT) for shift in value. 1. Measure the engine temperature and note the value. 2. Check the resistance of the engine CHTS temperature sensor. 3. Refer to Temperature vs. Resistance chart for resistance specifications. Is the actual resistance near the resistance value in the chart for the temperature that was noted?		Go to *Step 5*	Go to *Step 4*
4	Replace the CHT sensor. Is the action complete?		Verify repair	Go to *Step 5*
5	Locate and repair high resistance or improper connection in the CHTS signal circuit or the ECM grounds. Was a problem found?		Verify repair	Go to *Step 6*
6	Check for a faulty, plugged, or incorrectly installed PCV valve. Was a problem found?		Verify repair	Go to *Step 7*
7	Inspect the secondary ignition wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. Spraying the secondary ignition wires with a light mist of water may help locate an intermittent problem (key "ON", engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 8*
8	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 9*
9	1. Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 10*
10	Check the ECM grounds to verify that they are clean and tight. (Refer to the ECM wiring diagram.) Was a problem found?		Verify repair	Go to *Step 11*

HARD START SYMPTOM (Continued)

Step	Action	Value(s)	Yes	No
11	1. Check the ignition coil secondary resistance. 2. Replace the coil if it is not within the specified range of resistance. Did the coil require replacement?	Refer to Page 03-35	Verify repair	Go to *Step 12*
12	Check the electronic governor operation including the TPS function. (Refer to Fuel Section).		Verify repair	Go to *Step 13*
13	Check for water or alcohol contaminated fuel. Was a problem found?		Verify repair	Go to *Step 14*
14	Inspect the fuel delivery system to determined if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 15*
15	Check for the following engine mechanical problems (refer to Section 01 of this Manual): • Low compression • Leaking cylinder head gasket • Worn camshaft • Camshaft drive belt slipped or stripped. Was a problem found?		Verify repair	Go to *Step 16*
16	1 . Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical support Hotline 1-800-521-0370

ENGINE SURGES SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Engine power variation under steady throttle setting. Feels like the engine speeds up and slows down with no change in the governor switch or throttle position.				
1	Was a visual/physical check performed?		Go to *Step 2*	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure. Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	**NOTE:** Make sure engine is closed loop before proceeding. Check the heated oxygen sensor (H02S) operation. The H02S should respond quickly to different throttle positions. If it doesn't, check for silicone or other contaminants from fuel or use of improper RTV sealant. The sensor may have a white powdery coating. Silicone contamination sends a rich exhaust signal which causes the ECM to command an excessively lean air/fuel mixture. Was a problem found?		Verify repair	Go to *Step 4*
4	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 5*
5	Check electronic governor operation including throttle position sensor function. (Refer to Fuel System in this Manual.) Was a problem found?		Verify repair	Go to *Step 6*
6	Check items that can cause an engine to run rich. (Refer to DTC 42) Was a problem found?		Verify repair	Go to *Step 7*
7	Check items that can cause the engine to run lean. (Refer to DTC 32.) Was a problem found?		Verify repair	Go to *Step 8*
8	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 9*
9	Check the ECM grounds to verify that they are clean and tight. Refer to the ECM wiring diagram. Was a problem found?		Verify repair	Go to *Step 10*
10	Inspect the secondary ignition wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. Spraying the secondary ignition wires with a light mist of water may help locate an intermittent problem (key "ON", engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 11*

ENGINE SURGES SYMPTOM (Continued)

Step	Action	Value(s)	Yes	No
11	1. Check the ignition coil secondary resistance. 2. Replace the coil if it is not within the specified value. Did the coil require replacement?	Refer to Page 03-35	Verify repair	Go to *Step 12*
12	1 . Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes, heavy deposits or improper heat range. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 13*
13	1. Check the injector connectors. 2. If any of the connectors are connected at an improper cylinder, correct as necessary. Was a problem found?		Verify repair	Go to *Step 14*
14	Visually/physically check vacuum hoses for splits, kinks, and proper connections and routing. Was a problem found?		Verify repair	Go to *Step 15*
15	Check the exhaust system for a possible restriction: Damaged or collapsed pipe : Internal muffler failure. Was a problem found?		Verify repair	Go to *Step 16*
16	1 . Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

LACK OF POWER OR SLUGGISH SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Engine delivers less than expected power. Little or no increase in speed when throttle position is increased.				
1	Was a visual/physical check performed?		Go to Step 2	Go to *Visual/Physical Check*
2	1. Remove and check air filter element for dirt or restrictions. 2. Replace the air filter element if necessary. Was a repair required?		Verify repair	Go to *Step 3*
3	Perform MIL DTC retrieval procedure. Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 4*
4	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 5*
5	1. Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes, heavy deposits or improper heat range. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 6*
6	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 7*
7	Check for water or alcohol contaminated fuel. Was a problem found? ‘		Verify repair	Go to *Step 8*
8	Check the ECM grounds to verify that they are clean and tight. (Refer to the ECM wiring diagram.) Was a problem found?		Verify repair	Go to *Step 9*
9	Check the exhaust system for a possible restriction: • Damaged or collapsed pipe • Internal muffler failure Was a problem found?		Verify repair	Go to *Step 10*
10	Check for the following engine mechanical problems (refer to Section 01 of this Manual): • Low compression • Leaking cylinder head gasket • Worn camshaft • Camshaft drive chain worn, slipped or stripped • Is speed select switch actualy switching • Is the preset RPM being obtained • Is actuator responding Was a problem found?		Verify repair	Go to *Step 11*
11	1 . Review all the diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check. • All electrical connections within a suspected circuit and/or system. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

DETONATION/SPARK KNOCK SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: A mild to severe ping, usually worse under acceleration. The engine makes sharp metallic knocks that change with throttle opening.				
1	Was a visual/physical check performed?		Go to Step 2	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure: Ignition “ON”, engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	1. If no fault codes display from MIL light and there are no engine mechanical faults, fill the fuel tank with a known quality gasoline that has a minimum octane rating of 87. 2. Re-evaluate the engine performance. Is detonation present?		Go to *Step 4*	Verify repair
4	Check for obvious overheating problems: • Low engine coolant. • Restricted air flow to radiator, or restricted water flow through radiator. • Incorrect coolant solution. It should be a 50/50 mix of approved antifreeze/water. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Go to *Step 5*
5	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 6*
6	Check items that can cause an engine to run lean. (Refer to DTC 32.) Was a problem found?		Verify repair	Go to *Step 7*
7	Check spark plugs for proper heat range. (Refer to specification in the back of this section.)		Verify repair	Go to *Step 8*
8	1. Remove excessive carbon buildup with a top engine cleaner. Refer to instructions on the top engine cleaner can. 2. Re-evaluate engine performance. Is detonation still present?		Go to *Step 9*	Verify repair
9	Check for an engine mechanical problem. Perform a cylinder compression check. (Refer to Section 01 of this Manual.) Was a problem found?		Verify repair	Go to *Step 10*
10	1. Review all the diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

ROUGH, UNSTABLE, OR INCORRECT IDLE, STALLING SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Engine runs unevenly at idle. If severe, the engine may shake. Engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.				
1	Check for rough, unstable or incorrect idle, or stalling condition. Ensure that the following conditions are present: • Engine fully warm • Accessories are “OFF”. Does engine run rough, idle fluctuate, or stall?		Go to *Step 2*	
2	Perform a visual/physical check, including ignition coil and secondary ignition wire connections. Was a problem found?		Verify repair	Go to *Step 3*
3	Perform MIL DTC retrieval procedure: Ignition “ON”, engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 4*
4	**NOTE:** Make sure engine is closed loop before proceeding. Check the heated oxygen sensor (HO2S) operation: The H02S should respond quickly to different throttle positions. If it doesn’t, check for silicone or other contaminants from fuel or use of improper RTV sealant. The sensor may have a white powdery coating which is silicone contamination. Silicone contamination sends a rich exhaust signal which causes the ECM to command an excessively lean air/fuel mixture. Replace HO2S. Was a problem found?		Verify repair	Go to *Step 5*
5	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 6*
6	Inspect the secondary ignition wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. Spraying the secondary ignition wires with a light mist of water may help locate an intermittent problem (key “ON”, engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 7*
7	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 8*
8	1. Check ignition coil secondary resistance. 2. Replace the coil if it is not within the specified Did the coil require replacement?	Refer to Page 03-35	Verify repair	Go to *Step 9*
9	1 . Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 10*

ROUGH, UNSTABLE, OR INCORRECT IDLE, STALING SYMPTOM (Continued)

Step	Action	Value(s)	Yes	No
10	Check the ECM grounds to verify that they are clean and tight. (Refer to the ECM wiring diagram.) Was a problem found?	-	Verify repair	Go to *Step 11*
11	Check the items that can cause the engine to run rich. (Refer to DTC 42.) Was a problem found?	-	Verify repair	*Go to Step 12*
12	Check items that can cause the engine to run lean. (Refer to DTC 32.) Was a problem found?	-	Verify repair	Go to *Step 13*
13	Check the injector connections. If any of the injector connections are connected to an incorrect cylinder, correct as necessary. Was a problem found?	-	Verify repair	Go to *Step 14*
14	Visually/physically check the vacuum hoses for splits, kinks, and proper connections and routing. Was a problem found?		Verify repair	Go to *Step 15*
15	Check the exhaust system for a possible restriction: • Damaged or collapsed pipe • Internal muffler failure. Was a problem found?		Verify repair	Go to *Step 16*
16	Check for a faulty, plugged, or incorrectly installed PCV valve. Was a problem found?		Verify repair	Go to *Step 17*
17	Check the following engine mechanical problems (refer to Section 01 of this Manual): • Low compression • Leaking cylinder head gasket • Worn camshaft • Sticking or leaking valves • Valve timing • Broken valve springs • Camshaft drive chain worn, slipped or stripped. Was a problem found?		Verify repair	Go to *Step 18*
18	1. Check for faulty motor mounts. (Refer to Section 01 of this Manual.) 2. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Go to *Step 19*
19	1 . Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

EXCESSIVE FUEL CONSUMPTION SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Fuel economy is noticeably lower than expected. Also, economy is noticeably lower than it was at one time previously.				
1	Was a visual/physical check performed?		Go to *Step 2*	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure: Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	Visually/physically check: Vacuum hoses for splits, kinks, and improper connections and routing. Was a problem found?		Verify repair	Go to *Step 4*
4	Remove and check the air filter element for dirt or restrictions. Was a problem found?		Verify repair	Go to *Step 5*
5	1. Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes, or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 6*
6	Check for low engine coolant level. Was a problem found?		Verify repair	Go to *Step 7*
7	Check for an incorrect or faulty engine thermostat. (Refer to the Cooling Section of this Manual.)		Verify repair	Go to *Step 8*
	Check for low engine compression. (Refer to Section 01 of this Manual.) Was a problem found?		Verify repair	Go to *Step 9*
9	Check for excessive exhaust system back-pressure. Possible problems could be: • Damaged or collapsed pipe • Internal muffler failure. Was a problem found?		Verify repair	Go to *Step 10*
10	Check the air intake system and the crankcase for air leaks. Was a problem found?		Verify repair	Go to *Step 11*
11	1. Review all the diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All connections within a suspected circuit and/or system. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

DIESELING, RUN-ON SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Engine continues to run after key is turned "OFF", but runs very rough. If engine runs smoothly, check the ignition switch and adjustment.				
1	Was a visual/physical check performed?		Go to *Step 2*	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure: Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	Check for a short between B+ and the ignition feed circuit. Was a problem found?		Verify repair	Go to *Step 4*
4	1 . Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check. • All electrical connections within a suspected circuit and/or system. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

BACKFIRE SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.				
1	Was a visual/physical check performed?		Go to *Step 2*	Go to *Visual/ Physical Check*
2	Perform MIL DTC retrieval procedure: Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 4*
4	1 . Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 5*
5	Inspect the secondary ignition wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. spraying the secondary ignition wires with a light mist of water may help locate an intermittent problem (ignition "ON", engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 6*
6	Check for an intermittent ignition system malfunction: • Intermittent crankshaft position sensor signal. • Intermittent ignition feed circuit or sensor ground circuit to the crankshaft position sensor. Was a problem found?		Verify repair	Go to *Step 7*
7	Inspect the fuel delivery system to determined if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 8*
8	Check for the following engine mechanical problems (refer to Section 01 of this Manual): • Low compression • Leaking cylinder head gasket • Worn camshaft • Incorrect valve timing • Sticking or leaking valves • Camshaft drive chain worn, slipped or stripped. Was a problem found?		Verify repair	Go to *Step 9*
9	Check the intake and exhaust manifold(s) for casting flash. Was a problem found?		Verify repair	Go to *Step 10*
10	1. Review all the diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

HESITATION, SAG, STUMBLE SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Momentary lack of response as the throttle is opened. Can occur at any engine speed. Usually most pronounced when first trying to accelerate the engine. May cause the engine to stall if severe enough.				
1	Was a visual/physical check performed?		Go to *Step 2*	Go to *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure: Ignition "ON", engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 3*
3	**NOTE:** Make sure engine is closed loop before proceeding. Check the heated oxygen sensor (HO2S) operation (page 03-26 of this section): The HO2S should respond quickly to different throttle positions. If it doesn't, check for silicone or other contaminants from fuel or use of improper RTV sealant. The sensor may have a white powdery coating which is silicone contamination. Silicone contamination sends a rich exhaust signal which causes the ECM to command an excessively lean air/fuel mixture. Replace HO2S. Was a problem found?		Verify repair	Go to *Step 4*
4	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?	Fuel Pressure 62-64 PSI	Verify repair	Go to *Step 5*
5	Check electronic governor operation including throttle position sensor function. (Refer to Fuel Section of this Manual) Was a problem found?		Verify repair	Go to *Step 6*
6	Check items that can cause an engine to run rich. (Refer to DTC 42.) Was a problem found?		Verify repair	Go to *Step 7*
7	Check items that can cause the engine to run lean. (Refer to DTC 32.) Was a problem found?		Verify repair	Go to *Step 8*
8	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 9*
9	Inspect the secondary ignition wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. Spraying the secondary ignition wires with a light mist of water may help locate an intermittent problem (key "ON", engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 10*

HESITATION, SAG, STUMBLE SYMPTOM (Continued)

Step	Action	Value(s)	Yes	No
10	1. Check the ignition coil secondary resistance. 2. Replace the coil if it is not within the specified value. Did the coil require replacement?	Refer to Page 03-35	Verify repair	Go to *Step 11*
11	1 . Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 12*
12	Check the ECM grounds to verify that they are clean and tight. Refer to the ECM wiring diagram. Was a problem found?		Verify repair	Go to *Step 13*
13	Visually/physically check vacuum hoses for splits, kinks, and proper connections and routing. Was a problem found?		Verify repair	Go to *Step 14*
14	Check for a faulty, plugged, or incorrectly installed PCV valve. Was a problem found?		Verify repair	Go to *Step 15*
15	1 . Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

CUTS OUT, MISSES SYMPTOM

Step	Action	Value(s)	Yes	No
DEFINITION: Steady pulsation or jerking that follows engine speed; usually more pronounced as engine load increases.				
1	Check for incorrect idle speed. Ensure that the following conditions are present: • Engine fully warm • Accessories are “OFF”. Does engine cut out or miss?		Go to *Step 2*	
2	Perform a visual/physical check, including ignition coil and secondary ignition wire connections. Was a problem found?		Verify repair	Go to *Step 3*
3	Perform MIL DTC retrieval procedure: Ignition “ON”, engine not running, short STI connector to ground. Do any fault codes flash and display?		Refer to DTC chart, perform component and circuit test as required.	Go to *Step 4*
4	Check the heated oxygen sensor (HO2S) operation: The HO2S should respond quickly to different throttle positions. If it doesn’t, check for silicone or other contaminants from fuel or use of improper RTV sealant. The sensor may have a white powdery coating which is silicone contamination. Silicone contamination sends a rich exhaust signal which causes the ECM to command an excessively lean air/fuel mixture. Replace HO2S. Was a problem found?		Verify repair	Go to *Step 5*
5	Check the ECM grounds to verify that they are clean and tight. (Refer to the ECM wiring diagram.) Was a problem found?		Verify repair	Go to *Step 6*
6	Check the items that can cause the engine to run rich. (Refer to DTC 42.) Was a problem found?		Verify repair	Go to *Step 7*
7	Check items that can cause the engine to run lean. (Refer to DTC 32.) Was a problem found?		Verify repair	Go to *Step 8*
8	Inspect the fuel delivery system to determine if there is a problem with fuel delivery. Was a problem found?		Verify repair	Go to *Step 9*
9	Inspect the secondary ignition wires. Check for the following conditions: • Verify the resistance of all ignition wires is less than the specified value • Verify that ignition wires are correctly routed to eliminate cross-firing • Verify that ignition wires are not arcing to ground. Spraying the secondary ignition wires with a light mist of water may help to locate an intermittent problem (ignition “ON”, engine running). Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 10*
10	1. Check ignition coil secondary resistance. 2. Replace the coil if it is not within the specified range of resistance. Was a problem found?	Refer to Page 03-35	Verify repair	Go to *Step 11*

CUTS OUT, MISSES SYMPTOM (Continued)

Step	Action	Value(s)	Yes	No
11	Check for proper ignition voltage output with a suitable spark tester. Was a problem found?		Verify repair	Go to *Step 12*
12	Check the injector connections. If any of the injector connections are connected to an incorrect cylinder, correct as necessary. Was a problem found?		Verify repair	Go to *Step 13*
13	1. Remove spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair	Go to *Step 14*
14	Visually/physically check the vacuum hoses for splits, kinks, and improper connections and routing. Was a problem found?		Verify repair	Go to *Step 15*
15	Check the exhaust system for a possible restriction: • Damaged or collapsed pipe • Internal muffler failure. Was a problem found?		Verify repair	Go to *Step 16*
16	Check for a faulty, plugged, or incorrectly installed PCV valve. Was a problem found?		Verify repair	Go to *Step 17*
17	Check the following engine mechanical problems (refer to Section 01 of this Manual): • Low compression • Leaking cylinder head gasket • Worn camshaft • Sticking or leaking valves • Valve timing • Broken valve springs • Camshaft drive belt slipped or stripped. Was a problem found?		Verify repair	Go to *Step 18*
18	1. Check for faulty motor mounts. 2. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Go to *Step 19*
19	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection, including fuel quality check. • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

IGNITION SYSTEM DIAGNOSING AND TESTING

1. Check the following circuits with the volt ohmmeter per the following chart.

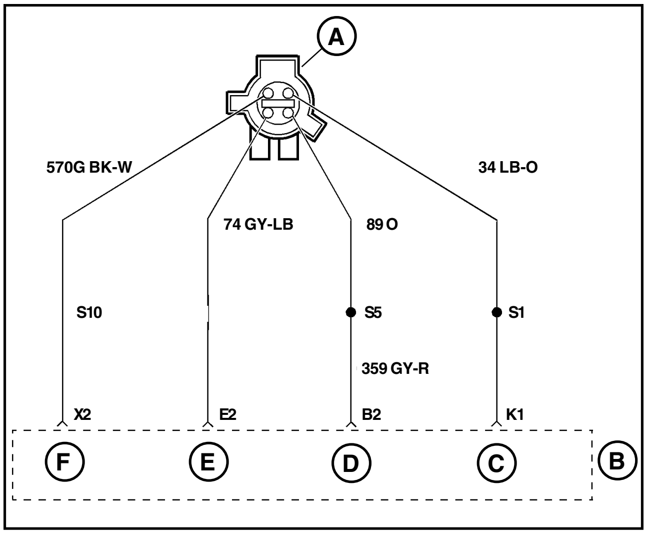
IGNITION SECONDARY SYSTEM RESISTANCE CHECKS

Test No.	Test Connections Pin Nos.	DVOM Set Selection	Reading Ohms	Description of Circuit
1	Coil Secondary Towers 1-5	Ohm	14,000	Coil Secondary Circuit
2	Coil Secondary Towers 4-3	Ohm	14,000	Coil Secondary Circuit
3	Coil Secondary Towers 2-6	Ohm	14,000	Coil Secondary Circuit
4	Ends of Each Spark Plug Wire	Ohm	6,000 to 16,000	Spark Plug Wire Resistance (approx. 6,000 Ohms per foot)

IGNITION SYSTEM DIAGNOSING AND TESTING (Continued)

HEATED OXYGEN SENSOR (HO2S)

DIAGNOSTIC TROUBLE CODE (DTC) 32-42



A Heated Oxygen Sensor (HO2S) Connector
B Engine Control Module (ECM)
C VPWR (B+)
D Signal Return
E Sensor Signal
F Power Ground

Circuit Description

The ECM supplies a voltage of about 0.45 volts to the heated oxygen sensor. This may read as low as 0.32 volts with a 10 megohm digital voltmeter. The oxygen sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about 0. 10 volts if the exhaust is lean. A cold sensor causes an open loop operation.

If the senor pigtail wiring, connector, or terminal is damaged the entire oxygen sensor assembly must be replaced. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the signal return wire. Any attempt to repair the wires, connector, or terminals could result in the obstruction of the air reference and degrade the sensor performance.

Conditions for Setting the DTC

- KOER.
- HO2S sensor voltage is greater than or equal to 0.65 volts or less than or equal to 0.20 volts for 20 consecutive seconds.

Action Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).

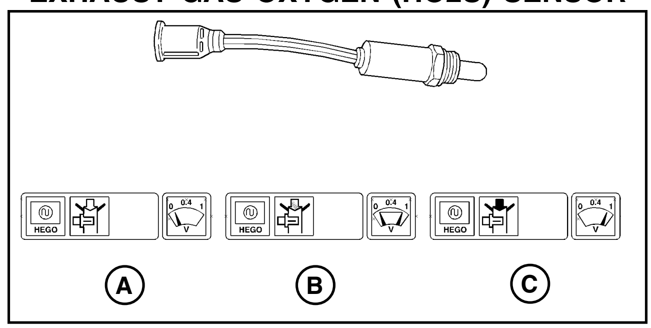
- The ECM will switch to open loop fuel control.

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 5 minutes.

- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data screen.

EXHAUST GAS OXYGEN (HO2S) SENSOR



A Lean Air/Fuel Mixture
B Stoichiometry
C Rich Air/Fuel Mixture

Describe:

- Heated exhaust gas oxygen (HO2S) sensor is a zirconium dioxide-type voltage generating sensor that converts oxygen levels in exhaust to a voltage signal.

- The HO2S sensor switches between approximately 0.10 and one volt. In lean conditions, the HO2S sensor generates a low voltage signal of less than 0.4 volts. In rich conditions, the HO2S sensor generates a high voltage signal greater than 0.6 volts.

- The ECM uses this input to determine if the air/ fuel mixture is lean or rich.

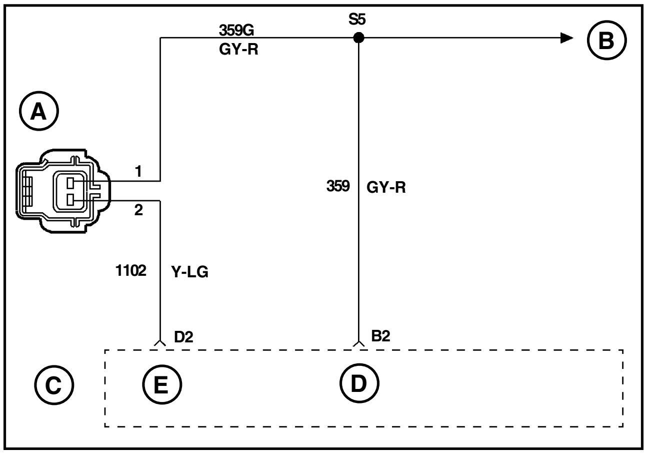
- The HO2S sensor does not operate until it reaches an operating temperature between 300°- 850°C (572°-1562°F).

- HO2S sensors are equipped with a heating element and begin operating at lower exhaust temperatures.

IGNITION SYSTEM DIAGNOSING AND TESTING (Continued)

ENGINE CYLINDER HEAD TEMPERATURE SENSOR (CHT)

DIAGNOSTIC TROUBLE CODE (DTC) 33-43



A Engine Cylinder Head Temperature Sensor Connector	**D** Sensor Ground
B Ground (B-)	**E** Sensor Signal
C Engine Control Module (ECM)	

Circuit Description

The engine cylinder head temperature (CHT) sensor is a termistor which measures the temperature of the engine cylinder head. The ECM supplies a ground circuit 359, Gray/Red from the sensor and monitors a voltage signal (circuit to 1102, Yellow/Lt. Green) to the sensor. When the engine coolant is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the CHT signal circuit. If the engine cylinder head is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 43 will set when the ECM detects an excessively low signal voltage, and DTC 33 when the ECM detects an excessively high signal voltage.

Conditions for Setting the DTC

- KOEO or KOER.
- CHT sensor signal is less than or equal to 0.22 volts or greater than 4.93 volts.
- Above conditions are present for a least 3 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the CHT sensor to a 50° F default value.

NOTE: Complete list of temperature sensor characteristics found on page 03-30 of this section.

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 5 minutes.
- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data screen.

Diagnostic Aids

The (CHT) sensor shares the same ground with other sensors. Check the ground circuit 359 (Gray/Red) if other DTCs are also set.

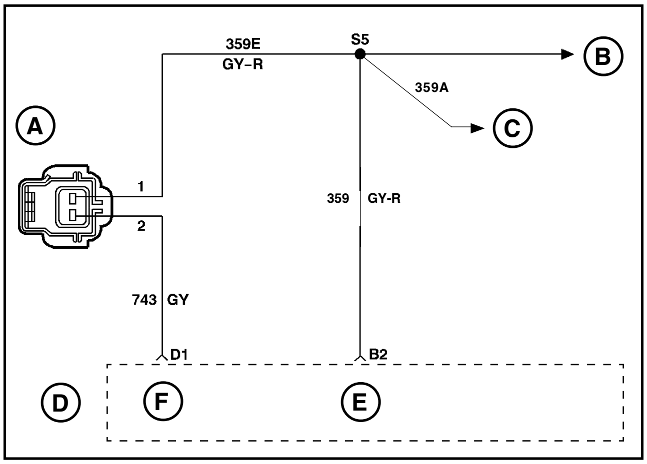
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, back probe the CHT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the CHT sensor. A change in the voltmeter display will indicate the location of the fault.

NOTE: Refer to Section 08.

IGNITION SYSTEM DIAGNOSING AND TESTING (Continued)

INTAKE AIR TEMPERATURE (IAT) SENSOR CIRCUIT (AIR CHARGE)

DIAGNOSTIC TROUBLE CODE (DTC) 35-45



A Intake Air Temperature Sensor (IAT) Connector
B MAP and ECT Sensors
C 42 Pin Connector
D Engine Control Module (ECM)
E Sensor Ground
F IAT Sensor Signal

Circuit Description

The intake air temperature (IAT) sensor is a thermistor which measure the temperature of the air entering the engine. The ECM supplies a ground (circuit 359, Gray/Red) to the sensor and receives a voltage signal (circuit 743, Gray) from the sensor. When the intake air is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the IAT signal circuit. If the intake air is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 35 will set when the ECM detects an excessively high signal voltage and DTC 45 for excessively low signal voltage on the intake air temperature sensor signal circuit.

Conditions for Setting the DTC

- DTC 35 $\leq$ 0.12V for $\geq$ 2.64 sec.
- DTC 45 $\geq$ 4.96V for $\leq$ 2.64 sec.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the ECT sensor to a 50°F default value.

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 5 minutes.
- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data Screen.

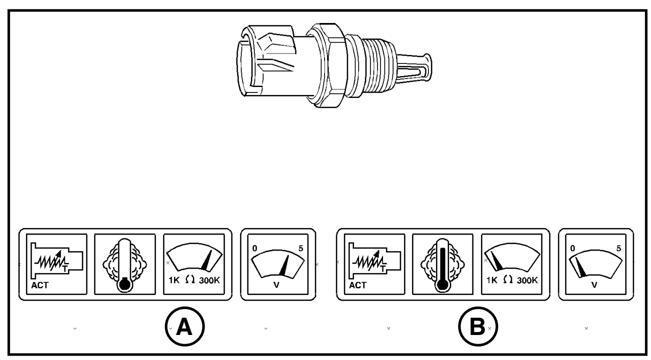
Diagnostic Aids

The **IAT** sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the CHTS. Check the ground circuit 359 (Gray/Red) if these DTCs are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the IAT sensor connector with a paper clip and DVOM and observe the voltage while moving connectors and wiring harnesses related to the IAT sensor.

A change in the voltmeter display will indicate the location of the fault.

INTAKE AIR TEMPERATURE (IAT) SENSOR



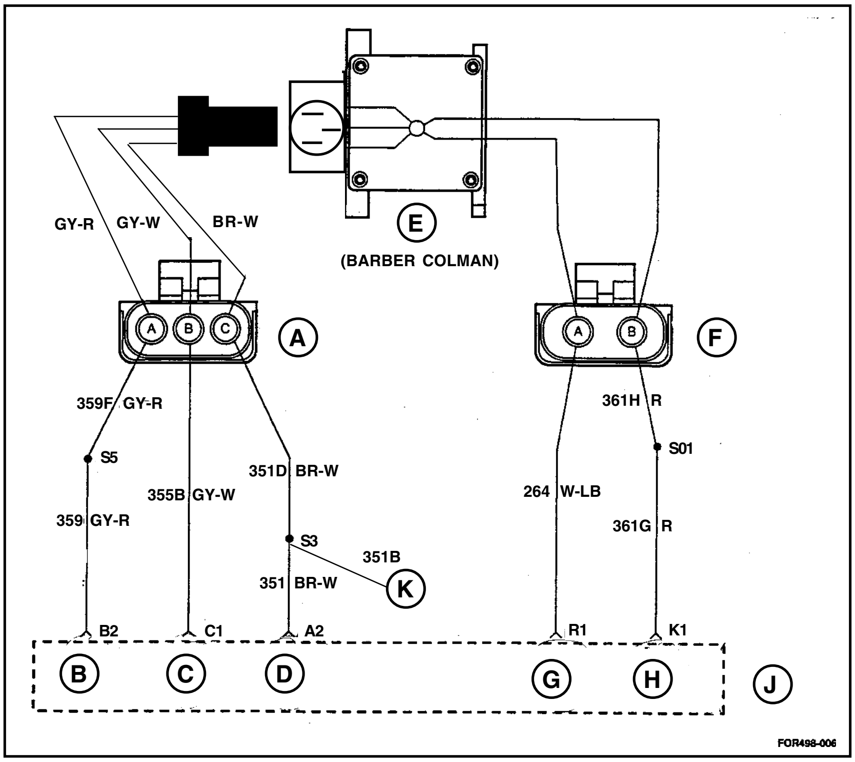
A Low Air Temperature
B High Air Temperature

- IAT sensor is a type of thermistor that converts air temperature to a voltage signal.
- Output is a variable voltage signal which typically ranges from 0.3 volt to 4.5 volts.
- As air temperature increases, the IAT resistance decreases.
- At -40°F (CHT) resistance is ± 269K ohms.
- At 77’°F (CHT) resistance is ± 29K ohms.
- At 248°F (CHT) resistance is ± 1.2K ohms.

IGNITION SYSTEM DIAGNOSING AND TESTING (Continued)

THROTTLE POSITION (TP) SENSOR

DIAGNOSTIC TROUBLE CODE (DTC) 12-22



- A — Throttle Position (TP) Sensor Connector
- B — Signal Return
- C — TP Sensor Signal
- D — MAP TP 5V Reference
- E — Electronic Governor
- F — Electronic Governor Connector
- G — PWM Throttle Control
- H — Power Feed
- J — Engine Control Module (ECM)
- K — 42 Pin Connector Pin #31 (VREF +5V)

Circuit 359:	Circuit 355:	Circuit 351:
K-Off = 0V	K-Off = 0V	K-Off = 0V
KOEO = Ground	KOEO = 1.5+/-	KOEO = 5V
KOER = Ground	KOER = 1.5V to 4.8V	KOER = 5V

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor or the stock Ford throttle body. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359F) and terminal C (Brown/White, circuit 351D) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355B) of the electronic governor. The TP signal varies from about 1.5V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions. DTC 12 will set when the ECM detects low voltage and DTC 22 for excessively high voltage.

Conditions for Setting the DTC

- KOEO or KOER.
- TP signal is $\leq$ 0.31V (12).
- TP signal is 4.9V or more (22).
- Above conditions are present for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM illuminates the (MIL).
- The ECM forces the throttle to default position of 6% open.

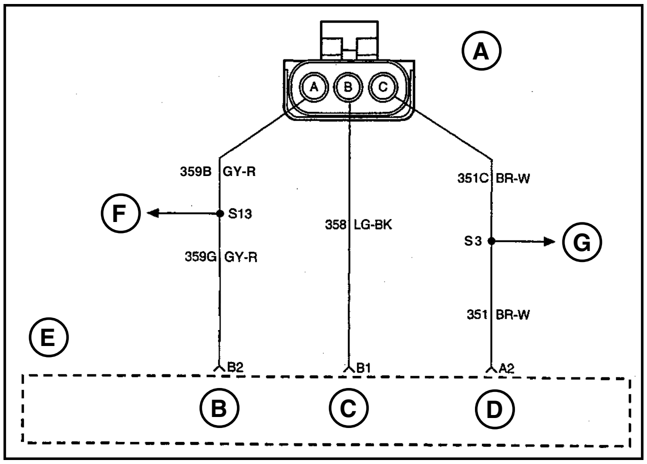
Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 5 minutes.
- If a personal computer (PC) is connect to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data screen.

IGNITION SYSTEM DIAGNOSING AND TESTING (Continued)

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

DIAGNOSTIC TROUBLE CODE (DTC) 14-24



A Manifold Absolute Pressure Sensor (MAP) Connector

B Signal Return

C Map Signal

D 5V Map Reference

E Engine Control Module (ECM)

F To CHT and IAT Sensors

G To TP Sensor

Circuit 359:
K-Off = 0V
KOEO = Ground
KOER = Ground

Circuit 358:
K-Off = 0V
KOEO = 4.8V
KOER = 1V (at idle) 4.8V (at Wide Open Throttle)

Circuit 351:
K-Off = 0V
KOEO = 5V
KOER = 5V

Circuit Description

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The ECM provides a 5V reference voltage to the MAP sensor between terminal A (Grey/Yellow, circuit 359K) and terminal C (Brown/White, circuit 351C) of the MAP sensor. A MAP signal is returned to the ECM from terminal B (Lt. Green/Black, circuit 358) of the MAP sensor. The MAP signal varies from about 1V at idle (high vacuum) to 4.8V with KOEO or at WOT (low vacuum). The MAP signal is used by the ECM as an indication of engine load. This information is used to control spark advance and air/fuel ratio. The MAP signal is also used at KOEO to indicate barometric pressure. This information is used for altitude compensation when establishing spark advance and air/fuel ratio. DTC 14 will set with a low voltage to ECM and DTC 24 will set with a high voltage to ECM.

Conditions for Setting the DTC

- KOEO or KOER.
- MAP signal is significantly lower than estimated by the ECM.
- Above conditions are present for at least 2 consecutive seconds.

Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM uses an estimated MAP value based on throttle position and engine rpm.

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 5 minutes.
- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data screen.

MST, CHT & IAT SENSOR DATA

Temperature Sensor Characteristics

TEMPERATURE (C)	(F)	NOM R, (OHMS)	NOM E_{OUT} (VOLTS)
-40	-40	925,021	4.54
-35	-31	673,787	4.50
-30	-22	496,051	4.46
-25	-13	368,896	4.41
-20	-4	276,959	4.34
-15	5	209,816	4.25
-10	14	160,313	4.15
-5	23	123,485	4.02
0	32	95,851	3.88
5	41	74,914	3.71
10	50	58,987	3.52
15	59	46,774	3.32
20	68	37,340	3.09
25	77	30,000	2.86
30	86	24,253	2.62
35	95	19,716	2.39
40	104	16,113	2.15
45	113	13,236	1.93
50	122	10,926	1.72
55	131	9,061	1.52
60	140	7,548	1.34
65	149	6,332	1.18
70	158	5,335	1.04
75	167	4,515	.91
80	176	3,837	.79
85	185	3,274	.70
90	194	2,804	.61
95	203	2,411	.53
100	212	2,080	.47
105	221	1,801	.41
110	230	1,564	.36
115	239	1,363	.32
120	248	1,191	.28
125	257	1,044	.25
130	266	918	.22
135	275	809	.19
140	284	715	.17
145	293	633	.15
150	302	563	.14

Voltage values calculated for VREF=5 volts (may vary 15% due to sensor and VREF variations).

ENGINE CRANKS BUT DOESN'T START

Circuit Description

The electronic distributorless ignition system uses a six-tower coil pack to provide spark distribution. In the coil pack, two adjacent coil towers share a common coil and are called a matched pair. The matched pairs in this application are cylinders 1 and 5, 2 and 6, and 4 and 3 cylinders.

During crank, the ECM monitors the Crankshaft Position Signal (CKP) signal. The CKP signals is used to determine which cylinder will fire first. After the CKP signal has been processed by the ECM, it will command all six injectors to allow a shot of fuel for all the cylinders. This is known as batch fire and occurs anytime while in open loop.

Diagnostic Aids

An intermittent problem may be caused by a poor connection, rubber-through wire insulation, or a wire broken inside the insulation. Check for the following items:

- Poor connection or damaged harness. Inspect the ECM harness and connectors for improper mating, broken locks, improperly formed or damaged terminals, poor terminal-to-wire connections, or a damaged harness.

Coil pack with crack or split at bottom of one or more coils may be caused by broken secondary wire or inoperative spark plug.

Engine Cranks But Doesn't Start Circuit Test

NOTE: Check fuel pressure and confirm within 60 to 68 PSI before proceeding with test. If unacceptable pressure, start Circuit Test at Step 28. Also check for spark and air before proceeding.

Step	Action	Value(s)	Yes	No
1	Perform Visual/Physical check. Verify that all accessories are "OFF". Was a Visual/Physical check performed?		Go to *Step 2*	Perform *Visual/Physical Check*
2	Perform MIL DTC retrieval procedure. If any DTC(s) are present, repair before proceeding. Is action complete (MIL circuit operation normal and DTC(s) if present repaired)?		Go to *Step 3*	Refer to *MIL Circuit Diagnosis*
3	Attempt to start the engine. Does the engine start?		Verify repair and test engine for proper operation at all temperatures	Before going to Step 4, go to Step 26, 27 & 28 If OK come back to Step 4 Go to *Step 4*
4	Check the ECM power relay for proper connection. If no problem is found, replace the relay with a known good relay. Does engine run?		Remove replacement relay and install original relay. Go to *Step 5*	Remove replacement relay and install original relay. Go to *Step 7*
5	Does engine run with original relay reinstalled?		Keep original power relay installed, verify repair and Go to MIL *DTC retrieval procedure if required.*	Remove original relay and reinstall replacement relay. Go to *Step 6*

ENGINE CRANKS BUT DOESN'T START CIRCUIT TEST (Continued)

Step	Action	Value(s)	Yes	No
6	Does engine run once again with replacement relay installed?		Leave replacement relay installed, verify repair and Go to *MIL DTC retrieval procedure if required*	Go to *Step 7*
7	Check the Fuel Pump relay for proper connection. If no problem is found, replace the relay with a known "good" relay. Does engine run?		Remove replacement relay.and install original relay	Remove replacement relay and install original relay Go to *Step 8*
8	Does engine run with original relay reinstalled?		Keep original relay installed, verify repair and Go to *MIL DTC retrieval procedure if required*	Remove original relay and reinstall replacement relay. Go to *Step 9*
9	Does engine run once again with replacement relay installed?		Leave replacement relay installed, Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 10*
10	1 . Ignition "ON". 2. Remove ECM relay and Fuel Pump relay from connectors. 3. Use a grounded test lamp to verify that B+ is available at the ECM relay and Fuel Pump relay connectors. Was B+ available at both connectors?		Go to *Step 12*	Go to *Step 11*
11	Repair open in ECM relay or Fuel Pump relay feed circuit. Is action complete (engine operation normal)?		Verify repair. Go to *MIL DTC* retrieval *procedure if required*	Go to *Step 12*
12	1. Ignition "OFF" 2. Disconnect the ECM connectors 3. Ignition "ON" 4. Probe the ignition feed circuit at the ECM harness connector with a test light to ground. Is the test light "ON"?		Go to *Step 13*	Go to *Step 15*
13	Probe the battery feed circuit at the ECM harness connector with a test light to ground. Is the test light "ON"?		Go to *Step 14*	Go to *Step 16*
14	1. Check for a faulty ECM ground or a poor ground connection at the ECM. 2. If a problem is found, repair as necessary. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 13*

ENGINE CRANKS BUT DOESN'T START CIRCUIT TEST (Continued)

Step	Action	Value(s)	Yes	No
15	Locate and repair open or short to ground in ECM ignition feed circuit. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 16*
16	Locate and repair open or short to ground in ECM battery feed circuit. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 17*
17	Install replacement ECM. Does engine start and run?		Remove replacement ECM and install original ECM	Go to *Step 18*
18	Does engine start and run?		Keep original ECM installed, Verify repair and Go to *MIL DTC retrieval procedure if required*	Remove original ECM and reinstall replacement ECM. Go to *Step 19*
19	Does engine start and run with replacement ECM installed?		Leave replacement ECM installed, Verify repair and Go to *MIL DTC retrieval procedure if required*	Go to *Step 20. (or Go to Step* 26 *if Steps 20-25 have already been performed)*
20	1. Ignition "OFF". 2. Disconnect CKP Sensor connector. 3. With a test light to ground, probe the harness connector ignition feed terminal. Is the light "ON"?		Go to *Step* 22	Go to *Step 21*
21	Check the ignition feed wire from the CKP sensor to the ECM for a short to ground or open circuit and repair as required. Is the action complete?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step* 22
22	1. Ignition "ON". 2. At the CKP harness connector, connect a test light between the ignition and ground terminals. Is the light "ON"?		Go to *Step* 24	Go to *Step 23*
23	Check the CKP sensor ground circuit for an open or short to voltage. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required.*	Go to *Step* 24
24	Check the signal circuit between the CKP sensor and the ECM for a short to ground, short to voltage, or an open. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 25*
25	Replace the CKP sensor. Is the action complete?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 17*

ENGINE CRANKS BUT DOESN'T START CIRCUIT TEST (Continued)

Step	Action	Value(s)	Yes	No
26	1. Test the fuel for water, alcohol, or other possible contamination. 2. If a problem is found, clean the fuel system and correct the contaminated fuel condition as necessary. Replace the fuel filter and replace any injectors that are not delivering fuel. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 27*
27	1. Ignition "OFF", install a suitable fuel pressure gauge at the fitting on the fuel rail. 2. Ignition "ON", observe the fuel pressure. Is the fuel pressure within the specified values, and does it hold steady?	62-64 PSI	Go to *Step 29*	Go to *Step 28*
28	Is any fuel pressure indicated?	-	Go to *Fuel System Electrical test*	Go to *Fuel System Diagnostic test*
29	1 . Ignition "OFF". 2. Install a test noid light at the injector harness connectors. (CAUTION: Do not apply battery voltage (B+) directly to the fuel injector electrical connector terminals. The solenoids may be damaged internally in a matter of seconds.) 3. Ignition "ON", crank engine. Does the light blink at each injector when the engine is cranked?		Go to *Step 30*	Go to *Step 40*
30	Check for B+ at coil connector. (Refer to Distributorless Ignition System Diagnosis.) 1 . Ignition "OFF". 2. Disconnect coil harness connector 3. Ignition "ON". 4. Measure voltage at coil connector between B+ Coil feed and ground (or use test light between feed and ground). 5. Ignition "OFF". Was voltage equal to the specified value (or is test light "ON")?	B+	Go to *Step 32*	Go to *Step 31*
31	Locate and repair open or short in coil ignition feed circuit. Was a problem found?		Verify repair, Go to *MIL DTC retrieval procedure if required*	Go to *Step 32*
32	Perform spark test. 1. Ignition "OFF". 2. Connect coil harness connector 3. Connect the end of one of the secondary spark plug wires to a suitable spark tester 4. Ignition "ON". 5. Observe the spark tester while the engine is cranking. 6. Ignition "OFF". Was a crisp blue spark observed? (Only one or two sparks followed by no result is considered the same as "No Spark".)		Verify repair, Go to *MIL DTC* retrieval *procedure if required*	Go to *Step 33*
33	Test the other 5 spark plug wires by using the test in Step 29 at each spark plug wire. When the engine is cranked, was a crisp blue spark observed? (Only one or two sparks followed by no result is the same as "No Spark".)		Go to *Step 35*	Go to *Step 34*

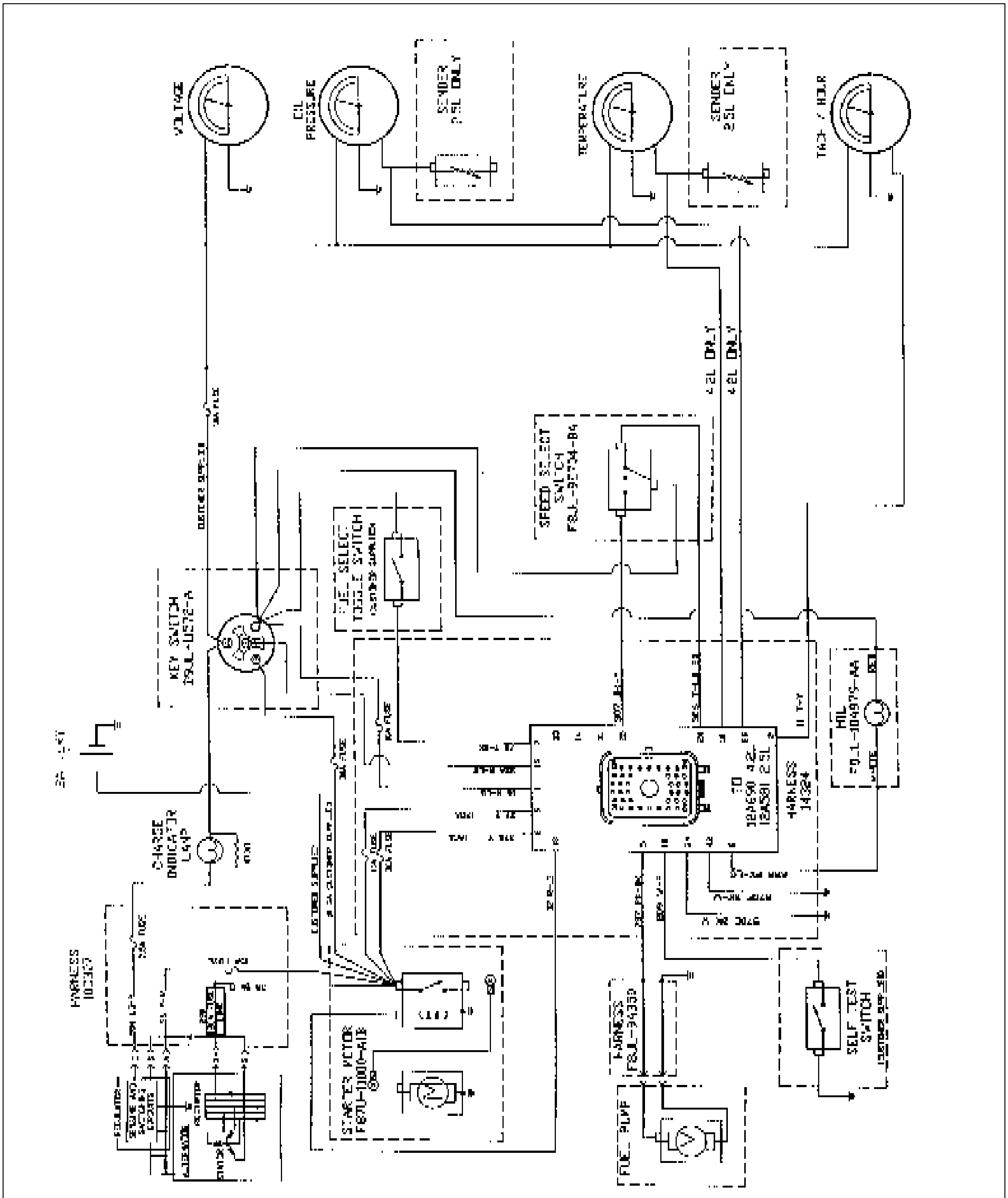
ENGINE CRANKS BUT DOESN'T START CIRCUIT TEST (Continued)

Step	Action	Value(s)	Yes	No
34	Inspect and test the secondary ignition spark plug wires. Check for the following conditions: • Verify that the resistance of all ignition wires is less than the specified value. • Verify that ignition wires are correctly routed to eliminate cross-firing. • Verify that ignition wires are not arcing to ground. • Spraying the secondary ignition wires with' a light mist of water may help locate an intermittent problem (key "ON", engine running). Was a problem found?	Refer to Page 03-35	Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 35*
35	1. Check the ignition coil primary resistance. 2. Replace the coil if it is not within the specified range of resistance. Did the coil require replacement?	Refer to Page 03-35	Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 36*
36	1. Check the ignition coil secondary resistance. 2. Replace the coil if it is not within the secondary range of resistance. Did the coil require replacement?	Refer to Page 03-35	Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 37*
37	1 . Remove the spark plugs and check for gas or oil fouling, cracks, wear, improper gap, burned electrodes or heavy deposits. 2. If spark plugs are fouled, the cause of fouling must be determined before replacing the spark plugs. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 38*
38	Check the electronic governor operation including the TPS function. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 39*
39	Check for the following engine mechanical problems. • Camshaft timing chain or gear slipped or stripped • Low compression • Leaking cylinder head gasket • Worn camshaft • Leaking or sticky valves or rings • Excessive valve deposits • Weak valve springs • Damaged, plugged or restricted exhaust system Is the action complete?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Go to *Step 40*
40	1. Check injectors wire circuit. 2. Check ECM ground and wire circuit. Was problem found?		Verify repair.	Go to *Step 41*
41	1. Replace ECM with known good one. Does the noid light blink at each injector while cranking?		Go to *Step 42*	Go to *Step 43*
42	1. Replace new ECM with old one. Does the noid light blink at each injector while cranking?		Check ECM connector pins and wire harness	Go to *Step 43*

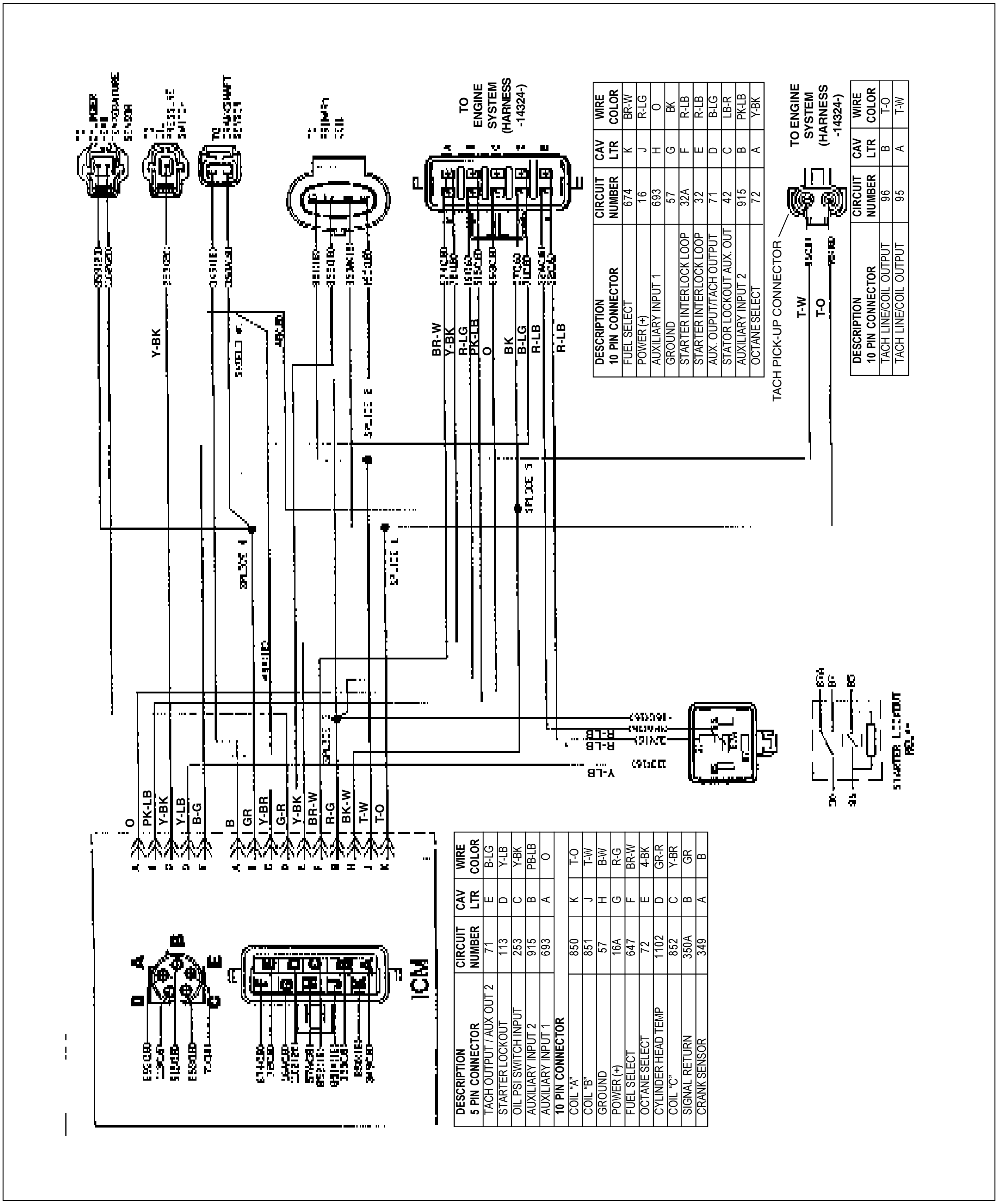
ENGINE CRANKS BUT DOESN'T START CIRCUIT TEST (Continued)

Step	Action	Value(s)	Yes	No
43	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/Physical inspection, including fuel quality check • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?		Verify repair. Go to *MIL DTC retrieval procedure if required*	Contact Ford Power Products Customer Service Center Technical Support Hotline 1-800-521-0370

Wiring Schematic – 4.2L & 2.5L Alternator, Gauges, Ignition and Discrete Governing



Wiring Assembly 4.2L DLX ICM



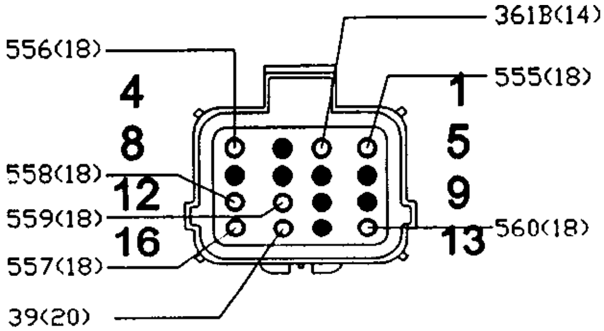
DESCRIPTION 10 PIN CONNECTOR	CIRCUIT NUMBER	CAV LTR	WIRE COLOR
FUEL SELECT	674	K	BR-W
POWER (+)	16	J	R-LG
AUXILIARY INPUT 1	693	H	O
GROUND	57	G	BK
STARTER INTERLOCK LOOP	32A	F	R-LB
STARTER INTERLOCK LOOP	32	E	R-LB
AUX. OUPUT/TACH OUTPUT	71	D	B-LG
STATOR LOCKOUT AUX. OUT	42	C	LB-R
AUXILIARY INPUT 2	915	B	PK-LB
OCTANE SELECT	72	A	Y-BK

DESCRIPTION 10 PIN CONNECTOR	CIRCUIT NUMBER	CAV LTR	WIRE COLOR
TACH LINE/COIL OUTPUT	96	B	T-O
TACH LINE/COIL OUTPUT	95	A	T-W

DESCRIPTION 5 PIN CONNECTOR	CIRCUIT NUMBER	CAV LTR	WIRE COLOR
TACH OUTPUT / AUX OUT 2	71	E	B-LG
STARTER LOCKOUT	113	D	Y-LB
OIL PSI SWITCH INPUT	253	C	Y-BK
AUXILIARY INPUT 2	915	B	PB-LB
AUXILIARY INPUT 1	693	A	O
10 PIN CONNECTOR			
COIL “A”	850	K	T-O
COIL “B”	851	J	T-W
GROUND	57	H	B-W
POWER (+)	16A	G	R-G
FUEL SELECT	647	F	BR-W
OCTANE SELECT	72	E	4-BK
CYLINDER HEAD TEMP	1102	D	GR-R
COIL “C”	852	C	Y-BR
SIGNAL RETURN	350A	B	GR
CRANK SENSOR	349	A	B

16 PIN CONNECTOR

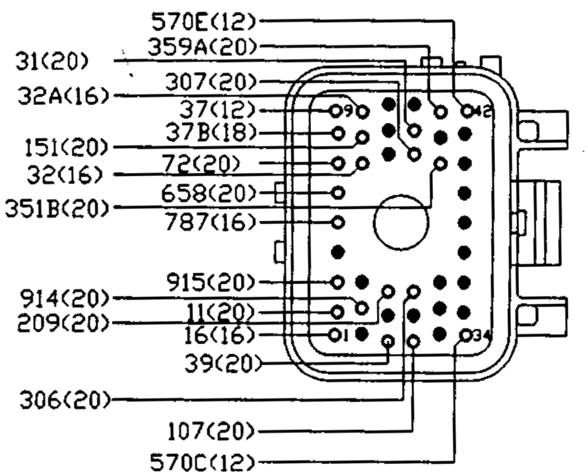
From Wire Harness XU1L-12A690-BA to 9D930



361B R 14	6	VPWR BATTERY (+)
39 R-W 18	15	WATER TEMP SENDER
558 BR-LB 18	12	FUEL INJECTOR # 4
557 BR-Y 18	16	FUEL INBJECTOR # 3
556 W 18	4	FUEL INJECTOR # 2
555 T 18	1	FUEL INJECTOR # 1
560 LG-O 18	13	FUEL INJECTOR # 6
559 T-BK 18	11	FUEL INJECTOR # 5

42 PIN CONNECTOR

From Wire Harness XU1L-12A690-BA to 14324

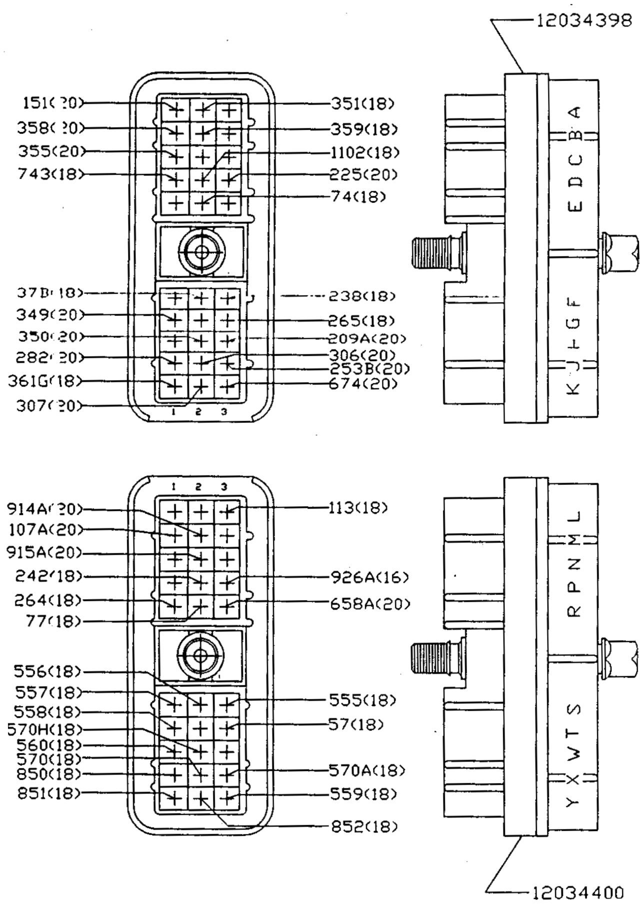


SPLICE # 2

NOT USED	28	
POWER (KEY ON)	01	16 R-LG 16
NOT USED	04	
NOT USED	20	
NOT USED	10	
NOT USED	12	
NOT USED	17	
NOT USED	19	
FUEL PUMP	05	787 PK-BK 16
KEEP ALIVE PWR-BATTERY (+)	08	37B Y 18
NOT USED	21	
NOT USED	23	
NOT USED	27	
TACH LEAD	02	11 T-Y 20
NOT USED	29	
NOT USED	30	
VREF (+5 V)	31	351B BR-W 20
NOT USED	32	
NOT USED	35	
NOT USED	36	
NOT USED	38	
POWER GROUND	34	570C BK-W 12
POWER GROUND	42	570E BK-W 12
NOT USED	39	
VPWR BATTERY (+)	09	37 Y 12
CUSTOMER WATER TEMP.	16	39 R-W 18
NOT USED	40	
NOT USED	41	
DATA LINK	22	107 P 20
DRIVE BY WIRE SIGNAL INPUT	14	151 LB-BK 20
NOT USED	37	
SELF TEST INPUT	18	209 W-P 20
GOVERNOR SPEED SELECT #1	24	306 T-LB 20
GOVERNOR SPEED SELECT #2	25	307 BK-Y 20
MALFUNCTION INDICATOR LAMP	06	658 PK-LG 20
FUEL SELECT	07	72 Y-BK 20
DATA LINK CONNECTOR (+)	11	914 T-O 20
DATA LINK CONNECTOR (-)	03	915 PK-LB 20
STARTER IN FROM SWITCH	15	32A R-LB 16
DRIVE BY WIRE SIGNAL RETURN	33	359A GY-R 20
STARTER LOCKOUT TO RELAY	13	32 R-LB 16
OIL PRESSURE SENDER	26	31 W-R 20

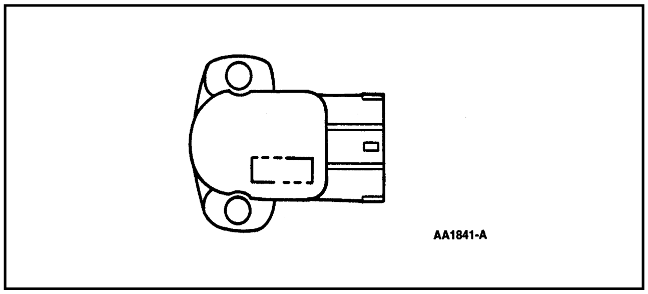
ECM CONNECTORS

From Wire Harness XU1L-12A690-BA to ECM



	C3	NOT USED
	F1	NOT USED
	W3	NOT USED
	L2	NOT USED
	H1	NOT USED
	A3	NOT USED
349 DB 20	G1	CRANKSHAFT SENSOR RETURN (+)
350 GY 20	H2	CRANKSHAFT SENSOR RETURN (-)
232 DB-O 20	J1	CAMSHAFT SENSOR FEED (+)
355 GY-W 20	C1	THROTTLE POSITION SENSOR INPUT
238 DG-Y 18	F3	FUEL PUMP MONITOR
37B Y 18	F2	KEEP ALIVE PWR-BATTERY (+)
560LG-O18	W2	FUEL INJECTOR #6
559T-B 18	Y3	FUEL INJECTOR #5
555 T 18	S3	FUEL INJECTOR #1
556 W 18	S2	FUEL INJECTOR #2
557 BR-Y 18	S1	FUEL INJECTOR #3
558 BR-LB 18	T1	FUEL INJECTOR #4
351 BR-W 18	A2	VREF (+5 V)
77 DB-Y 18	R2	DRY FUEL MODULATOR
	B3	NOT USED
	C2	NOT USED
570 BK-W 18	X2	POWER GROUND
570A BK-W 18	X3	POWER GROUND
570B BK-W 18	W1	POWER GROUND
	N1	NOT USED
	G2	NOT USED
	E3	NOT USED
	P1	NOT USED
852 Y-W 18	Y2	COIL 'C' IGNITION MODULE
107A P 20	M1	DATA LINK
151 LB-BK 20	A1	DRIVE BY WIRE
	L1	NOT USED
209A W-P 20	H3	SELF TEST INPUT
306 T-LB 20	J2	GOVERNOR SPEED SELECT #1
307 BK-Y 20	K2	GOVERNOR SPEED SELECT #2
658A PK-LG 20	R3	MALFUNCTION INDICATOR LAMP
72 Y-BK 20	K3	FUEL SELECT
914A T-O 20	M2	DATA LINK CONNECTOR (+)
915A PK-LB 20	N2	DATA LINK CONNECTOR (-)
926A LB-O 16	P3	FUEL PUMP RELAY CONTROL
	M3	NOT USED
361G R 18	K1	VPWR BATTERY (+)
	N3	NOT USED
57A BK 18	T3	GROUND
359 GY-R 20	B2	SIGNAL RETURN
	E1	NOT USED
743 GY 20	D1	INTAKE AIR TEMP SENSOR INPUT
358 LG-BK 20	B1	MAP SENSOR INPUT
1102 Y-GR 20	D2	CHT SENSOR INPUT
	T2	NO USAGE
113 Y-LB 18	L3	STARTER LOCKOUT
850 Y-BK 18	X1	COIL 'A' IGNITION MODULE
264 W-LB 18	R1	ACTUATOR
225 BK-Y 20	D3	DRY FUEL SENSOR
253 DG-W 20	J3	OIL PRESSURE SWITCH
265 LG-W 18	G3	IDLE AIR CONTROL
242 DG 16	P2	DRY FUEL LOCKOFF- TO RELAY
851 Y- R 18	Y1	COIL 'B' IGNITION MODULE
74 GY-LB 20	E2	HEGO SENSOR SIDE

Drive-By-Wire Foot Pedal Switch



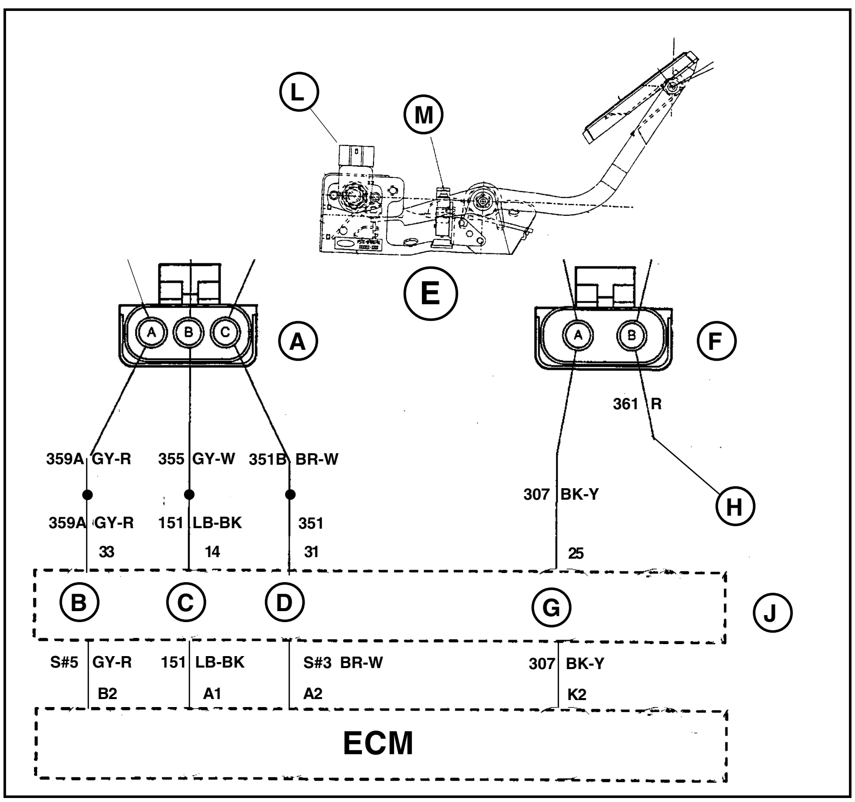
Typical Foot Pedal Switch

Circuit Description

The Pedal Position (PP) sensor is a potentiometer which is attached to the pedal assembly pivot shaft. The ECM provides a 5V reference voltage to the PP sensor between terminal A (Grey/Red, circuit 359) and terminal C (Brown/White, circuit 351B) of the pedal assembly. A PP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the pedal assembly. The PP signal varies from about .7 or .8V at idle to 4.8V at WOT. The PP signal is an important input used by the ECM for RPM control. DTC 13 will set when the ECM detects low voltage and DTC 23 for excessively high voltage. DTC 16.

The Idle Validation Switch (IVS) is an off/on switch (normally opened), with 12V as a power supply from the ignition switch, on Circuit 361. When the IVS fails or is out of adjustment, it will set DTC 16. This code will be set when the Pedal Position (PP) sensor is out of set range while IVS off, damaged, misadjusted, IVS malfunction, damaged wiring, electrical failure or mechanical failure.

First Version Foot Pedal



- **A** Pedal Position (PP) Sensor Connector
- **B** Signal Return
- **C** PP Sensor Signal
- **D** PP 5V Reference
- **E** Pedal Assembly
- **F** Connector for Idle Validation Switch M
- **G** Pedal Assembly Switch Return Signal
- **H** Power Feed From Ignition Switch
- **J** 42-Pin Connector
- **L** Connector for A
- **M** Idle Validation Switch

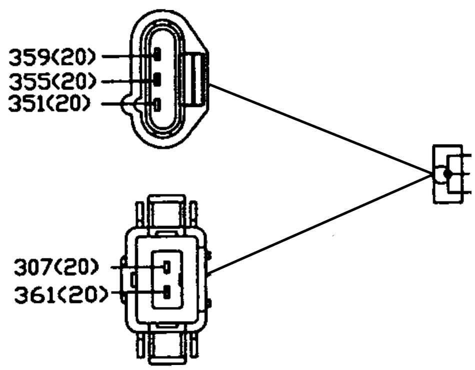
Circuit 359:
K-Off = 0V
KOEO = Ground
KOER = Ground

Circuit 355:
K-Off = 0V
KOEO = $\pm$ 0.70V
KOER = $\pm$ 0.70V to 4.8V

Circuit 351:
K-Off = 0V
KOEO = 5V
KOER = 5V

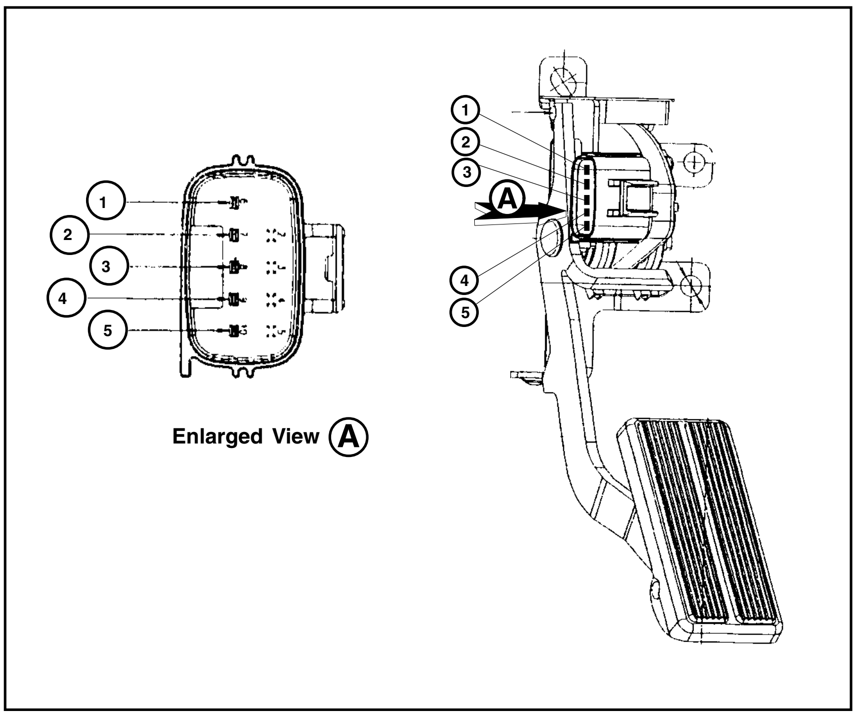
Circuit 307:
K-Off = 0V
KOEO = 0V (w/foot pedal at rest)
KOER $\begin{cases} \text{0V (w/foot pedal at rest)} \\ \text{12V (w/foot pedal depressed)} \end{cases}$

Drive-By-Wire Foot Pedal Wiring Harness – F8JL-12B476-AA



Circuit Number	Circuit Description	Color	Wire Size
361	VPWR (+) 12	R	20
359	Signal Return	GY-R	20
355	Drive by Wire Input	GY-W	20
351	VREF (+) 5V	B-W	20
307	Governor Select #2	BK-Y	20

Second Version Foot Pedal



A Enlarged View

1 Signal Return

2 PP Sensor Signal

3 PP 5V Reference

4 Pedal Assembly Switch Return Signal (Ground)

5 Power Feed From Ignition Switch

NOTE: All wires connect to the 42 Pin Connector as previous pedal on Page 03-52.

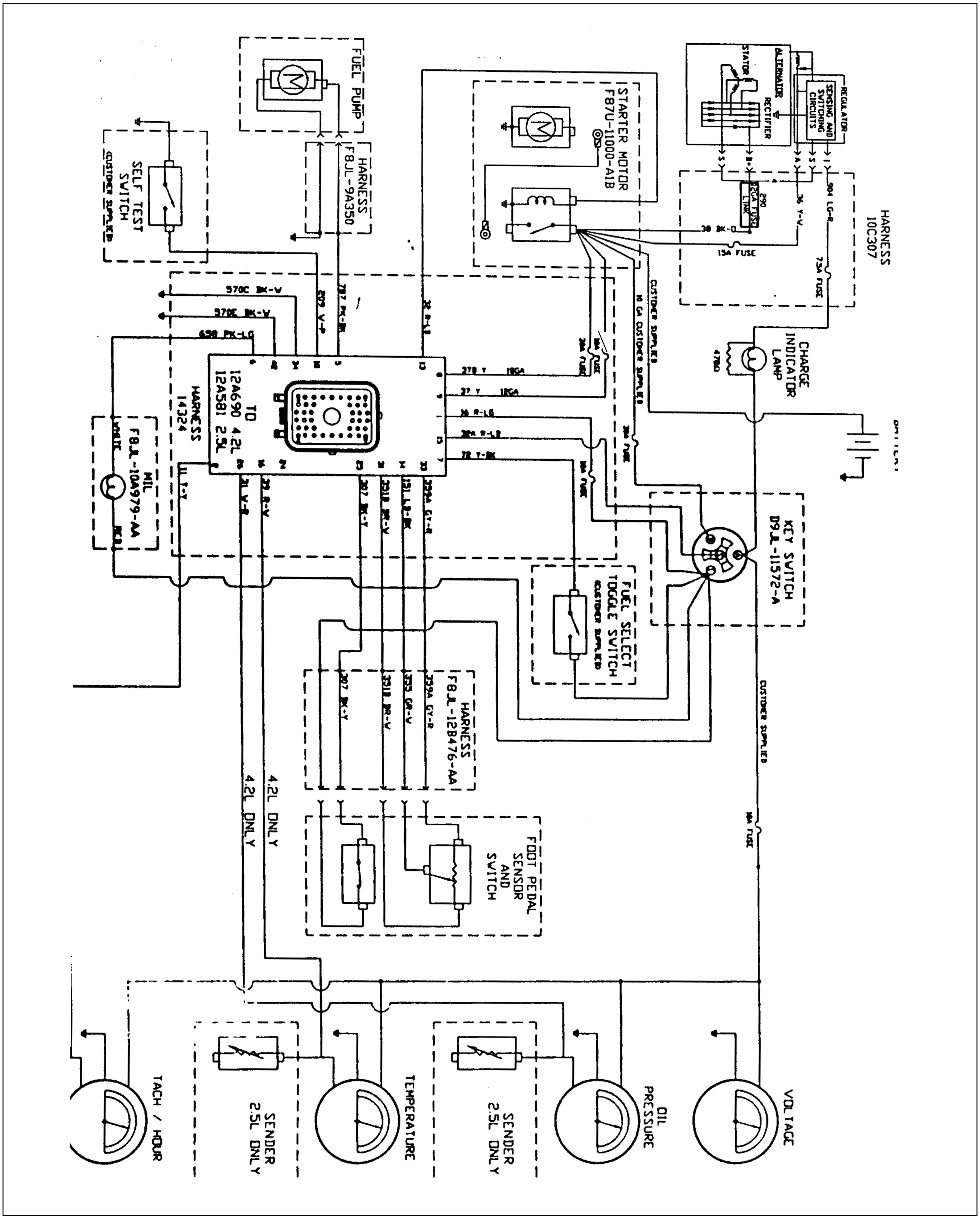
Circuit 359:
K-Off = 0V
KOEO = Ground
KOER = Ground

Circuit 355:
K-Off = 0V
KOEO = $\pm$ 0.70V
KOER = $\pm$ 0.70V to 4.8V

Circuit 351:
K-Off = 0V
KOEO = 5V
KOER = 5V

Circuit 307:
K-Off = 0V
KOEO = 12V (w/foot pedal at rest)
KOER – 12V (w/foot pedal at rest)
KOER – 0V (w/foot pedal depressed)

Wiring Schematic – 4.2L & 2.5L Alternator, Gauges, Ignition – Drive-By-Wire



REMOVAL AND INSTALLATION INSTRUCTIONS OF ECM/ICM

NOTE: Make sure correct program is installed before condeming ECM. To download or upload program for validation, use Interface Communication Cable Part Number F8JL-9A820-AA. Call your nearest FPP Distributor listed in the back of this manual.

Removal:

1. Remove the negative (ground) battery cable.
2. Loosen the bolts (2) and remove the wire connectors (2).

NOTE: Remove the vacuum hose from the ICM

3. Remove the module hold down bolts (4).

Installation:

CAUTION: The installation instruction for the ECM & ICM must be followed or potential failure of component is likely.

NOTE: If the ECM or ICM's was not installed correctly when servicing, please call FPP Customer Service (800) 521-0370.

1. Install the ECM or ICM in a vertical position with the electrical connectors facing downward.

NOTE: The mounting location should be away from all heat source in an area that will not exceed 180°F.

2. Install the hold down bolts (4) and tighten for ICM 8-10 Nm (71-88 lb/in). The ECM bolts (4) tighten to .8 Nm (15 lb/in).
3. Insert the two wire connectors using great care not to bend or push out the terminals.

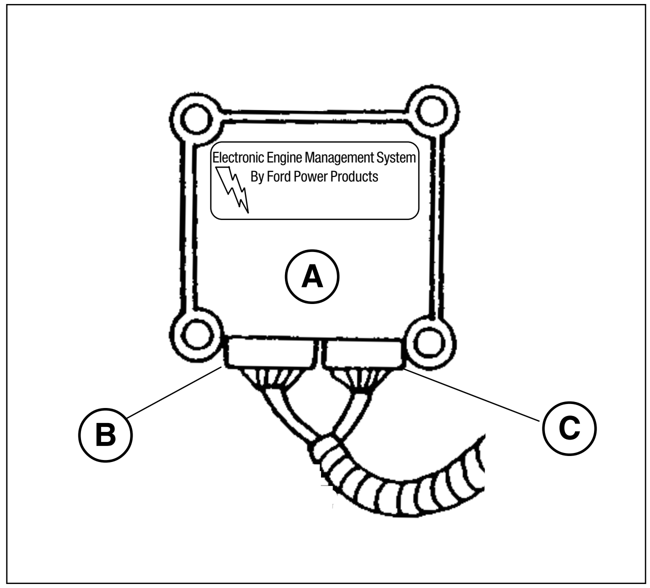
NOTE: The connectors are keyed for correct installation always apply a small amount of dielectric grease to the face of the connectors.

4. Tighten the ECM connector bolts (2) to .8-2.5 Nm (15-19 lb/in).

NOTE: When the program has been changed on an ECM, please mark on the outside of ECM cover the date, program installed, and initial.

5. Re-connect the vacuum hose on the ICM.
6. Re-connect the negative (ground) battery cable.

Engine Control Module (ECM)

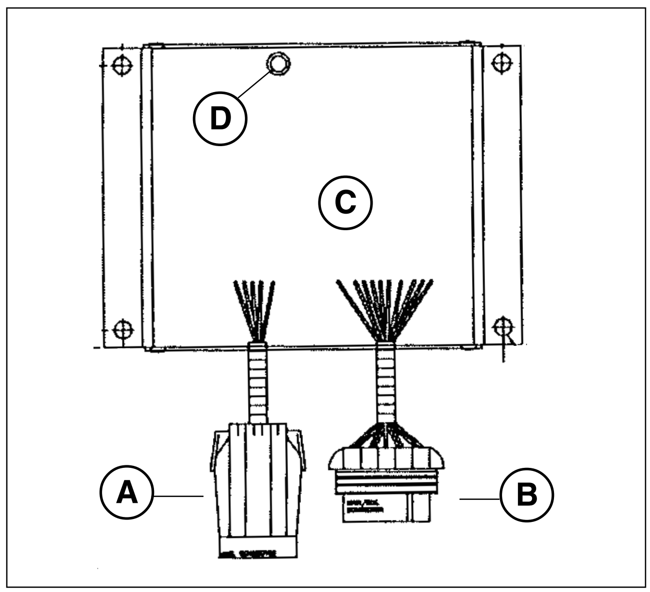


A **ECM**

B **Connector Port for A thru K (Connector #12034391)**

C **Connector Port L thru Y (Connector #12034400)**

Ignition Control Module (ICM)



A **5 Pin Auxiliary Connector (Round)**

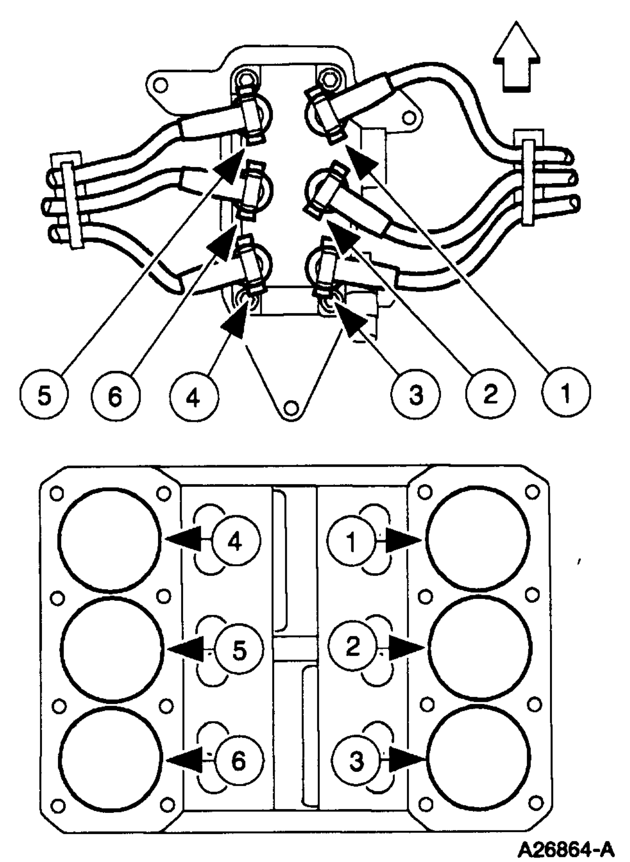
B **10 Pin Main Connector (Oblong)**

C **Ignition Control Module**

D **Vacuum Port (5/32'' I.D.) MAP Sensor**

SPECIFICATIONS

Spark Plug Wire Routing



General Specifications

Item	Specification
Base Timing	10 Degrees Before Top Dead Center
Firing Order	1-4-2-5-3-6
Spark Plug Gap mm (Inch)	1.12 (.44 in.)
Replacement Spark Plug (Either Side)	Motorcraft AGSF-42FCM
Lubricant – Silicone Dielectric Compund Motorcraft WA-10 D7AZ-19A331-A	ESE-M1C171-A

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Air Intake Sensor	8-10	-	71-89
Camshaft Position Sensor Bolts (2)	2.3-3.5	-	20.4-27.5
Camshaft Synchronizer Bolt (1)	20-30	15-22	-
Crankshaft Position Sensor	2-4	-	18-36
Cylinder Head Temperature Sensor	9-11	-	80-95
Engine Control Module Mounting Bolts	.8	-	15
Engine Control Module Wire Connector	.8-2.5	-	15-19
Foot Pedal Mounting Bolts	Non-Ford, Use OEM Specifications		
Heated Oxygen Sensor	36-46	27-34	-
Idle Air Control (IAC) Valve	11	-	84
Ignition Coil Nuts and Stud Bolt	8-11	-	71-97
Ignition Control Module Mounting Bolts	8-10	-	71-88
Manifold Skin Temperature Sensor	8-10	-	71-88
Spark Plugs	10-20	8-14	-
Throttle Position Sensor	2.8-3.4	-	25-30
42 Pin Connector Bolt	4-5.6	-	35.50

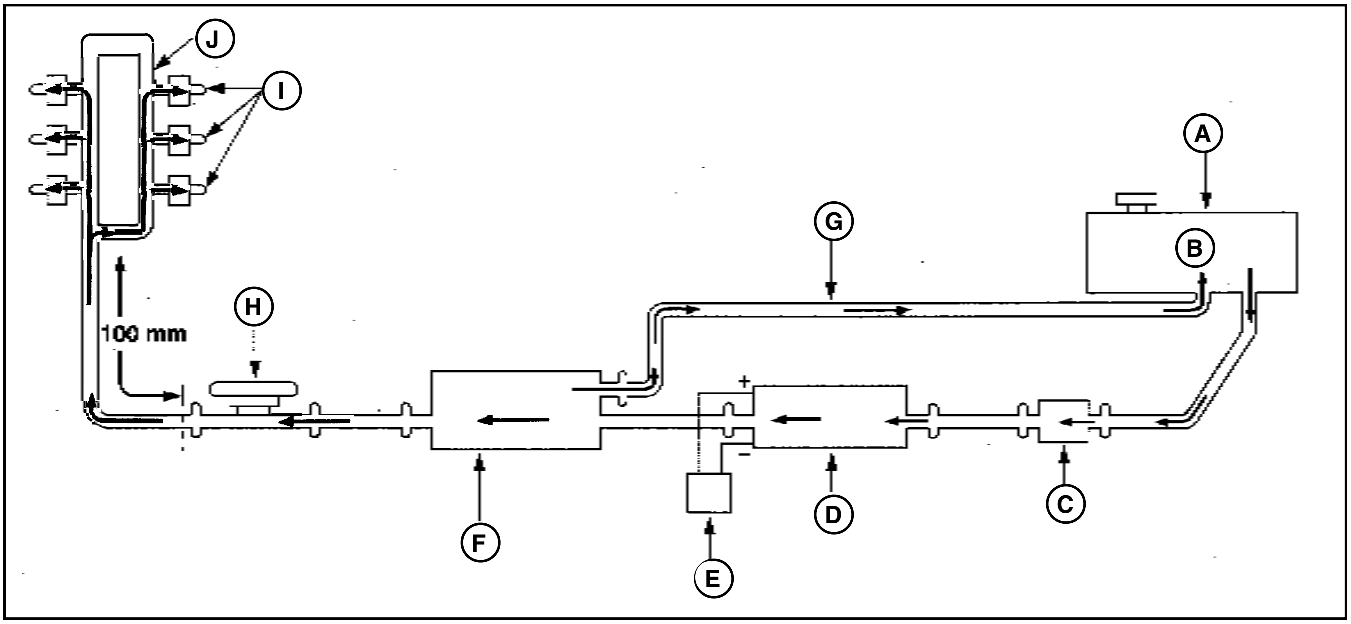
FUEL INDEX

04

FUEL SYSTEM DESCRIPTION AND OPERATION

The fuel system is designed to deliver fuel safely, and an adequate supply as demanded. All connections are designed to prevent leaks and to prevent lines from working loose. The delivery system consists of a fuel tank, filter, pump, pressure regulator, damper assembly, fuel rail, and injectors.

Fuel Flow Diagram for Gasoline/Petrol EFI



- (A) Fuel Tank
- (B) Gasoline
- (C) Fuel Filter
- (D) Fuel Pump
- (E) Fuel Pump Relay
- (F) Fuel Pressure Regulator & Fuel Filter
- (G) Return Fuel Line to Fuel Tank
- (H) Damper Assembly
- (I) Fuel Injectors
- (J) Fuel Rail

A. Fuel tanks:
- The DOEM or OEM supplies tanks.
- Have a fuel outlet and return inlet.
- The gas cap must be vented.

B. Fuels: The following fuels must all be UNLEADED AND CLEAN:
- Gasoline/petrol: This engine is designed to operate on unleaded 87 or 89 octane gasoline.
- Gasohol/Ethanol: A mixture of gasoline and ethanol (grain alcohol) containing up to 10% ethanol by volume with properly formulated cosolvents and other necessary additives. Blends index of 87 or 89.
- Gasohol/Methanol: A mixture of gasoline and alcohol (wood alcohol, etc.) containing up to 5% methanol by volume with properly formulated cosolvents and other necessary additives. Blends index of 87 or 89.

C. Fuel filter:
- Low pressure.
- In-line type that has 20 micron filtration.
- Non serviceable.
- Must be replaced as needed.

D. Fuel pump:

CAUTION: The electric fuel pump MUST NOT be mounted directly on the engine assembly, as engine vibration will shorten the life of the pump.

- Inlet tube (7.9mm / 5/16 in.).
- Is a high-pressure fuel pump.
- Mounted on the frame rail, not on the engine.
- Must be mounted in packed foam.
- Is powered by B+ through a relay.
- Positive spade 5/16 in. is larger in size compared to negative spade 1/4 in.
- Outlet tube (7.9mm / 5/16 in.) located at the electrical connector end of pump.

E. Fuel pump relay:
- Powered by B+ from ECM.
- Controlled by the ECM.
- Directs B+ to fuel pump.
- Is identical and interchangable with the power, starter, and alternate fuel relays.

FUEL SYSTEM DESCRIPTION AND OPERATION (Continued)

F. Fuel pressure regulator and filter:
- Fuel enters through (7.9mm / 5/16 in.) inlet tube located at center of the end of the regulator with return outlet tube.
- Controls the fuel pressure at a constant 441 + or -10 kPa (64 psi + or -1.5 psi) to the fuel rail.
- Directs excess fuel through the return outlet tube (9.5mm / 3/8 in.) located off center of end with inlet tube.
- Contains a fuel filter (filter media PMS 120 high capacity pleated phenolic treated paper) that cannot be serviced. Must replace complete unit to service.
- Directs fuel out the single outlet tube (9.5mm / 3/8 in.) located at center of opposite end of regulator.

NOTE: Cannot be serviced; must be replaced when plugged or inoperative.

G. Fuel return line:
- Fuel returning to tank is under pressure and may be as high as 689 kPa (100 psi) if the line is blocked.
- Excess fuel supplied by the fuel pump but not needed by the engine is returned to the fuel tank.

H. Damper assembly:
- Absorbs high-pressure spikes caused by shut downs from high RPM and high demand of fuel under a sudden full load.
- Must be mounted within 100mm from fuel rail.

I. Fuel injectors (6 injectors):
- Sequential multiport fuel injectors.
- Batch fired during crank at start up.
- Solenoid operated electrically controlled by the ECM.
- Positioned so their tips direct fuel just ahead of the engine intake valves.
- Atomize the fuel as the fuel is delivered.
- Are deposit resistance. Do not clean.

NOTE: Cannot be serviced; must be replaced when plugged or inoperative.

J. Fuel rail:
- Attaches to the lower intake manifold.
- Receives fuel from the fuel supply line.
- Delivers fuel to the 6 injectors.
- Must be replaced as a complete unit if it fails.
- Holds the pressure test/relief Schrader valve.

The fuel charging and controls system consist of the:

- Throttle body (9E926).
- Fuel charging wiring.
- Fuel pressure relief valve (9H321).
- Fuel injectors.

The fuel charging and controls system is:

- A sequential, multiport fuel injection (SFI) system.
- Pulse-width modulated.

The Actuator (throttle body):

- Controls air supply to the upper intake manifold (9424) by positioning the throttle plate at different angles from wide open throttle, to partially opened at idle.

⚠ CAUTION: Do not force the throttle plate open. This may cause permanent damage to the actuator.

- Is not adjustable.
- Cannot be cleaned.

NOTE: These two types of governors are controlled by pre-determined setting electronically set in the ECM. These settings are not adjustable. They can only be programmed by authorized personnel only. Contact your local FPP Distributor listed in the back of this manual for information.

The fuel pressure relief valve:

- Is a Schrader valve.
- Located on the fuel rail.
- Used to inspect and relieve fuel pressure.
- Can be replaced.

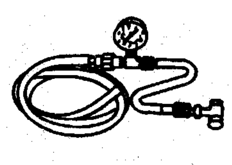
GENERAL PROCEDURES

Pressure Relief

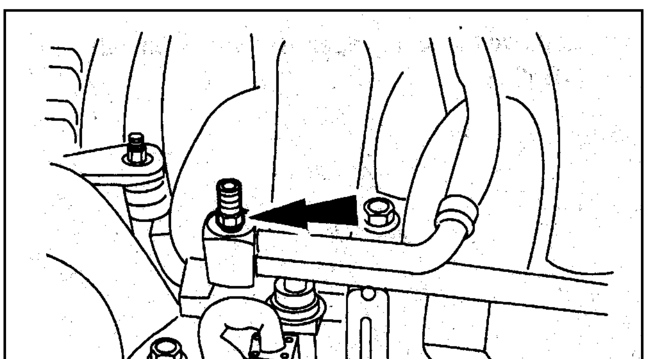
WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE SERVICING OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED TO PREVENT ACCIDENTAL SPRAYING OF FUEL, CAUSING PERSONAL INJURY OR A FIRE HAZARD.

Special Tool(s)

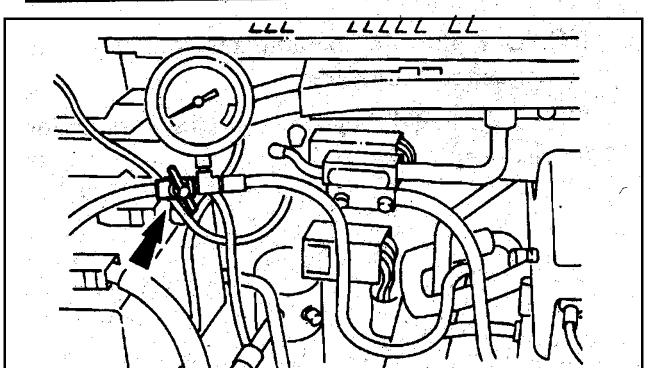
 ST1371-A	Fuel Pressure Gauge 310-012 (T80L-9974-B)

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).



AV0292-A

1. Remove the Schrader valve cap and install the Fuel Pressure Gauge.



V9690-A

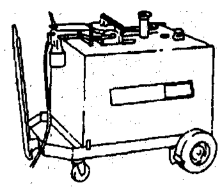
WARNING: PLACE OR STORE ALL FUEL IN A SUITABLE CONTAINER THAT COMPLIES WITH OSHA REQUIREMENTS AND IS FM APPROVED TO HELP PREVENT FIRES OR EXPLOSION WHICH COULD RESULT IN PERSONAL INJURY.

2. Open the manual valve slowly on the Fuel Pressure Gauge and relieve the fuel pressure.
   - This will drain some fuel out of the system.

GENERAL PROCEDURES (Continued)

Pressure Relief (Continued)

Special Tool(s)

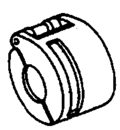
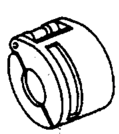
 ST1134-A	Fuel Storage Tanker 164-R3202 or equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Coupling – Spring Lock

Disconnect spring lock.

Special Tool(s)

 ST1146-A	Spring Lock Coupler Tool 310-D004 (D87L-9280-A) or equivalent
 ST1147-A	Disconnect Tool (1/2 inch) 310-D005 (D87L-9280-B) or equivalent

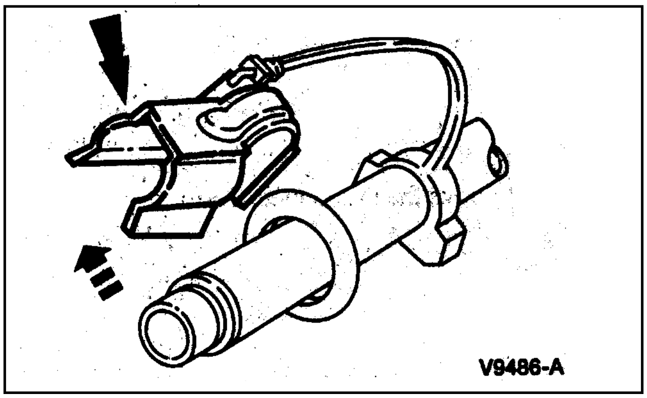
Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

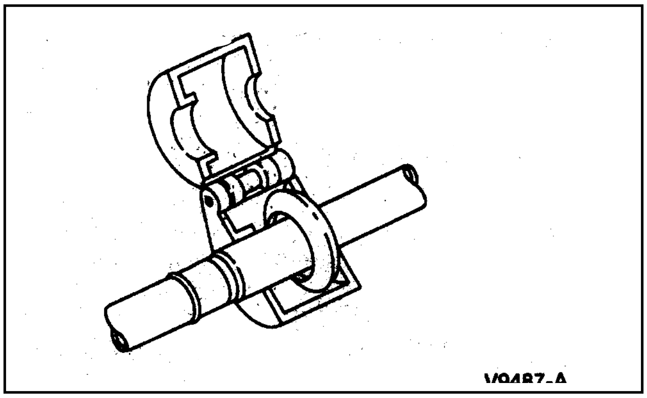
WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE SERVICING OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED TO PREVENT ACCIDENTAL SPRAYING OF FUEL, CAUSING PERSONAL INJURY OR A FIRE HAZARD.

1. Disconnect the battery ground cable.
2. Relieve the fuel pressure. For additional information, refer to Pressure Relief in this section.

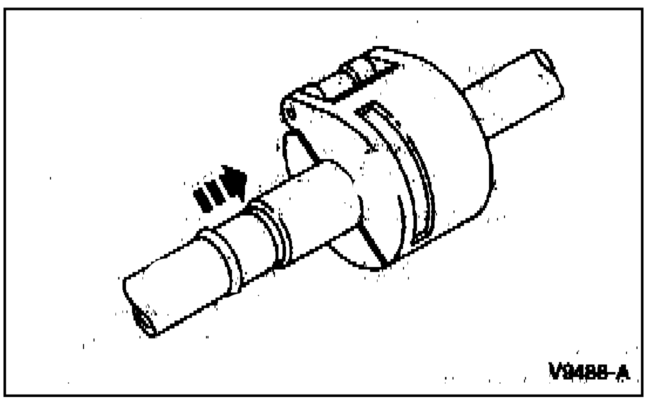
GENERAL PROCEDURES (Continued)



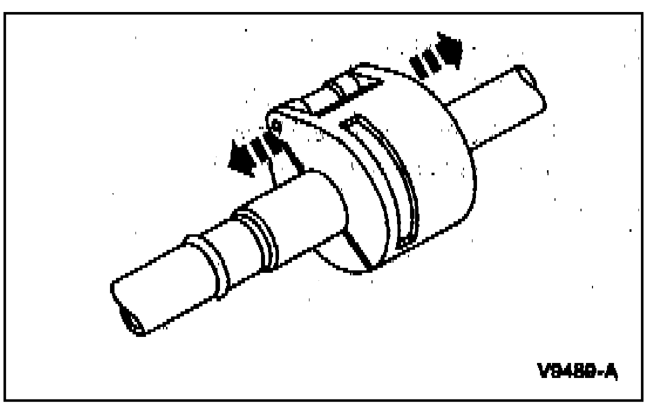
3. Remove the fuel tube clip.



4. Install the Disconnect Tool.

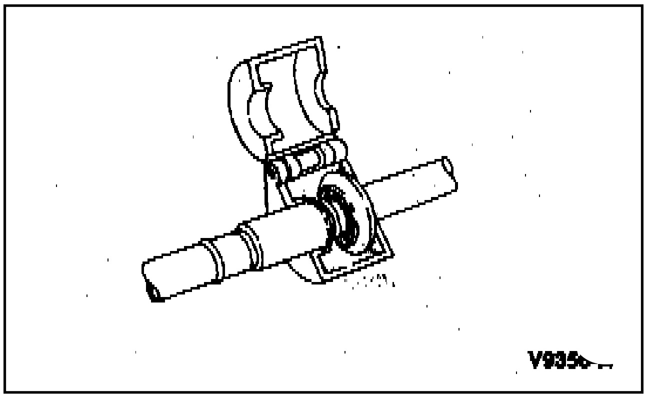


5. Close and push the Disconnect Tool into the open side of the cage.



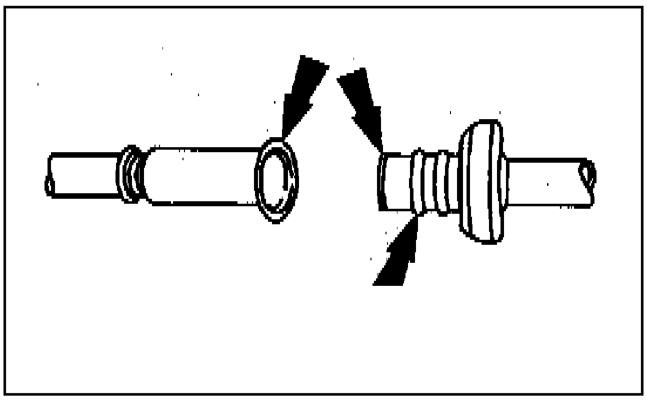
6. Separate the fitting.

GENERAL PROCEDURES (Continued)



7. Remove the Disconnect Tool.

Connect Spring Lock

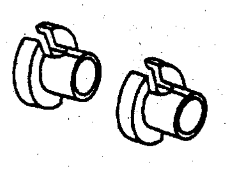


1. Connect the fitting.
   - Inspect and clean both the coupling ends.
   - Lubricate the O-rings with clean engine oil meeting Ford specification WSS-MN2C153-F.
   - Connect the fitting.
   - Pull on the fitting ot make sure it is fully engaged.
   - Install the safety clip.
2. Connect the battery ground cable.

GENERAL PROCEDURES (Continued)

Fittings – Push Connect

Special Tool(s)

 ST1399-A	Fuel Line Disconnect Tool 310-S039 (T90T-9550-S)

Special Service Tools called for by the procedures can be obtained by calling:

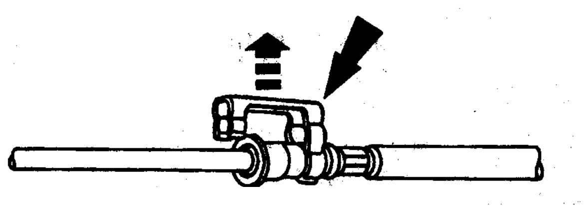
1-800-ROTUNDA (1-800-768-8632).

Disconnect

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

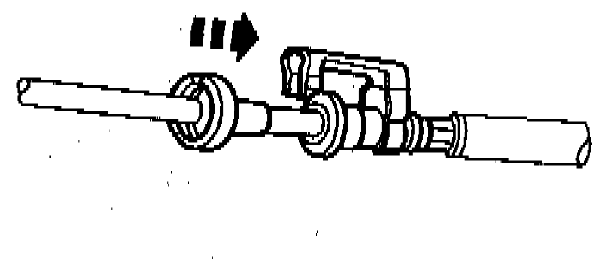
WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE SERVICING OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED TO PREVENT ACCIDENTAL SPRAYING OF FUEL, CAUSING PERSONAL INJURY OR A FIRE HAZARD.

1. Disconnect the battery ground cable.
2. Relieve the fuel pressure. For additional information, refer to Pressure Relief in this section.
3. Disconnect the safety clip from the male hose.

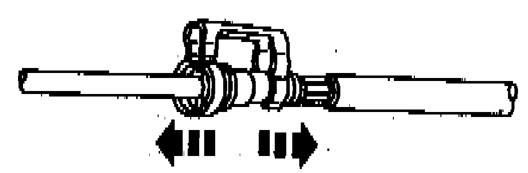


V9506-A

GENERAL PROCEDURES (Continued)

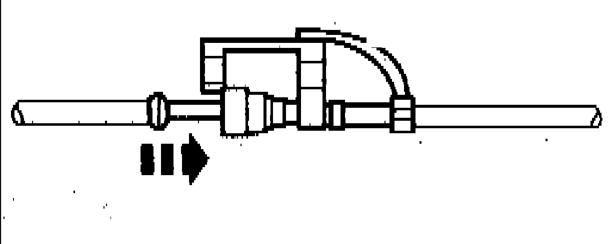

AV0311-A

4. Install the Fuel Line Disconnect Set and push into the fitting.

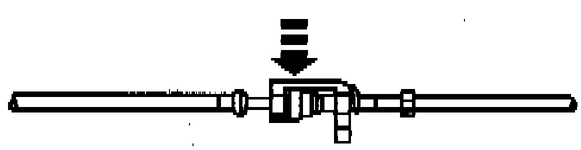

V9463-A

5. Separate the fittings.
   - Inspect for damage.
   - Clean the fittings.

Connect


AV0312-A

1. Connect the fitting.
   - Lubricate the tube end with clean engine oil meeting Ford specification WSS-M2C153-F to easy assembly.
   - Align the tube to the fitting and push until you hear a click.


V9465-A

2. First pull on the fitting to make sure it is fully engaged, then install the safety clip.
3. Connect the battery ground cable.

GENERAL PROCEDURES (Continued)

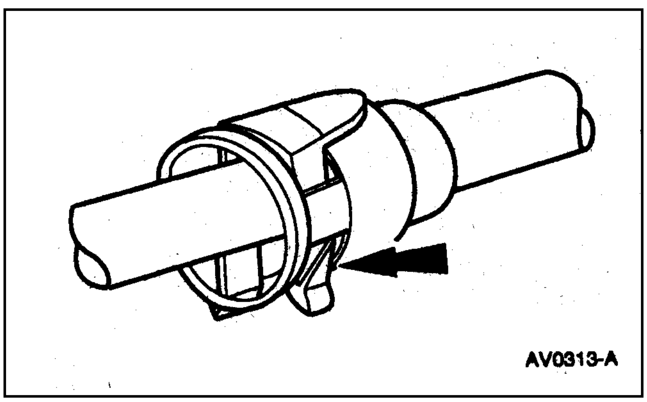
Fittings – R-Clip

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

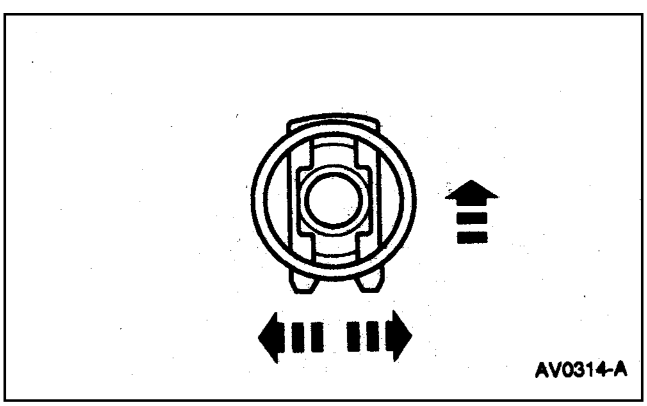
WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE SERVICING OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED TO PREVENT ACCIDENTAL SPRAYING OF FUEL, CAUSING PERSONAL INJURY OR A FIRE HAZARD.

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

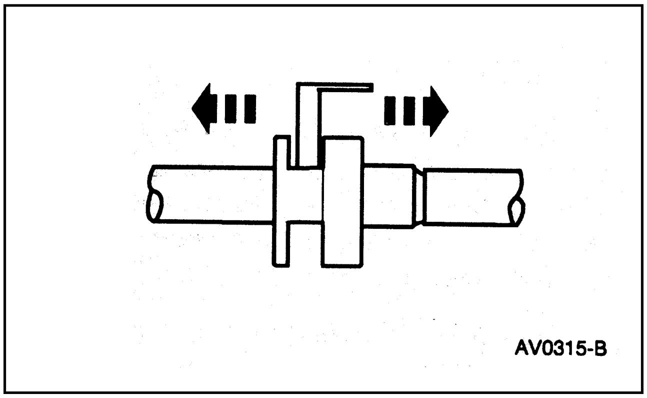
1. Disconnect the battery.
2. Relieve the fuel pressure. For additional information, refer to Pressure Relief in this section.
3. Remove the shipping tab by bending downward.



4. Spread the hairpin clip legs and push the clip into the fitting.



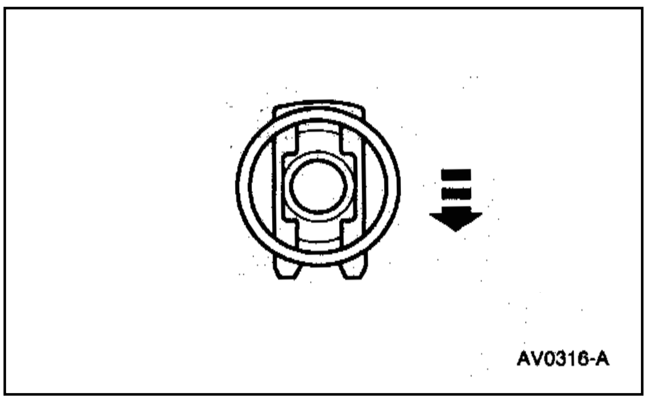
GENERAL PROCEDURES (Continued)



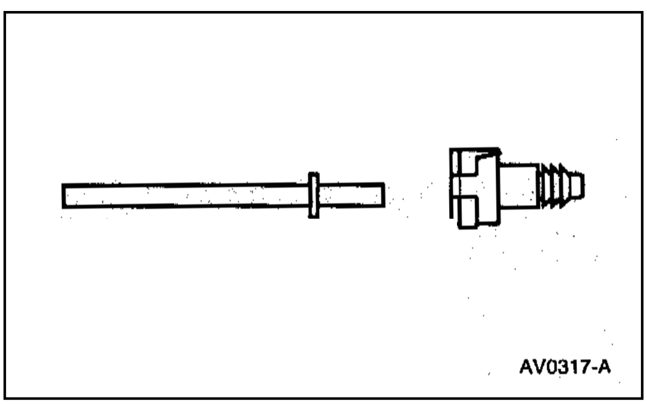
5. Separate the fitting from the tube.

Connect

1. Inspect the fitting and the tube for damage. Remove any dirt or obstructions.
2. Apply a light coat of clean engine oil meeting Ford specification WSS- M2C153-F to the male tube end.

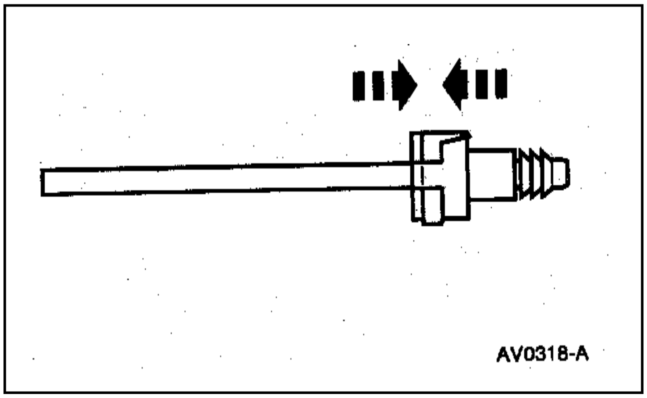


3. Insert the hairpin clip into the fitting.

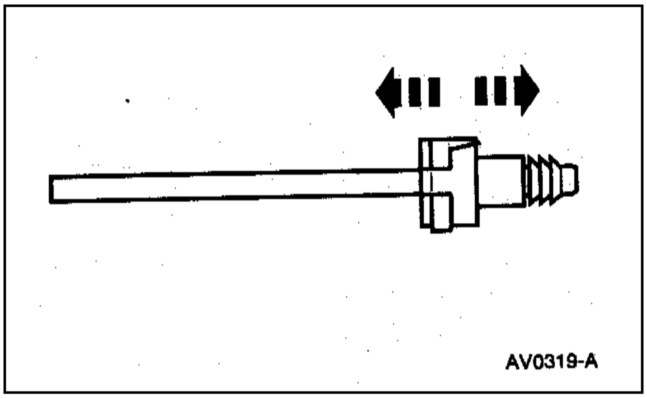


4. Align the tube and the fitting.

GENERAL PROCEDURES (Continued)



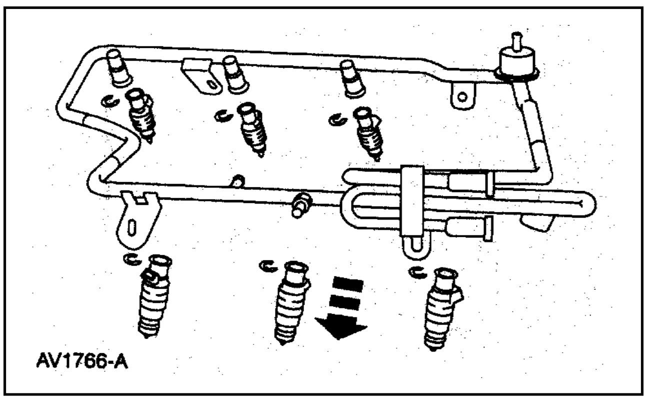
5. Insert the tube in the fitting and push together until a click is heard.



6. Pull on the connection to make sure it is fully engaged.
7. Connect the battery.

REMOVAL AND INSTALLATION

Fuel Injectors



Removal

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE WORKING ON OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

1. Disconnect the battery ground cable.
2. Relieve fuel pressure. For additional information, refer to this section.
3. Remove the fuel injection supply manifold (9F792). For additional information, refer to Supply Manifold – Fuel Injection in this section.
4. **CAUTION: The fuel injectors (9F593) are deposit-resistant. Do not clean the fuel injectors.**

   Remove the fuel injector retaining clips and the fuel injectors. Inpsect the fuel injector O-rings and, if necessary, install new O-rings.

Installation

1. **CAUTION: Install the injector clips in the uppermost groove of the fuel injectors.**

   NOTE: Lubricate new O-rings with clean engine oil, XO-10W30-QSP or DSP or equivalent meeting Ford specification WSS-M2C153-G, to aid installation.

   To install, reverse the removal procedure.
2. Connect the battery ground cable.

REMOVAL AND INSTALLATION (Continued)

Supply Manifold – Fuel Injection

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE WORKING ON OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

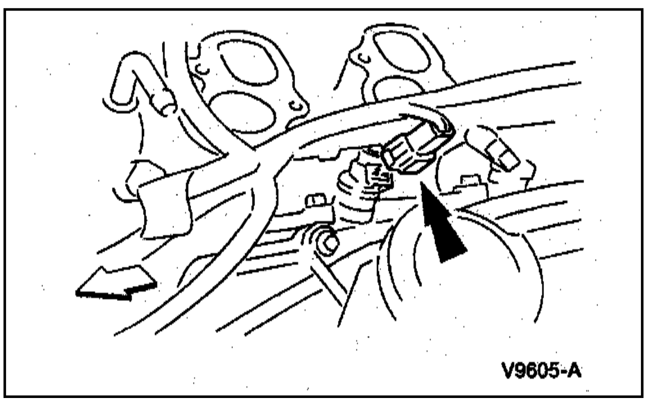
1. Disconnect the battery ground cable.

2. Relieve fuel pressure. For additional information, refer to this section.

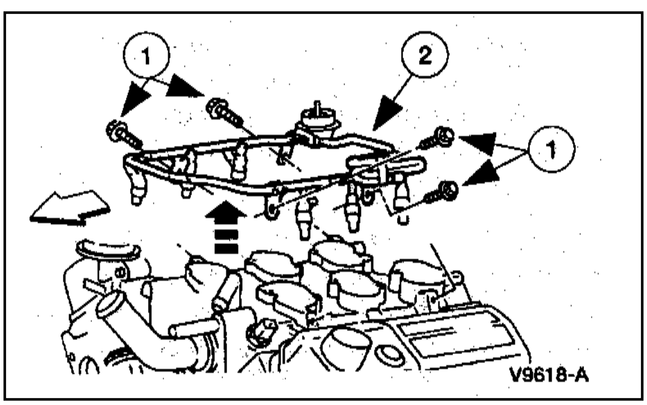
3. Remove the upper intake manifold (9424). For additional information, refer to Section 02.

4. **CAUTION: After disconnecting, plug the fuel lines to prevent leakage.**

   Disconnect the fuel lines. For additional information, refer to this section.



5. **NOTE**: One fuel injector is shown, all are similar. Disconnect the six fuel injector electrical connectors.

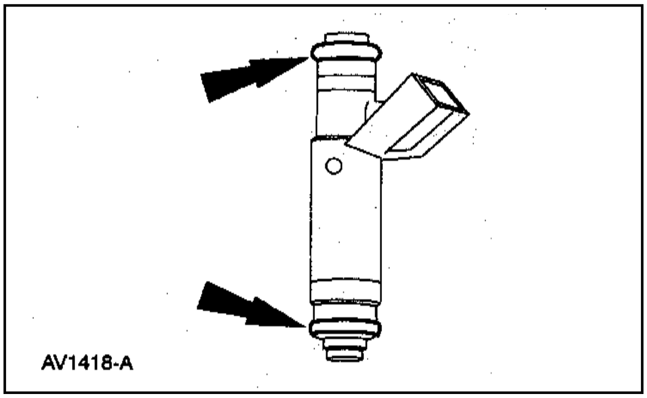


6. Remove the fuel injection supply manifold (9F792).

   1. Remove the bolts.

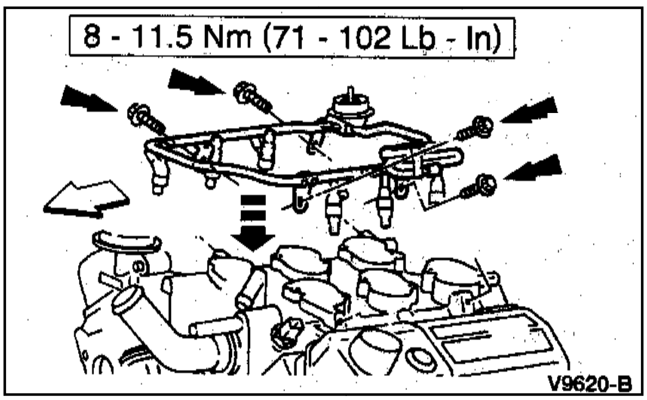
   2. Remove the fuel injection supply manifold.

REMOVAL AND INSTALLATION (Continued)



7. Inspect the two O-rings from each fuel injector. Install new O-rings as needed.

Installation



1. **NOTE:** Lubricate new O-rings with clean engine oil, XO-5W20-QSP or DSP or equivalent meeting Ford specification WSS-M2C153-G, to aid installation.

   To install, reverse the removal procedure. The injectors are pushed into lower intake manifold. Use care aligning all injectors into each hole before applying downward pressure on the supply manifold until each of the injectors are completely seated.

2. Connect the battery ground cable.

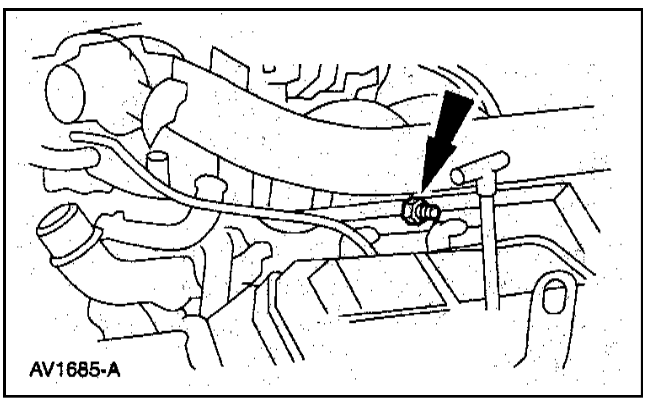
REMOVAL AND INSTALLATION (Continued)

Pressure Relief Valve

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE WORKING ON OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

1. Disconnect the battery ground cable.
2. Relieve fuel pressure. For additional information, refer to this Section.
3. Remove the fuel pressure relief valve (9H321) with the fuel pressure relief valve cap (9H323).

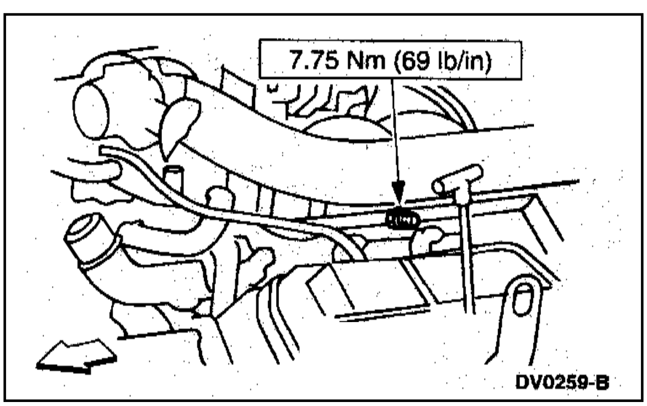


Installation

1. To install, reverse the removal procedure.

NOTE: Use teflon tape on threads using caution not to allow tape particles to enter fuel system. Do not use in excess.

2. Connect the battery ground cable.



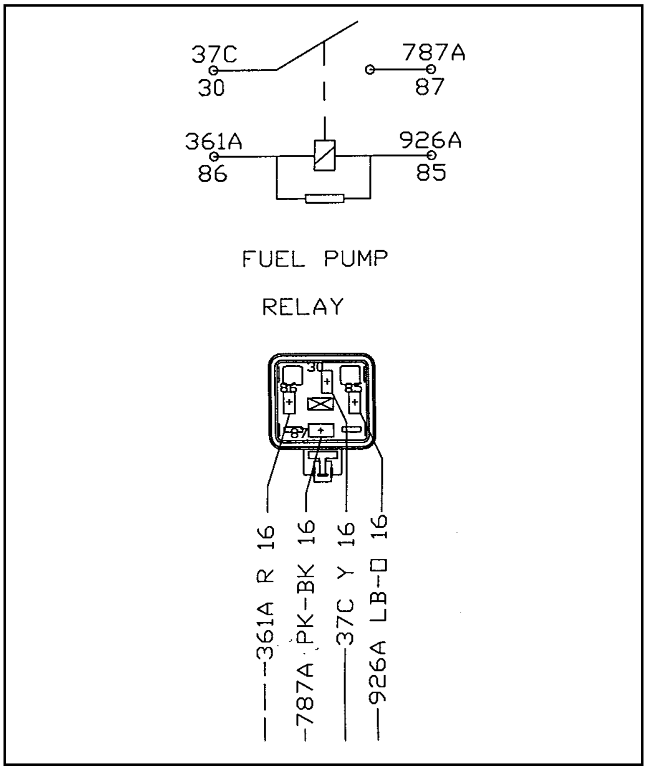
FUEL SYSTEM DESCRIPTION AND TESTING

Electrical

1. Connect the positive lead of a voltmeter to the pump power wire, circuit 787 (PK-BK) from pin #5 of 42 pin connector, and the negative lead to a known good ground.

2. Turn on the ignition switch.

3. The voltmeter should read 12 volts, for 3 seconds. If not, check the power supply from the fuel pump relay to the pump, and the ground wire between pump and engine cylinder block.



Fuel Pump Relay

Circuit 926A → ECM Pin P3
K- Off = 0V
KOEO = B+
KOER = B-
Crank = B-

Circuit 787A → Splice #11 → ECM 238 DG-Y 18g @ Pin F3: Also #42 Pin Conn @ Pin 05
K- Off = 0V
KOEO = B+ (3 seconds)
KOER = B+
Crank = B+

Circuit 37C → Splice #01 → 42 Pin Conn @ Pin 09
B+ all times

Circuit 361A → Splice #1 → Power Relay Circuit 361A
K- Off = 0V
KOEO = B+
KOER = B+
Crank = B+

4. Once you have established the integrity of the power supply and ground to the pump, if it still will not operate, replace the pump assembly.

Fuel Supply and Pressure

If a problem with fuel supply or delivery is suspected, first ensure that there is fuel in the tank. Next ensure that the in line filter between the fuel tank and the pump is clean. Once these items have been checked and verified, proceed as follows:

1. Connect a pressure gauge onto the pressure relief valve at the fuel rail.

2. Turn on the ignition switch, but do not start the engine.

3. The pump should “click” rapidly for 3 seconds, and pressure should built to, and level off at 64 PSI.

   NOTE: Ignition switch may have to be cycled twice to build pressure to 64 psi.

4. If pressure fails to come up, check for an obstruction in the supply line from the tank to the pump, and between the pump and fuel rail.

5. If pressure starts to drop off, block return line to fuel tank. Recycle ignition switch and recheck pressure. If pressure continues to drop off, check for leaks in line or a leaking injector(s).

6. Ensure that the fuel cap vent is operating properly. The vent should allow air to enter the tanks as fuel is removed. Correct any obstruction or restriction found.

NOTE: If no obstruction is found, and the electrical supply, ground, and fuel supply to the pump as described above, are verified all right, replace the pump assembly.

7. Start the engine and allow it to come up to operating temerature.

8. Fuel pressure should be maintained at 62 PSI.

FUEL SYSTEM DESCRIPTION AND TESTING (Continued)

9. If fuel pressure cannot be maintained, verify that all of the above checks have been carried out.

NOTE: If all of the above checks have been carried out, and fuel pressure cannot be maintained, replace the fuel pump assembly.

SERVICE CHECK CHART

CONDITION	POSSIBLE SOURCE	ACTION
Insufficient fuel delivery	• Clogged pump filter, plugged fuel tank vent, pressure regulator, or fuel filter. • A break or restriction in fuel lines. • Clogged fuel pump, pressure regulator or fuel tank vent/cap.	• Replace as needed. • Repair fuel line or remove restriction. • Repair or replace as needed.
Pump not operating	• Inoperative or damaged pump, loose ground, or improper wiring. • Faulty fuel pump relay.	• Replace pump. • Inspect all monting or wiring. • Replace fuel pump relay.
Flooding	• Leaking injector • Pressure regulator malfunction. • Air leak on inlet side of pump due to holes in fuel line or loose fittings.	• Replace injector. • Replace pressure regulator. • Replace fuel line, and tighten fittings (apply a sealer, if necessary).
Fuel pump leaks	• Fuel line fitting connections at pump are loose or dirty.	• Tighten and clean all connections at pump.

General Information

Water and dirt that accumulate in the fuel tank can cause a restricted fuel line, filter, or malfunction of the fuel pump. Condensation, which is the greatest source of water entering the fuel tank, is formed by moisture in the air when it strikes the cold interior walls of the fuel tank.

If the accumulation of dirt and water in the filter is excessive, the fuel tank should be removed and flushed, and the line from the fuel pump to the tank should be blown out. Air leakage in the fuel inlet line can cause low fuel pump pressure and volume.

A restricted fuel tank vent can cause low fuel pump pressure and volume and can result in collapsed inlet hoses or a collapsed fuel tank. High or low pressure are the two most likely fuel pump troubles that will affect engine performance. Low pressure will cause a lean mixture and fuel starvation at high speeds, and excessive pressure will cause high fuel consumption and possible flooding.

If a problem seems to occur in one engine cylinder, the ignition system or a fuel injector may be at fault. If the problem seems to occur in all engine cylinders, then the problem could be either fuel or ignition. Check the fuel system first. Dirt or water in the gas tank, leaks in the fuel lines, ECM, or a defective fuel pump. Observation, pressure test and volume tests on the fuel system show whether the fuel system is the cause of the problem.

Flooding

When flooding occurs disconnect power to fuel pump relay and start engine. When engine stops re-connect relay and re-start engine.

Hard Starting

Dripping fuel injectors, blocked air intake passage, low fuel volume or pressure. Repair, adjust or replace components as necessary.

Stalling

Improper air/fuel supply IAC malfunctioning or an idle speed set too low causes an engine to stall.

NOTE: Idle speed is set by using a computer. Refer to Diagnostic Manual. Correct these systems as necessary. The stalling problem may be due to a loose throttle shaft in the bore of the throttle body. Repair as necessary. Throttle body icing (7.2°C/45°F and lower) is also a cause of stalling.

Rough Idle

An improper air/fuel supply can cause rough idle. Adjust, repair, or replace.

Surging Above Idle

Surging above idle may be caused by a fuel pressure too low, due to faulty cylinder head temperature sensor CHTS or faulty fuel pressure regulator, restricted fuel passages, faulty fuel pump, governors, or ECM. Adjust, clean, or replace as necessary.

FUEL SYSTEM DESCRIPTION AND TESTING (Continued)

Poor Acceleration or Load Response Time

Poor acceleration may be caused by a mixture being too rich or too lean. If a rich mixture is the cause of poor acceleration, the fault may be fuel pressure, faulty injector, or injectors, IAT, CHTS, fuel pump, fuel pressure regulator. Repair or replace as necessary.

If a lean mixture is the cause of poor acceleration, the fault may be low fuel pressure, faulty fuel pressure regulator, fuel pump. Air leaks are also responsible for a lean mixture causing poor acceleration. Leaks may occur at the actuator to the intake manifold, upper intake to lower intake, or the lower intake manifold to the cylinder head. Cracks in the assemblies or worn gaskets cause these air leaks. Clean, repair or replace as necessary.

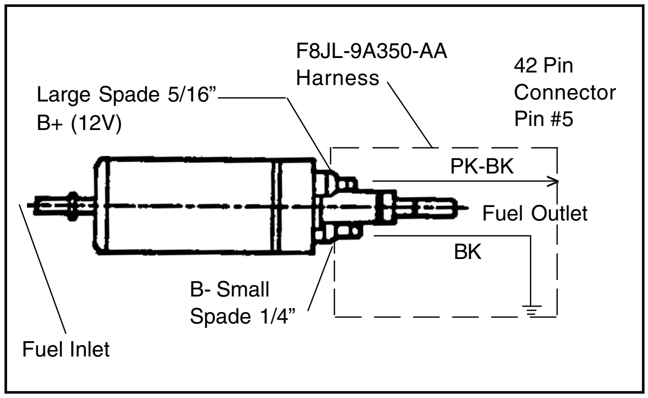
Inconsistant Idle Speed

Inconsistant idle speed is mostly a throttle-related problem. A sticking throttle shaft, or a loose shaft in the actuator body or bore can cause inconsistent idle speed. A faulty idle air control motor (IAC) will also cause the problem. Repair, replace or adjust as necessary.

Reduced Power Output

Reduced power output may be caused by a throttle plate not opening fully, or low fuel pressure. Clean, adjust, repair, or replace as necessary.

Fuel Pump



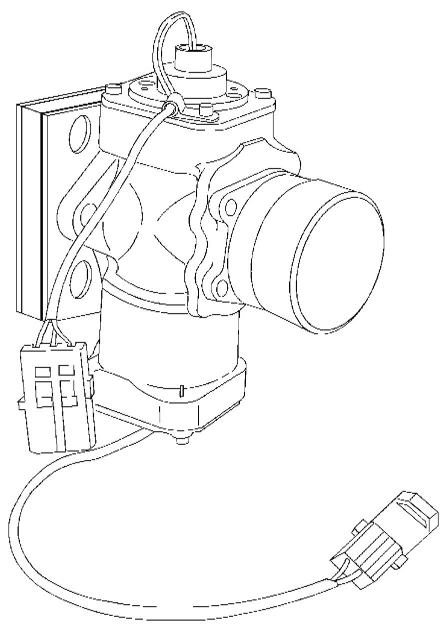
B+ VPWR
K-Off = OV
KOEO = VPWR (B+) for 3 seconds
KOER = VPWR (B+)
Crank = VPWR (B+)

B- Ground

Actuator

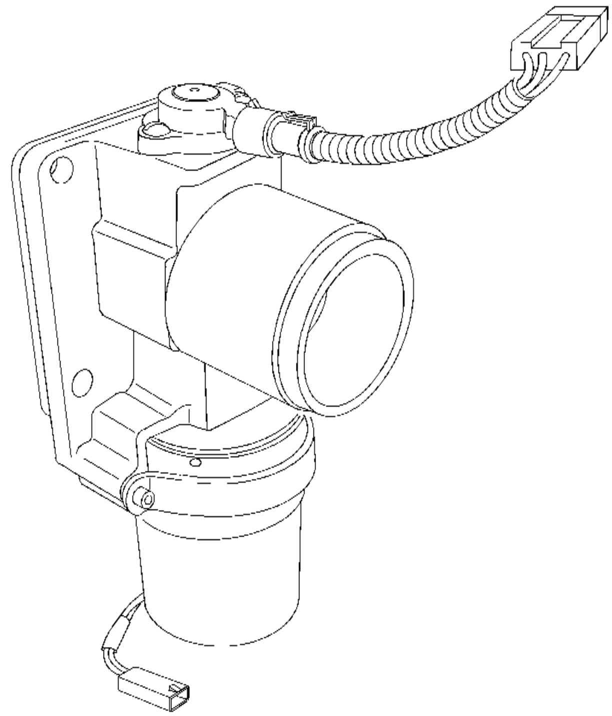
Two types of actuators are available as options for electronic variable speed governing – EFI. Either a Barber Coleman or Precision Governor Actuator are available.

Barber Coleman Phase II Governor Actuator

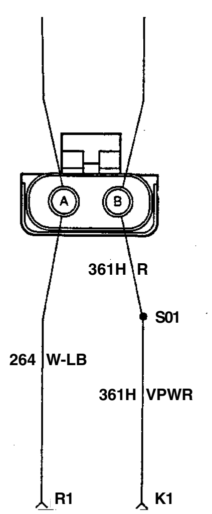


The ECM can, within the operating parameters, be programmed to accept up to four engine speeds. The speed is selected by means of a remote toggle switch.

Precision Governor Actuator

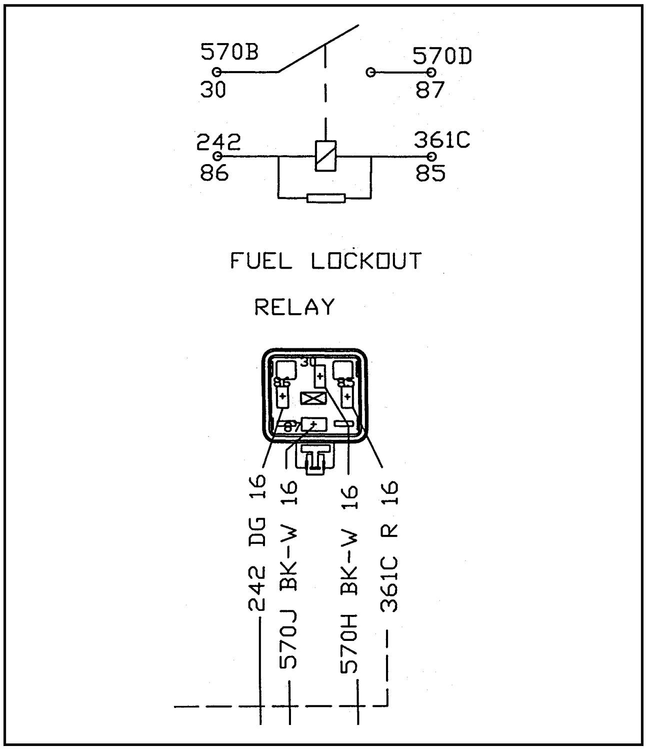


ALL ACTUATORS (DRY FUEL MODULATOR)



Liquid Petroleum Gas and Natural Gas (LPG & NG)

Fuel Lockout Relay



NOTE: Alternate fuel select switch is supplied by customer. All test must be completed with fuel select switch in the alternate fuel position.

NOTE: Make all following checks with connector connected to relay and back probe wire circuits with paper clip.

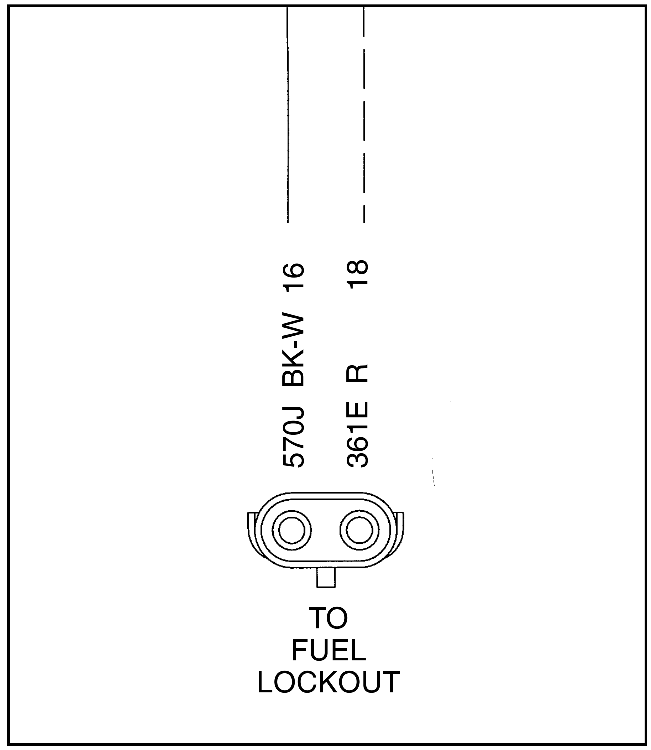
Circuit 242 → ECM Connector Pin #P2
K- Off = 0V
KOEO = B- (Ground)
KOER = Ground

Circuit 570J → To Fuel Lockout Relay
K-Off = 0V
KOEO =
KOER =
Same voltage if unit has fuel lockout solenoid

Circuit 570H → Splice #10 → 42 Pin Connector Pin 34 or 42
K-Off = B-
KOEO = B-
KOER = B-

Circuit 361C → Splice #1
K-Off = 0V
KOEO = 12V Fuse or wiring
KOER = 12V Fuse

Fuel Lockout Connector (Closed Loop)



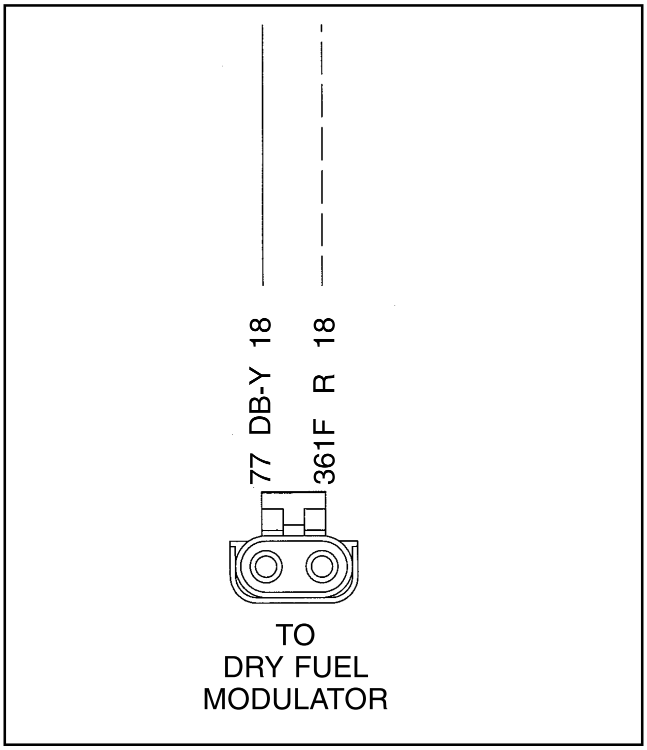
NOTE: Fuel Lockout solenoid is supplied by customer.

Circuit 570J → Fuel Lockout Relay
K-Off = 0V
KOEO = Ground = Bad relay - ECM - Wiring
KOER = Ground

Circuit 361E → Splice #1

Liquid Petroleum Gas and Natural Gas (LPG & NG)

Dry Fuel Modulator Connector

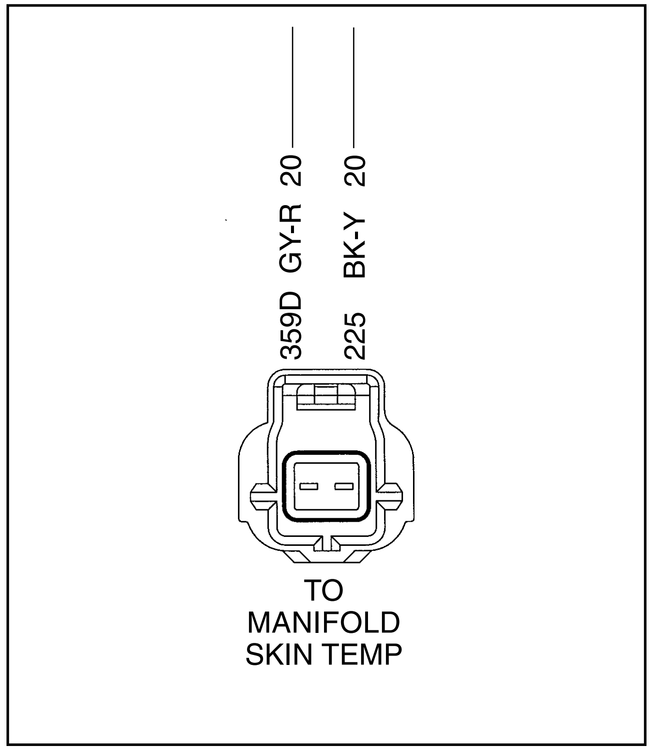


NOTE: For future application controls alternate fuel closed loop system.

Circuit 77 → R-2
K-Off = 0V
KOEO = N/A
KOER = N/A

Circuit 361F → Splice #1
K-Off = 0V
KOEO = N/A
KOER = N/A

Manifold Skin Temp Connector



Manifold skin temperature reads manifold surface (SKIN) temperature.

Circuit 359D → Splice #5 → ECM Pin #B2
K-Off = 0V
KOEO = 5V
KOER = 5V

Circuit 225 → ECM Pin #D3
K-Off = 0V
KOED, KOER: Use chart on Page 04-24 for volt reading

NOTE: Check for Ohm reading across the two pins of DFT sensor unplugged per chart on Page 04-24.

MST, CHT, ECT & IAT SENSOR DATA

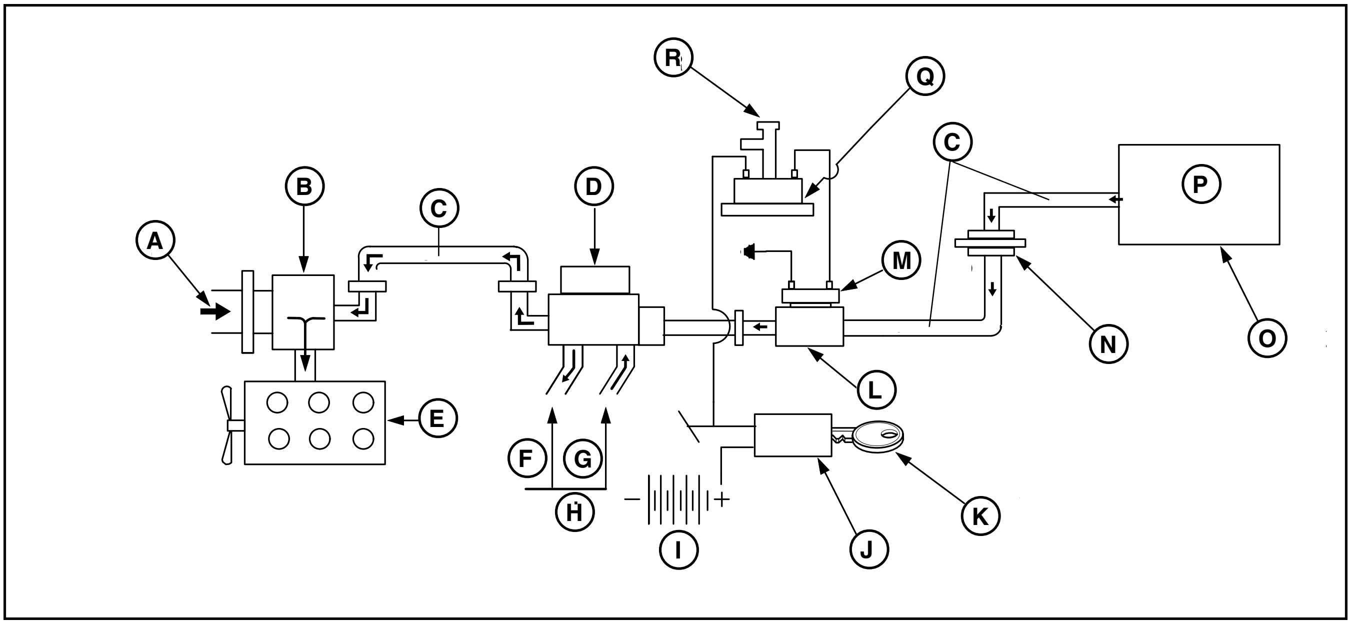
Temperature Sensor Characteristics

TEMPERATURE (C)	(F)	NOM R, (OHMS)	NOM E_{OUT} (VOLTS)
-40	-40	925,021	4.54
-35	-31	673,787	4.50
-30	-22	496,051	4.46
-25	-13	368,896	4.41
-20	-4	276,959	4.34
-15	5	209,816	4.25
-10	14	160,313	4.15
-5	23	123,485	4.02
0	32	95,851	3.88
5	41	74,914	3.71
10	50	58,987	3.52
15	59	46,774	3.32
20	68	37,340	3.09
25	77	30,000	2.86
30	86	24,253	2.62
35	95	19,716	2.39
40	104	16,113	2.15
45	113	13,236	1.93
50	122	10,926	1.72
55	131	9,061	1.52
60	140	7,548	1.34
65	149	6,332	1.18
70	158	5,335	1.04
75	167	4,515	.91
80	176	3,837	.79
85	185	3,274	.70
90	194	2,804	.61
95	203	2,411	.53
100	212	2,080	.47
105	221	1,801	.41
110	230	1,564	.36
115	239	1,363	.32
120	248	1,191	.28
125	257	1,044	.25
130	266	918	.22
135	275	809	.19
140	284	715	.17
145	293	633	.15
150	302	563	.14

Voltage values calculated for VREF=5 volts (may vary 15% due to sensor and VREF variations).

FUEL SYSTEM DESCRIPTION AND OPERATION

Fuel Flow Diagram for LPG



(A) Air Intake
(B) Mixer
(C) Fuel Line
(D) Vaporizer Regulator
(E) Engine
(F) Outlet
(G) Inlet
(H) Coolant Hoses
(I) Battery
(J) Ignition Switch
(K) Key
(L) Shut Off Valve
(M) Solenoid
(N) Fuel Filter
(O) Fuel Tank
(P) LPG
(Q) Vacuum Operated On/Off Switch
(R) Vacuum Connector

VAPORIZER/REGULATOR

Type: 2 stage	
Max. inlet pressure:	2150 kPa
Primary outlet pressure:	10.3 kPa
Secondary outlet pressure:	0.37 kPa
Fuel inlet connection:	1/4 NPTF
Fuel outlet connection:	1 NPTF
Coolant connections:	3/8 NPTF
Fuel outlet hose:	19.1 mm inside dia.
Coolant hose:	15.8 mm inside dia.

THROTTLE BODY – FORD POWER PRODUCTS

Type:	Butterfly plate
Angle of operation:	75° total movement
Bore:	27.0 mm dia.
Throttle linkage connection:	6.35 mm dia. ball
Retaining studs spacing:	76.2 mm

MIXER

Type:	Air valve venturi
Air inlet bore:	77.8 mm diameter
Fuel inlet connection:	3/4 NPTF
Mixture outlet bore:	60.3 mm diameter
Vacuum pipe nipple:	6.35 mm outside diameter

SHUT-OFF VALVE

Type:	Double poppet valve
Max. working pressure:	2150 kPa
Inlet connection:	1/4 NPTF
Outlet connection:	1/4 NPTF
Coil:	12V 6W

SAFETY SWITCH

Type:	Vacuum operated

FUEL

Fuel:	Liquefied Petroleum Gas (LPG)
Fuel Specifications:	EN 589 (European) HO-5 (USA)

SYSTEM OPERATION – LPG

WARNING:

WHEN INSTALLING ANY LIQUID PETROLEUM GAS/FUEL SYSTEMS, FOLLOW ALL COUNTRY AND LOCAL CODES.

IN THE USA FOLLOW ALL REGULATIONS AND STANDARDS MANDATED BY THE NATIONAL FIRE PROTECTION ASSOCIATION, INC. INCLUDING NEPA 37, NFPA 52, AND NFPA 58, PLUS ANY OTHER STANDARDS. YOU CAN OBTAIN COPIES FROM YOUR LOCAL FIRE DEPARTMENT.

FOR CANADIAN CODES SEE NATIONAL STANDARDS OF CANADA.

IN THE UNITED KINGDOM FOLLOW THE CODE OF PRACTICE ELEVEN PRODUCED BY THE LPG/NG ASSOCIATION.

High pressure liquefied Petroleum Gas passes through a solenoid operated fuel shut-off valve into an engine coolant heated vaporizer/regulator unit where it is converted into a low pressure gas. This gas is then fed into the carburetor body/mixer where a vacuum operated gas metering valve ensures that the correct air-to-fuel ratio is maintained.

When the engine is switched off, the electrical supply to the fuel shut-off solenoid is disconnected and the valve closes, cutting off the high pressure fuel supply to the vaporizer/regulator. The electrical supply to fuel shut-off valve passes through a vacuum operated safety switch. Should the engine stall, the vacuum switch opens and cuts off the electrical supply to the fuel shut-off valve. When starting the engine, there is sufficient vacuum present, even at cranking speed, to close the safety switch.

FUEL SYSTEMS – FIELD CALIBRATIONS/ GENERAL

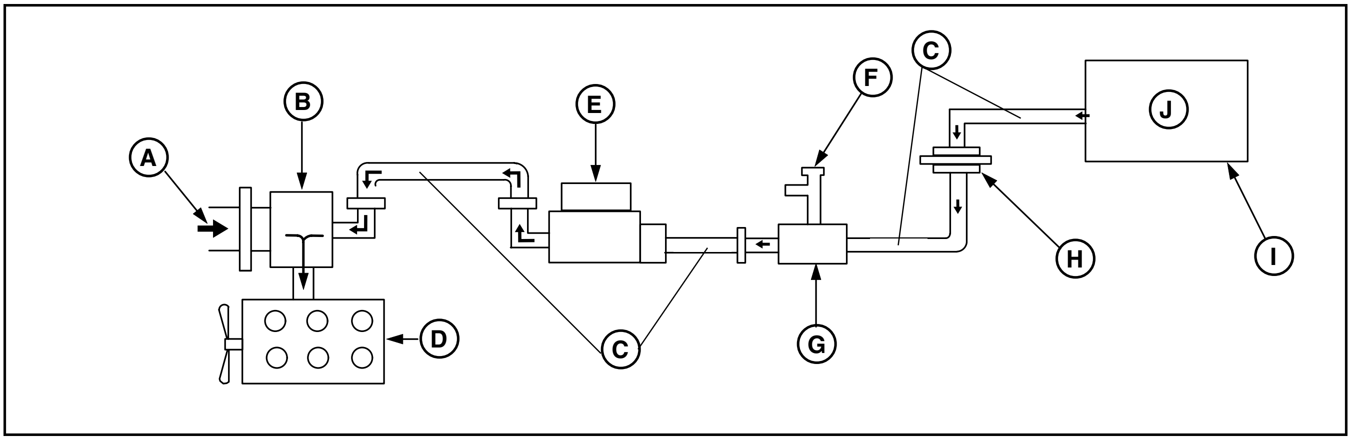
When performing field calibrations on LPG & NG systems, it should be noted that improper fuel calibrations and/or improper hardware installation may result in decreased durability/life of the cylinder head valve train. Validation testing on the valve train was conducted in a controlled laboratory environment with proper air-fuel distribution and proper air-fuel ratios which fall within acceptable ranges.

Since your LPG & NG units are not purchased through Ford Power Products, they are not calibrated specifically to your application. It is a requirement that each of these units are calibrated by the customer within the acceptable limits provided by Ford Power Products Engineering.

Development testing is underway to provide the customer with appropriate guidelines to successfully calibrate their LPG & NG fuel systems. Recommendations may include but are not be limited to: air-fuel ratios, exhaust temperatures, and mixer/regulator orientation.

FUEL SYSTEM DESCRIPTION AND OPERATION

Fuel Flow Diagram for Natural Gas



A	Air Intake	D	Engine	G	Shut Off Valve	J	NG
B	Mixer	E	Regulator	H	Fuel Filter		
C	Fuel Line	F	Vacuum Connector	I	Fuel Tank		

REGULATOR – 5.0 kPa Inlet, 1.5 kPa Outlet
This is to be supplied by the OEM to suit the operating conditions (gas supply pressure).

THROTTLE BODY – FORD POWER PRODUCTS

Type:	Butterfly plate
Angle of operation:	75° total movement
Bore:	27.0 mm dia.
Throttle linkage connection:	6.35 mm dia. ball
Retaining studs spacing:	68.26 mm

MIXER

Type:	Air valve venturi
Air inlet bore:	77.8 mm diameter
Fuel inlet connection:	3/4 NPTF
Mixture outlet bore:	60.3 mm diameter
Max. inlet pressure:	1.5 kPa

SHUT-OFF VALVE

Type:	Double poppet valve
Max. working pressure:	2150 kPa
Inlet connection:	3/4 NPTF
Outlet connection:	3/4 NPTF
Coil:	12V 6W

SAFETY SWITCH

Type:	Vacuum operated

FUEL

Fuel:	Natural Gas
Fuel Specifications:	38.7 MJ/m^3 (UK)
	39.0 MJ/m^3 (USA)

FUEL SYSTEM DESCRIPTION AND OPERATION

SYSTEM OPERATION – NATURAL GAS

WARNING:

WHEN INSTALLING ANY NATURAL GAS/FUEL SYSTEMS, FOLLOW ALL COUNTRY AND LOCAL CODES.

IN THE USA FOLLOW ALL REGULATIONS AND STANDARDS MANDATED BY THE NATIONAL FIRE PROTECTION ASSOCIATION, INC. INCLUDING NEPA 37, NFPA 52, AND NFPA 58, PLUS ANY OTHER STANDARDS. YOU CAN OBTAIN COPIES FROM YOUR LOCAL FIRE DEPARTMENT.

FOR CANADIAN CODES SEE NATIONAL STANDARDS OF CANADA.

IN THE UNITED KINGDOM FOLLOW THE CODE OF PRACTICE ELEVEN PRODUCED BY THE LPG/NG ASSOCIATION.

Natural gas passes through a vacuum operated fuel shut-off valve into a regulator unit where it is converted into a low pressure gas. This gas is then fed into the mixer where a vacuum operated gas metering valve ensures that the correct air-to-fuel ratio is maintained.

When the engine is switched off, vacuum supply to the fuel shut-off vacuum is disconnected and the valve closes, cutting off the fuel supply to the regulator.

Should the engine stall, the loss of vacuum will close the fuel shut-off valve. When starting the engine, there is sufficient vacuum present, even at cranking speed, to open the fuel shut-off valve.

The system is similar to the LPG system, except a convertor (vaporizer) is not used, and the coolant connections are also not needed. A regulator is required and must be supplied by the OEM to suit the mains gas supply pressure.

SPECIFICATIONS

General Specifications

Item	Specification
Fluid/Lubrication Specification	
Engine oil XO-10W30-QSP or DSP	WSS-M2C153-G

Torque Specifications

Description	Nm	Lb/In
42 Pin Engine Wiring Harness Electrical Connector Bolt	4-5.6	35-50
Fuel Injection Supply Manifold Bolts	8-11.5	71-102
Fuel Pressure Relief Valve	7.75	69
Throttle Body Nuts and Bolts	10	89

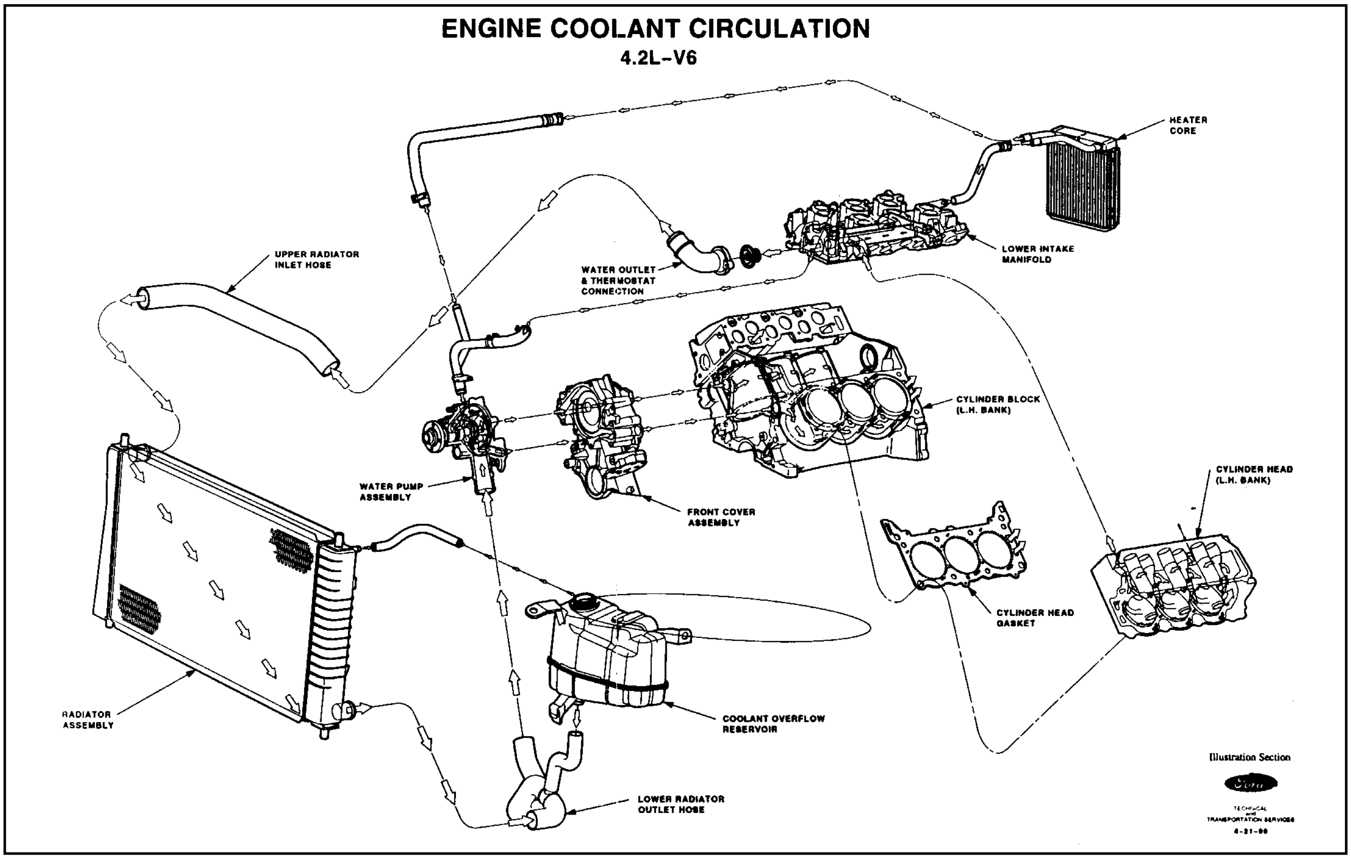
Pressure

	Normal	Maximum	Minimum
Fuel Pump	441 kPa (64 psi)	451 kPa (66 psi)	431 kPa (62 psi)

NOTE: Fuel pump has capability to produce 100+ PSI.

COOLING INDEX

COOLING SYSTEM, DESCRIPTION AND OPERATION



Engine Cooling

Walter C. Avrea, the owner of patents 3,601,181 and RE27,965, has granted Ford Motor Company rights with respect to cooling systems covered by these patents.

The cooling system components are:

- Block heater (6A051).
- Engine coolant temperature sensor (ECT sensor) (12A648).
- Fan blade (8600).
- Fan clutch (8A616).
- Fan shroud (8146).
- Radiator (8005).
- Radiator cap (8100).
- Radiator degas bottle (8A080).
- Radiator draincock (8115).
- Water temperature indicator sender unit (10884).
- Water thermostat and gasket assembly.
- Upper radiator hose (8B275).
- Lower radiator hose (8B273).
- Bypass hose and heater hose system.

Degas bottle:

- Radiator degas bottle (8A080).
  - Holds surplus coolant when hot.
  - De-aerates the system reducing engine hot spots.
  - Location for service fill.
  - Allows coolant expansion and system pressurization [110 kPa (16 psi)].
  - Air separation during operation.
  - Replenishes coolant to system.

COOLING SYSTEM, DESCRIPTION AND OPERATION (Continued)

The Coolant Fan:

– The fan blade can either draw or push air through the radiator to help cool the system coolant.

– The fan clutch is a thermostatic-controlled clutch that controls the fan drive.

Coolant flow is as follows:

• The water pump (8501) circulates the coolant.

• From the water pump to the engine block and the cylinder heads (6049) to the thermostat.

– Thermostat closed, the coolant returns to the water pump through bypass hose.

– Thermostat open, the coolant flows back to the radiator.

– To the radiator for heat rejection then back to the lower radiator hose.

– From the lower radiator hose (8286) to the water pump.

The Radiator:

– The radiator allows excess heat to be transferred to the air.

– The radiator can be serviced.

The Radiator Cap:

– Maintains 16 lbs. pressure.

– Coolant under pressure.
  • Raises the boiling point of the coolant
  • Helps prevent vapor locks in engine block and cooling system.

Coolant:

• Use a 50/50 mix of Ethylene Glycol Permanent Antifreeze and water. This mixture is to be used year-round with temperatures above -34.4°C (-30°F).

Recycled coolant:

• Use recycled engine coolant produced by Ford approved processes. Not all coolant recycling processes produce coolant which meets Ford specification ESE-M97B44-A or WSS-M97B44-D, and use of such a coolant may harm engine and cooling system components.

Unsatisfactory coolant materials:

• Alcohol-type antifreeze does not provide adequate water pump lubrication.

– Has a lower boiling point.

– Provides reduced antifreeze protection.

⚠ **CAUTION: Alkaline brine solutions will cause serious engine cooling system damage.**

⚠ **CAUTION: Do not nuse. 100,000 mile, red in color antifreeze, it is not compatable with copper radiators.**

The water temperature indicator sender unit:

– Provides a signal to the temperature gauge.

The block heater:

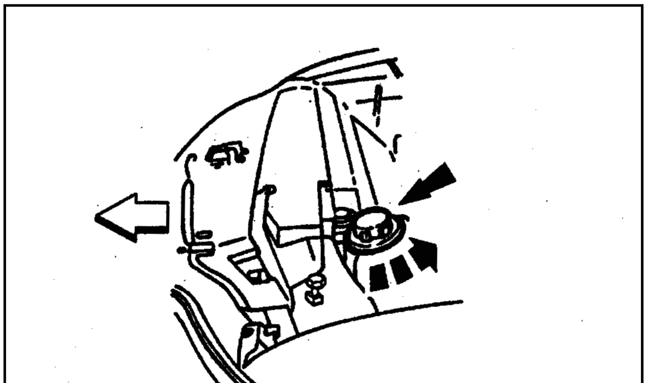
• Is an optional electrical heating element installed in a core plug opening.

– Uses a standard 110v electrical supply.

– Keeps the engine coolant warm during cold weather.

GENERAL PROCEDURES

Cooling System Draining, Filling and Flushing


GQ0082-A

Draining

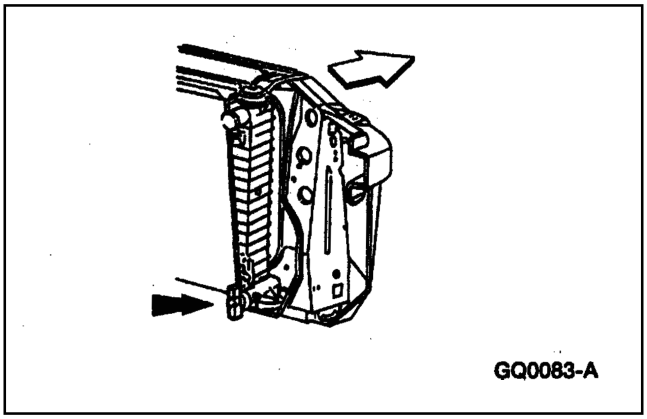
WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. TO AVOID HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE DEGAS BOTTLE WHEN REMOVING THE PRESSURE RELIEF CAP, WAIT UNTIL THE ENGINE HAS COOLED DOWN TO AT LEAST 43.3°C (110°F).

1. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

GENERAL PROCEDURES (Continued)

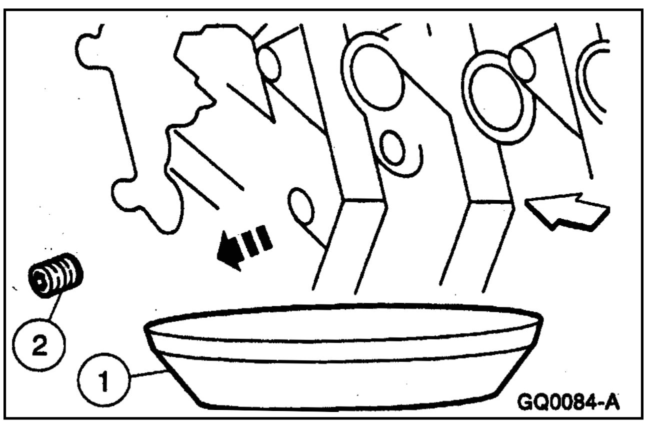
CAUTION: The coolant must be recovered in a suitable, clean container for reuse. If the coolant is contaminated it must be recycled or disposed of properly.

NOTE: About 80% of coolant capacity can be recovered with the engine in the vehicle. Dirty, rusty or contaminated coolant requires replacement.


GQ0083-A

3. Place a suitable container below the radiator draincock (8115). If equipped, disconnect the coolant return hose at the fluid cooler.

4. Open the radiator draincock.



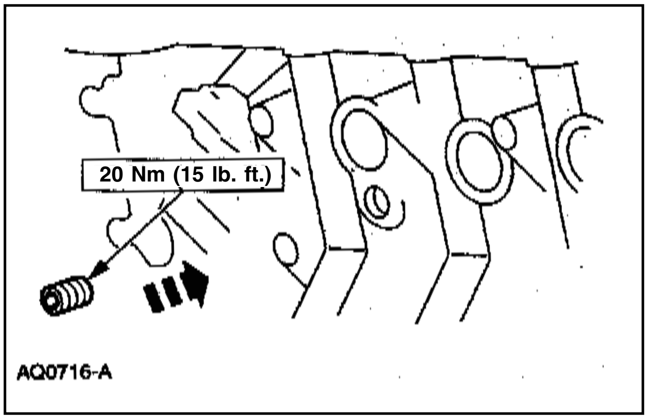
GQ0084-A

5. Remove the cylinder drain plug, if equipped, to drain the coolant from the cylinder block (6010).

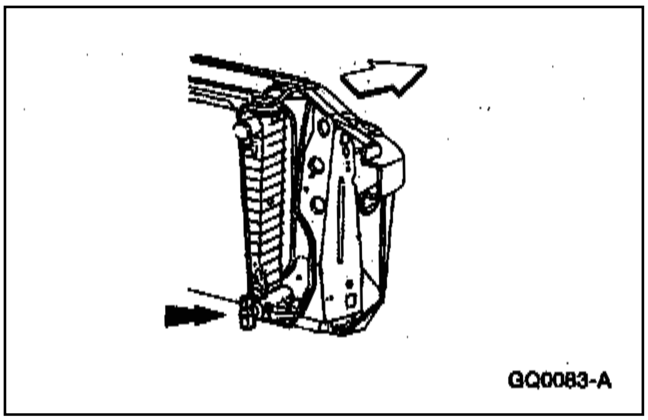
   1. Place a drain pan below the cylinder block.

   2. Remove the drain plugs.

GENERAL PROCEDURES (Continued)

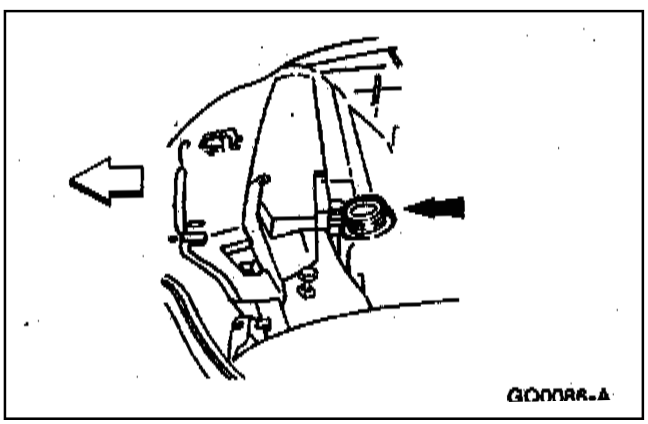


6. When the coolant is drained, make sure drain plugs are installed and tight.



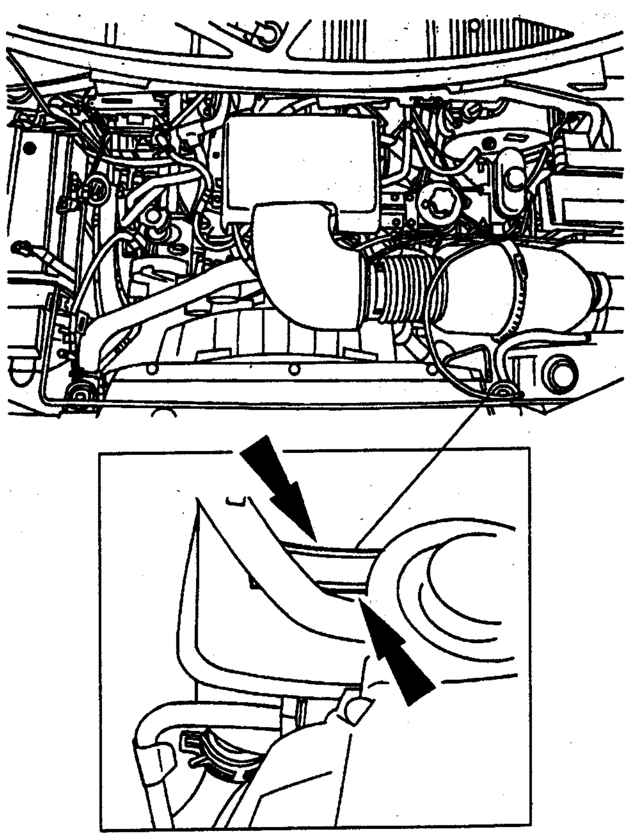
7. Close the radiator draincock when finished.

Filling



1. Add the proper engine coolant mixture to the degas bottle or radiator.
2. Move the temperature blend selector to the full warm position when equipped.
3. Run the engine until it reaches operating temperature.

GENERAL PROCEDURES (Continued)



GQ0088-A

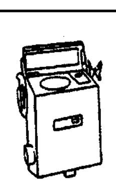
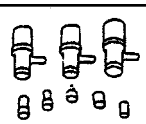
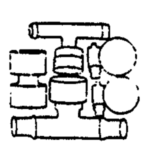
4. Add the proper engine coolant mixture to the degas bottle or radiator until the coolant level is between the "COOLANT FILL LEVEL" marks.

   NOTE: Systems without degas bottle fill radiator up to 1 inch below the filler neck.

5. Turn off the engine and allow the cooling system to cool.
6. Repeat Steps 1 through 5 until the degas bottle/ radiator level is OK.

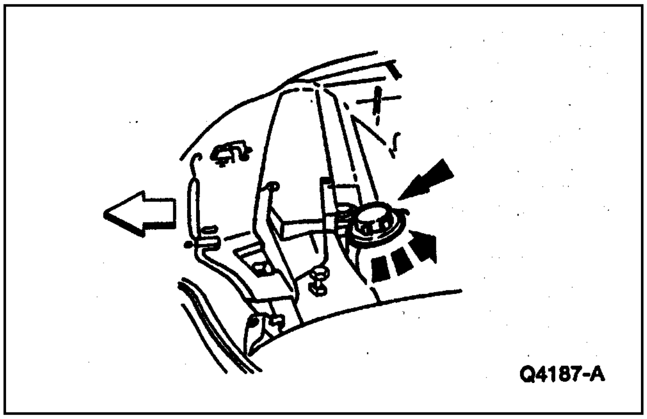
Flushing – Engine and Radiator

Special Tool(s)

 ST1166-A	Coolant System Drain/Flush/ Fill. 164-R3673
 ST1167-A	Flush Kit Hardware Package 164-R3658 or equivalent
 ST1168-A	Drain Kit 164-R3662 or equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

GENERAL PROCEDURES (Continued)

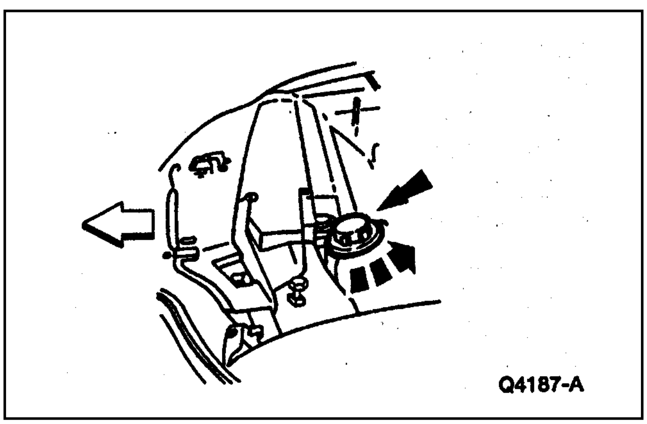


1. **WARNING: DO NOT OPEN THE COOLING SYSTEM WHILE IT IS HOT OR WHILE THE ENGINE IS RUNNING. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.**

   Drain the cooling system. For additional information, refer to Draining in this section.

2. Remove the water thermostat (8575).
3. Install the water hose connection (8592) without the water thermostat.
4. Use cooling system Flush-All, Flush Kit Hardware Package and Drain Kit to flush the engine and radiator.
5. When flushing operation is complete, install the water thermostat.
6. Back flush the heater core (18476) if necessary. For additional information, refer to Flushing – Engine and Radiator in this section.
7. Fill the cooling system. For additional information, refer to Filling in this section.

Flushing – Heater Core



1. **WARNING: DO NOT OPEN THE COOLING SYSTEM WHILE IT IS HOT OR WHILE THE ENGINE IS RUNNING. FAILURE TO FOLLOW THIESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.**

   Partially drain the cooling system. For additional information, refer to Draining in this section.

2. Use cooling system Flush-All, Flush Kit Hardware Package and Drain Kit to back flush the heater core. Use Ford Premium Cooling System Flush F1AZ-19A503-A or equivalent meeting Ford specification ESR-M14P7-A.
3. When flushing operation is complete, fill the cooling system. For additional information, refer to Filling in this section.

COOLING SYSTEM, REMOVAL AND INSTALLATION

Radiator Hose

Removal

Radiator hoses should be replaced whenever they become cracked, rotted or have a tendency to collapse.

Drain the radiator into appropriate container then loosen the clamps at each end of the hose to be removed. Slide the hose off the radiator connection and the engine water outlet connection (upper hose) or the water pump connection (lower hose).

Installation

Position the clamps at least 1/8 inch from each end of the hose. Coat the connection areas with an approved water-resistant sealer and slide the hose on the connection. Make sure the clamps are beyond the bead and placed in the center of the clamping surface of the connections. Tighten the clamps. Fill the radiator with the recommended permanent antifreeze and water mixture. Operate the engine for several minutes, then check the hoses and connections for leaks.

Thermostat

Removal

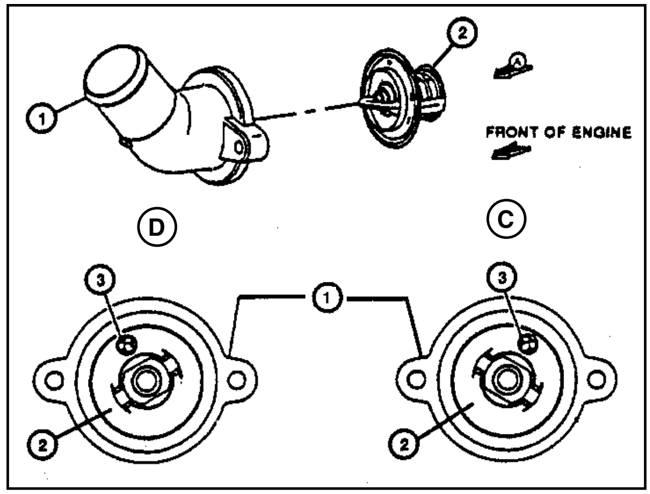
⚠ WARNING: AVOID INJURY FROM HOT COOLANT WHEN ENGINE IS HOT.

1. Allow the engine to cool down until the coolant has lowered in temperature to below 110°F.
2. Drain the radiator so that the coolant level is below the thermostat.
3. Disconnect upper radiator hose form the thermostat housing.
4. Remove the coolant outlet housing retainer bolts and remove housing. Remove the thermostat and gasket.

Installation

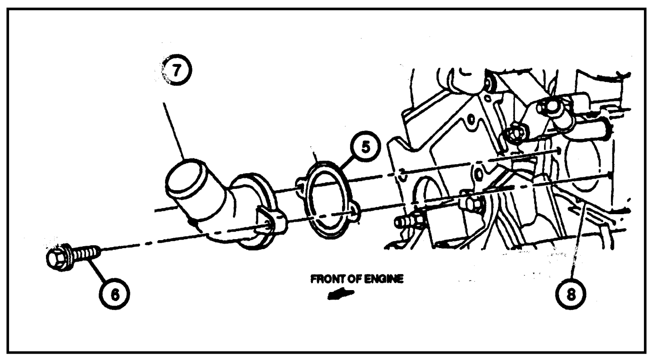
Check the thermostate before installing it, following the procedure under Thermostat Test – Thermostat Removed.

1. Clean the coolant outlet housing and manifold gasket surfaces. Coat a new gasket with water resistant sealer.



(1) Coolant Outlet Connection (3) Vent Pin
(2) Thermostat

2. Install thermostat **2** into coolant outlet connection **1** rotating in a clockwise or counter-clockwise direction, to engage cam on thermostat securely. Thermostat vent pin **3** should be located at the 1 o'clock **C** or 11 o'clock **D** position.



Sub-Assembly

(5) Thermostat Housing Gasket (8) Lower Intake Manifold (Front)
(6) Hold Down Bolt
(7) Thermostat Housing Sub Assembly

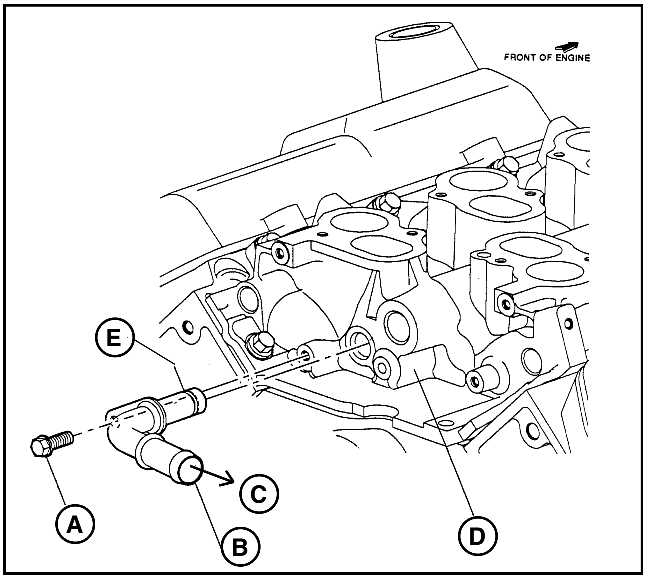
3. Install water outlet connection/thermostat sub-assembly **7** and gasket **5** to lower intake manifold **8.**
4. Install two hold down bolts and washers **6** and rundown to specified torque. **(8 Nm then rotate 55-65 degrees)**.
5. Connect upper radiator hose and clamp to coolant connector.
6. Fill cooling system with a 50/50 mixture of Ethylene Glycol (green or green/yellow in color not red) and water.

COOLING SYSTEM, REMOVAL AND INSTALLATION (Continued)

With or Without Heater or Dry Fuel Evaporator Plumbing

Installation of Heater Water Inlet Tube (18696)

1. Install new “O” ring **E** on portion of tube that fits into intake manifold. Lubricate “O” ring **E** with ESE-M99B144-B Surfactant or other approved lubricant. Insert tube into hole located at the left rear of lower intake manifold.

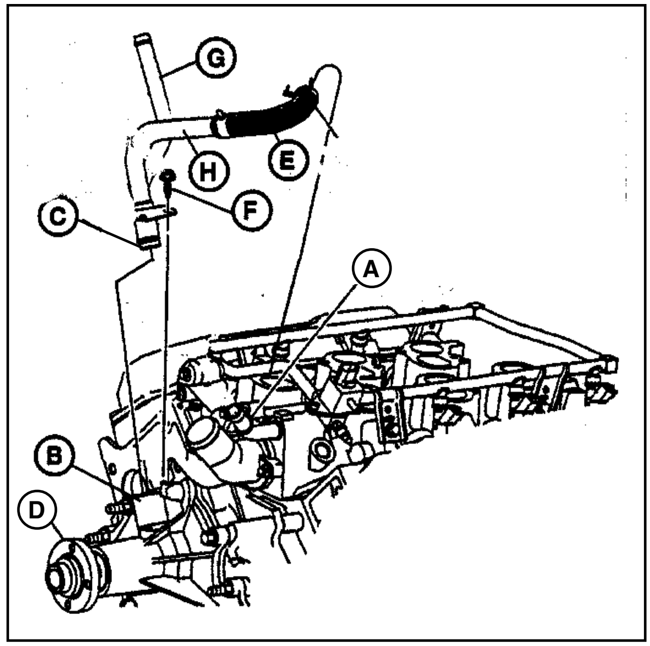


A Hold Down Bolt
B Outlet Tube
C Indicates direction of coolant flow
D Lower Intake Manifold (Rear)
E “O” Ring

Start hold down bolt **A** through flange and into intake manifold. Torque hold down bolt to 8-11.5 Nm.

2. Install rubber cap and clamp on outlet **B** tube if not using LPG Fuel or cab heater.
3. When running on LPG fuel or using a cab heater perform the following. Install heater hose 19mm (3/4 in) (customer to supply and cut to proper length) from the water inlet tube **B** to either the cab heater inlet or the LPG evaporator inlet.
4. Follow step 5 in the next process installation of water heater outlet tube assembly with bypass hose.
5. Fill cooling system with 50/50 mixture of Ethylene Glycol (green or green/yellow in color, not red) and water.

Installation of Water Heater Return Tube Assembly with by-pass Hose



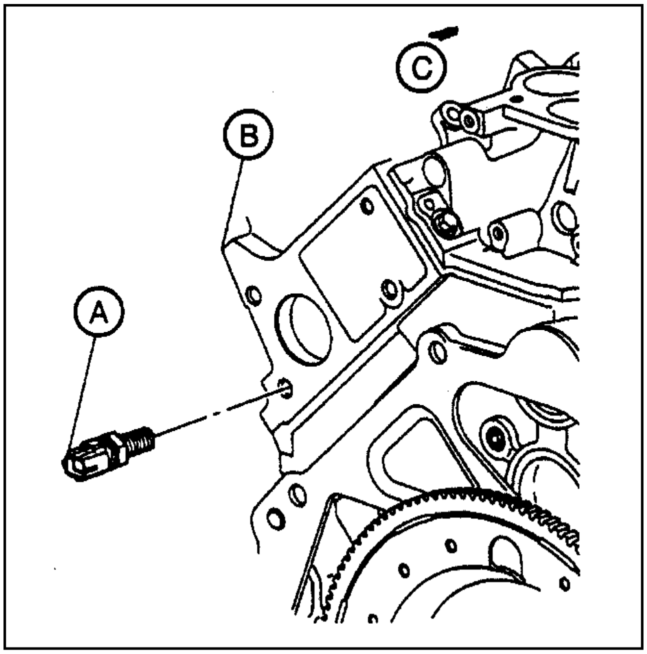
A Bypass Tube
B Inlet Tube Hole
C “O” Ring
D Water Pump
E Bypass Hole
F Hold Down Bolt
G Heater Tube
H Heater Water Return Tube

1. Install new “O” ring **C** on portion of tube going into water pump **B** and lubricate “O” ring **C** with ESE-M99B144-B Surfactant or other approved lubricant.
2. Insert tube **H** into hole in upper portion of water pump **B**.
3. Align hold down flange and insert bolt **F**. Torque bolt to 8-11.5 Nm.
4. Attach the by-pass hose **E** along with two hose clamps to bypass tube **A** and to Heater Water Return Tube **H** that is directed toward Thermostat/Water Outlet Connector and connect.
5. Attach heater hose (5/8 in.) to Heater Tube **G** of Heater Water Return Tube Assembly. (Customer to supply and cut to proper length).

   NOTE: If heater hose is not needed, cap outlet **G** with rubber cap (5/8 in.) and hose clamp.

COOLING SYSTEM, REMOVAL AND INSTALLATION (Continued)

Cylinder Head Temperature Sensor



(A) **Cylinder Head Temp Sensor (CHT) Torque 9-11 Nm.**

(B) **Cylinder Head Asy. – LH.**

(C) **Front of Engine.**

Removal (Located rear of left cylinder head **B**).

1. Disconnect wire connector.

2. Remove sensor **A.**

Installation

1. Install sensor dry.

NOTE: Without any sealer on threads.

⚠ **CAUTION: Do not over torque. May damage sensor.**

2. Torque to 9-11 Nm.

3. Reconnect wire connector.

COOLING SYSTEM, REMOVAL AND INSTALLATION (Continued)

Cooling Fan

Removal

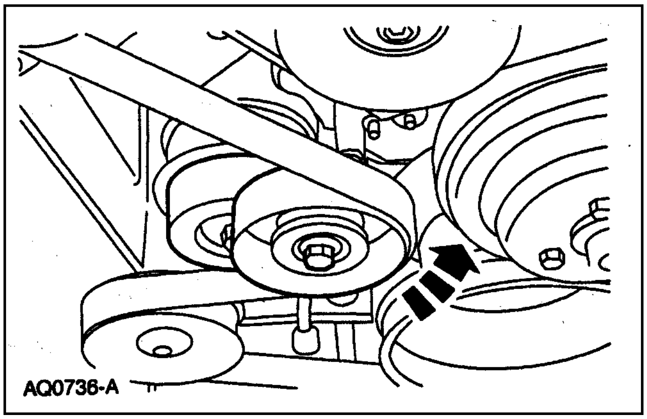
Remove fan drive belt. Refer to fan drive belt removal on this page. Remove the screws and washer assemblies attaching the fan and pulley to the water pump hub. Remove the fan and pulley.

Installation

Position the fan and pulley on the water pump hub. Install the lock washer and screws and torque the capscrews to specifications (55 Nm). Install drive belt. Refer to fan drive belt installation on this page.

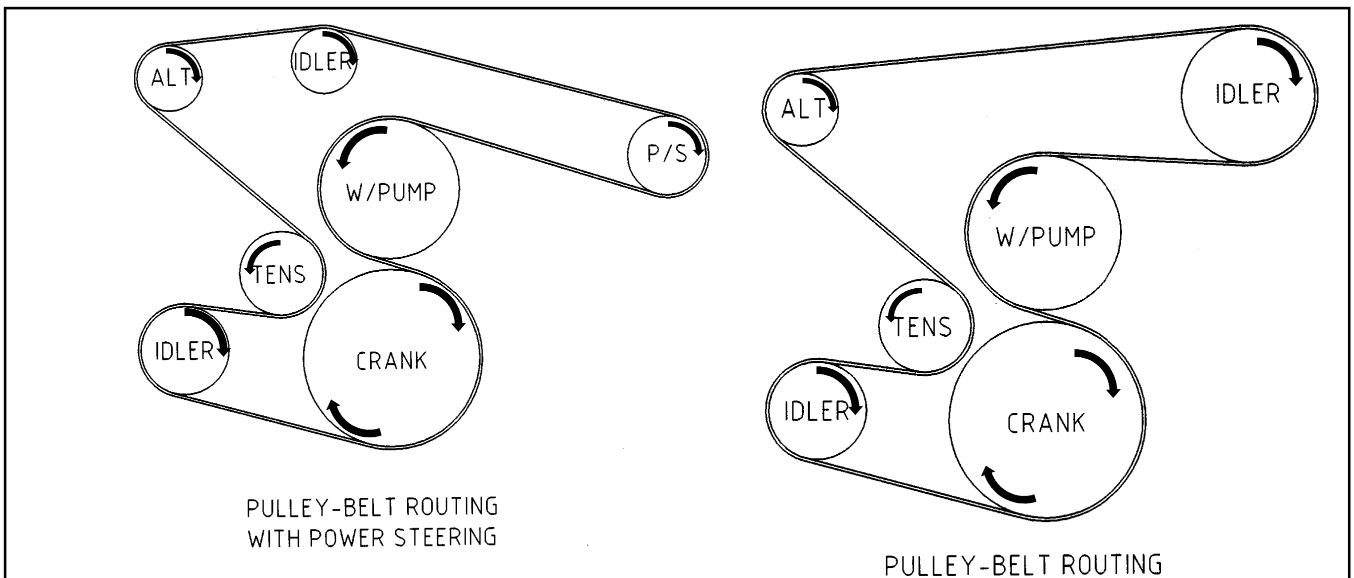
Fan Drive Belt

Removal



1. With engine off, using a 1/2" breaker bar, pry against the tension of the tensioner.
2. Rotate the tensioner counterclockwise and remove the drive belt.

Installation



NOTE: View looking at crankshaft from front of engine.

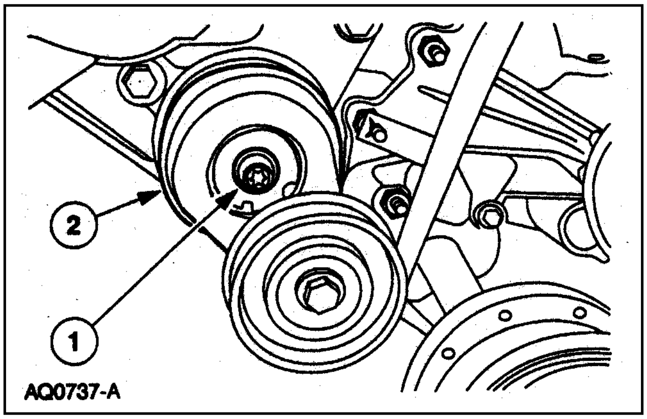
Pulley	Rotation
Crankshaft	CW
Water Pump	CCW
Alternator	CW
Idler – (Large)	CW
Tensioner	CCW
Idler – (Small)	CW
Power Steering	CW

Installation

1. To install, reverse the removal procedure. Refer to component locations for drive belt routing.

REMOVAL AND INSTALLATION

Belt Tensioner

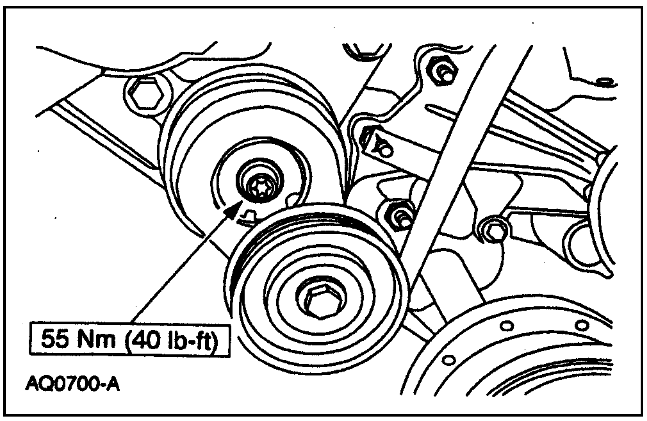


Removal

1. Remove the drive belt (8620). For additional information, refer to Belt in this section.
2. Remove the belt tensioner.

   1. Remove the bolt.

   2. Remove the belt tensioner.

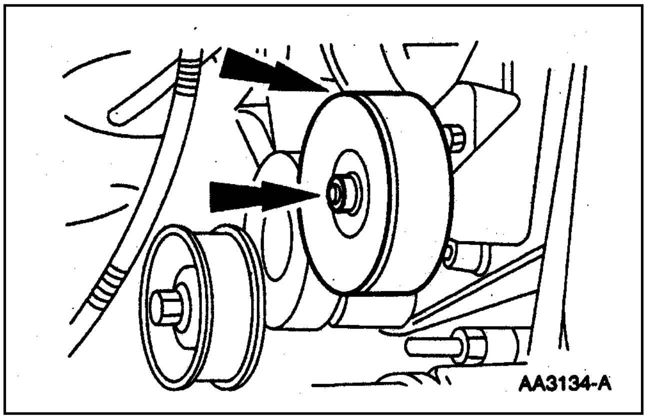


Installation

1. To install, reverse the removal procedure.

REMOVAL AND INSTALLATION (Continued)

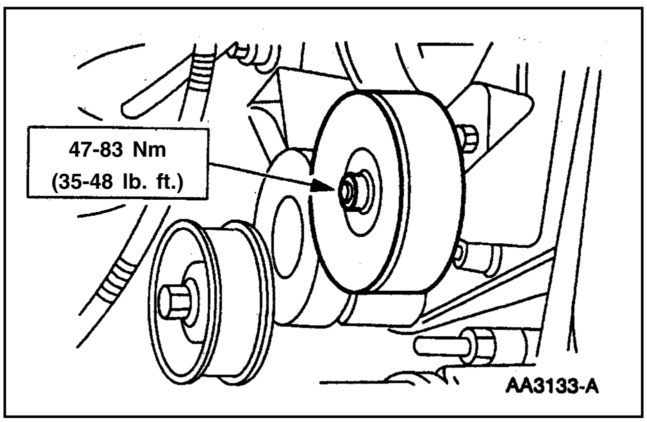
Belt Idler Pulley



Removal

1. Remove the drive belt (8620) off of the belt idler pulley (8678). For additional information, refer to Belt in this section.
2. **NOTE:** The belt idler pulley shown is for a vehicle with air conitioning; the belt idler pulley for a vehicle without air conditioning is ribbed.

   Remove the bolt and the belt idler pulley.



Installation

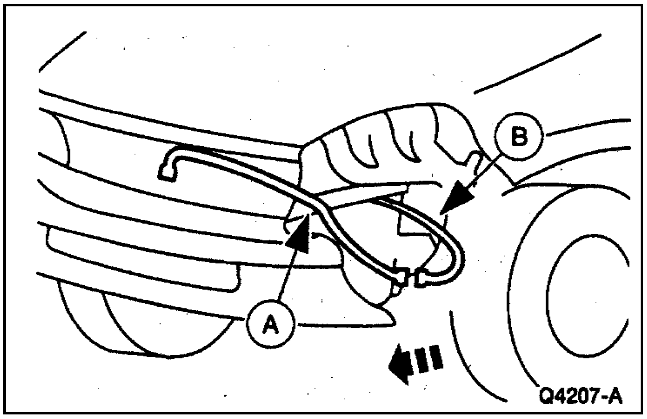
1. To install, reverse the removal procedure.

REMOVAL AND INSTALLATION (Continued)

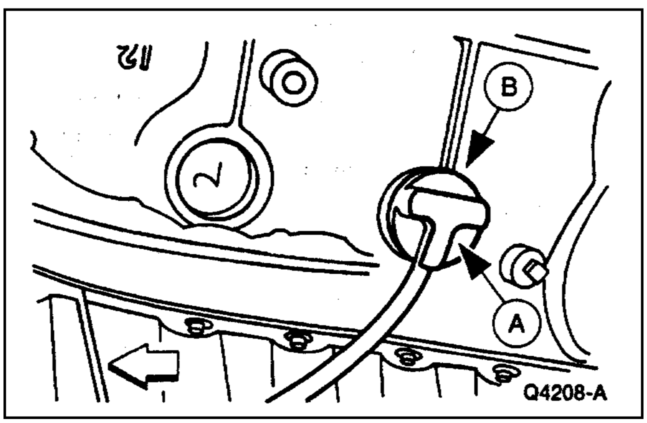
Block Heater

Removal

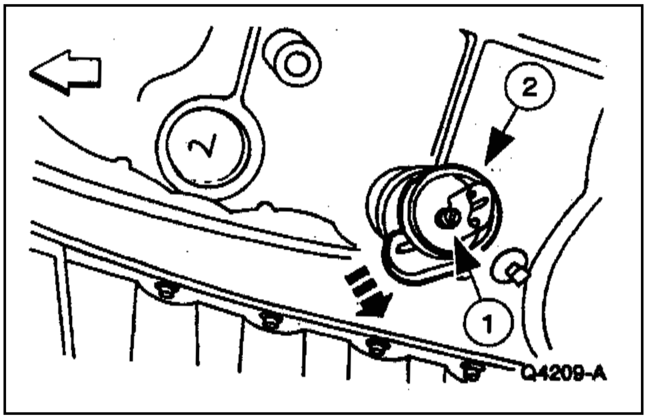
1. Disconnect battery ground cable.
2. Drain the cooling system. For additional information, refer to Draining in this section.
3. Disconnect the **A** block heater wire extension (6B019) from the **B** block heater wiring (6B018) and remove.
4. Raise and support the vehicle.



5. Disconnect the **A** block heater wiring from the **B** block heater (6A051) and remove.



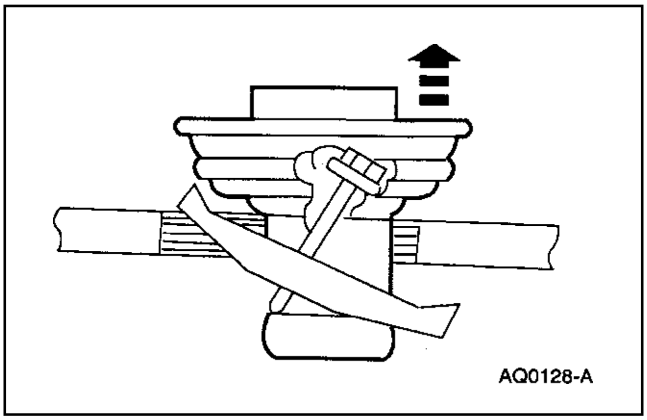
REMOVAL AND INSTALLATION (Continued)



6. Remove the block heater.

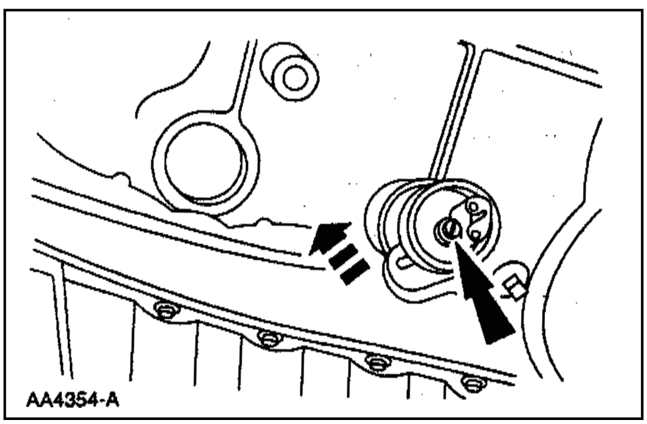
   1. **NOTE:** Do not loosen the block heater retaining screw more than necessary for removal.

      Loosen the block heater retaining screw.



   2. Twist and slide the block heater to release the retainer clip and remove. Discard the retainer clip.

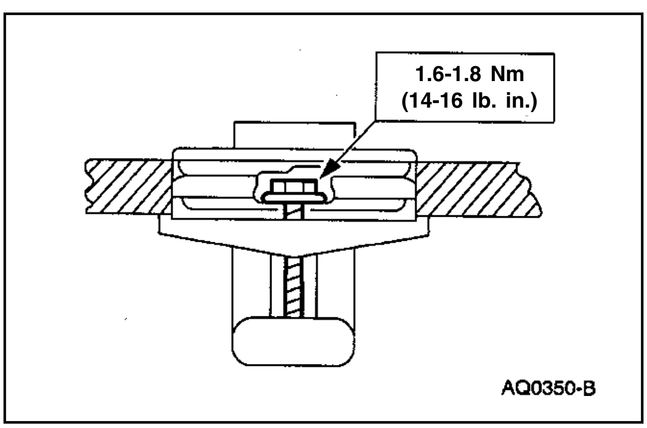
Installation



1. To install, reverse the removal procedure.

   NOTE: Clean the inside diameter of the cylinder block hole machined surface and hole entrance.

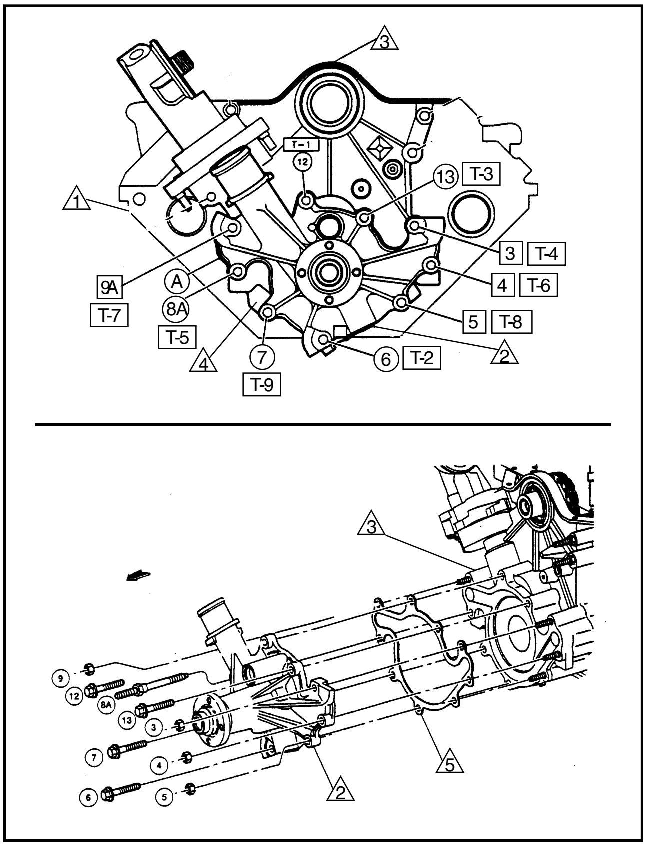
   NOTE: To ease installation, coat the block heater seal and the cylinder block hole with Premium Long Life Grease XG-1-C or equivalent meeting Ford specification ESA-M1C75-B.



2. Tighten retaining screw 1.6-1.8 Nm (14-16 lb. in.).
3. Refill engine cooling system.
4. Connect battery ground cable.
5. Start engine and check for leaks.

REMOVAL AND INSTALLATION (Continued)

Water Pump



Torque Specs:
Bolt #1,2,6,7,8A,10,11,12 & 13 = 20-30 Nm.
Stud #3, 4, 5 & 9A = 6-8 Nm.

1 - Install studs torque to 6-8 Nm.
2 - Install front cover gasket (-6020-).
3 - Install front cover & oil pump assy. (-6F008-).
4 - Install water pump gasket (-8507-).
5 - Install water pump assy. (-8501-).
6 - Install remaining fasteners.
7 - Torque all bolts and nuts to 20-30 Nm making sure to follow the sequence as shown above.

NOTE: T-# Indicates the torque sequence order.

1 Cylinder Block Assy.

2 Water Pump Assy. (8501).

3 Front Cover & Oil Pump Assy. (6F008).

4 Wire Retention Hole.

5 Water Pump Gasket (8507).

Removal

NOTE: A small amount of antifreeze coming out the water pump weep hole may be normal.

1. Drain the cooling system. For additional information, refer to Draining in this section.
2. Remove the drive belt. For additional information, refer to Belt in this section.
3. Remove the cooling fan and pulley. For additional information, refer to Cooling Fan in this section.
4. Remove the Water Heater Return Tube Assembly. For additional information refer to Water Heater Outlet Tube in this section.
5. Remove the bolts and nuts from water pump.
6. Remove water pump.

Installation

1. Clean all gasket surface on the front cover. Clean gasket surface on water pump if not replacing with a new one.
2. Align water pump and water pump gasket to engine front cover.
3. Install all water pump bolts and nuts finger tight.
4. Torque all bolts and nuts to specification and in the sequence as illustrated.
5. Replace Water Heater Return Tube Assembly. For additional information refer to Water Heater Tube Assembly in this section.
6. Replace Cooling Fan. For additional information refer to Fan in this section.
7. Replace Drive Belt. For additional information refer to Belt in this section.
8. Fill cooling system with approved type and mixture of antifreeze. For additonal information refer to Filling in this section.

COOLING SYSTEM, DIAGNOSING AND TESTING

Diagnosis

Refer to the following Diagnosis Chart for cooling system problems, their possible cause and recommended correction. Refer to the pertinent part for testing and repair.

The most frequent cooling system complaints are leakage and overheating. Either of these problems will soon render the vehicle inoperable.

Most vehiles use an ethylene glycol base antifreeze solution to which the manufacturers have added a dye color. The dye color makes the antifreeze solution an excellent leak detector. If this type of solution is not being used in the cooling system, a vegetable dye may be added to aid in locating external leakage.

NOTE: A small amount of antifreeze coming out the water pump weep hole may be normal.

CONDITION	POSSIBLE SOURCE	ACTION
• Loss of coolant.	• Pressure cap and gasket. • Leakage. • Internal leakage.	• Inspect washer gasket and test. Replace only if cap will not hold pressure to specification • Pressure test system. • Inspect hose, hose connection, radiator, edges of cooling system gaskets, core plugs and drain plugs, transmission oil cooler lines, water pump, heater system components. Repair or replace as required. • Disassembly engine as necessary – check for: cracked intake manifold, blown head gaskets, warped head or block gasket surfaces, cracked cylinder head or cylinder block.
• Engine overheats.	• Low coolant level. • Loose fan belt. • Pressure cap. • Radiator obstruction. • Closed thermostat. • Fan drive clutch. • Ignition. • Temp. gauge. • Engine. • Coolant mixture.	• Fill as required. Check for coolant loss. • Replace belt or tensioner as required. • Test. replace if necessary. • Remove bugs, leaves, etc. • Test, replace if necessary. • Test, replace if necessary. • Check timing and timing advance. Adjust as required. • Check electrical circuits and repair as required. • Check water pump and block for blockage. • 1/2 water and 1/2 permanent antifreeze mixture.
• Engine fails to reach normal operating temperature.	• Open thermostat. • Temperature gauge.	• Test, replace if necessary. • Check electrical circuits and repair as required.

General Test Procedures

Visual Inspection

Check for leakage at:
1. All hoses and hose connections.
2. Radiator seams, radiator core, and radiator drain petcock.
3. All block core plugs and drain plugs.
4. Edges of all cooling system gaskets.
5. Transmission oil cooler.
6. Water pump shaft and bushing.

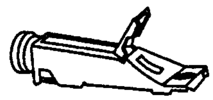
NOTE: A small amount of antifreeze coming out the water pump weep hole may be normal.

Examine oil dipstick for evidence of coolant contaminated engine oil (white milky appearance). Check radiator for evidences of oil in coolant (leakage at transmission oil cooler).

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

Cooling System Visual Test

Special Tool(s)

 ST1720-A	Battery/Anti-Freeze Tester 014-R1060 or equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. 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 DOWN TO AT LEAST 110°F.

1. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

   CAUTION: If there is engine coolant in the engine oil the cause must be corrected and the oil changed or engine damage may occur.

   CAUTION: If there is coolant in the transmission fluid, the cause must be corrected or transmission damage may occur.

   NOTE: Check the engine coolant in the degas bottle and radiator (8005) if vehicle has been allowed to reach normal operating temperature. This will make sure sufficient engine coolant exchange has occurred.

3. Inspect the coolant in both the radiator and the degas bottle for coolant color:
   - Clear, light green or blue indicates higher water content than required
   - Dark brown indicates unauthorized stop leak may have been used. Use cooling system Stop Leak Powder E6AZ-19558-A or equivalent meeting Ford specification ESE-M99B170-A only.
   - A light or reddish-brown color indicates rust in the cooling system. Flush the system and refill with the correct mixture of water and Premium Engine Coolant (green in color), E2FZ-19549-AA or equivalent meeting Ford specification ESE-M97B44-A.
   - An irridescent sheen on top of the coolant indicates a trace of oil is entering the cooling system.
   - A milky-brown color indicates that oil is entering the cooling system.
   - The causes of the leak might be:

     – A blown head gasket (6051).

     – A cracked or warped cylinder head (6049).

     – A crack in the engine oil gallery and the cooling passageways.
   - If engine coolant is present in the engine oil, the cause of the leak might be:

     – A blown head gasket.

     – A cracked or warped cylinder head.

     – A crack in the engine oil gallery and cooling passageways.
   - If engine coolant is present in the transmission fluid, the cause might be:

     – A leaking radiator.

     – A leaking auxiliary fluid cooler.
   - A reddish milky appearance indicates transmission fluid is entering the system.

     The causes of the leak might be:

     – A leaking radiator.

     – A leaking auxiliary fluid cooler.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

4. If the engine coolant appearance is good, test the engine coolant range with the battery and antifreeze tester:

   - Maximum ratio is 60/40 (antifreeze/water).

   - Minimum ratio is 45/55 (antifreeze/water).

5. Check the engine coolant system conditions:

   - If the engine cooling fluid is low, add specified coolant mixture only.

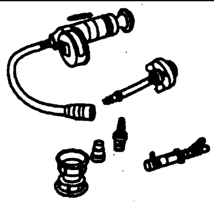
   - If the engine coolant fluid tests weak, add straight engine coolant until the readings are within acceptable levels.

   - If the engine coolant tests strong, remove some of the engine coolant and add water until readings are within acceptable levels.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

Engine Cooling

Special Tool(s)

 ST1474-A	Radiator/Heater Core Pressure Tester 014-R1072 or equivalent
 ST1137-A	Rotunda 73 Digital Multimeter 105-R0051 or equivalent

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

Visual Inspection Chart

Mechanical	Electrical
• Leaks • Damaged hoses • Loose/damaged hose clamps • Damaged water thermostat gasket • Damaged head gaskets • Damaged intake manifold gasket • Damaged water pump • Damaged radiator • Damaged degas bottle • Damaged heater core • Damaged fan/fan clutch	• Damaged engine coolant temperature sensor • Damaged wiring

Inspection and Verification

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.
3. If the inspection reveals an obvious concern that can be readily identified, repair as necessary.
4. If the concern remains after the inspection, determine the symptom(s) and go to the Symptom Chart.

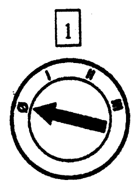
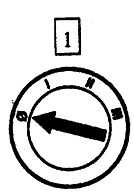
Symptom Chart

Condition	Possible Source	Action
• Loss of Coolant	• Radiator. • Water pump seal. • Radiator hoses. • Heater hoses/tubes. • Heater core. • Engine gaskets. • Degas bottle.	• GO to Pinpoint Test A.
• The Engine Overheats	• Water thermostat. • Water pump. • Internal engine coolant leak. • Radiator. • Heater core. • 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 (6A051) Does Not Operate Properly	• Block heater power cable.	• GO to Pinpoint Test D.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

Pinpoint Tests

PINPOINT TEST A: LOSS OF COOLANT

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
A1 CHECK THE ENGINE COOLANT LEVEL	
NOTE: Allow the engine to cool before checking the engine coolant level.	
	2 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 **A6.**
A2 CHECK THE PRESSURE RELIEF CAP	
	1 Perform the Pressure Relief Cap Test. For additional information, refer to Component Tests, Cap-Pressure Relief in this section. • Is pressure relief cap OK? ► **Yes** GO to **A3.** ► **No** INSTALL a new pressure relief cap. TEST the system for normal operation.
A3 CHECK THE ENGINE COOLANT FOR INTERNAL LEAK	
	1 Inspect the engine coolant in degas bottle for signs of transmission fluid or engine oil. • Is oil or transmission fluid evident in coolant? ► **Yes** If engine oil or transmission fluid is evident, REPAIR or INSTALL a new radiator as necessary. ► **No** GO to **A4**.

(Continued)

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

PINPOINT TEST A: LOSS OF COOLANT (Continued)

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
A4 CHECK THE ENGINE AND THE TRANSMISSION FOR COOLANT	
	1 Remove the oil level dipsticks (6750) from the engine and the transmission. • Is coolant evident in oil or transmission fluid? ▶ **Yes** If coolant is in engine, GO to Section 01. If coolant is in transmission (7003), INSTALL a new radiator or REPAIR as necessary. GO to Transmission Service Manual to repair the automatic transmission[1]. ▶ **No** GO to **A5.**
A6 CHECK THE COOLANT RECOVERY SYSTEM	
	1 **WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. 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 DOWN TO AT LEAST 110°F.** 2 Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system. 3 When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap. 4 Inspect the pressure relief cap for foreign material between the sealing gasket and the diaphragm. 5 Pressure test cap using tool ST1474-A. • Is a 7 lb. pressure maintained? • Is the pressure relief cap OK? ▶ **Yes** GO to **A7.** ▶ **No** CLEAN or INSTALL a new pressure relief cap. TEST the system for normal operation. GO to **A1**.

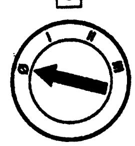
[1]Can be purchased separately.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

PINPOINT TEST A: LOSS OF COOLANT (Continued)

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
A7 CHECK THE DEGAS BOTTLE	
	1 **NOTE:** The engine must be cool when coolant is added to the degas bottle. Add coolant to the degas bottle until fluid is between the coolant fill level marks. • Does the degas bottle leak? ► **Yes** INSTALL a new degas bottle. TEST the system for normal operation. ► **No** PERFORM the cooling system pressure test. For additional information, refer to Component Tests, Pressure Test in this section. REPAIR as necessary. TEST the system for normal operation.

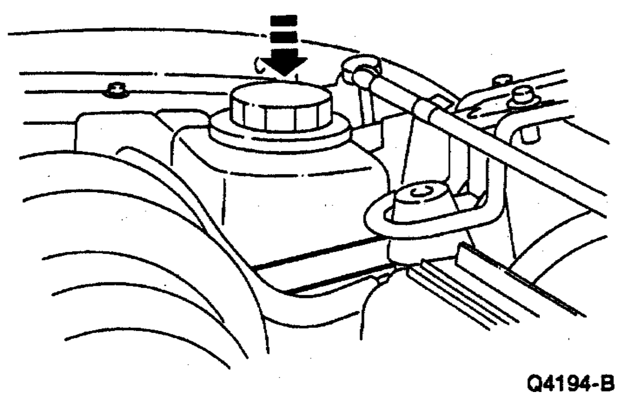
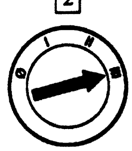
PINPOINT TEST B: THE ENGINE OVERHEATS

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
B1 CHECK THE ENGINE COOLANT LEVEL	
NOTE: If the engine is hot, allow the engine to cool before proceeding.	
1 	1 **WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. 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 DOWN TO AT LEAST 110°F.** 2 Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system. 3 When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap. 4 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.

(Continued)

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

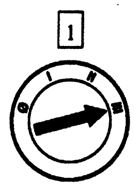
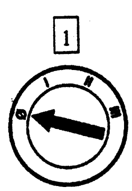
PINPOINT TEST B: THE ENGINE OVERHEATS (Continued)

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
B2 CHECK THE COOLANT CONDITION	
	1 Check the coolant for contaminants such as rust, corrosion, or discoloration. • Is the coolant condition OK? ▶ **Yes** GO to **B3.** ▶ **No** FLUSH the engine cooling system. For additional information, refer to Flushing – Engine and Radiator in this section. TEST the system for normal operation.
B3 CHECK FOR AN AIRFLOW OBSTRUCTION	
	1 Inspect the radiator for obstructions such as leaves or dirt. • Is there an obstruction? ▶ **Yes** REMOVE the obstruction. CLEAN the radiator. TEST the system for normal operation. **No** ▶ GO to **B4.**
B4 CHECK THE HEATER CORE OPERATION AND/OR LPG EVAPORATOR	
 2 	1 Install the pressure relief cap.

(Continued)

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

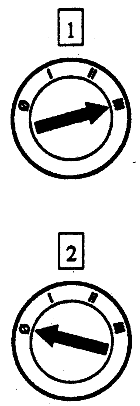
PINPOINT TEST B: THE ENGINE OVERHEATS (Continued)

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
B4 CHECK THE HEATER CORE OPERATION AND/OR LPG EVAPORATOR (Continued)	
	3 As the engine starts to heat up, feel the inlet and outlet heater water hoses (18472). They should feel approximately the same after three or four minutes. • Is the outlet heater water and/or LPG evaporation hose approximately the same temperature as the inlet heater water hose? ► **Yes** GO to **B5.** ► **No** TURN the engine off. REPAIR or INSTALL a new heater core or clear the LPG evaporation coolant passage way. TEST the system for normal operation.
B5 CHECK THE WATER THERMOSTAT OPERATION	
	1 Start the engine and allow the engine to run for ten minutes. 2 Feel the inlet and outlet heater water hoses and the underside of the upper radiator hose (8260). • Are the upper radiator hose and the heater water hoses cold? ► **Yes** INSTALL a new water thermostat. TEST the system for normal operation. ► **No** Go to **B6.**
B6 CHECK THE COOLING FAN OPERATION	
	1 Perform the cooling fan component tests. For additional information, refer to the Component Tests in this section. • Is the cooling fan operation OK? ► **Yes** GO to Section 01 for diagnosis and testing of the engine. ► **No** INSTALL a new component determined to be faulty. For additional information, refer to Fan – Blade, Clutch and Shroud in this section. TEST the system for normal operation.

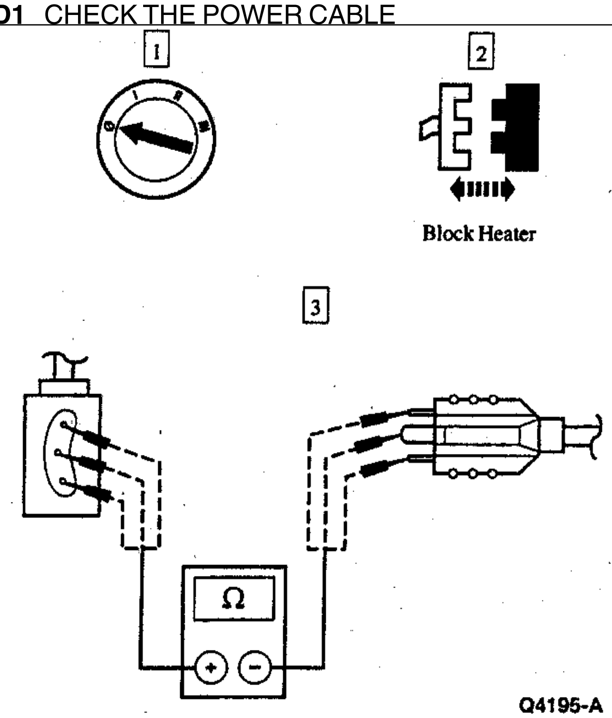
(Continued)

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

PINPOINT TEST C: THE ENGINE DOES NOT REACH NORMAL OPERATING TEMPERATURE

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
C1 CHECK THE ENGINE TEMPERATURE	
	1 Start the engine and allow the engine to idle for ten minutes. Feel the inlet and heater water hoses and the underside of the upper radiator hose. • Are the upper radiator hose and the heater water hoses cold? ► **Yes** INSTALL a new water thermostat. ► **No** Test and diagnose the engine coolant temperature gauge.

PINPOINT TEST C: THE BLOCK HEATER DOES NOT OPERATE PROPERLY

TEST CONDITIONS	TEST DETAILS/RESULTS/ACTIONS
D1 CHECK THE POWER CABLE	
	3 Check resistance in circuits 1, 2, and 3 of the block heater. • Is the resistance in circuits 1, 2, and 3 less than 5 ohms? ► **Yes** INSTALL a new block heater. ► **No** INSTALL a new power cable. TEST the system for normal operation.

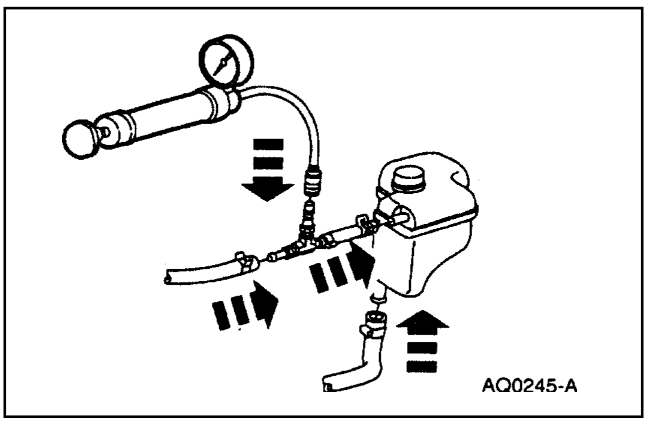
COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

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. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. 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 DOWN TO AT LEAST 43°C (110°F).**
3. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
4. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

   Check the engine coolant level. For additional information, refer to Cooling System Draining, Filling and Flushing in this section.



5. Connect 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.
6. **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.
7. 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.
7. If 48 kPa (7 psi) cannot be reached, install a new pressure relief cap. If more than 83 kPa (12 psi) shows on gauge, install a new pressure relief cap.
9. **NOTE:** If the pressure drops, check for leaks at the engine to heater core hoses, engine to LPG evaporator hose, 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. For additional information, refer to Specifications in this section. Pressure should not drop during this time.
10. 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. For additional information, refer to Cooling System Draining, Filling and Bleeding in this section.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

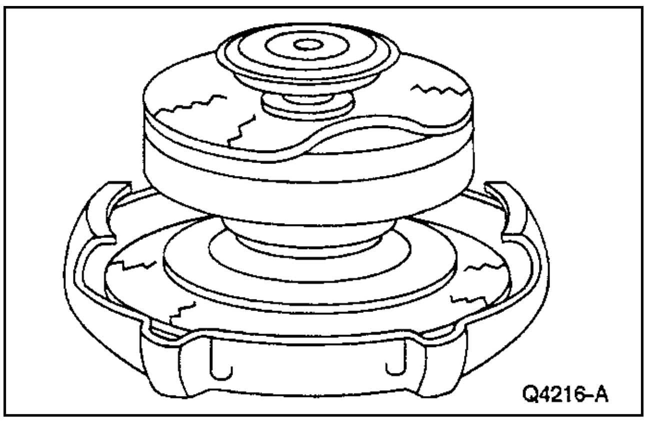
Cap – Pressure Relief

1. **WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. 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 DOWN TO AT LEAST 110°F.**

2. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.

3. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

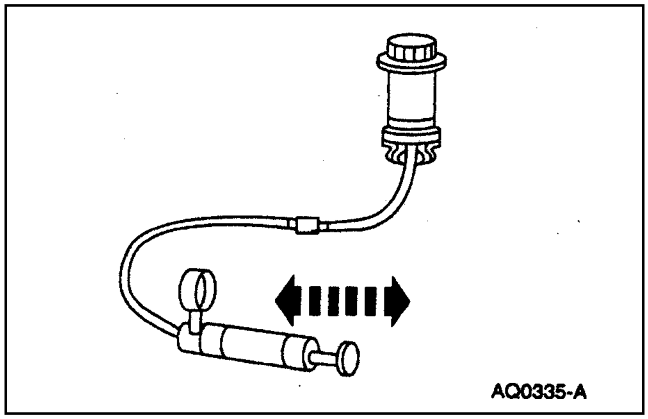
   Inspect the pressure relief cap and seals for damage or deterioration. Replace the pressure relief cap if necessary.



4. Fit the pressure relief cap to Radiator/Heater Core Pressure Tester Kit using the aftermarket adapter.

5. **NOTE:** If the plunger of the pressure tester is depressed too fast, an incorrect pressure reading will result.

   Slowly pump the pressure tester until the pressure gauge stops increasing and note the highest pressure reading. Release pressure and repeat test. Install a new pressure relief cap if the pressure is not 48 kPa (7 psi).



Thermostat

The water thermostat should be replaced only after the following test has been performed.

Thermostat Test – Thermostat Removed

WARNING: USE CAUTION WORKING WITH HOT BOILING WATER AND WEAR APPROPRIATE PROTECTIVE GEAR. MAY CAUSE BODILY HARM.

Remove the thermostat and immerse it in boiling water. Replace the thermostat if it does not open at least 0.230" after one minute at 212°F.

If the problem being investigated is the inability of the cooling system to reach normal operating temperature, the thermostat should be checked for leakage. This may be done by holding the thermostat up to a lighted background. Leakage of light all around the thermostat valve (thermostat at room temperature) indicates that the thermostat is unacceptable and should be replaced. It is possible, on some thermostats, that a slight leakage of light at one or two locations on the perimeter of the valve may be detected. This should be considered normal.

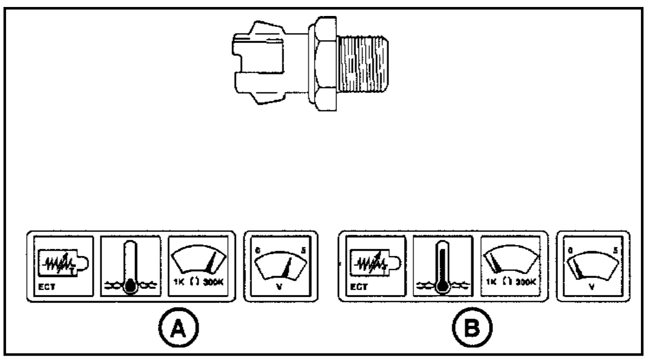
COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

Radiator Leak Test, Removed From 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.

1. Always install plugs in the oil cooler fittings before leak-testing or cleaning any radiator.
2. Clean the radiator before leak-testing to avoid contamination of the tank.
3. Leak-test the radiator in clean water with 138 kPa (20 psi) air pressure.

ENGINE CYLINDER HEAD TEMPERATURE (CHT) SENSOR

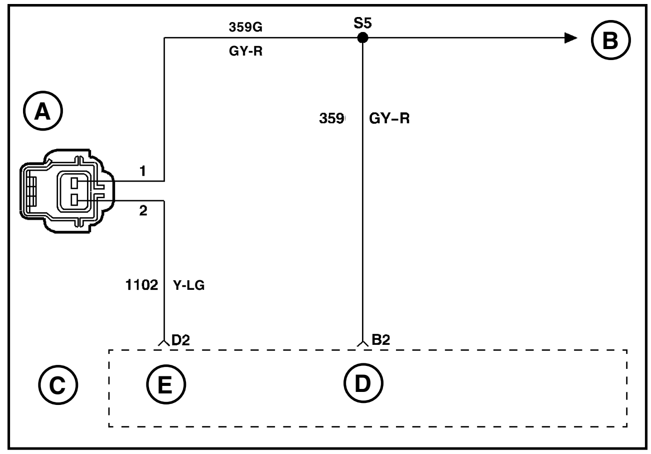


A Low Coolant Temperature
B High Coolant Temperature

- Engine cylinder head temperature (CHT) sensor is a type of thermistor that converts engine temperature to an electrical voltage signal.
- The electrical resistance of the (CHT) sensor changes with temperature. As engine coolant temperature increases, the (CHT) resistance decreases.
- Output is a variable voltage signal which typically ranges from 0.3 volt to 4.5 volts.
- At -40°F (CHT) resistance is approximately 269K ohms.
- At 77°F (CHT) resistance is approximately 29K ohms.
- At 248°F (CHT) resistance is approximately 1.2K ohms.

NOTE: Complete list of temperature sensor characteristics can be found on page 05-34 of this section.

DIAGNOSTIC TROUBLE CODE (DTC) 43 ENGINE CYLINDER HEAD TEMPERATURE LOW VOLTAGE AND DTC 33 FOR HIGH VOLTAGE



A Engine Cylinder Head Temperature Sensor Connector
B Ground (B-)
C Engine Control Module (ECM)
D Sensor Ground
E Sensor Signal

Circuit Description

The engine cylinder head temperature (CHT) sensor is a termistor which measures the temperature of the engine cylinder head. The ECM supplies a ground (circuit 359, Gray/Red) from the sensor and monitors voltage signal (circuit to 1102, Yellow/Lt. Green) to the sensor. When the engine coolant is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the CHT signal circuit. If the engine cylinder head is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 43 will set when the ECM detects an excessively low signal voltage, and DTC 33 when the ECM detects an excessively high signal voltage.

Conditions for Setting the DTC

- KOEO or KOER.
- CHT sensor signal is less than or equal to 0.22 volts or greater than 4.93 volts.
- Above conditions are present for a least 3 consecutive seconds.

COOLING SYSTEM, DIAGNOSING AND TESTING (Continued)

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the CHT sensor to a 50° F default value.

NOTE: Complete list of temperature sensor characteristics found on page 05-34 of this section.

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery ground cable for 5 to 20 minutes.

NOTE: Touching the two disconnected battery cables will only clear the trouble codes from the PC not from the ECM.

- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the “C” key while in the View Sensor Data screen.

Diagnostic Aids

The (CHT) sensor shares the same ground with other sensors. Check the ground circuit 359 (Gray) if other DTCs are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, back probe the CHT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the CHT sensor. A change in the voltmeter display will indicate the location of the fault.

NOTE: For installation and removal procedures for the CHT, refer to page 05-12 of this section.

MST, CHT, ECT & IAT SENSOR DATA

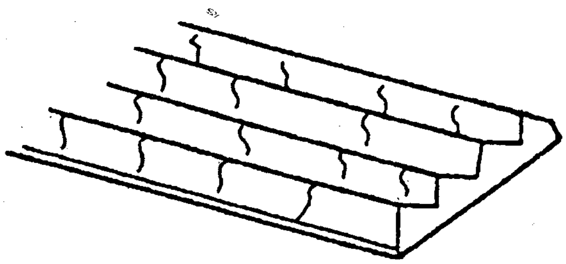
Temperature Sensor Characteristics

TEMPERATURE (C)	(F)	NOM R, (OHMS)	NOM E_{OUT} (VOLTS)
-40	-40	925,021	4.54
-35	-31	673,787	4.50
-30	-22	496,051	4.46
-25	-13	368,896	4.41
-20	-4	276,959	4.34
-15	5	209,816	4.25
-10	14	160,313	4.15
-5	23	123,485	4.02
0	32	95,851	3.88
5	41	74,914	3.71
10	50	58,987	3.52
15	59	46,774	3.32
20	68	37,340	3.09
25	77	30,000	2.86
30	86	24,253	2.62
35	95	19,716	2.39
40	104	16,113	2.15
45	113	13,236	1.93
50	122	10,926	1.72
55	131	9,061	1.52
60	140	7,548	1.34
65	149	6,332	1.18
70	158	5,335	1.04
75	167	4,515	.91
80	176	3,837	.79
85	185	3,274	.70
90	194	2,804	.61
95	203	2,411	.53
100	212	2,080	.47
105	221	1,801	.41
110	230	1,564	.36
115	239	1,363	.32
120	248	1,191	.28
125	257	1,044	.25
130	266	918	.22
135	275	809	.19
140	284	715	.17
145	293	633	.15
150	302	563	.14
Voltage values calculated for VREF=5 volts (may vary 15% due to sensor and VREF variations).			

COOLING SYSTEM DIAGNOSING AND TESTING (Continued)

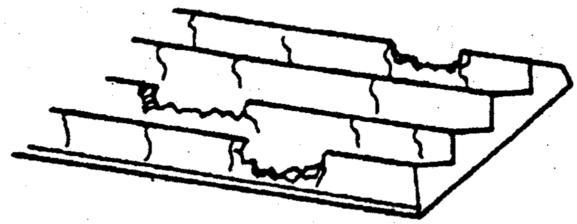
V-Ribbed Serpentine Drive Belt

Cracks Across Ribs



A22988-A

Chunks of Rib Missing



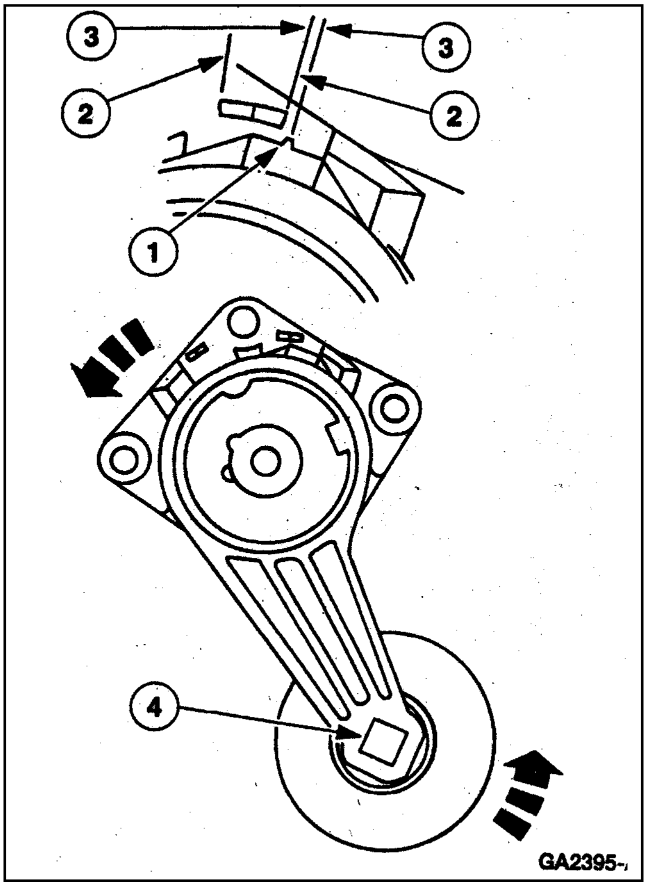
A22989-A

Symptom Chart

Condition	Possible Source	Action
• Drive belt cracking • Drive belt chunking.	• Worn out. • Overheated • Chemical or oil spilled on belt.	• REPLACE the drive belt; Refer to Belt in this section.
• Drive belt noise or squeal.	• Pulley misalignment. • Excessive pulley groove runout. • Damaged drive belt tensioner (6B209). • Fluid or contamination on the drive belt. • Excessive A/C head pressure.	• DETERMINE from which pulley the noise originates. CHECK that area with a straightedge and LOOK for for accessory pulley to be out of position in the fore/aft direction or at an angle to the straightedge. REPLACE the pulley or the component; • Replace belt tensioner. • CLEAN or REPLACE the drive belt; Refer to Belt this section.

COOLING SYSTEM DIAGNOSING AND TESTING (Continued)

4.2L Belt, Drive Tensioner/Belt Length Indicator



Item	Part Number	Description
1	–	Belt Length Indicator
2	–	Acceptable Belt Installation and Wear Range
3	–	Belt Replacement Range
4	–	Belt Tension Relief Point (Use 1/2 Inch Ratchet)

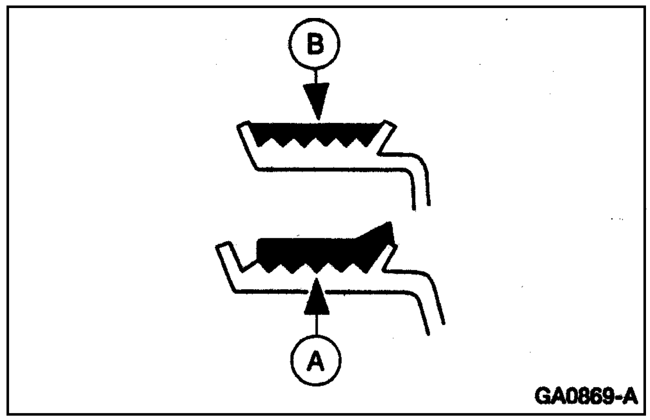
Automatic tensioners are calibrated at the factory to provide the correct amount of tension to the belt. Unless a spring within the tensioner assembly breaks or some other mechanical part of the tensioner fails, there is no need to check tensioners for proper tension.

The only mechanical check that need be made, if you have any doubt about the tensioner function, would be to remove the belt in the area of the tensioner, to avoid belt contact, then using the proper tool, rotate the tensioner from its relaxed position throught its full stroke and back to the relaxed position to assure that there is no "stick, grab, bind," and to assure that there is tension on the spring. It is a normal condition for the tensioner to be moving, under certain conditions, when the engine is running. If the tensioner meets this criteria, it should be assumed to be a good tensioner.

Drive Belt Misalignment

⚠ CAUTION: Incorrect drive belt installation will cause excessive drive belt wear and may cause the drive belt to come off the drive pulleys.

Non-standard replacement drive belts may track differently or improperly. If a replacement drive belt tracks improperly, replace it with an original equipment drive belt to avoid performance failure or loss of belt.



With the engine running, check drive belt tracking. If the **A** edge of the drive belt rides beyond the edge of the pulleys, noise and premature wear may occur. Make sure the **B** drive belt rides correctly on the pulley. If a drive belt tracking condition exists, proceed with the following:

Visually check the drive belt tensioner for damage, especially the mounting pad surface. If the drive belt tensioner is not installed correctly, the mounting surface pad will be out of position. This will result in a chirp or squeal noises.

- With the engine running, visually observe the grooves in the pulleys (not the pulley flanges or pulley front surfaces) for excessive wobble. Replace components as required.

- Check all accessories, mounting brackets and the drive belt tensioner for any interference that would prevent the component from mounting properly. Correct any interference condition and recheck belt tracking.

- Tighten all accessories, mounting brackets, and drive belt tensioner retaining hardware to specification. Recheck the drive belt tracking.

SPECIFICATIONS

General Specifications

Item	Specification
Drive Belt	6 Ribs
Capacity 4.2L L[1] (qts)	16.4 (17.3)
Coolant Mixture With Water	50%[2]
Pressure Relief Cap Opening Pressure kPa (psi)	110 (16)
Radiator Pressure Test	138 kPa (20 psi)
Water Pump Pulley Ratio	1.2
Water Thermostat Start To Open Temperature C (F)	86.7-90.6°C (188-195°F)
Water Thermostat Full Open Temperature C (F)	97.8-101.7°C (208-215°F)
Lubrication & Sealants	
Ford Premium Cooling System Flush F1AZ-19A503-A	ESR-M14P7-A
Pipe Sealant with Teflon® D8AZ-19554-A	WSK-M2G350-A2
Premium Long Life Grease XG-1-C	ESA-M1C75-B
Stop Leak Powder E6AZ-19558-A	ESE-M99B170

[1] Includes radiator coolant recovery reservoir fluid level between the "COOLANT FILL LEVEL" lines.

[2] Ford Premium Engine Coolant (green in color) E2FZ-19549-AA or -B (Canada: Motorcraft CXC-8-B, Oregon: F5FZ-19549) Recycled Coolant or equivalent meeting Ford specification ESE-M97B44-A.

Torque Specifications

Description	Nm	Lb-Ft
Belt Idler Pulley Bolt (4.2L)	55	40
Drive Belt Tensioner Bolt (4.2L)	55	40

Description	Nm	Lb-Ft	Lb-In
Block Heater	1.6-1.8	–	14-16
Cylinder Head Temperature Sensor	9-11	–	80-95
Fan Assembly To Fan Clutch Bolts	17	13	–
Fan Assembly and Fan Clutch To Water Pump	55	41	–
Fan Shroud Screws	9	–	80
Degas Bolts	9	–	80
Radiator Draincock	0.7-1.4	–	6-12
Radiator Support Bracket Bolts	30	22	–
Transmission Fluid Cooler Fittings	20	15	–
Water Inlet and Outlet Connection Bolts	9	–	80
Water Pump Bolts	20-30	15-22	–
Water Pump Pulley Bolts	20-30	15-22	–

WATER PUMP AND FRONT COVER FASTENERS						
HOLE NO.	W/P	F/C	PART NO.	PART NAME	DESCRIPTION	HEX SIZE
1.		X	N805112	Stud Bolt	M8 X 1.25 X 98	(15mm Hex)
2.		X	N805112	Stud Bold	M8 X 1.25 X 98	(15mm Hex)
3.	X		N805757	Stud	M8 x 1.25 X 137	(N/A)
4.	X		N804853	Stud	M8 X 1.25 X 156	(N/A)
5.	X		N805757	Stud	M8 X 1.25 X 137	(N/A)
6.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
7.	X		N808217	Bolt	M8 X 1.25 X 117.5	(10mm Hex)
8.	X		N804852	Stud Bolt	M8 X 1.25 X 160.3	(15mm Hex)
9.	X		N804853	Stud	M8 X 1.25 X 156	(N/A)
10.		X	N804839	Bolt	M8 X 1.25 X 105	(10mm Hex)
11.		X	W701885	Socket Head Cap Screw	M8 X 1.25 X 19.5	(N/A)
12.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
13.	X		N605908	Bolt	M8 X 1.25 X 38	(10mm Hex)
3,4,5,9	X		N804745	Nut	M8 X 1.25	(15mm Hex)

NOTE: Bolt information on installation page this section.

CHARGING INDEX

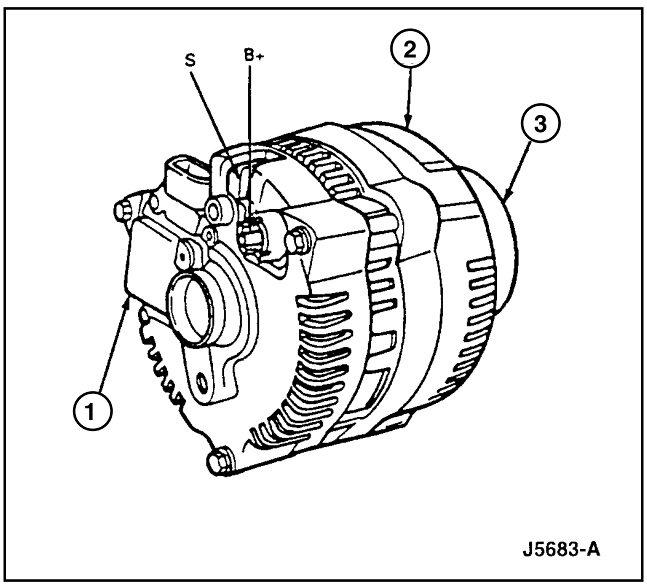
GENERATOR, INTEGRAL REAR MOUNT REGULATOR, INTERNAL FAN TYPE DESCRIPTION AND OPERATION

Generator

With the key in the RUN position, voltage is applied through the charge indicator lamp "I" circuit to the voltage regulator. This turns the voltage regulator on allowing current to flow from the battery sense "A" circuit to the generator field coil. When the engine (6007) is started, the generator (10346) begins to generate alternating (AC) current which is converted to direct (DC) current by the rectifier internal to the generator. This current is then supplied to the electrical system through the Battery Positive voltage (B+) terminal located on the rear of the generator.

Once the generator begins generating current, a voltage signal is taken from the stator and fed back to the voltage regulator "S" circuit, turning off the charge indicator/lamp.

With the system functioning normally, the generator output current is determined by the voltage at the "A" circuit. This voltage is compared to a set voltage internal to the voltage regulator, and the voltage regulator controls the generator field current to maintain proper generator output. The set voltage will vary with temperature and is typically higher in the winter than in the summer, allowing for better battery recharge.



1. Generator Regulator 10316
2. Generator 10346
3. Generator Pulley 10344

Circuit Description

Battery Positive Voltage (B+) Output

The generator output circuit 38 (BK/O) is supplied through the battery positive voltage (B+) output connection to the battery and electrical system. The B+ circuit is hot at all times. This circuit is protected by a 12 gage fuse link.

"I" Circuit

The "I" circuit, or ignition switch (11572), circuit 904 (LG/R) is used to turn on the voltage regulator. This circuit is closed with the ignition switch in the RUN position. This circuit is also used to turn the charge indicator lamp on if there is a fault in the charging system operation or associated wiring circuits.

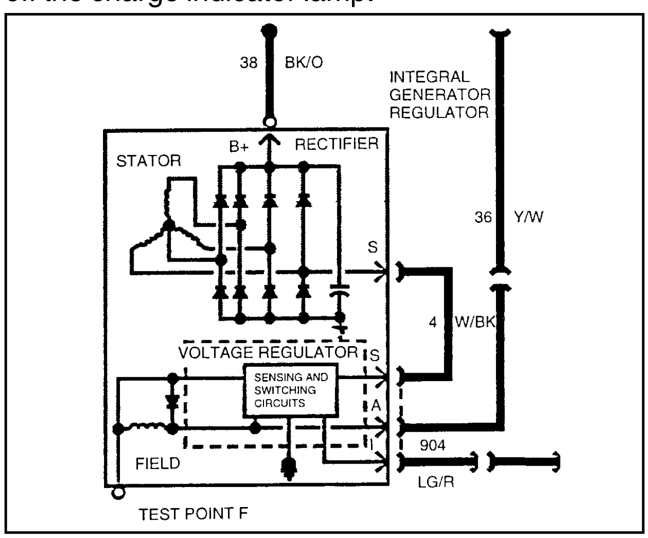
"A" Circuit

CAUTION: The "A" circuit is electrically hot at all times.

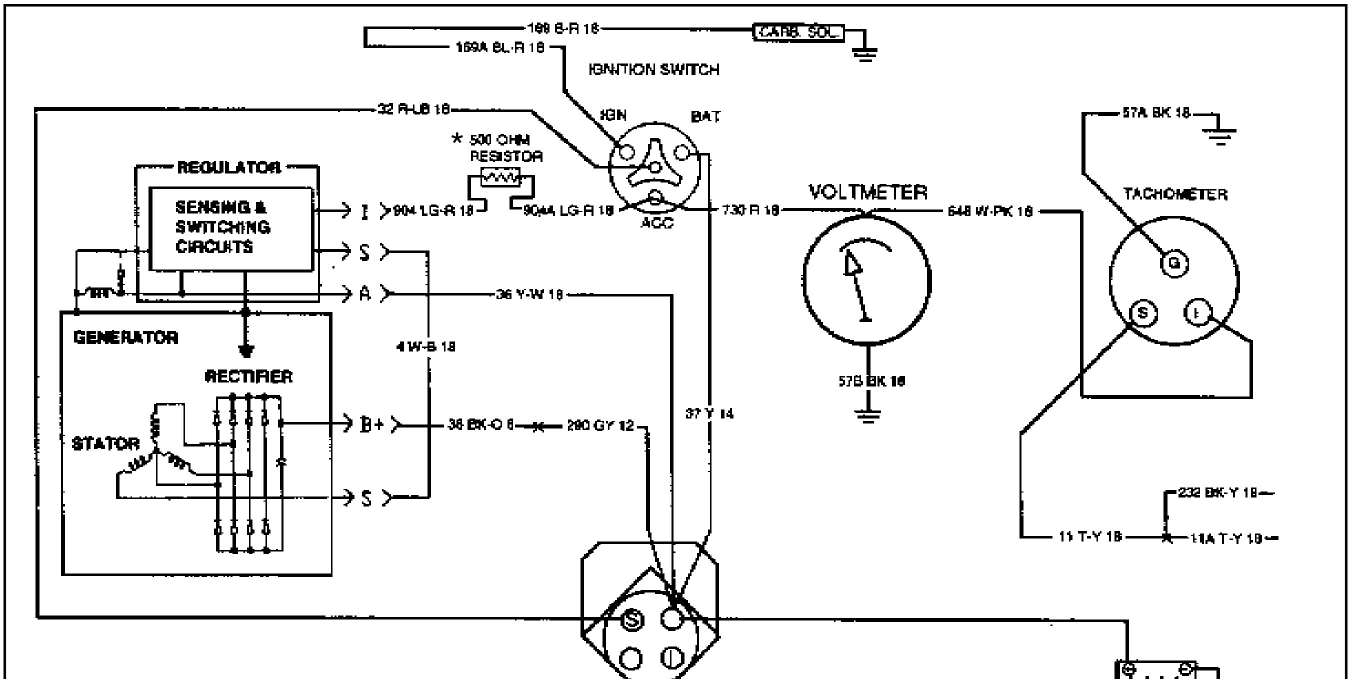
The "A" circuit, or battery sense circuit, circuit 36 (Y/W) is used to sense the battery voltage. This voltage is used by the voltage regulator to determine the output. This circuit is also used to supply power to the field coil. This circuit is protected by a 15 amp fuse in the power distribution box or a fuse link.

"S" Circuit

The "S" circuit, or stator circuit, circuit 4 (W/BK) is used to feed back a voltage signal from the generator to the voltage regulator. This voltage, typically 1/2 battery voltage when the generator is operating, is used by the voltage regulator to turn off the charge indicator lamp.



GENERATOR DIAGNOSIS AND TESTING

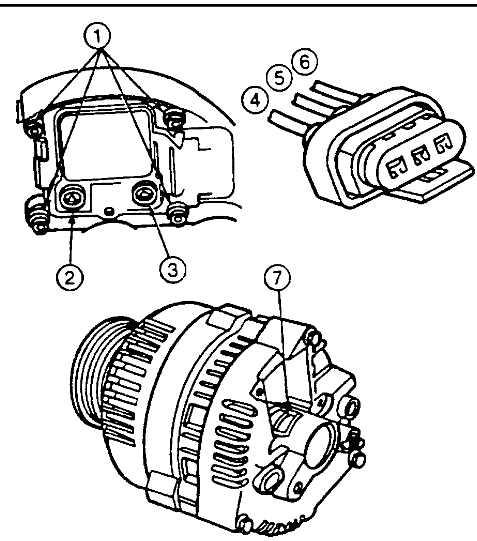


* Located after alternator harness at green/red wire to ignition switch.

FPP00219

NOTE: The generator (main) wiring diagram (14305) for the engine, is found at the back of this section.

Before performing generator tests on the unit, note conditions such as: slow cranking, dead battery, charge indicator lamp stays on with engine running, etc. This information will aid in isolating the part of the system causing the symptom.



J5695-A

Voltage Regulator and Back of Generator

Item	Part Number	Description
1	–	Mounting Screws (Ground Connection) (4 req'd). Tighten to 1.7-2.8 Nm (15-25 In-Lb) (Part of 10316).
2	–	Brush Holder Screw (Test Point "F") (Part of 10316).
3	–	Brush Holder Screw (Test Point "A") (Part of 10316).
4	LG-R	I Circuit 904 (Part of 14305).
5	W-B	S Circuit 4 (Part of 14305).
6	Y-W	A Circuit 36 (Part of 14305).
7	10328	Rotor Slip Ring.

Visual Inspection

Preliminary checks to the charging system should be made regardless of the fault condition. These checks include:

1. Check battery posts and cable terminals for clean and tight connections. Clean the posts and the cables to ensure good electrical contact.

2. Check for secure connections at the generator output, regulator, and engine ground. Also check the connection at the load distribution point (starter relay).

GENERATOR DIAGNOSIS AND TESTING (Continued)

3. Check the fuses/fuse links and wiring to the generator to ensure that they are not burned or damaged. This condition, resulting in an open circuit or high resistance, can cause erratic or intermittent charging system concerns.

4. Check the battery voltage. If the voltage is less than 12.3 volts with the engine and all accessories off, charge battery before proceeding.

In order to check the generator, the use of Rotunda Starting and Charging System Tester 078-00005 (VAT-40) [Rotunda Tools (1-800-578-7375)] or equivalent, is recommended.

Generator Output Test

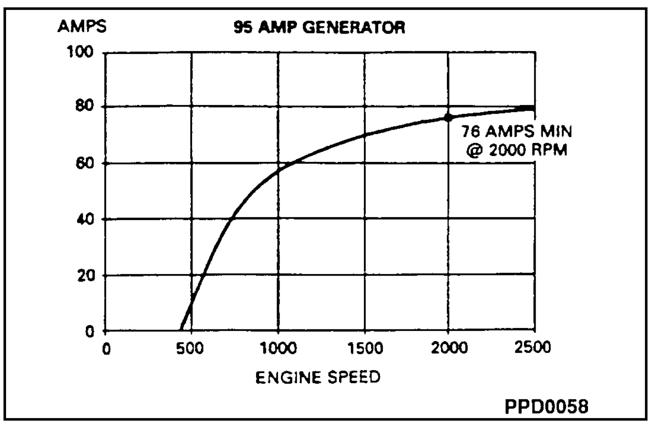
NOTE: Refer to the test equipment user's manual for complete directions on examining the charging system.

1. Switch the tester to ammeter function.

2. Connect the positive and negative leads of the tester to the battery.

3. Connect current probe to generator B+ output lead Circuit 38 (BK/O) (to measure generator output).

4. With the engine running at 2000 rpm, adjust the VAT-40 or equivalent load bank to determine the output of the generator. Generator output should be greater than values given in graph below. If not, refer to symptom chart in this Section.



Generator Voltage Test

1. Switch the tester to the voltmeter function.

2. Connect the positive lead to the generator A-terminal connector and the negative lead to ground.

3. Turn off all electrical accessories.

4. With the engine running at 2000 rpm, check the generator voltage.

5. Voltage should be between 13.0-15.5 volts.

   NOTE: If voltage is **not** within specifications, refer to symptom chart in this Section.

GENERATOR DIAGNOSIS AND TESTING

SYMPTOM CHART

CONDITION	POSSIBLE SOURCE	ACTION
• Dead battery. Battery will not stay charged. Slow crank. Low battery voltage. No generator output	• Key-off battery drain. • Open/voltage drop in B+, Circuit 38 (BK/O), 290, and 37. • Open/voltage drop in A, Circuit 36 (Y/W). • Open/high resistance in I, Circuit 904 (LG/R). • Voltage regulator. • Generator.	• Go to Pinpoint Test A.
• Indicator lamp on with engine running.	• Open A, Circuit 36 (Y/W). • Shorted I, Circuit 904 (LG/R). • Open/high resistance in S, Circuit 4 (W/BK). • Voltage regulator. • Generator.	• Go to Pinpoint Test B.
• Indicator lamp flickers or intermittent.	• Loose connection to generator, voltage regulator battery. • Loose fuse or poor connection in Circuit 36 (Y/W). • Loose brush holder screw. • Voltage regulator. • Generator	• Go to Pinpoint Test C.
• Battery overcharging (Battery voltage greater than 15.5 volts).	• Voltage drop in A, Circuit 36 (Y/W). • Voltage drop in I, Circuit 904 (LG/R). • Poor ground. • Voltage regulator. • Generator.	• Go to Pinpoint Test D.
• Indicator lamp off, key on, engine not running.	• Open/high resistance in I, Circuit 904 (LG/R). • Burned out bulb. • Poor ground. • S, Circuit 4 (W/BK) shorted to B+. • Voltage regulator. • Generator.	• Go to Pinpoint Test E.
• Generator noisy.	• Accessory drive belt. • Accessory brackets. • Bent generator pulley. • Generator. • Other components.	• Go to Pinpoint Test F.
• Indicator lamp on, key off.	• Lamp circuit, (GY/W) shorted to B+. • Improper lamp circuit wiring.	• Go to Pinpoint Test H.

GENERATOR DIAGNOSIS AND TESTING (Continued)

Pinpoint Tests

All voltage measurements are referenced to the negative (-) battery post unless otherwise specified.

CAUTION: Do not make jumper connections except as directed. Improper connections may damage the voltage regulator or fuses/fuse links.

All "key ON" measurements are made with the engine not running unless directed to "start engine."

PINPOINT TEST A: DEAD BATTERY/NO GENERATOR OUTPUT

TEST STEP		RESULT ▶	ACTION TO TAKE
A1	CHECK FOR KEY-OFF DRAIN		
	• Turn key to OFF position. • Turn off all accessories. • Connect an ammeter or test lamp between the negative (-) battery cable and the negative battery post. • **Is current drain less than 100 mA (or test lamp off)?**	Yes ▶ No ▶	GO to **A2.** Check to ensure that the key switch is functioning properly, and that all lights and accessories are "off" with the key switch in the "off" position.
A2	CHECK FOR OPEN B+ CIRCUIT		
	• Measure voltage at B+ terminal on the back of the generator. Circuit 38 (BK/O). • **Is voltage at B+ terminal equal to battery voltage?**	Yes ▶ No ▶	GO to **A3.** Check fuse link in Circuit 38, 290, and 37 and REPLACE if required. If OK, REPAIR open in Circuits 38, 290, and 37.
A3	CHECK FOR OPEN A CIRCUIT		
	• Measure voltage at test point A on the voltage regulator. • **Is voltage at test point A equal to battery voltage?**	Yes ▶ No ▶	GO to **A4.** Check fuse link in Circuit 38, 290, and 37 and REPLACE if required. If OK, REPAIR open in Circuits 38, 290, and 37.
A4	CHECK FOR OPEN FIELD CIRCUIT		
	• Measure voltage at test point F on the voltage regulator. • **Is voltage at test point F equal to battery voltage?**	Yes ▶ No ▶	GO to **A5.** GO to **A11**.
A5	CHECK FOR OPEN I CIRCUIT		
	• Turn key to ON position. • Measure voltage at wiring harness I terminal, Circuit 904 (LG/R). NOTE: Voltage regulator must be connected to wiring harness for this test. • **Is voltage greater than 1 volt?**	Yes ▶ No ▶	GO to **A6.** REPAIR open or high resistance in Circuit 904 (LG/R).
A6	CHECK VOLTAGE DROP IN A CIRCUIT		
	• Measure voltage drop between test point A on the voltage regulator and the positive (+) battery post. • **Is voltage drop less than 0.25 volts?**	Yes ▶ No ▶	GO to **A7.** REPAIR excess voltage drop in Circuit 36 (Y/W). CHECK fuses or fuse link and connectors in Circuit 36 and SERVICE as required.
A7	CHECK FIELD TURN-ON		
	• Measure voltage at test point F on the voltage regulator. • **Is voltage at test point F less than 2 volts?**	Yes ▶ No ▶	GO to **A8.** GO to **A11**.

GENERATOR DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST A: DEAD BATTERY/NO GENERATOR OUTPUT (Continued)

TEST STEP		RESULT ▶	ACTION TO TAKE
A8	CHECK FOR SHORTED RECTIFIER		
	• Remove one-pin S connector from generator. • Measure voltage between the S terminal on the back of the generator and ground. • Measure voltage between the positive (+) battery terminal and the S terminal on the back of the generator. • **Is either voltage reading greater than 1 volt?**	Yes ▶ No ▶	REPLACE generator. GO to **A9**.
A9	CHECK VOLTAGE DROP IN B+ CIRCUIT		
	• Install S connector. • Start engine. • Turn on headlights or any accessory. • With engine running at 2000 RPM, measure voltage drop between the B+ terminal on the back of the generator and the positive (+) battery post. • **Is voltage drop less than 0.5 volt?**	Yes ▶ No ▶	GO to **A10**. REPAIR excess voltage drop in Circuits 38, 290, and 37. CHECK fuse link in Circuits 38, 290, and 37 and the connections between the battery and under-hood fuse box.
A10	CHECK FOR OPEN STATOR PHASE		
	• Connect test point F on the voltage regulator to the negative (-) batter post using a jumper wire. • Repeat Generator Output Test. • **Is generator output greater than the minimum output specified?**	Yes ▶ No ▶	REPLACE voltage regulator. REPLACE generator.
A11	CHECK FOR OPEN/SHORTED FIELD		
	• Remove generator. • Remove voltage regulator. • Measure resistance between the generator slip rings. • **Is resistance greater than 10 ohms OR less than 1 ohm?**	Yes ▶ No ▶	REPLACE generator. CHECK for worn brushes (less than 8mm long) or open brush leads and REPLACE if required. If OK REPLACE voltage regulator.

PINPOINT TEST B: INDICATOR LAMP ON, ENGINE RUNNING

TEST STEP		RESULT ▶	ACTION TO TAKE
B1	CHECK FOR OPEN A CIRCUIT		
	• Measure voltage at test point A on the voltage regulator. • **Is voltage at test point A equal to battery voltage?**	Yes ▶ No ▶	GO to **B2**. CHECK fuse or fuse link in Circuit 36 and REPLACE if required. If OK, REPAIR open in Circuit 36 (Y/W).
B2	CHECK FOR SHORTED I CIRCUIT		
	• Remove three-pin voltage regulator connector. • Turn key to ON position • **Is indicator lamp on?**	Yes ▶ No ▶	REPAIR short to ground in Circuit 904 (LG/R). GO to **B3**.
B3	CHECK S CIRCUIT FUNCTION		
	• Install voltage regulator connector. • Remove one-pin S connector. • Connect wiring harness S terminal, Circuit 4 (W/BK) to the positive (+) battery post using a jumper wire. • **Is indicator lamp on?**	Yes ▶ No ▶	REMOVE jumper wire. GO to **B4**. REMOVE jumper wire. GO to **B5**.

GENERATOR DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST B: INDICATOR LAMP ON, ENGINE RUNNING (Continued)

TEST STEP		RESULT ▶	ACTION TO TAKE
B4	CHECK FOR OPEN S CIRCUIT		
	• Remove three-pin S voltage regulator connector. • Measure wiring resistance between the one-pin S connector and the S (center) pin of the voltage regulator connector. • **Is resistance greater than 1 ohm?**	Yes ▶	REPAIR open or excess resistance in Circuit 4 (W/BK).
		No ▶	CHECK for loose or bent pin in voltage regulator or connector. If OK, REPLACE voltage regulator.
B5	CHECK STATOR OUTPUT VOLTAGE		
	• Start engine. • Measure voltage at the S terminal on the back of the generator. • **Is voltage at least 1/2 of battery voltage?**	Yes ▶	GO to **B6**.
		No ▶	GO to Pinpoint Test A to find the cause of low generator output.
B6	CHECK GENERATOR OUTPUT VOLTAGE		
	• Measure voltage at the B+ terminal on the back of the generator with the engine running at 2000 RPM and all accessories turned off. • **Is voltage greater than 15.5 volts?**	Yes ▶	GO to Pinpoint Test D to find the cause of high output voltage.
		No ▶	REPLACE voltage generator.

PINPOINT TEST C: INDICATOR LAMP FLICKERS/INTERMITTENT

TEST STEP		RESULT ▶	ACTION TO TAKE
C1	CHECK FOR LOOSE CONNECTIONS		
	• Check these connections for corrosion, loose or bent pins, or loose eyelets: – Three-pin voltage regulator connector. – One-pin S connector. – Generator B+ eyelet. – Battery cables • **Are all connections clean and tight?**	Yes ▶	GO to **C2**.
		No ▶	CLEAN or REPAIR connections as required.
C2	CHECK FOR FIELD CIRCUIT DRAIN		
	• Turn key to OFF position. • Measure voltage at test point F on the voltage regulator. • **Is voltage at test point F equal to battery voltage?**	Yes ▶	GO to **C3**.
		No ▶	GO to **C5**.
C3	CHECK FOR LOOSE A CIRCUIT FUSE		
	• Start engine. • Check the generator fuse loose connection by wiggling the fuse with the engine running. • **Does indicator lamp flicker?**	Yes ▶	REPAIR loose fuse connection.
		No ▶	GO to **C4**.
C4	CHECK A CIRCUIT CONNECTIONS		
	• With engine running, connect test point A on the voltage regulator to the positive (+) battery post using a jumper wire. • **Does indicator lamp flicker?**	Yes ▶	REPLACE voltage regulator. If problem still exists, REPLACE generator.
		No ▶	GO to **C4**.
C5	CHECK BRUSH HOLDER SCREWS		
	• Remove generator from unit. • Check the brush holder screws, located on the voltage regulator (test points F and A). • **Are the brush holder screws tight?**	Yes ▶	GO to **C6**.
		No ▶	TIGHTEN screws to specification. 2.8-4.0 Nm (25-35 In-Lb).

GENERATOR DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST C: INDICATOR LAMP FLICKERS/INTERMITTENT (Continued)

	TEST STEP	RESULT ▶	ACTION TO TAKE
C6	CHECK FOR GROUNDED SLIP RING		
	• Remove voltage regulator. • Measure resistance from each generator slip ring to the generator housing. • **Is resistance from either slip ring to housing less than 200 ohms?**	Yes ▶	If grease or dirt has accumulated near the slip rings, CLEAN the slip rings and RECHECK resistance. If still less than 200 ohms, REPLACE generator.
		No ▶	REPLACE voltage regulator.

PINPOINT TEST D: CHARGING VOLTAGE HIGH

	TEST STEP	RESULT ▶	ACTION TO TAKE
D1	CHECK VOLTAGE DROP IN A CIRCUIT		
	• Turn key to ON position. • Measure voltage between test point A on the voltage regulator and the positive (+) battery post. • **Is voltage drop less than 0.25 volt?**	Yes ▶	GO to **D2**.
		No ▶	REPAIR excess voltage drop in Circuit 36 (Y/W). CHECK fuse or fuse link and connections in Circuit 36 and SERVICE as required.
D2	CHECK VOLTAGE DROP IN I CIRCUIT		
	• Measure voltage at wiring harness I terminal, Circuit 904 (LG/R). NOTE: Voltage regulator must be connected to wiring harness for this test. • **Is voltage greater than 1 volt?**	Yes ▶	GO to **D3**.
		No ▶	REPAIR high resistance in Circuit 904 (LG/R).
D3	CHECK FOR POOR GROUND		
	• Check for poor ground connections between voltage regulator and generator, generator and engine, or engine and battery. • **Are all ground connections clean and tight?**	Yes ▶	GO to **D4**.
		No ▶	CLEAN or REPAIR grounds as required.
D4	CHECK FOR FIELD CIRCUIT DRAIN		
	• Turn key to OFF position. • Measure voltage at test point F on the voltage regulator. • **Is voltage at test point F equal to battery voltage?**	Yes ▶	Generator is OK, REPLACE voltage regulator.
		No ▶	CLEAN or REPAIR grounds as required.
D5	CHECK FOR GROUNDED SLIP RING		
	• Remove generator from vehicle. • Remove voltage regulator. • Measure resistance from each generator slip ring to the generator housing. • **Is resistance from either slip ring to housing less than 200 ohms?**	Yes ▶	If grease or dirt has accumulated near the slip rings, CLEAN the slip rings and RECHECK resistance. If still less than 200 ohms, REPLACE generator.
		No ▶	REPLACE voltage regulator.

GENERATOR DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST E: INDICATOR LAMP OFF, KEY ON, ENGINE NOT RUNNING

TEST STEP		RESULT ▶	ACTION TO TAKE
E1	CHECK FOR OPEN I CIRCUIT		
	• Remove three-pin voltage regulator connector. • Turn key to ON position. • Measure voltage at wiring harness I terminal, Circuit 904 (LG/R). • **Is voltage greater than 0 volts?**	Yes ▶	GO to **E2**.
		No ▶	REPAIR open in Circuit 904 (LG/R).
E2	CHECK FOR BURNED OUT BULB		
	• Connect wiring harness I terminal, Circuit 904 (LG/R) to ground with a jumper wire. • **Is indicator lamp on?**	Yes ▶	REMOVE jumper wire. GO to **E3**.
		No ▶	REPLACE bulb or REPAIR high resistance in bulb socket or Circuit 904 (LG/R).
E3	CHECK FOR POOR GROUNDS		
	• Check for poor ground connections between voltage regulator and generator, generator and engine, or engine and battery. • **Are all ground connections clean and tight?**	Yes ▶	GO to **E4**.
		No ▶	CLEAN or REPAIR grounds as required.
E4	CHECK S CIRCUIT WIRING		
	• Remove one-pin S connector from generator. • Measure voltage at wiring harness S terminal, Circuit 4 (W/BK). • **Is voltage greater than 0 volts?**	Yes ▶	SERVICE Circuit 4 (W/BK). Circuit should be hot only when engine is running. CHECK for swapped wires in voltage regulator connector.
		No ▶	GO to **E5**.
E5	CHECK FOR SHORTED RECTIFIER		
	• Measure voltage at the S terminal on the back of the generator. • **Is voltage greater than 1 volt?**	Yes ▶	If lamp is on with one-pin S connector removed, REPLACE generator.
		No ▶	REPLACE voltage regulator.

PINPOINT TEST F: GENERATOR NOISY

TEST STEP		RESULT ▶	ACTION TO TAKE
F1	CHECK FOR ACCESSORY-DRIVE NOISE		
	• Check the drive belt to make sure that it is installed properly and is not damaged. • Check the accessory mounting brackets for loose bolts or out of alignment condition. • Check for a bent pulley. • **Is accessory drive OK?**	Yes ▶	GO to **F2**.
		No ▶	SERVICE accessory drive as required.
F2	SUBSTITUTE KNOWN GOOD GENERATOR		
	• Remove generator and replace with a known good generator. • **Is noise present with known good part?**	Yes ▶	Generator is OK. INSTALL original part. CHECK other accessories to find the cause of the noise.
		No ▶	REPLACE generator.

GENERATOR DIAGNOSIS AND TESTING (Continued)

PINPOINT TEST G: RADIO FREQUENCY

TEST STEP		RESULT ▶	ACTION TO TAKE
G1	VERIFY RADIO FREQUENCY		
	• Start engine. • Tune radio to a station where interference is present. • Remove three-pin voltage regulator connector. **• Is accessory drive OK?**	Yes ▶	Generator is OK. Interference is occurring elsewhere in the electrical system.
		No ▶	Go to **G2**.
G2	SUBSTITUTE KNOWN GOOD GENERATOR		
	• Remove generator and replace with a known good generator. **• Is interference present with known good part?**	Yes ▶	Generator is OK. Interference is occurring elsewhere in the electrical system.
		No ▶	REPLACE generator.

PINPOINT TEST H: INDICATOR LAMP ON, KEY OFF

TEST STEP		RESULT ▶	ACTION TO TAKE
H1	CHECK LAMP CIRCUIT WIRING		
	• Turn key to OFF position. • Remove three-pin voltage regulator connector. • Measure voltage at wiring harness I terminal, Circuit 904 (LG/R). **• Is voltage greater than 0 volts?**	Yes ▶	SERVICE Circuit 904 (LG/R). Circuit should be hot in RUN position only.
		No ▶	SERVICE instrumentation system. Indicator lamp circuit is finding a path to ground at a point other than the generator.

GENERATOR REMOVAL AND INSTALLATION

WARNING: BATTERIES NORMALLY PRODUCE EXPLOSIVE GASES WHICH CAN CAUSE PERSONAL INJURY. THEREFORE, DO NOT ALLOW FLAMES, SPARKS OR LIGHTED SUBSTANCES TO COME NEAR THE BATTERY. WHEN CHARGING OR WORKING NEAR A BATTERY, ALWAYS SHIELD YOUR FACE AND PROTECT YOUR EYES. ALWAYS PROVIDE VENTILATION. WHEN LIFTING A PLASTIC-CASED BATTERY, EXCESSIVE PRESSURE ON THE END WALLS COULD CAUSE ACID TO SPEW THROUGH THE VENT CAPS, RESULTING IN PERSONAL INJURY. LIFT WITH A BATTERY CARRIER OR WITH YOUR HANDS ON OPPOSITE CORNERS.

WARNING: KEEP BATTERIES OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH THE SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF FIFTEEN MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

Generator

Removal

1. Disconnect battery ground cable (14301).
2. Remove snow/ice shield.
3. Disconnect the generator voltage regulator wiring (14305) to the voltage regulator.
4. Remove wiring connector bracket.
5. Loosen the drive belt tensioner (613209) and remove the drive belt.
6. Remove the bolts holding the generator to the generator bracket (10A313).
7. Remove the generator from the generator bracket.

Installation

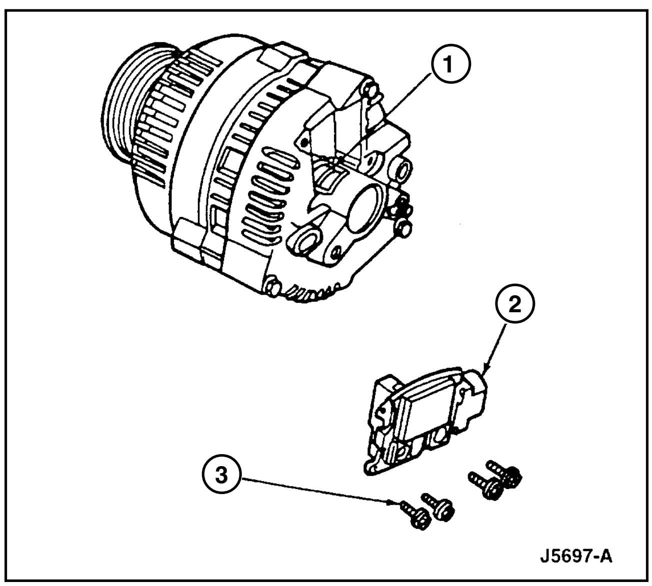
1. Position the generator on the generator bracket.
2. Install the bolts and tighten to 40-55 Nm (30 - 40 ft-lb).
3. Install the drive belt over the generator pulley.
4. Install the drive belt over tensioner as outlined in Section 05.
5. Connect generator voltage regulator wiring to the voltage regulator. Tighten generator Battery Positive Voltage (B+) wire attaching nut to 9-12 Nm (6.5-9 ft-lb).
6. Install wiring connector bracket.
7. Install snow/ice shield.
8. Connect battery ground cable.

Regulator

Removal

1. **NOTE:** for ease or removal and installation of regulator, remove the generator from engine as described above.

   Remove the four screws (T20 Torx type head) attaching the voltage regulator to the generator housing. Remove the voltage regulator with generator brush holder (10351) attached, from the generator.

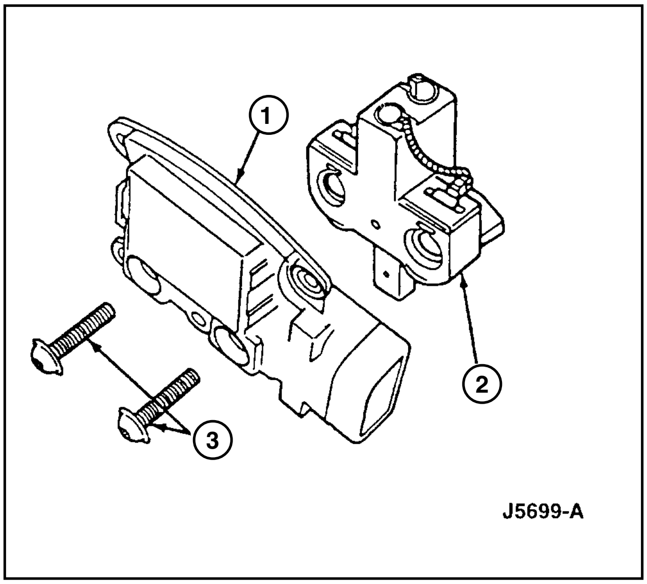


1 Slip Rings 10328	3 Screw 4 Req'd. Tighten to 2.3-3.4 Nm (20-30 In-Lb)
2 Regulator 10316 and Brush Holder Assembly 10347	

GENERATOR REMOVAL AND INSTALLATION (Continued)

2. Hold the voltage regulator in one hand and pry off the cap covering the A screw head with a screwdriver.

3. Remove two screws (T20 Torx type head) attaching the regulator to the generator brush holder. Separate the regulator from generator brush holder.



1 Voltage Regulator 10316

2 Generator Brush Holder 10347

3 Screw (2 Req'd) Tighten to 2.8-4.0 Nm (25-35 In-Lb)

Installation

1. Replace generator brush holder to voltage regulator and install attaching screws.

2. Replace cap on the head of the A terminal screw.

3. Depress the generator brushes in the generator brush holder.

   • Hold the generator brushes in position by inserting a standard size paper clip (or equivalent) through both the location hole in the voltage regulator and through the holes in the generator brush holders.

4. Install the voltage regulator and generator brush holder to the generator with attaching screws.

   • Remove paper clip (or equivalent) from the regulator.

5. Install generator following installation in this section.

NOTE: Only the regulator, brush holder and generator pulley are serviceable. If the generator needs further service, it must be replaced as an assembly.

BATTERY MOUNTING AND CABLES

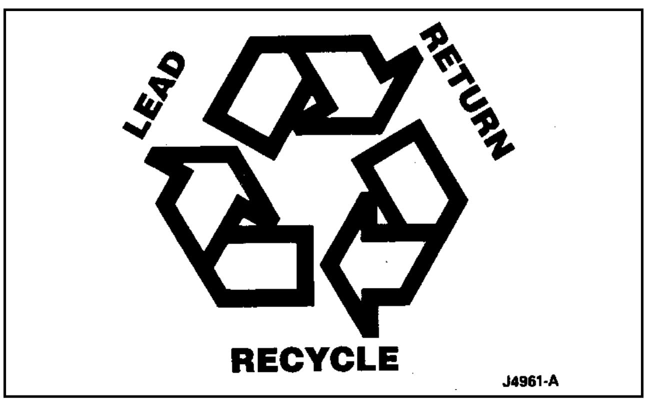
WARNING: WHEN LIFTING PLASTIC-CASED BATTERY, EXCESSIVE PRESSURE ON THE END WALLS COULD CAUSE ACID TO SPEW THROUGH THE VENT CAPS, RESULTING IN PERSONAL INJURY, DAMAGE TO THE VEHICLE OR BATTERY. LIFT WITH A BATTERY CARRIER OR WITH YOUR HANDS ON OPPOSITE CORNERS.

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES, OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

Removal and Installation

Environmental Protection

Ford Motor Company strongly recommends that lead-acid batteries (10655) be returned to an authorized recycling facility for disposal.



Battery

Removal

1. Remove battery cables from battery terminals (battery ground cable (14301) first).

2. Remove battery hold down clamp (10718).

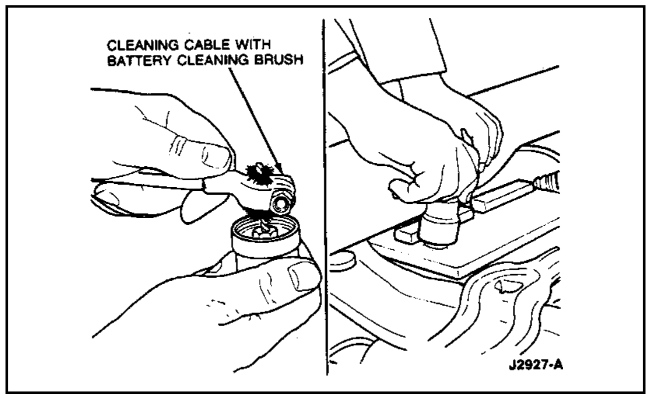
3. **CAUTION: When lifting a plastic-cased battery (10655), excessive pressure on the end walls could cause acid to spew through the vent caps, resulting in personal injury, damage to the vehicle or battery. Lift with a battery carrier or with your hands on opposite corners.**

   Remove battery from vehicle or equipment.

Installation

1. **NOTE:** The battery terminal cleaning operation shown in the following illustration is typical for all vehicles and equipment.

   Clean cable terminals and battery hold down clamp with a wire brush. Replace all cables or parts that are worn or frayed.



2. Clean battery tray (10732) with a wire brush and scraper.

3. Place battery in battery tray with positive and negative terminals in same position as previous battery (10653).

4. Assemble and tighten battery hold down clamp so battery is secure. Do not tighten excessively.

5. Secure cables (battery to starter relay cable (14300) first) to proper terminals. Tighten to 7-10 Nm (5-7 lb-ft). Apply petroleum jelly to terminals.

BATTERY MOUNTING AND CABLES (Continued)

Service Procedures

Battery Charging

NOTE: If excessive gassing or electrolyte spewing occurs during the charge, discontinue charging. The battery (10655) has reached serviceable charge. If the battery will not accept at least 5A after 20 minutes of charging, replace the battery.

WARNING: WEAR SAFETY GLASSES. BATTERY CHARGING CAN BE DANGEROUS. WHILE BEING CHARGED, THE BATTERY PRODUCES A POTENTIALLY EXPLOSIVE MIXTURE OF HYDROGEN AND OXYGEN GASSES. KEEP SPARKS, FLAMES AND LIGHTED CIGARETTES AWAY FROM BATTERIES. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH LARGE AMOUNTS OF WATER. GET MEDICAL ATTENTION.

Inspect and service any of the following pre-existing conditions before recharging a discharged battery.

- Loose drive belt (8620).
- Pinched or grounded generator voltage regulator wiring (14305).
- Loose connections of the generator voltage regulator wiring at the generator (GEN)(10346) or voltage regulator (VR)(10316).
- Loose or corroded connections at battery, grounded starter motor cutout relay (11433) or engine (6007).
- Excessive battery drain due to any of the following conditions on some types of equipment:
  - Compartment lamp (15702), glove compartment and interior lamps (13776) remaining energized (damaged or misadjusted switch, glove compartment left open, etc.).
  - Lamp switch (13713) continuously on.

Maintenance-Free and Low-Maintenance Batteries

Cold batteries will not readily accept a charge. Therefore, batteries should be allowed to warm up to approximately 5°C (41°F) before charging. This may require four to eight hours at room temperature depending on the initial temperature and battery size.

A battery which has been completely discharged may be slow to accept a charge initially, and in some cases may not accept charge at the normal charger setting. When batteries are in this condition, charging can be started by use of the dead battery switch on chargers so equipped.

To determine whether a battery is accepting a charge, follow charger manufacturer's instructions for use of dead battery switch. If switch is the spring-loaded type, it should be held in the ON position for up to three minutes.

After releasing switch and with charger still on, measure battery voltage. If it shows 12 volts or higher, the battery is accepting a charge and is capable of being recharged. However, it may require up to two hours of charging with batteries colder than 5°C (41°F) before charging rate is high enough to show on the charger ammeter. It has been found that all non-damaged batteries can be charged by this procedure. If a battery cannot be charged by this procedure, it should be replaced.

A rapid recharge procedure has been developed for recharging batteries that only need a quick recharge. This can be due to battery in-service no-start battery failures (vehicles will not crank due to low battery state of charge) or battery discharged in vehicle due to key-off loads.

The battery can be rapidly recharged by using either of the following methods.

- Perform a two-hour charge using 20A constant current (manual setting on charger).
- Perform a two-hour charge using a constant potential (automatic setting on charger).

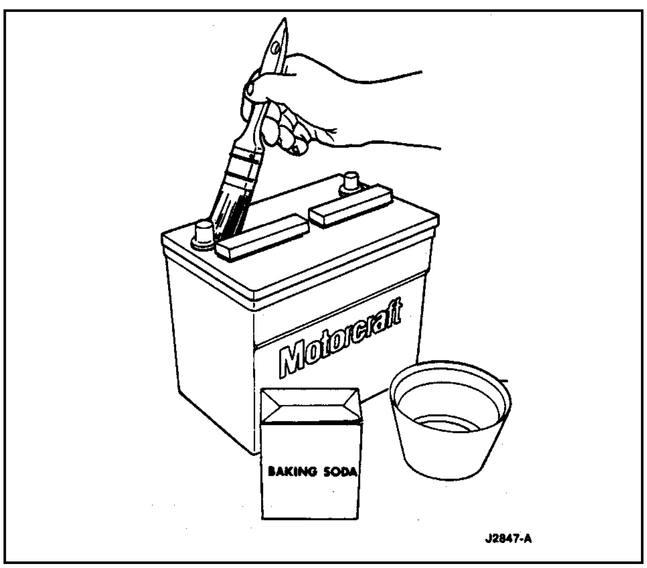
BATTERY MOUNTING AND CABLES (Continued)

Cleaning and Inspection

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES, OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

Keeping the battery (10655) top clean and dry reduces the need for service and extends battery life. Also, make certain the cable clamps are tightly fastened to the battery posts. If corrosion is found, disconnect the cables and clean clamps and posts with a wire brush. Neutralize the corrosion with a solution of baking soda and water. After installing cables, apply a small quantity of Premium Long-Life Grease XG-1-C or -K or equivalent grease meeting Ford specification ESA-M1C75-B to each battery post to help prevent corrosion.

The battery cleaning operation shown in the following illustration is typical for all vehicles and equipment.



Tools

Anyone working with a battery (10655) needs the proper tools. Using the right tools will prevent damage to the battery, battery cables and battery hold down clamp (10718).

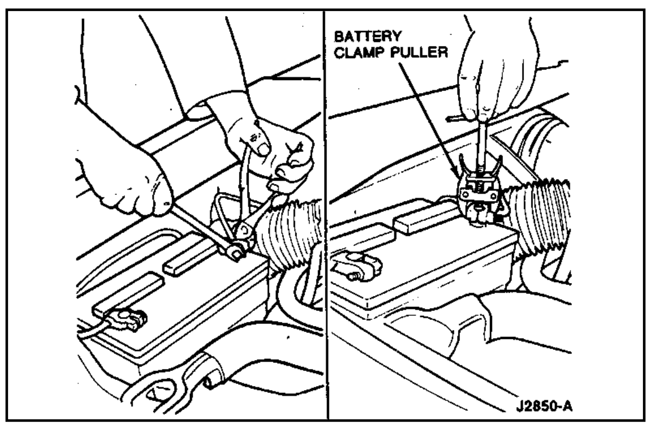
Tools and equipment manufactured for servicing batteries (10653) have parts insulated to help prevent arcing should the tool be dropped or placed accidentally between a terminal and some other contact surface.

Pliers

CAUTION: Always remove the negative cable first to prevent possible arcing possibly damaging other electrical components.

Battery pliers have jaws specifically designed for gripping cable clamp bolts securely. Care should be taken when removing or replacing the cable clamp bolts so that the battery terminal is not subjected to any excessive lateral or twisting forces. Such forces could cause major damage to the internal components of the battery, and leakage at the terminals.

The battery terminal removal operation shown in the following illustration is typical for all vehicles and equipment.



BATTERY MOUNTING AND CABLES (Continued)

Clamp Puller

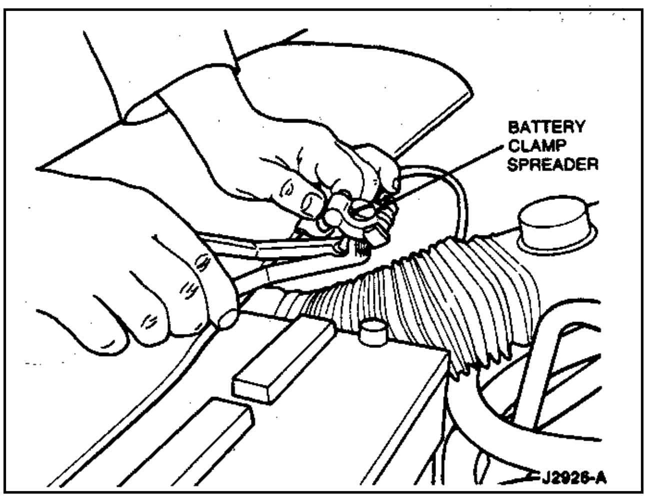
CAUTION: Always remove the negative cable first to prevent possible arcing possibly damaging other electrical components.

Use a clamp puller to remove a cable clamp from the battery terminal. With the jaws gripping the underside of the cable clamp, pull the clamp up by means of pressure exerted against the top of the battery terminal. Proper use of this tool avoids the damaging lateral or twisting forces that result when using a pry bar or pliers.

Battery Clamp Spreader

The spreader is used to expand the cable clamp after it has been removed from the terminal and the clamp bolt has been loosened. The cable clamp can then be easily placed in its correct position completely on the terminal.

The battery clamp spreading operation shown in the following illustration is typical for all vehicles and equipment.



Terminal Cleaning Brush

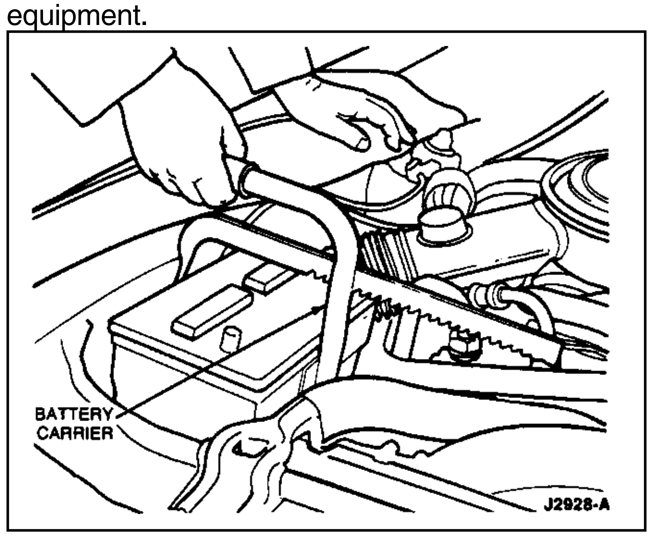
The terminal cleaning brush is designed with units to clean both tapered battery terminal and the mating surface of the cable clamp. Refer to illustration under Battery Installation.

Carrier

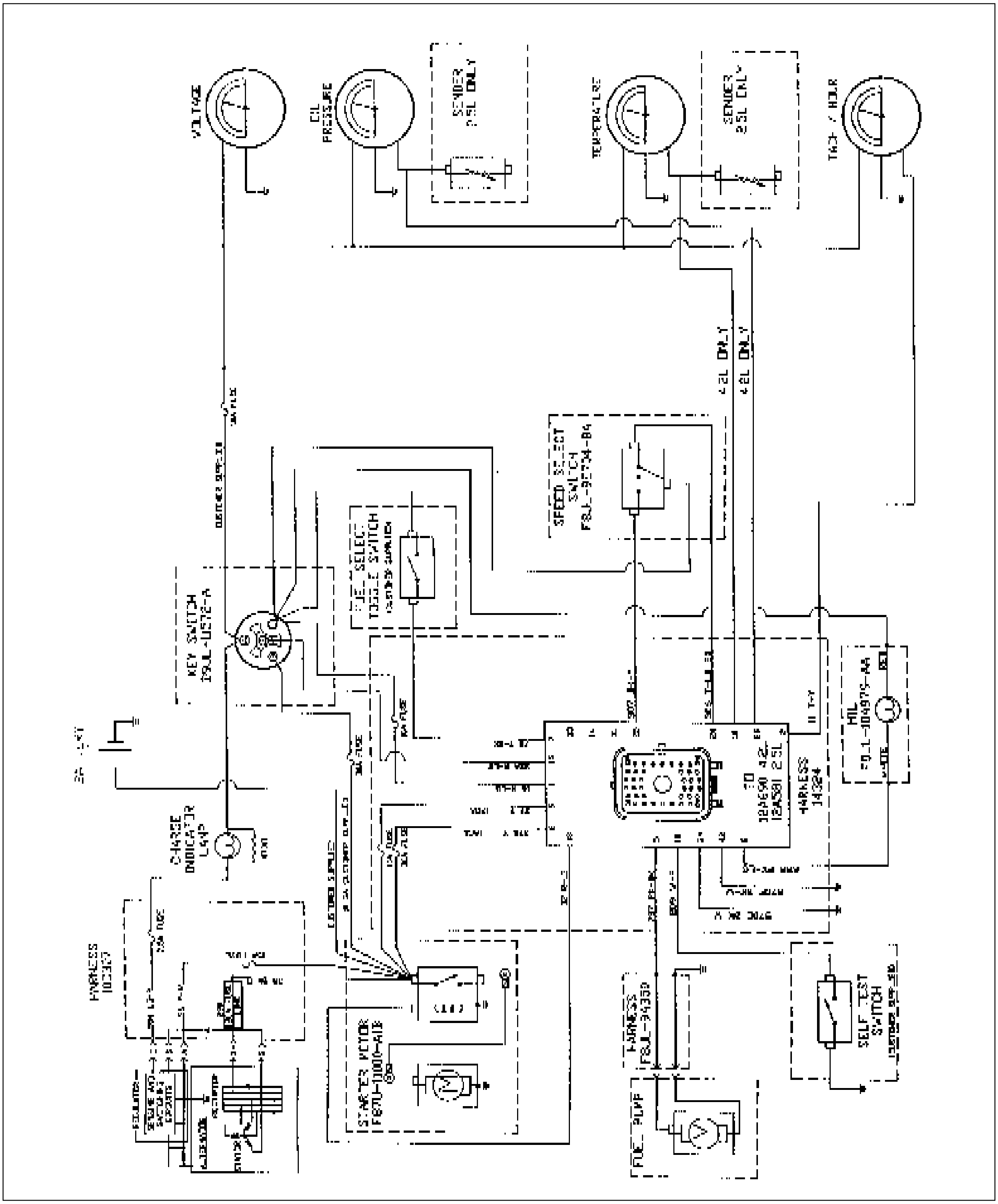
WARNING: GRIPPING THE END WALLS ON THE PLASTIC-CASED BATTERY COULD CAUSE ELECTROLYTE TO SPEW FROM SOME OF THE CELLS, RESULTING IN PERSONAL INJURY AND POSSIBLE CAUSE DAMAGE TO SOME OF THE INTERNAL COMPONENTS.

Use a suitable battery carrier for lifting and transporting the battery. The illustration shows a clamp-type carrier used to grip the sidewalls of the container just below the lip of the cover. The carrier is used on the sidewalls, rather than the end walls, since the sidewalls have additional strength from the inner cell partitions. This is particularly important with the plastic-cased battery which has end walls that are flexible.

The battery removal operation shown in the following illustration is typical for all vehicles and equipment.



Wiring Schematic – 4.2L & 2.5L Alternator, Gauges, Ignition and Discrete Governing



SPECIFICATIONS

GENERATOR MOUNTING SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	Nm	Lb-Ft	Lb-In
Mounting Bolts (2)	40-55	30-40	–
Regulator Attachment Screw (4)	1.7-2.8	-	15.26
Battery Wire Attaching Nut (1)	9-12	6.5-9	78-108

CHARGING SYSTEM SPECIAL SERVICE TOOLS/EQUIPMENT

ROTUNDA EQUIPMENT

Tool Number	Description
078-00005	VAT-40 Starting/charging Tester

BATTERY TORQUE SPECIFICATIONS

Description	Nm	Lb-Ft	Lb-In
Battery Cable Bolts	7-10	5-7	–
Battery Hold-Down Bracket Bolt	10-14	7-10	–
Generator voltage Regulator Wiring Nut and Washer (Ranger with 2.3L Engine)	5-11	–	44-97
Relay Cable-to-Body Panel Screws (Ranger and Explorer)	10-14	7-10	–

GENERATOR PARTS CROSS-REFERENCE

Base Part #	Part Name	Old Part Name
6007	Engine	
6B209	Drive Belt Tensioner	
8620	Drive Belt	
9A624	Engine Air Cleaner Intake Tube	
10A313	Generator Bracket	Alternator Mounting Parts
10316	Drive Belt Tensioner	Alternator Mounting
10344	Generator Pulley	Alternator Pulley
10346	Generator	Alternator
10351	Generator Brush Holder	
14301	Battery Ground	
14305	Generator Voltage Regulator Wiring	

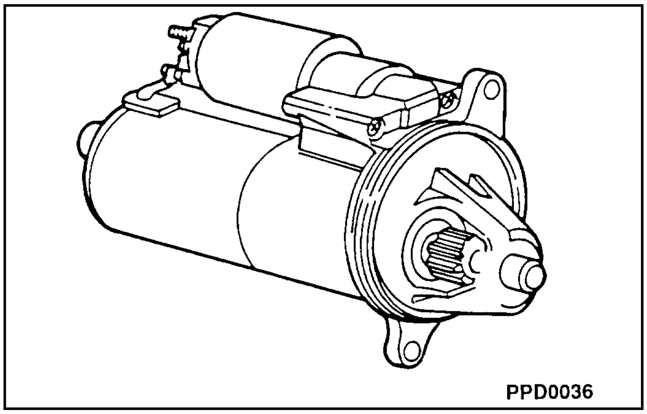
STARTER INDEX

07

STARTER, PERMANENT MAGNET DESCRIPTION AND OPERATION

The function of the starting system is to crank the engine at a speed fast enough to permit the engine to start. Heavy cables, connectors, and switches are used in the starting system because of the large current required by the starter while it is cranking the engine. The amount of resistance in the starting circuit must be kept to an absolute minimum to provide maximum current for starter operation. A discharged or damaged battery, loose or corroded connections, or partially broken cables will result in slower than normal cranking speeds, and may even prevent the starter from cranking the engine.

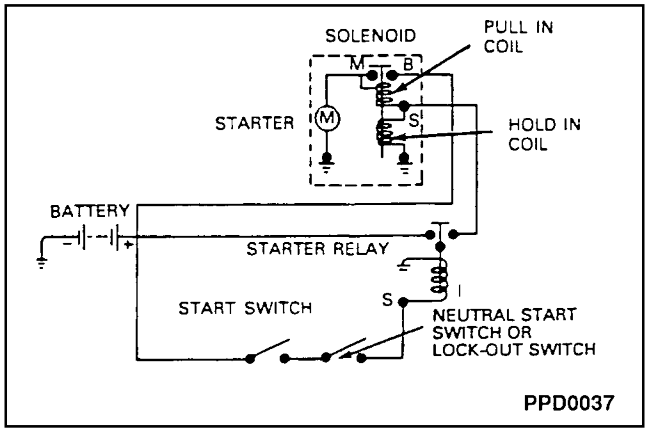
The starting system includes the permanent magnet gear-reduction starter motor with a solenoid-actuated drive, the battery, a remote control starter switch (part of the ignition switch), the starter relay, the heavy circuit wiring, and may include starter lock-out, controlled by the ECM through a starter lockout relay.



Starter Motor Assy 11001

Sequence Of Operation

1. The ignition switch is turned to the START position.
2. A remote starter relay is energized, which provides voltage to the starter solenoid. The starter solenoid is energized, creating a magnetic field in the solenoid coil.
3. The iron plunger core is drawn into the solenoid coil.
4. A lever connected to the drive assembly engages the drive pinion gear to the flywheel ring rear.
5. When the iron plunger core is all the way into the coil, its contact disc closes the circuit between the battery and the motor terminals.
6. The current flows to the motor, and the drive pinion gear drives the flywheel and the engine crankshaft.
7. As current flows to the motor, the solenoid pull in coil is bypassed.
8. The hold-in coil keeps the drive pinion gear engaged with the flywheel.
9. The gear remains engaged until the ignition switch is released from the START position.



NOTE: When the ECM is programmed to lock starter out when the engine is over 400 rpm (600 rpm for ICM) the following sequence takes place:

Starter Lockout Relay

See page 07-6 for further details.

1. During start up with key in the on position 12V (B+) is applied to relay through circuit 16A (R-LG) 16G.
2. With ignition switch turned to the crank position, current flows from ignition switch to relay circuit 32A (R-LB) 16G through relay and out circuit 32 (R-LB) 16G to starter solenoid.
3. The starter than should respond as in steps 2 through 9 in sequence of operation circuit 113 (4-LB) 18G is connected to the ECM L3 terminal. The ECM keeps circuit 113 open until it reads 400+ engine rpm. Over 400 rpm the ECM grounds circuit 113 causing the relay to open circuits 32A and 32. This will prevent starter engagement while engine is running.

NOTE: An overrunning clutch in the drive assembly protects the starter from the excessive speeds during the brief period before the driver releases the ignition switch from the START position (as the engine starts).

STARTER, PERMANENT MAGNET DESCRIPTION AND OPERATION (Continued)

Field Service

For cases of a starter that cranks the engine very slowly, connect a 12-volt booster battery to the system.

Jump Starting

To avoid damage to the vehicle or equipment and battery or the possibility of personal injury, follow these instructions and precautions:

WARNING: HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD) YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

CAUTION: Do not disconnect the battery of the vehicle to be started. Disconnecting the battery could damage the vehicle's electronic system.

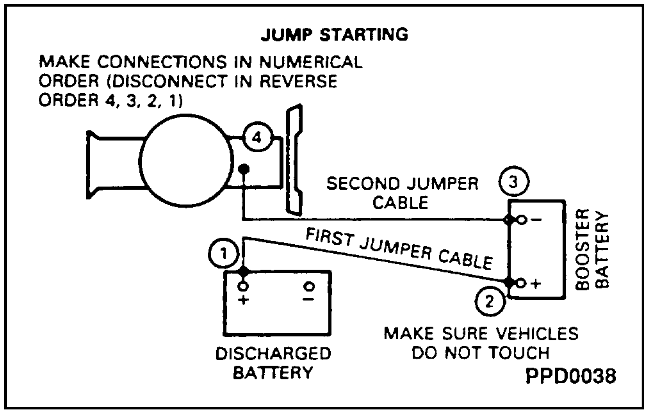
Negative Grounded Battery

WARNING:TO AVOID INJURY, USE PARTICULAR CARE WHEN CONNECTING A BOOSTER BATTERY TO A DISCHARGED BATTERY.

1. Position vehicles or equipment so jumper cables will reach, being careful that vehicles do not touch.

WARNING: MAKING THE FINAL CABLE CONNECTION COULD CAUSE AN ELECTRICIAL SPARK NEAR THE BATTERY AND COULD CAUSE AN EXPLOSION. REFER TO WARNING AT THE BEGINNING OF THE JUMP STARTING PROCEDURE.

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER UNDERHOOD WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.



NOTE: Be sure to disconnect battery negative cable before servicing starter.

2. Make jumper cable connections.
   a. Connect one end of first jumper cable to positive (+) **1** terminal of discharged battery and other end of positive (+) **2** terminal of booster battery.
   b. Connect one end of second jumper cable to negative (-) **3** terminal of booster battery. Connect other end to an engine bolthead or good metallic contact spot on engine **4** of equipment to be started. NOT TO NEGATIVE (-) BATTERY TERMINAL.
   c. Make sure jumper cables are not in way of moving engine parts.
   d. Start engine of vehicle with good battery. Run engine at a moderate speed.
   e. Start engine of vehicle with discharged battery. Follow starting instructions in the Owner Guide.

3. Completely discharged batteries may require an electrical load to initialize charging.

4. Remove cables in exact REVERSE sequence. Begin by removing negative (-) cable from engine of vehicle **4** that had discharged battery.

If the starter does not turn the engine over, even with the booster battery attached, refer to On Vehicle Testing.

STARTER, PERMANENT MAGNET DIAGNOSIS AND TESTING

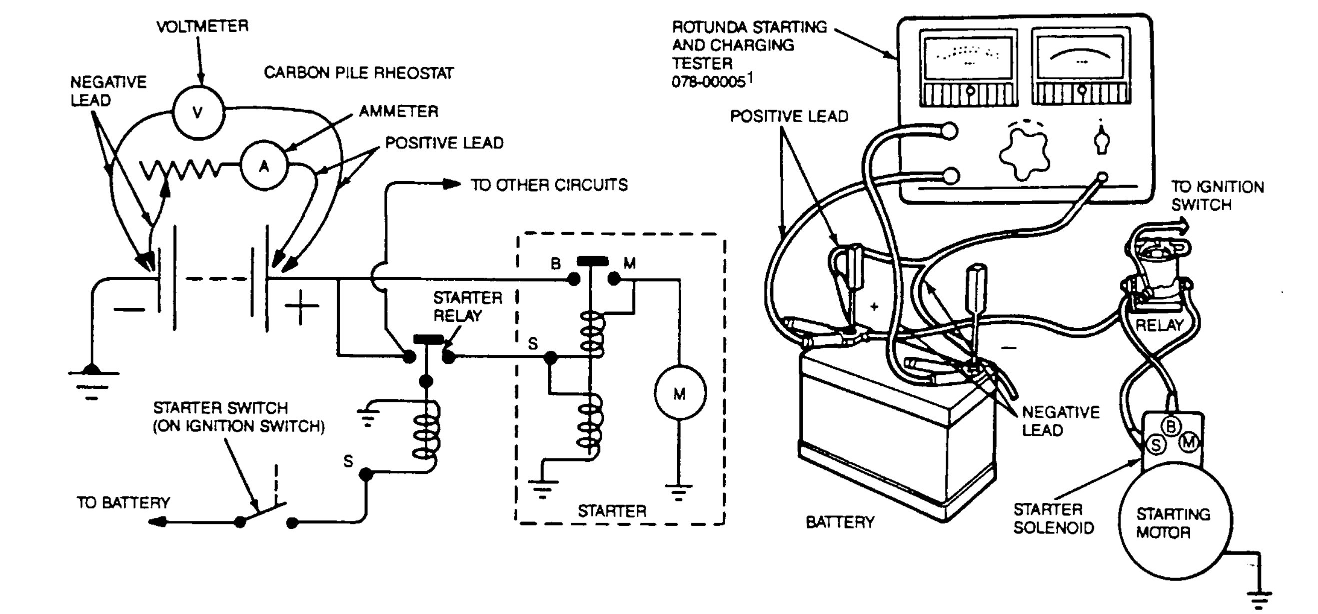
Starter Load Test

Conduct this test if the starter cranks slowly and it is desired to compare current to specifications.

1. Connect Rotunda Starting and Charging Tester 078-00005 or equivalent. Make sure that current is not flowing thorugh ammeter and heavy-duty carbon pile rheostat portion of circuit (rheostat at maximum counterclockwise position).

2. Disconnect load from engine. Place transmission or transaxle in NEUTRAL. Crank engine with ignition off, and determine exact reading on voltmeter. This test is accomplished by disconnecting push-on connector "S" at starter relay and by connecting a remote control starter switch from positive battery terminal to "S" terminal starter relay.

3. Stop cranking engine and reduce resistance of carbon pile until voltmeter indicates same reading as that obtained while starter cranked the engine. The ammeter will indicate starter current draw under load. Check this with value listed in Specifications.



PPD0039

Bench Tests

⚠CAUTION: Make sure that the starter is securely mounted in bench vise while energizing, as starter will move or jump.

1. Connect a fully charged battery, Rotunda Starting and Charging Tester 078-00005, or equivalent. Make sure that the battery and starter motor are grounded.

2. Engage the remote starter switch.

3. The starter motor should eject the starter drive and run smoothly. If the starter motor does not run smoothly, replace it.

4. While the starter motor is running, check the voltmeter and ammeter.

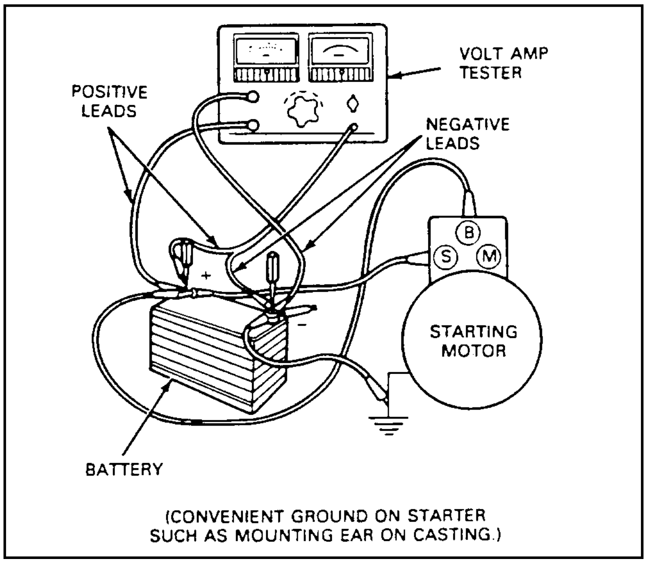
5. If the voltage is lower than the 11.0 volts, or the amperage is higher than 70 amps, replace the starter motor.

NOTE: Service parts for rebuilding permanet magnet starter are not available from Ford Power Products.

[1]Rotunda 1-800-578-7375

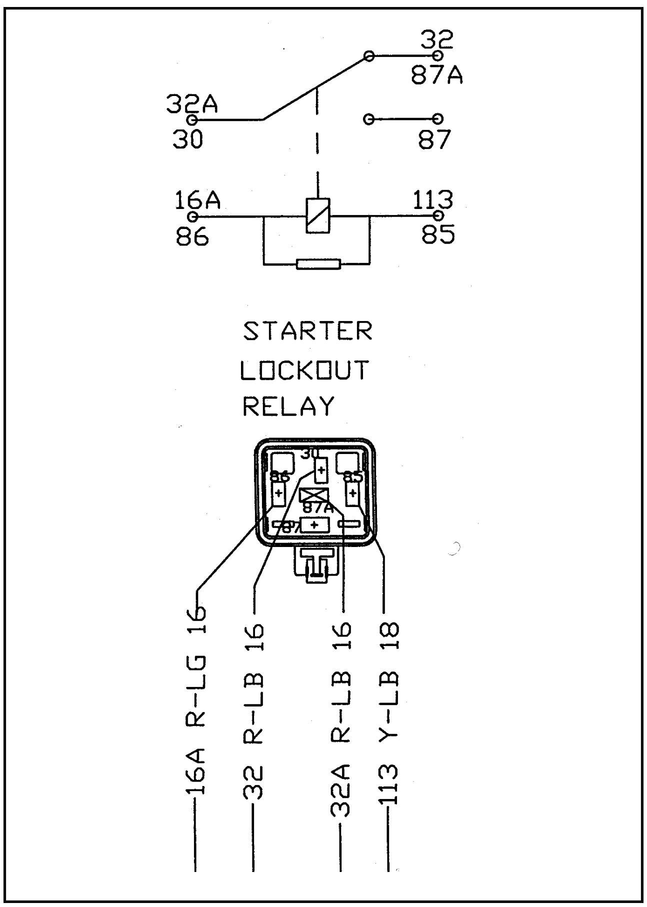
STARTER, PERMANENT MAGNET DIAGNOSIS AND TESTING (Continued)

Starter No-Load Test



⚠CAUTION: Make sure that the starter is securely mounted in bench vise while energizing, as starter will move or jump.

Starter Lock-out Relay



NOTE: All readings are made with connector attached to relay and back probing connector using a paper clip and fully charged battery.

Function	Normal Specs.	Area to Check (Out of Specs.)
Circuit 16A → Splice #2 → 42 Pin Connector #01		
K- Off =	0V	
KOEO =	B+	Check fuse and wiring
KOER =	B+	Check fuse and wiring
Crank =	B+	Ignition switch or wiring
Circuit 32 → 42 Pin Connector #13		
K- Off =	0V	Wiring
KOEO =	0V	Ignition switch & wiring
KOER =	0V	Ignition switch & wiring
Crank =	B+	Ignition switch & wiring
Circuit 32A → 42 Pin Connector #15		
K- Off =	0V	Wiring
KOEO =	0V	Ignition or wiring
KOER =	0V	Ignition or wiring
Crank =	B+	Ignition or wiring
Circuit 113 → ECM Connector Pin #L-3		
K- Off =	0V	
KOEO =	B+	ECM or wiring
KOER Grd.=	0V	Relay or ECM
Crank =	B+	ECM or wiring

STARTER, PERMANENT MAGNET DIAGNOSIS AND TESTING (Continued)

System Inspection

CAUTION: When disconnecting the plastic hardshell connector at the solenoid "S" terminal, grasp the plastic connector and pull lead off. DO NOT pull separately on lead wire.

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.

NOTE: Be sure to disconnect battery negative cable before servicing starter.

1. Inspect starting system for loose connections.
2. If system does not operate properly, note condition and continue diagnosis using the symptom chart.

WARNING: WHEN WORKING IN AREA OF THE STARTER, BE CAREFUL TO AVOID TOUCHING HOT EXHAUST COMPONENTS.

SYMPTOM CHART

CONDITION	POSSIBLE SOURCE	ACTION
Starter solenoid does not pull in and starter does not crank (audible click may or may not be heard).	• Open fuse. • Low battery. • Defective remote relay. • Open circuit or high resistance in external feed circuit to starter solenoid. • Defective starter. • Defective neutural park switch.	• Check fuse continuity. • Refer to appropriate battery service manual. • Go to Test B. (Page 07-8). • Go to Test A. (Page 07-8). • Replace starter. See removal and installation procedure this section. • Replace switch.
Unusual starter noise during starter overrun.	• Starter not mounted flush (cocked). • Noise from other components. • Ring gear tooth damage or excessive ring gear runout. • Defective starter.	• Realign starter on transmission bell housing or SAE housing. • Investigate other powertrain accessory noise contributors. • Replace flywheel ring gear. • Replace starter. See removal and installation procedure this section.
Starter cranks but engine does not start.	• Problem in fuel system. • Problem in ignition system. • Engine-related problem.	• Refer to fuel system section. • Refer to ignition system section. • Refer to Section 01, Diagnosis and Testing.
Starter cranks slowly.	• Low battery. • High resistance or loose connections in starter solenoid battery feed or ground circuit. • Ring gear runout excessive. • Defective starter.	• Charge or replace battery. • Check that all connections are secure. • Replace ring gear. • Replace starter. See removal and installation procedure this section.
Starter remains engaged and runs with engine.	• Shorted ignition switch. • Battery cable touching solenoid "S" terminal (defective or mispositioned cable). • Defective starter.	• Replace ignition switch. • Replace or relocate cable. • Replace starter. See removal and installation procedure this section.
Starter clicks and engages but engine will not crank.	• Hydrolocked cylinder. • Seized main or rod bearing.	• Remove all plugs one at a time while checking for fluid in cylinders. • Repair as needed. Refer to Section 01.

STARTER, PERMANENT MAGNET DIAGNOSIS AND TESTING (Continued)

Evaluation Procedure 1

NOTE: Remove plastic safety cap on starter solenoid and disconnect hardshell connector at solenoid "S" terminal as described under "Removal and Installation" in this section.

CHECK STARTER MOTOR – TEST A

TEST STEP		RESULT ▶	ACTION TO TAKE
A1	CHECK FOR VOLTAGE TO STARTER		
	• Key OFF, Transmission in Neutral, PTO disengaged. • Check for voltage between starter B+ terminal and starter drive housing. • Is voltage OK? (12-12.45V).	Yes ▶ No ▶	Go to **A2**. CHECK wire connections between battery and starter solenoid and the ground circuit for open or short.
A2	CHECK STARTER MOTOR		
	• Key OFF, Transmission in Neutral, PTO disengaged. • Connect one end of a jumper wire to the starter B+ terminal and momentarily touch the other end to solenoid "S" terminal. • Does starter crank?	Yes ▶ No ▶	CHECK connections from output of starter relay to "S" terminal for open or short. Defective starter. REPLACE starter.

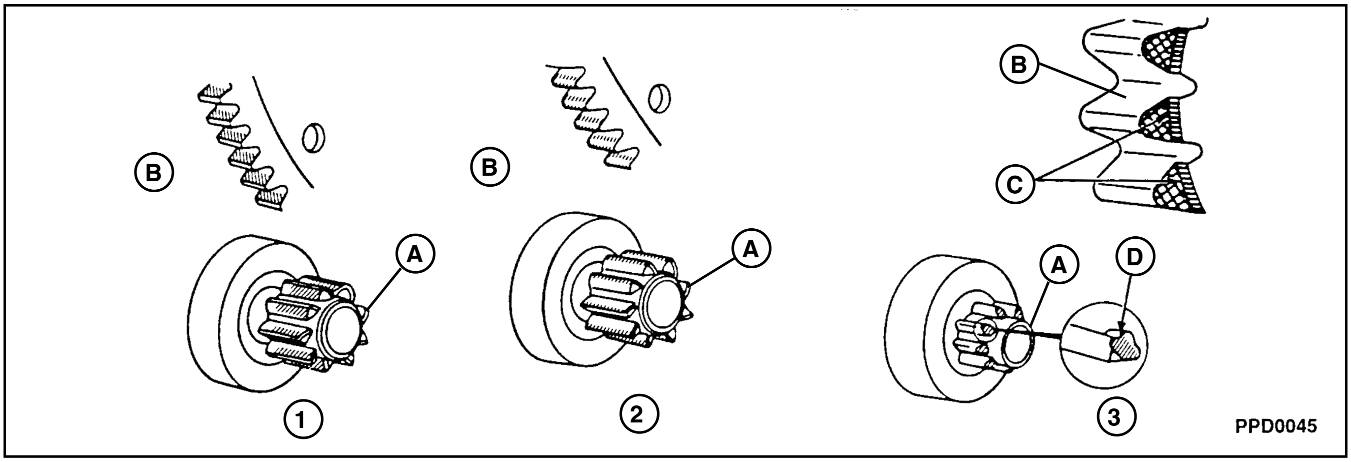
Evaluation Procedure 2

CHECK RELAY – TEST B

TEST STEP		RESULT ▶	ACTION TO TAKE
B1	CHECK STARTER RELAY		
	• Key in START. Transmission in Neutral, PTO disengaged. • Is case ground OK?	Yes ▶ No ▶	Go to **B2**. REPAIR ground. GO to **B2**.
B2	CHECK VOLTAGE AT STARTER RELAY START TERMINAL		
	• Key in START. Transmission in Neutral, PTO disengaged. • Check for voltage between relay start terminal and case ground. • Is voltage OK? (12-12.45 V).	Yes ▶ No ▶	GO to **B3**. Open circuit or high resistance exits in external circuit wiring or components. Check the following: – All circuit connections including plastic hard-shell connector at solenoid "S" terminal to make sure it is not broken or distorted. – Ignition switch. – Neutral switch or manual lever position sensor.
B3	CHECK STARTER TERMINAL		
	• Key in START. Transmission in Neutral, PTO disengaged. • Check for voltage at output terminal of remote relay. • Is voltage OK?	Yes ▶ No ▶	REFER to Starter System Diagnosis in this section. Defective starter relay. REMOVE and REPLACE relay.

DIAGNOSIS AND TESTING

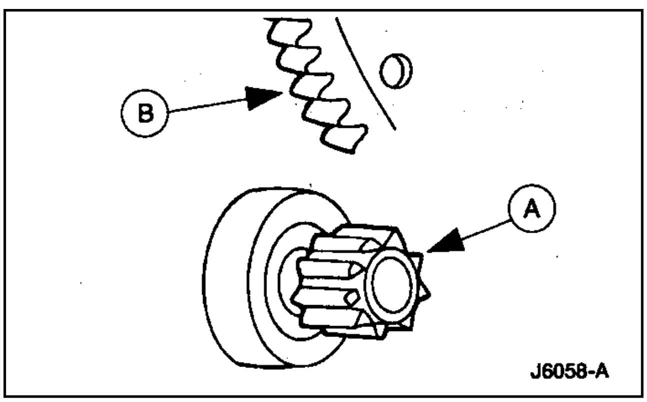
Pinion and Ring Gear Wear Patterns



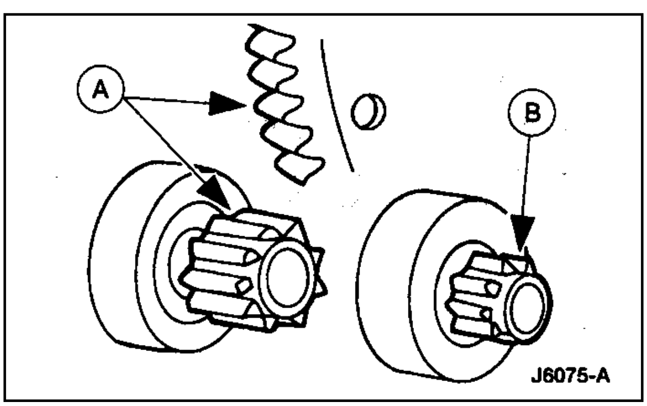
(1) **NORMAL WEAR PATTERN**	(2) **SMALL WEAR PATTERN**	(3) **MILLED GEARS**
(A) Armature Gear	(A) Armature Gear	(A) Armature Gear
(B) Flywheel Gear	(B) Flywheel Gear	(B) Flywheel Gear
		(C) Milled Condition Excessive Wear on 3 or 3 Teeth
		(D) Milled Tooth Metal Build-up Will Not Permit Engagement

General Procedures

Starter Drive and Flywheel Ring Gear Inspection

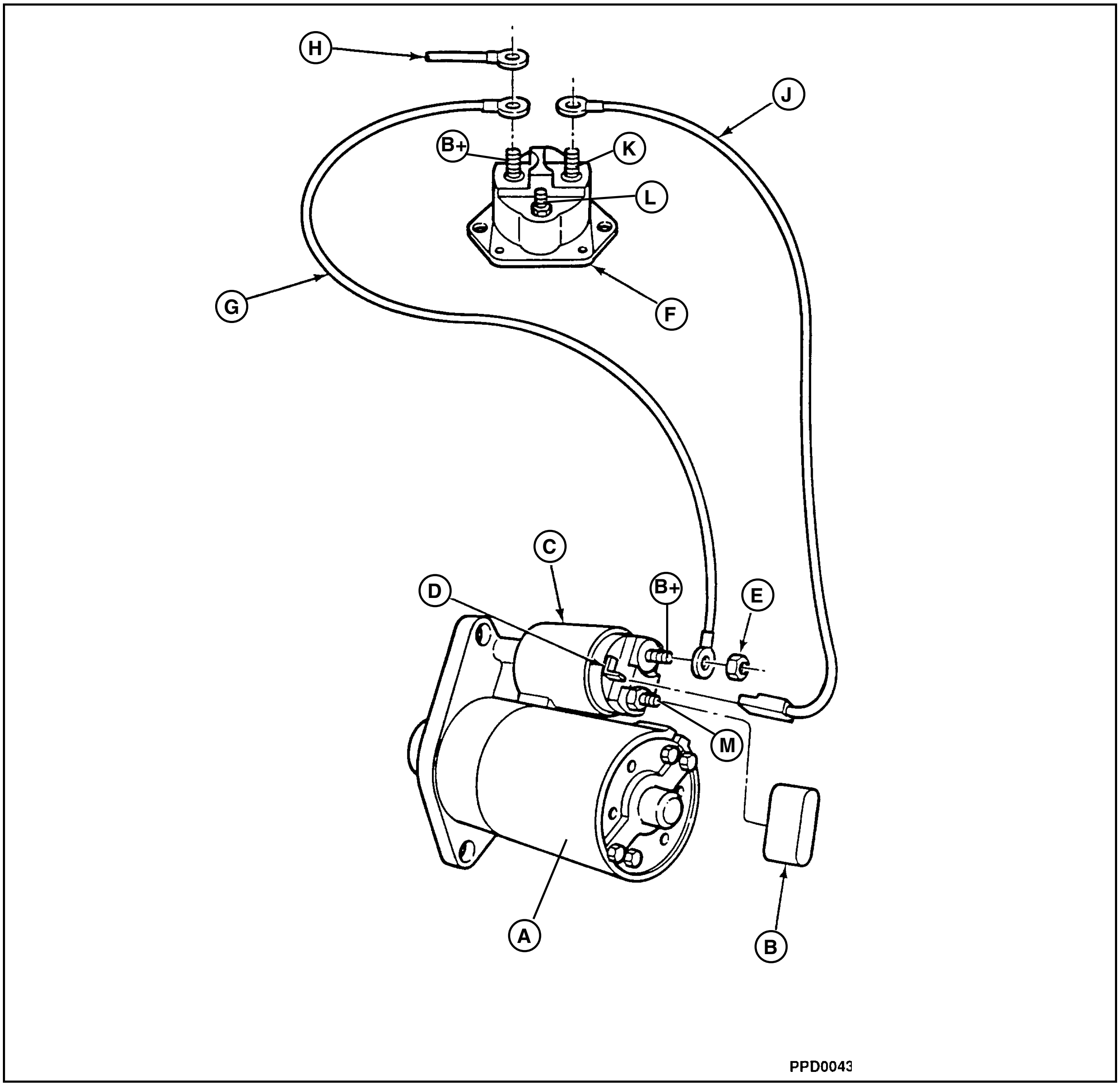


1. Check the wear patterns on the (A) starter drive (11350) and the (B) flywheel ring gear. If the wear pattern is normal, install the starter motor; refer to Starter Motor in this section.



2. If the (A) starter drive gear and the flywheel ring gear are not fully meshing or the gears are (B) milled or damaged, replace the starter motor; refer to Starter Motor in this section. Replace the flywheel ring gear.

STARTER, PERMANENT MAGNET REMOVAL AND INSTALLATION



CAUTION: A jumper wire must not be installed between the large round electrical terminal and the solenoid blade terminal at the starter. If done, voltage is generated to the solenoid by the spinning starter after release of the start key or button, causing the starter to remain engaged, resulting in failure.

- A Permanent Magnet Starter
- B Terminal Cover
- B+ 12 Volt Battery Supply Terminal
- C Starter Motor Solenoid
- D Solenoid Blade Terminal or Post/Nut Connection
- E Nut
- F Starter Relay
- G Starter Cable
- H Battery Positive Cable
- J #12 Gauge Wire (Red) E9SF-11A004-AB
- K B+ when relay is energized from ignition switch in crank position to “S” Terminal
- L “S” Terminal
- M “M” Terminal Positive Brush Connector

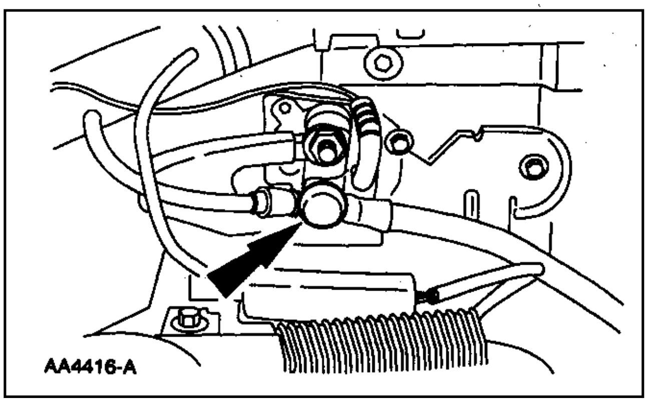
REMOVAL AND INSTALLATION

Switch – Relay Solenoid

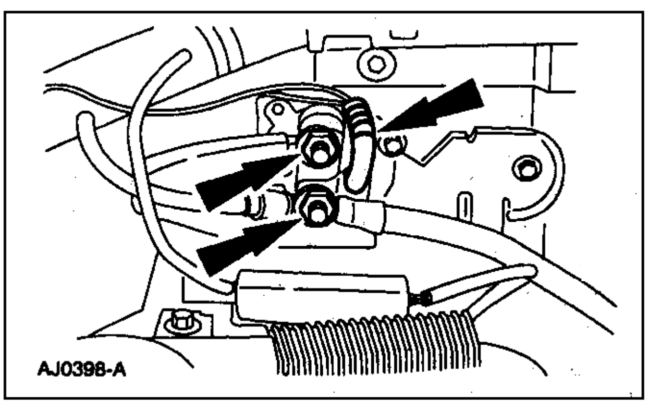
Removal

WARNING: WHEN CARRYING OUT MAINTENANCE ON THE STARTER SYSTEM BE AWARE THAT HEAVY GAUGE LEADS ARE CONNECTED DIRECTLY TO THE BATTERY. MAKE SURE PROTECTIVE CAPS ARE IN PLACE WHEN MAINTENANCE IS COMPLETE. FAILURE TO FOLLOW THIS PROCEDURE MAY RESULT IN PERSONAL INJURY.

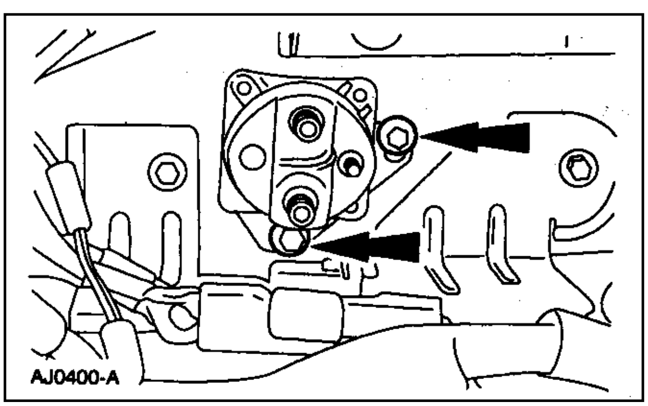
1. Disconnect the battery ground cable (14301).



2. Remove the insulator.



3. Disconnect the starter motor solenoid relay switch wires and cables.
   - Disconnect the engine control sensor wiring terminal.
   - Remove the starter motor solenoid relay switch terminal nuts.
   - Remove the wiring.



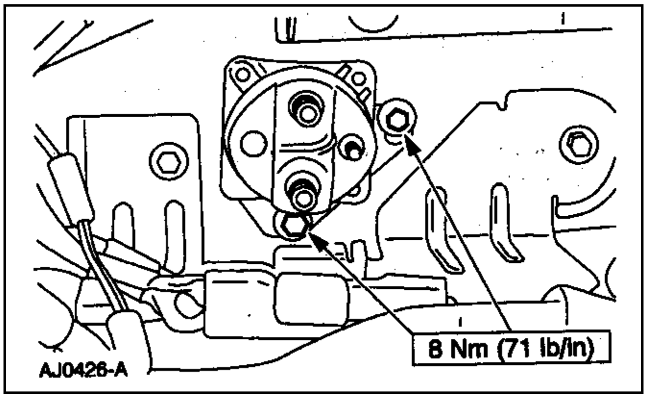
4. Remove the starter motor solenoid relay switch (11450).
   - Remove the bolts.
   - Remove the starter solenoid relay switch.

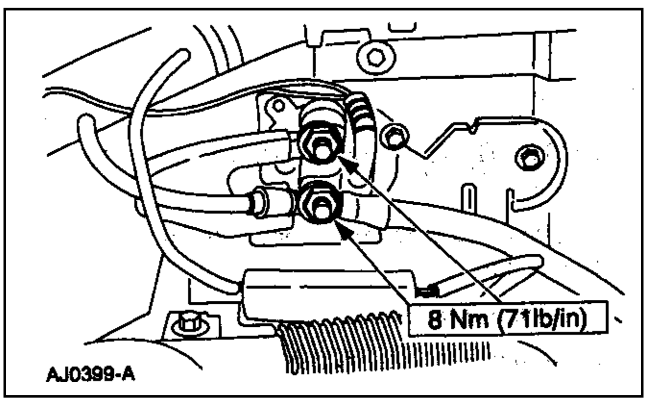
REMOVAL AND INSTALLATION (Continued)

Installation

WARNING: WHEN CARRYING OUT MAINTENANCE ON THE STARTER SYSTEM BE AWARE THAT HEAVY GAUGE LEADS OR CONNECTED DIRECTLY TO THE BATTERY. MAKE SURE PROTECTIVE CAPS ARE IN PLACE WHEN MAINTENANCE IS COMPLETE. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

1. Follow the removal procedure in reverse order.
2. Reconnect battery ground cable.





Starter Motor

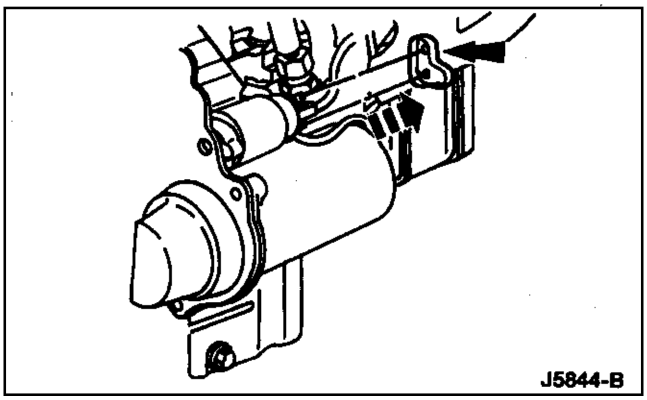
Removal

WARNING: WHEN CARRYING OUT MAINTENANCE ON THE STARTER SYSTEM BE AWARE THAT HEAVY GAUGE LEADS OR CONNECTED DIRECTLY TO THE BATTERY. MAKE SURE PROTECTIVE CAPS ARE IN PLACE WHEN MAINTENANCE IS COMPLETE. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

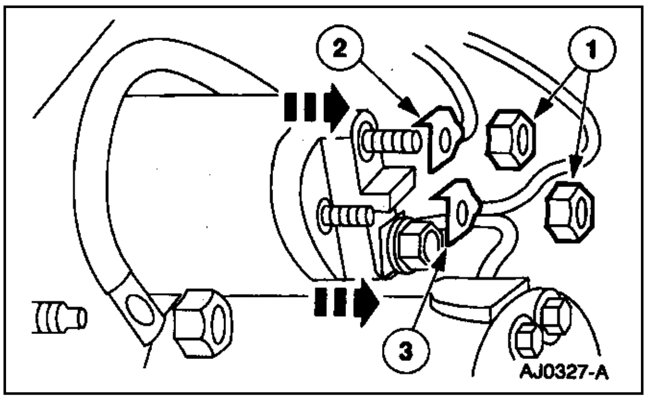
1. Disconnect the battery ground cable (14301).

REMOVAL AND INSTALLATION (Continued)

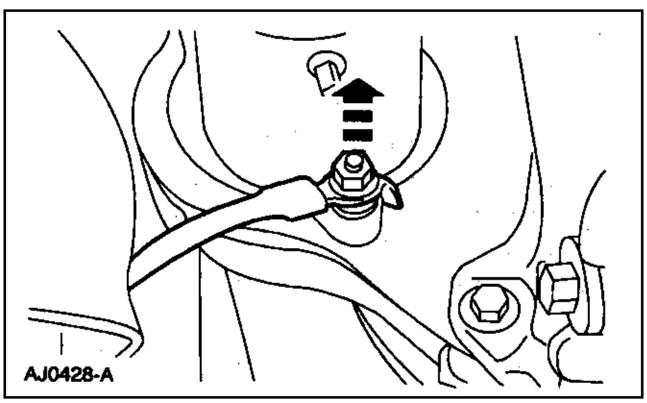
2. Raise and support the vehicle or equipment.



3. Remove the starter motor solenoid terminal cover (11N087).

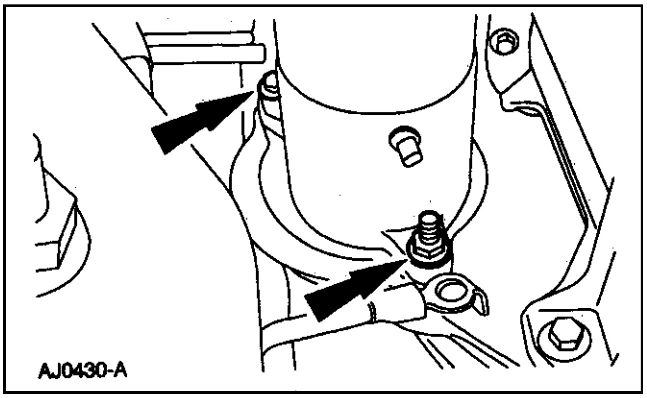


4. Disconnect the starter motor electrical connections.
   1. Remove the two nuts.
   2. Remove the battery cable.
   3. Remove the starter solenoid wire.

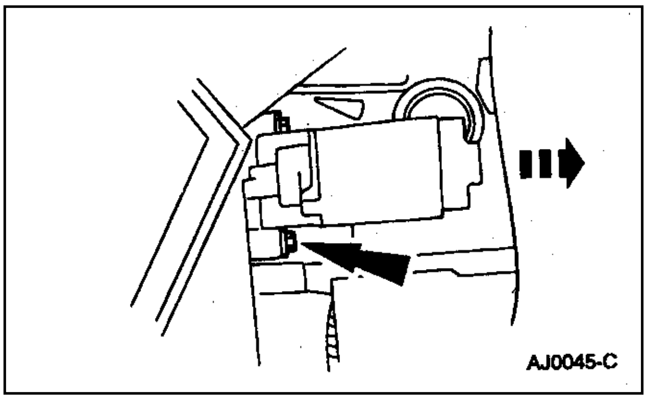


5. Remove the nut and the starter motor ground cable when equipped.

REMOVAL AND INSTALLATION (Continued)



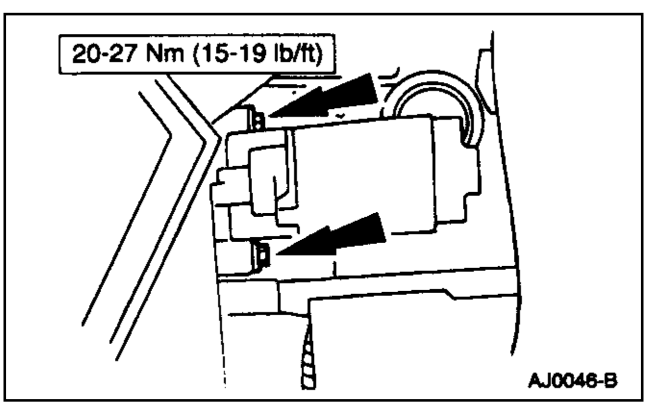
6. Remove the starter.
   1. Remove the bolt and stub bolt.
   2. Remove the starter.



7. Remove the stud bolt, bolts and the starter.

Installation

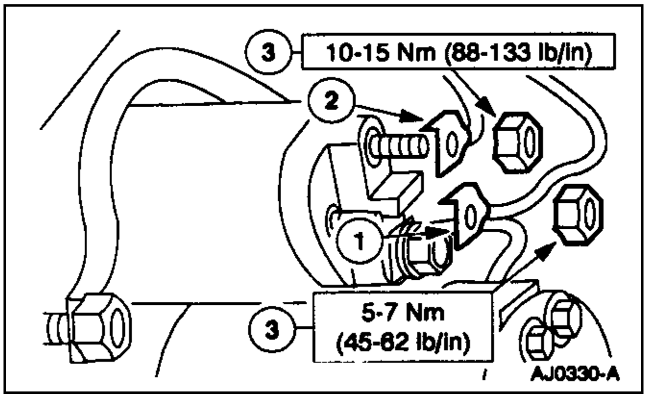
WARNING: WHEN CARRYING OUT MAINTENANCE ON THE STARTER SYSTEM BE AWARE THAT HEAVY GAUGE LEADS ARE CONNECTED DIRECTLY TO THE BATTERY. MAKE SURE PROTECTIVE CAPS ARE IN PLACE WHEN MAINTENANCE IS COMPLETE. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.



NOTE: It is recommended that wiring service kit F2PZ-11K162-A be used, which includes a 70 inch long #12 gauge wire, a terminal nut, a terminal cover, four tie wraps and insulation instructions.

1. Install the starter motor.
   1. Position the starter motor.
   2. Install the bolts.

REMOVAL AND INSTALLATION (Continued)

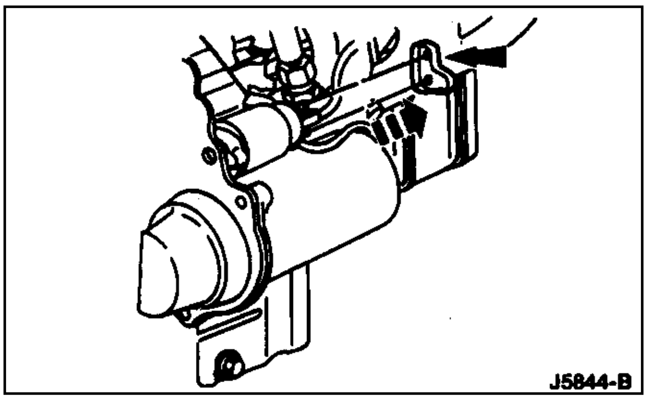


2. Connect the starter motor electrical connections.

    1. Position the starter solenoid wire.

    2. Position the battery cable.

    3. Install the nuts.



3. Install the starter motor solenoid termial cover.

4. Connect the battery ground cable.

STARTER, PERMANENT MAGNET SPECIFICATIONS

TORQUE SPECIFICATIONS

Description	Nm	Lb-In
Brush Plate Screw	2.3-3.4	20-30
Mounting Bolt	20.3-27	15-20 (Lb-Ft)
Solenoid Bolt	5.1-9.6	45-85
Starting Circuit Max. Voltage Drop (Engine Temp. Normal) Volts		0.5
Terminal Nut "M"	10-14	84-120
Terminal Nut "B"	10-14	84-120
Through-Bolt	5.0-9.5	45-84

Starter Motor						Max. Load	No Load	Starter Brushes			
Motor Diameter		Current Draw Under Normal Load	Normal Engine Cranking Speed	Min. Stall Torque @ 5 Volts				Mfg. Length		Spring Tension	
mm	Inches	Amps	RPM	Nm	Lb-Ft	Amps	Amps	mm	Inches	N	oz.
108	4	130-220	140-220	14.7	11.0	800	70 ± 10	16.8	0.66	18	64

Maximum commutator runout is 0.12mm (0.005 inch). Maximum starting circuit voltage drop (battery positive terminal to starter terminal) at normal engine temperature is 0.5 volt.

STARTING SYSTEM SPECIAL SERVICE TOOLS/EQUIPMENT

ROTUNDA EQUIPMENT

Tool Number	Description
078-00005	VAT-40 Starting/charging Tester

Special Service Tools called for by the procedures can be obtained by calling:
1-800-ROTUNDA (1-800-768-8632).

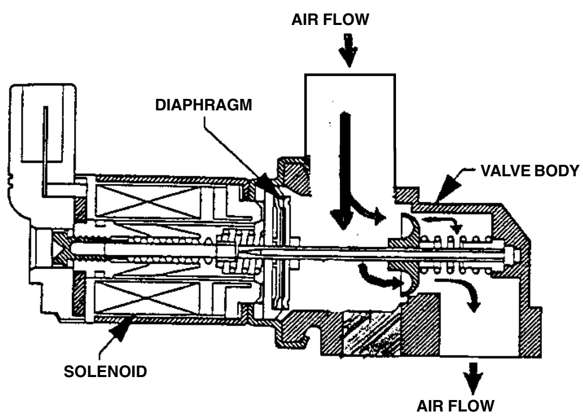
ELECTRONICS & DIAGNOSTIC TROUBLE CODES INDEX

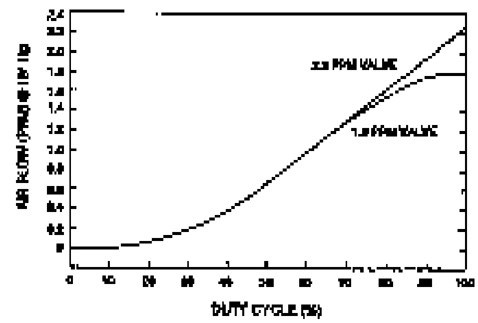
08

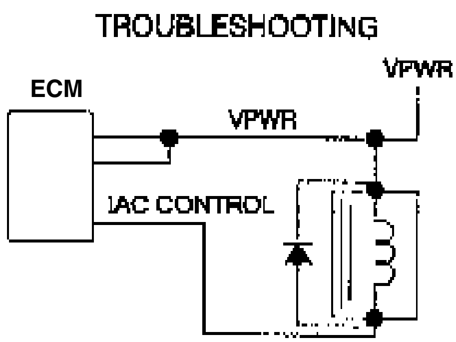
IDLE AIR CONTROL (IAC) VALVE

Part Description

The Engine Control Module (ECM) modulates the position of the IAC solenoid to regulate the air flow which controls engine RPM at idle.

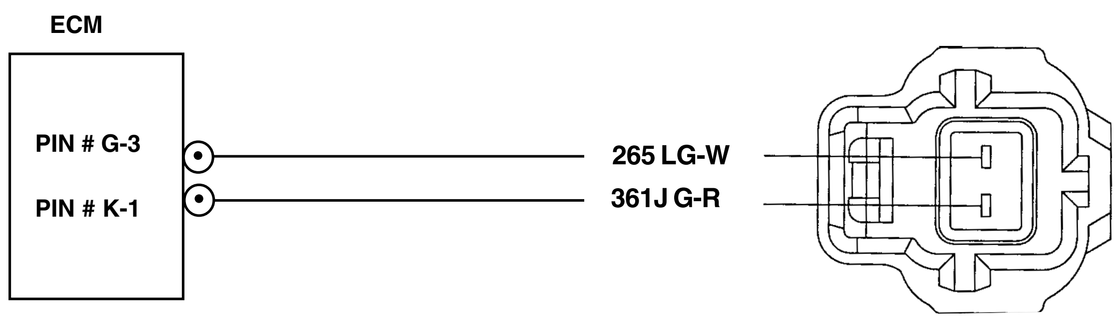






RESISTANCE: SUPPLY & CONTROL
(ECA / PCM DISCONNECTED)

7 - 13 Ω	NORMAL



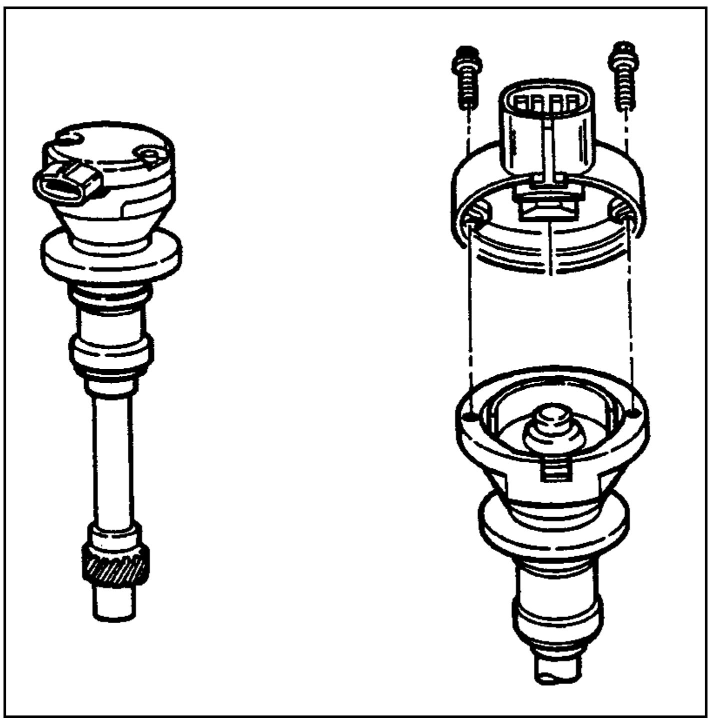
PINS LOCATED ON ALL HARNESS CONNECTORS VIEWED INTO MATING SURFACE

IDLE AIR CONTROL SOLENOID HARNESS CONNECTOR

CAMSHAFT POSITION SENSOR (CMP) (HALL EFFECT)

Part Description

This device provides cylinder identification information to the Engine Control Module (ECM) for fuel synchronization. The sensor contains a Hall-effect device, an integrated circuit, and a magnet. An air gap between the magnet and the Hall device allows the tooth (and space) mounted on a rotating vane to pass between them. This results in a change in the flux density reaching the Hall device. As a tooth nears the centerline of the sensor, a threshold (Firepoint) is reached where the output voltage changes state from low to high. When the trailing edge of the tooth nears the centerline of the sensor, the output reaches a second threshold (operate point) and returns to a low state. This sensor (as shown) was designed to be installed in the bore originally provided for the distributor on the 3.8L engine; other mountings are used on the 4.2L, 5.4L and 6.8L engines. A single tooth vane is used on all applications.

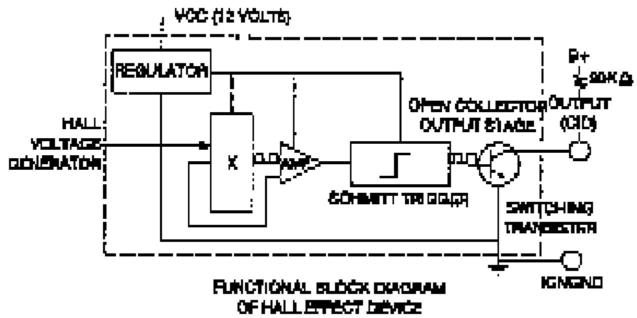


Cylinder Identification (CID)

This input provides camshaft position information for determining the position of cylinder #1, which is required for phasing fuel injection and ignition coil synchronization.

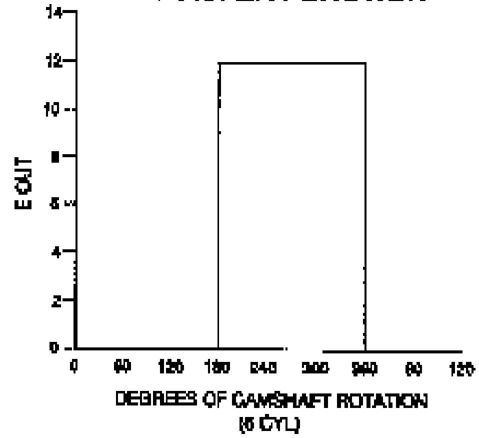
CAMSHAFT POSITION SENSOR (CMP) (HALL EFFECT) (Continued)

SENSOR OPERATION

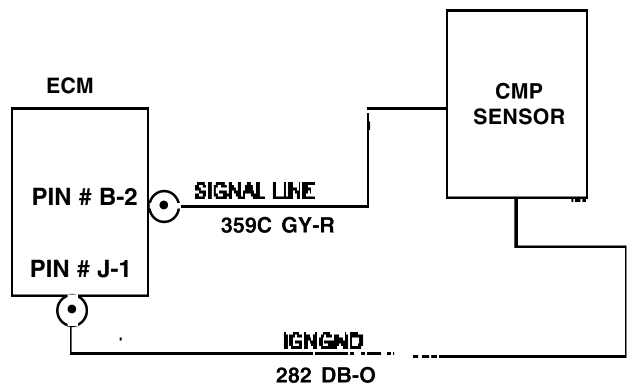


FUNCTIONAL BLOCK DIAGRAM OF HALL EFFECT DEVICE

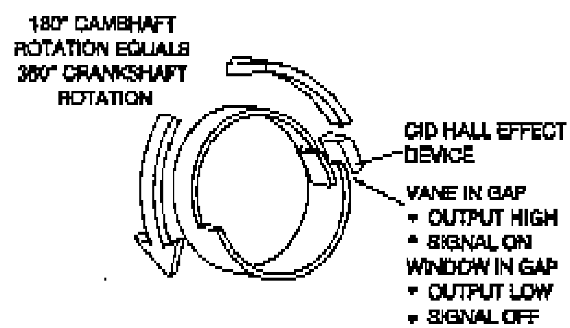
TRANSFER FUNCTION

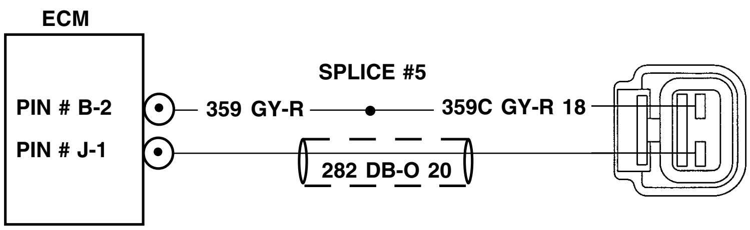


TROUBLESHOOTING



6 CYLINDER





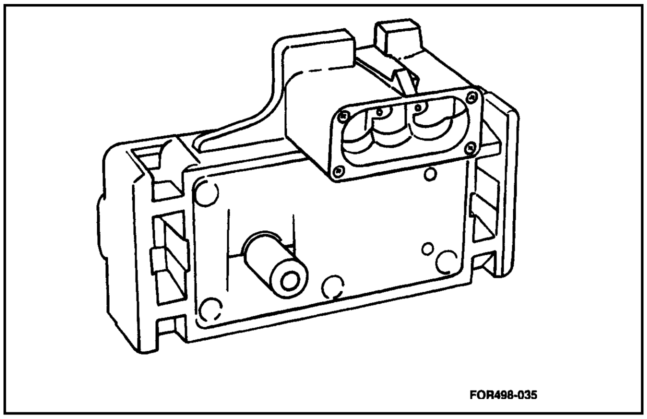
VOLTAGE: SIGNAL & IGNGND

0-0.4	KOEO WINDOW
B+	KOEO VANE
1/2 B+	KOER

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

Part Description

The MAP sensor consists of a pressure sensing element (capacitor) and signal conditioning electronics. The capacitor has a vacuum/pressure reference which results in one surface (diaphragm) of the capacitor being partially deflected. Further changes in pressure produce corresponding changes in the deflection of the diaphragm and therefore a change in capacitance. This capacitance change is converted to a frequency by the conditioning electronics.



MAP sensor.

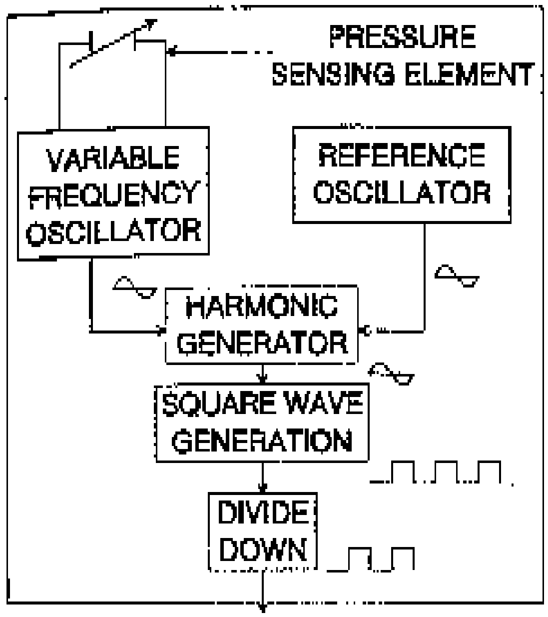
Specifications

- Range of Measurement: 12-105 kPa
- Measurement Accuracy: $\pm$ 1.7 kPa
- Sensor Response Time: 3 to 15 msec.
- Resolution: 0.1 kPa max.

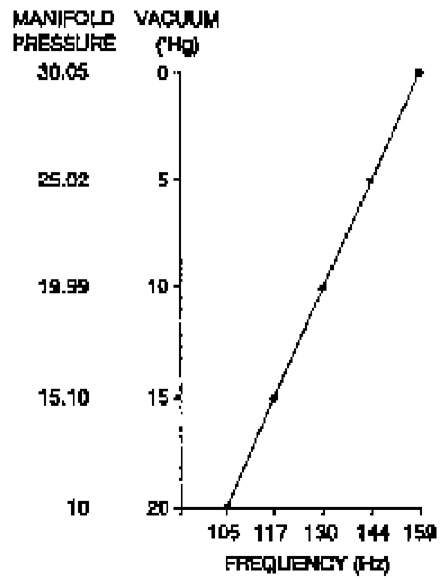
Present design: Silicon Capacitive Absolute Pressure (SCAP) Sensor with a maximum operating temperature of 100°C. The output is a 50% duty cycle wave form whose frequency is proportional to the pressure input.

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP) (Continued)

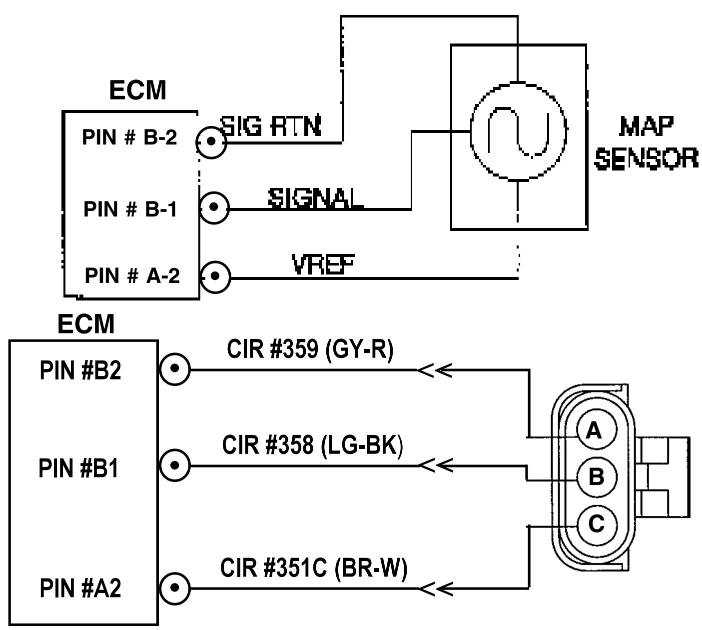
SENSOR OPERATION



TRANSFER FUNCTION



TROUBLESHOOTING

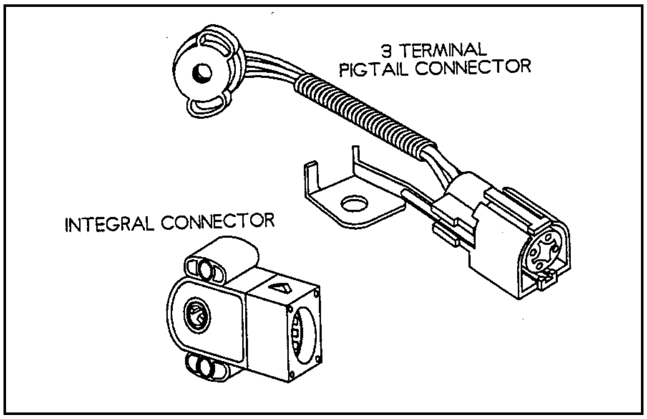


FREQUENCY	SIGNAL RETURN
SIGNAL	92 - 162 Hz

THROTTLE POSITION SENSOR (TP)

Part Description

The TP sensor is a rotary potentiometer that uses a variable resistive element which is packaged inside a plastic housing with either a three terminal pigtail connector or integral connector. The resistive element varies linearly and is directly proportional to the throttle plate angle. The Engine Control Module (ECM) applies reference voltage and ground to the sensor and monitors the sensor's ratio metric output voltage to determine precise throttle position.



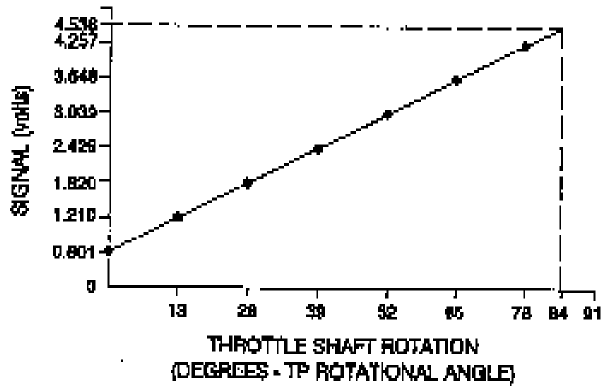
TP sensor (typical).

Specifications

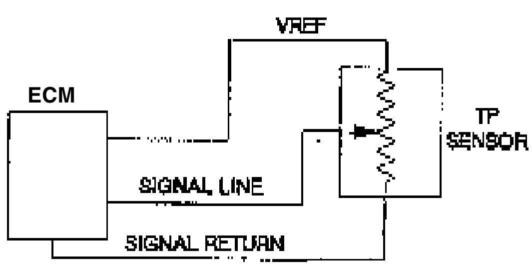
- Range of Measurement: 0 to 85° (angular)
- Measurement Accuracy: ± 2% of VREF
- Resolution: 0.5° max.

THROTTLE POSITION SENSOR (TP) (Continued)

TRANSFER FUNCTION



TROUBLESHOOTING

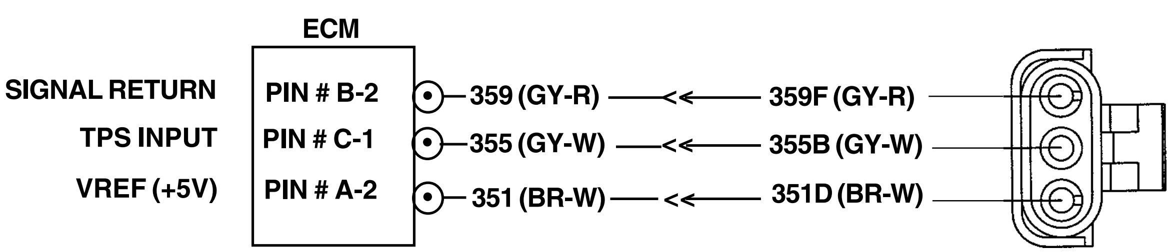


VOLTAGE: SIGNAL & SIGNAL RETURN

0.6 - 4.5	OPERATIONAL
<0.6	SHORTED
>4.5	OPEN

RESISTANCE: SIGNAL & SIGNAL RETURN
(ECM DISCONNECTED)

700Ω	CLOSED THROTTLE
3.9 KΩ	WIDE OPEN THROTTLE



PINS LOCATED ON ALL HARNESS
CONNECTORS VIEWED INTO MATING SURFACE

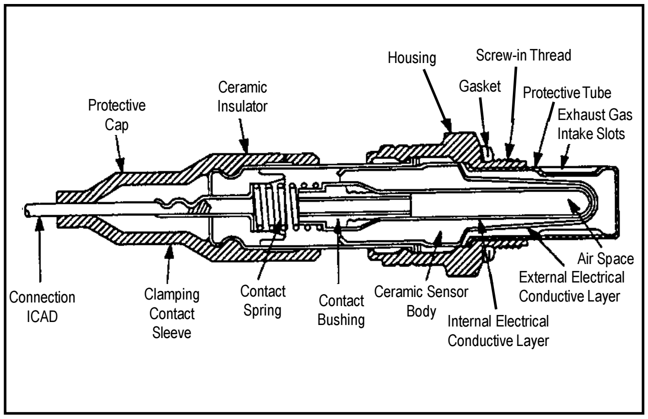
HEATED OXYGEN SENSOR (HO2S)

Part Description

The 4-wire HO2S indicates whether the air/fuel ratio is rich or lean with respect to stoichiometry.

The signal from this sensor contains valid air/fuel ratio in formation only when the sensor element has reached its normal operating temperature.

The 4-wire HO2S also has an isolated case ground which goes to Signal Return (SIGRTN) either in the processor (as a dedicated HO2S ground) or as a jumper to SIGRTN in the wiring harness.



HO2S sensor (typical).

Specifications

• Accuracy of Measurement: $\pm$ 1.5%

• Operating Temp. Range: 350°C to 850° (sensor tip)

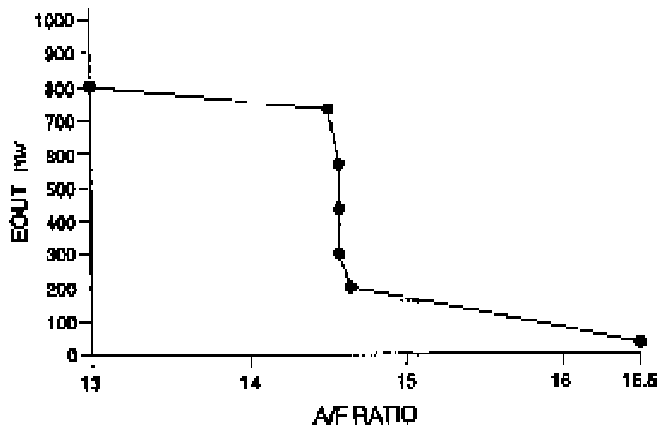
• Sensor Response Time: 300 to 1500 msec.

• Heater Current Draw: 1 A steady state

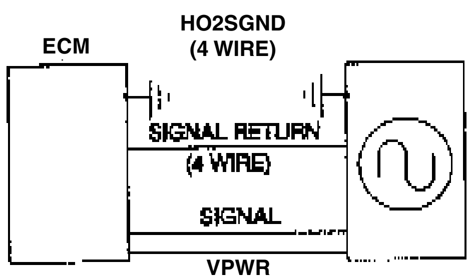
• Voltage Output:
 – -500 to 300 mV (lean exhaust gas)
 – 600 to 1100 mV (rich exhaust gas)

HEATED OXYGEN SENSOR (HO2S) (Continued)

TRANSFER FUNCTION

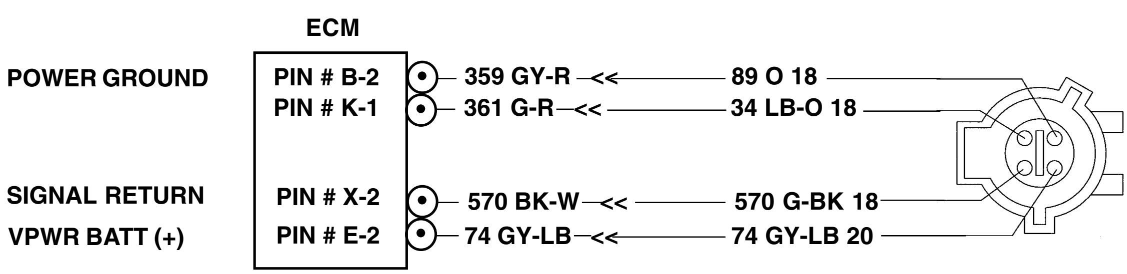


TROUBLESHOOTING



VOLTAGE (HOT EGO)

0.1 - 1.0	OPERATIONAL
<0.3	LEAN
>0.6	RICH
SWITCHING RICH - LEAN	CLOSED-LOOP



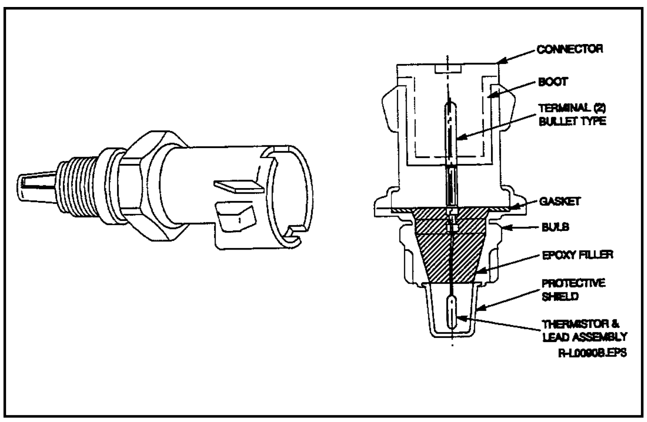
INTAKE AIR TEMPERATURE SENSOR (IAT)

Part Description

The IAT sensor is a temperature sensitive resistor (thermistor) which interfaces with a resistor network internal to the Engine Control Module (ECM/ICM) to provide a ratio metric output voltage inversely proportional to intake air, or air charge mixture temperature.

The sensor is mounted in the air intake assembly or threaded into a cylinder runner of the intake manifold. It provides the strategy with intake air temperature information. The sensor input is used as a density corrector for air flow calculations, to proportion the cold enrichment fuel flow, and to modify spark advance.

The sensor element is 0.095 inch diameter disc thermistor with soldered leads and a plastic protective coating. The thermistor resistance varies non-linearly and inversely with respect to temperature. The element is packaged in a brass bulb housing or molded plastic housing with a protective cap which optimizes response time, and a two terminal integral natural-colored nylon plastic connector.

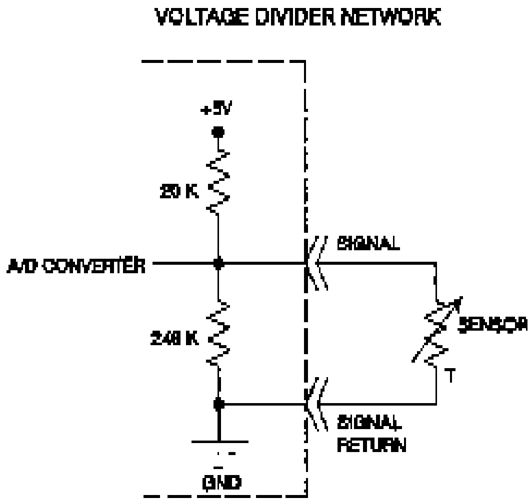


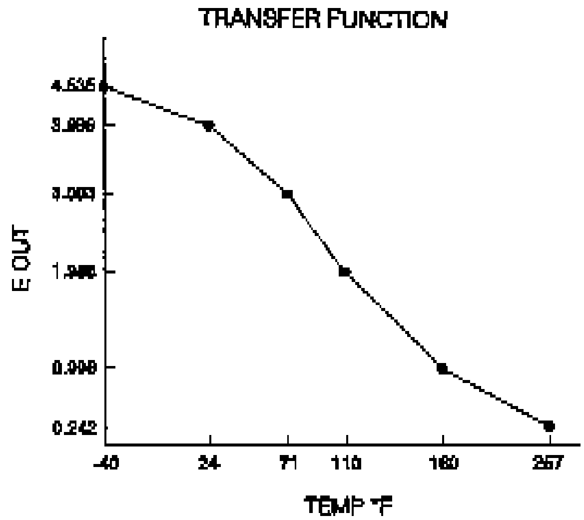
IAT sensor (typical).

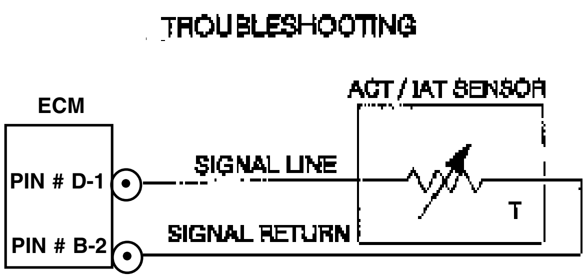
Specifications

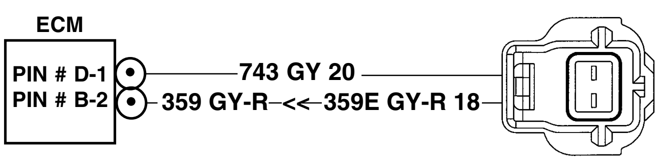
- Range of Measurement:
  -40°C / -40°F to 125°C / 57°F
- Measurement Accuracy: ± 3°C
- Resolution: 0.6°C max.
- Output Range: 4.8% min. to 91% max. of VREF
- Current Draw: < 5 mA from VREF
- Load Impedance: ≥ 100 kohms

INTAKE AIR TEMPERATURE SENSOR (IAT) (Continued)









VOLTAGE: SIGNAL & SIGNAL RETURN

0.242 - 4.535	OPERATIONAL
<0.242	SHORTED
>4.535	OPEN

RESISTANCE: SIGNAL & SIGNAL RETURN (ECM/ICM DISCONNECTED

-40 °F	269 KΩ
32 °F	85 KΩ
77 °F	29 KΩ
248 °F	1.2 KΩ

IAT Detail Sheet

MANIFOLD SKIN TEMPERATURE SENSOR (MST)

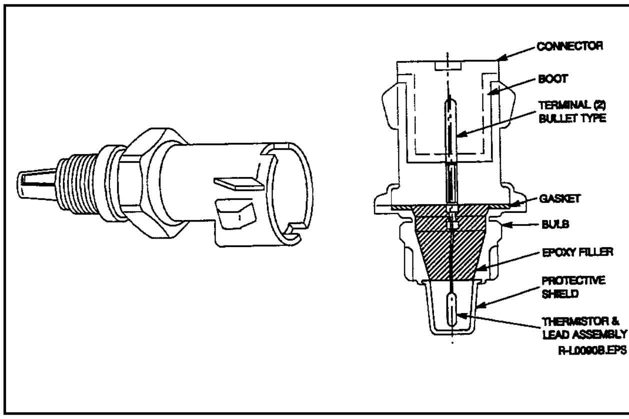
Part Description

NOTE: The MST is the same in appearance and specification as the brass IAT.

The MST sensor is a temperature sensitive resistor (thermistor) which interfaces with a resistor network internal to the Engine Control Module (ECM) or Ignition Control Module (ICM) to provide a ratio metric output voltage inversely proportional to the outside air very close to the lower intake manifold.

The sensor is screwed into a mounting bracket located at the right rear of the lower intake manifold. It provides the strategy with skin temperature of the lower intake manifold monitoring the air right next to the manifold. The sensor input is used as a density corrector for air flow calculations, and to proportion the cold enrichment fuel flow, and to modify spark.

The sensor element is a 0.095 inch diameter disc thermistor with soldered leads and a plastic protective coating. The thermistor resistance varies non-linearly and inversely with respect to temperature. The element is packaged in a brass bulb housing with a protective cap which optimizes response time, and a two terminal integral natural-colored nylon plastic connector.

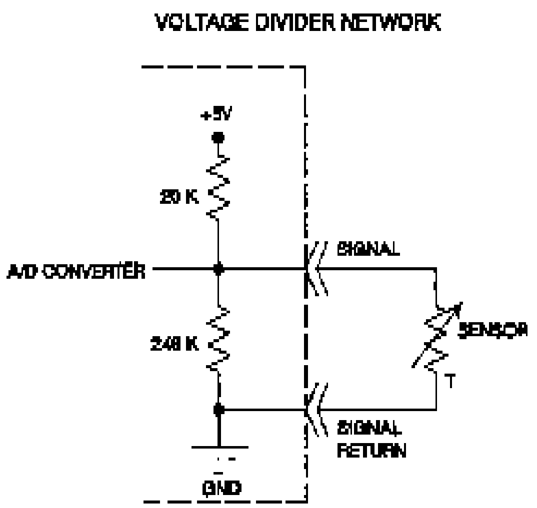


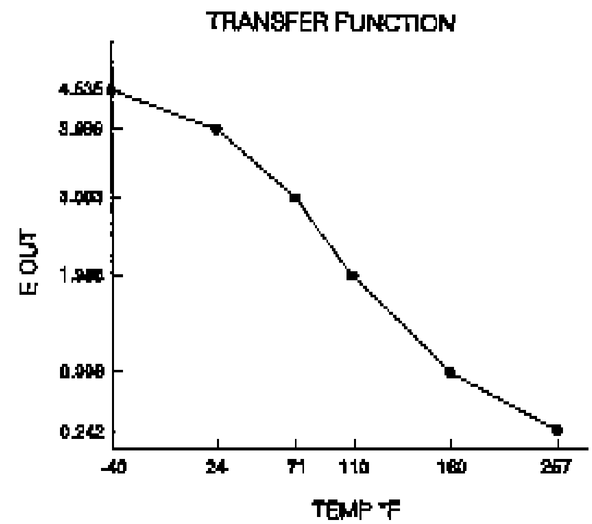
MST sensor (typical).

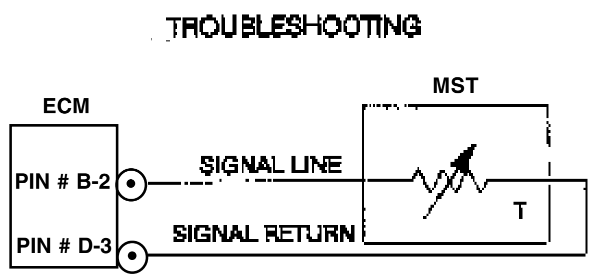
Specifications

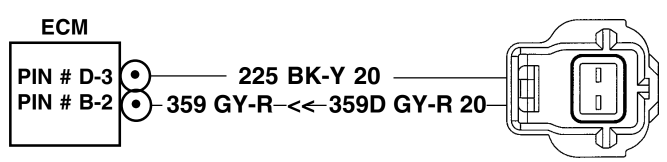
- Range of Measurement:
  -40°C / -40°F to 125°C / 57°F
- Measurement Accuracy: $\pm$ 3°C
- Resolution: 0.6°C max.
- Output Range: 4.8% min. to 91% max. of VREF
- Current Draw: < 5 mA from VREF
- Load Impedance: $\geq$ 100 kohms

MANIFOLD SKIN TEMPERATURE SENSOR (MST) (Continued)









VOLTAGE: SIGNAL & SIGNAL RETURN

0.242 - 4.535	OPERATIONAL
<0.242	SHORTED
>4.535	OPEN

RESISTANCE: SIGNAL & SIGNAL RETURN
(ECM/ICM DISCONNECTED

-40 °F	269 KΩ
32 °F	85 KΩ
77 °F	29 KΩ
248 °F	1.2 KΩ

MST Detail Sheet

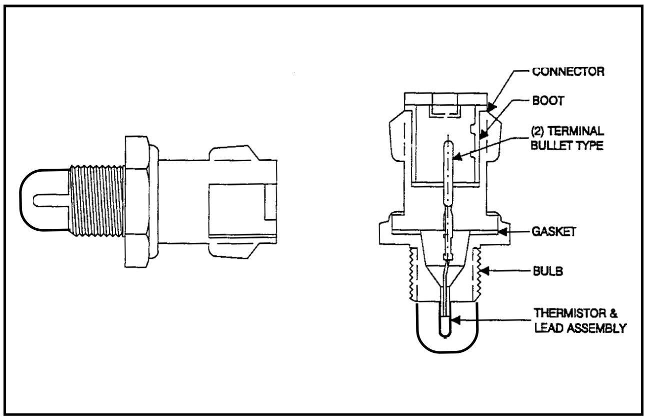
ENGINE CYLINDER HEAD TEMPERATURE SENSOR (CHT)

Part Description

The CHT sensor is a temperature sensitive resistor (thermistor) which interfaces with a resistor network internal to the Engine Module (ECM) to provide a ratio metric output voltage inversely proportional to engine coolant temperature.

The sensor is threaded into the rear of the right cylinder head of engine to read cylinder head temperature. For engine control applications, the signal is used to modify ignition timing and air/fuel ratio. The output is used to control a coolant temperature indicator.

The sensor element is a 0.095 inch diameter disc thermistor with soldered leads and a plastic protective coating. The thermistor resistance varies non-linearly and inversely with respect to temperature. The element is packaged in a brass bulb housing or molded plastic housing with a two terminal integral brown nylon plastic connector.



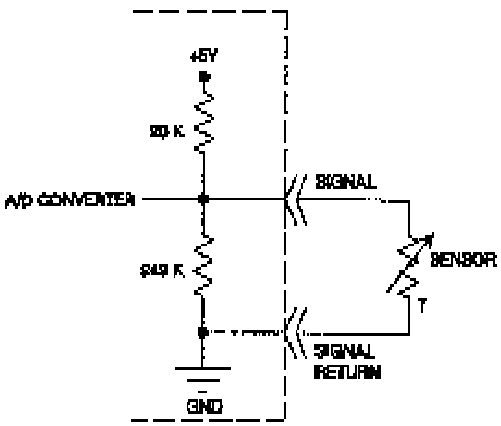
CHT sensor (typical).

Specifications

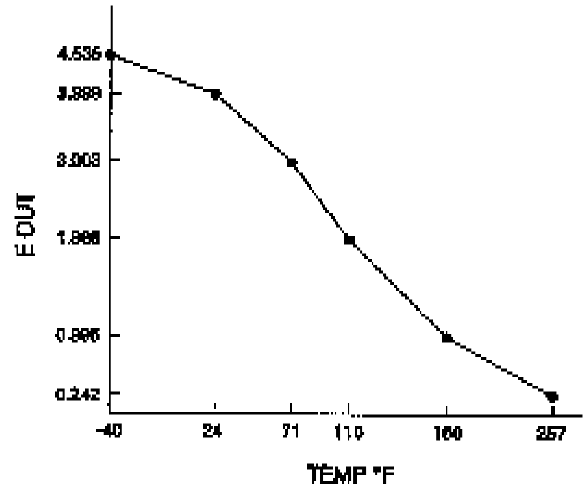
- Range of Measurement: -40°C / -40°F to 125°C / 257°F
- Measurement Accuracy: ± 3°C
- Response Time: 10 sec. max. for full range
- Resolution: 0.6°C max.
- Output Range: 4.8% min. to 91% max. of VREF
- Current Draw: < 5 mA from VREF
- Load Impedance: ≥ 100 k ohms

ENGINE CYLINDER HEAD TEMPERATURE SENSOR (CHT) (Continued)

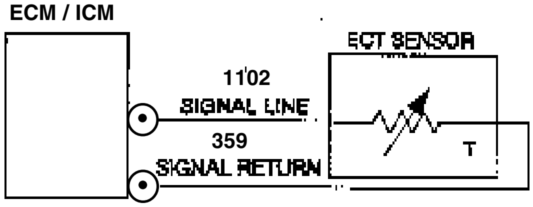
VOLTAGE DIVIDER NETWORK

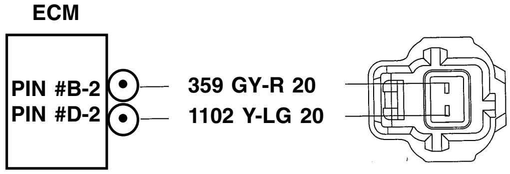


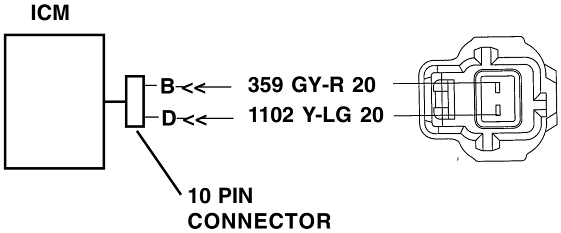
TRANSFER FUNCTION



TROUBLESHOOTING







VOLTAGE: SIGNAL & SIGNAL RETURN

0.242 - 4.535	OPERATIONAL
<0.242	SHORTED
>4.535	OPEN

RESISTANCE: SIGNAL & SIGNAL RETURN
(ECM / ICM DISCONNECTED)

-40 °F	269 KΩ
32 °F	95 KΩ
77 °F	29 KΩ
248 °F	1.2 KΩ

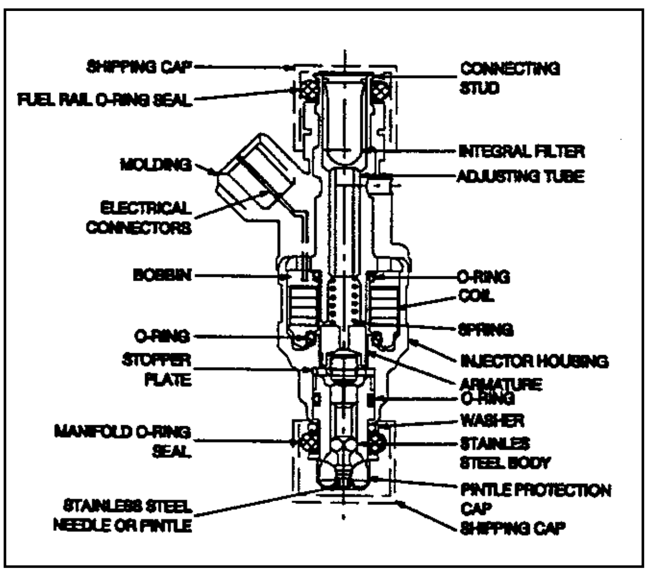
INJECTOR ASSEMBLY

Part Description

The fuel injectors are electromechanical devices that meter and atomize the fuel delivered to the engine. With Multiport Fuel Injection (MFI), the injectors are mounted in the lower manifold and are positioned so that their tips are directing fuel just upstream of the intake valves. The injector is a solenoid that actuates a normally closed ON/OFF needle valve assembly. The valve assembly (pintle) sits above a fixed size orifice (seat). The fuel pressure regulator maintains a constant pressure on the fuel; therefore, fuel flow to the engine is regulated only by how long the solenoid is energized. An electrical signal from the Engine Control Module (ECM) activates the solenoid, causing the pintle to move off its seat allowing the fuel to flow through the orifice. Atomization of the fuel is obtained by contouring the needle to cause fuel separation.

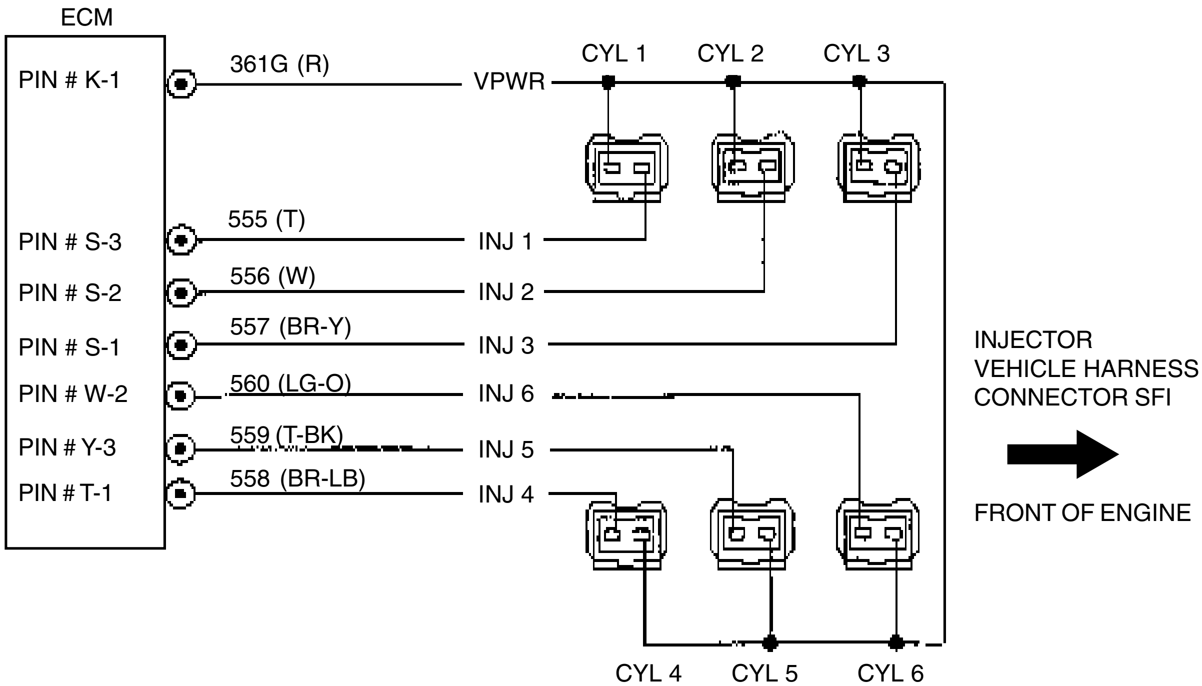
MFI injector design prevents lean flow tendencies that are caused by injector tip deposit formations.

⚠ **CAUTION: Do not apply battery voltage to the injectors during any type of diagnostics.**



MFI Fuel Injector (typical).

INJECTOR ASSEMBLY (Continued)



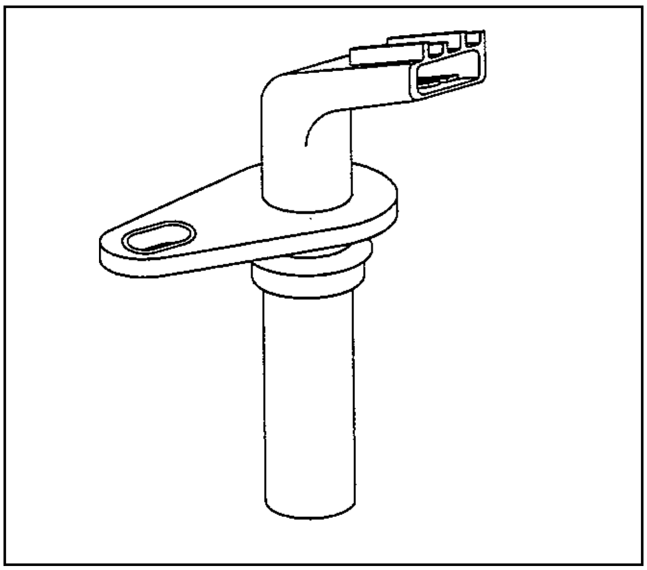
Single Injector Resistance
Specification Table

ALL ENGINES
11.0 - 18.0Ω

CRANKSHAFT POSITION SENSOR (CKP) (VARIABLE RELUCTANCE)

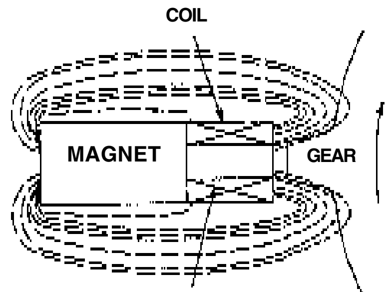
Part Description

The Variable Reluctance (VR) sensor reacts to variations in flux density created by a rotating (36-1 tooth) wheel attached to the crankshaft. The sensor contains a coil wire, a magnet, and a pole piece. The changing flux field induces an A/C voltage to the CKP sensor. One A/C cycle is generated for each tooth on the wheel. Normally, a zero detector circuit (located in the signal conditioning electronics) is used to convert the A/C signal into a digital pulse. This sensor is used on all Electronic Ignition High Data Rate (EI HDR) applications (4.6L shown) to provide basic spark timing data for the Engine Control Module (ECM).

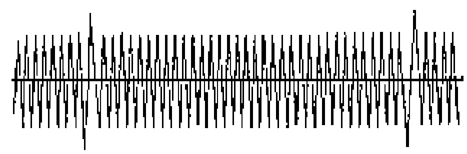


CKP Sensor (typical).

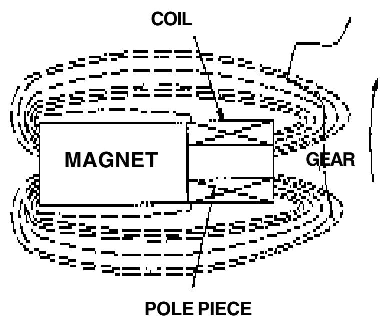
CRANKSHAFT POSITION SENSOR (CKP) (VARIABLE RELUCTANCE) (Continued)



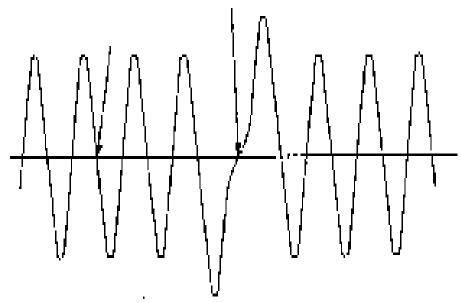
LOW-RESISTANCE POSITION OF VRS SENSOR



MISSING TOOTH REGION



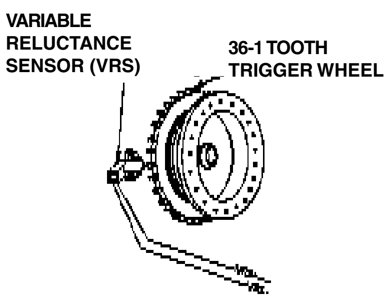
HIGH-RESISTANCE POSITION OF VRS SENSOR

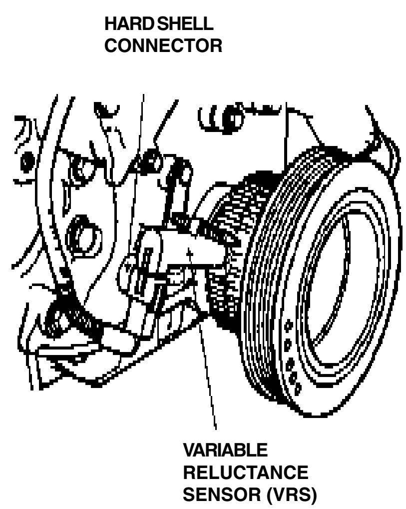


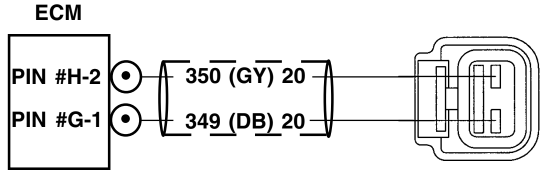
VRS WAVEFORM

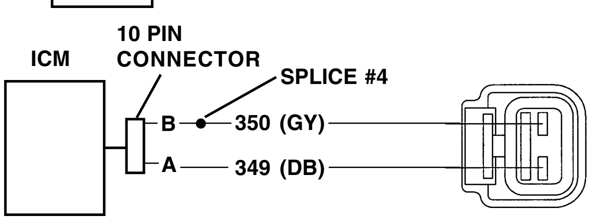
CKP sensor output voltage is 150 millivolts peak-to-peak at a minimum engine speed of 30 RPM

CKP sensor output voltage is 300 volts peak-to-peak at a maximum engine speed of 8000 RPM







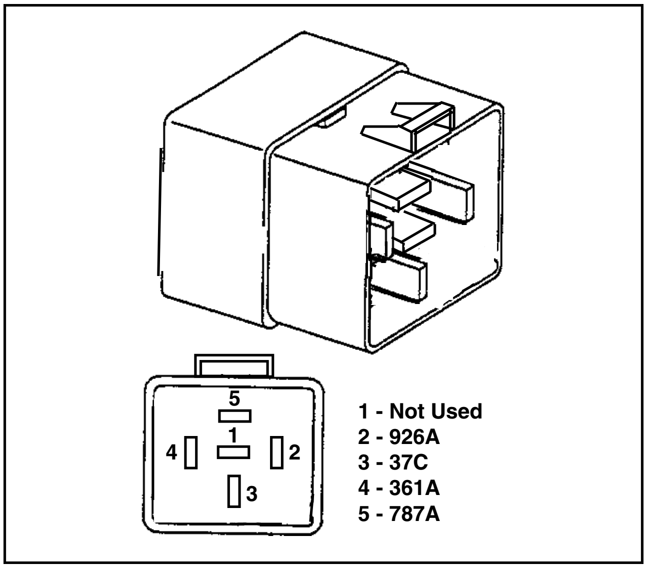


FUEL PUMP RELAY (FP)

Part Description

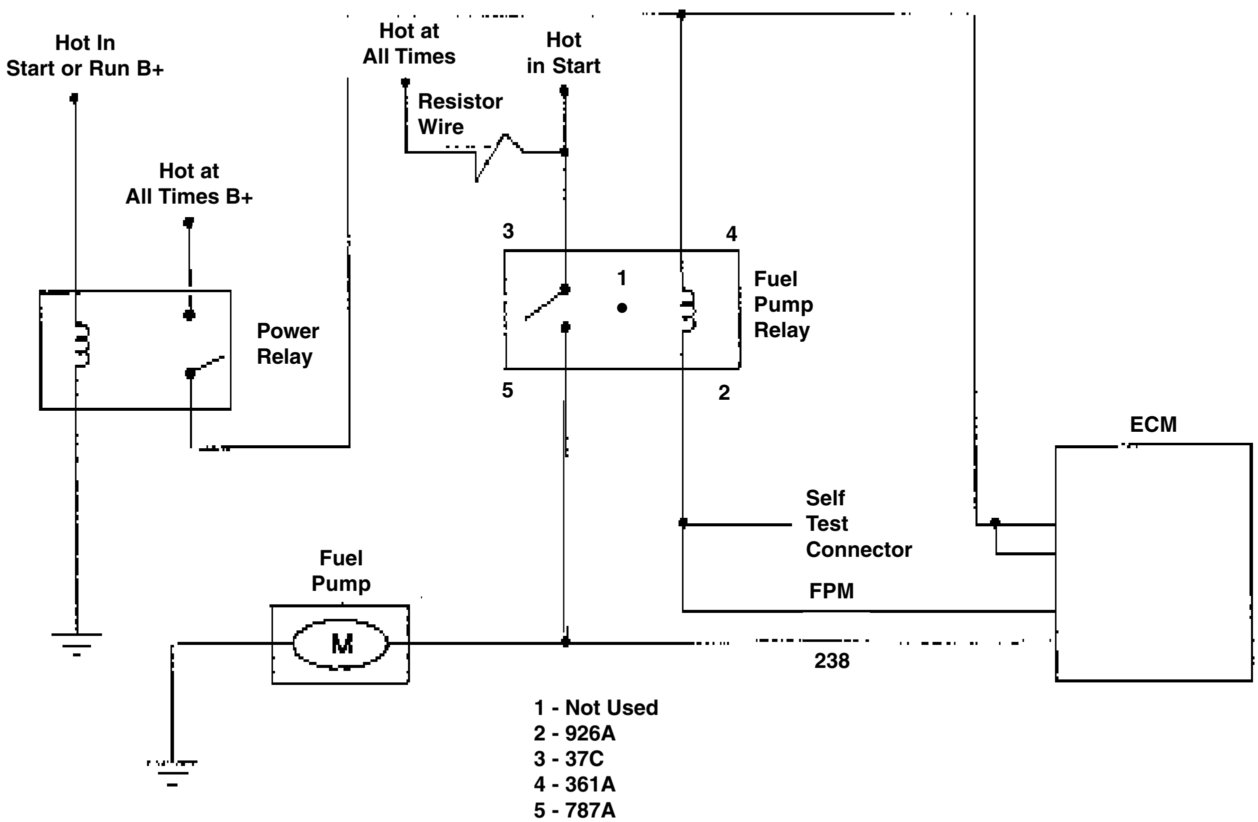
The Fuel Pump Relay is a Normally Open relay that supplies voltage to the electric fuel pump. When the ignition key is turned to the START or RUN position, the Engine Control Module (ECM) grounds the control pin which activates the relay (closes the contacts) and sends voltage to the fuel pump. If the ECM does not receive a RPM signal (indicating the engine is running) within 1 second, the ground on the control pin will be removed and the fuel pump will turn off.

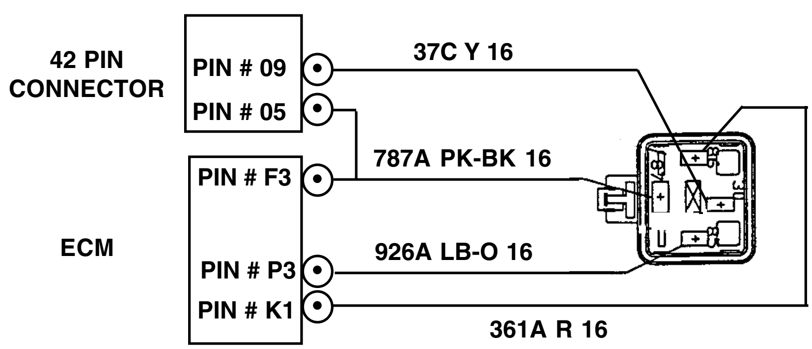
The Fuel Pump Monitor (FPM) circuit is wired into the fuel pump circuit and allows the ECM to monitor failures in the secondary circuit.



FP Relay (typical).

FUEL PUMP RELAY (Continued)





SPECIFICATIONS

Torque Specifications

Description	Nm	Lb/Ft	Lb/In
Air Intake Sensor	8-10	-	71-89
Camshaft Position Sensor Bolts (2)	2.3-3.5	-	20.4-27.5
Camshaft Synchronizer Bolt (1)	20-30	15-22	-
Crankshaft Position Sensor	2-4	-	18-36
Cylinder Head Temperature Sensor	9-11	-	80-95
Engine Control Module Mounting Bolts	.8	-	15
Engine Control Module Wire Connector	.8-2.5	-	15-19
Foot Pedal Mounting Bolts	Non-Ford, Use OEM Specifications		
Heated Oxygen Sensor	36-46	27-34	-
Idle Air Control (IAC) Valve	11	-	84
Ignition Coil Nuts and Stud Bolt	8-11	-	71-97
Ignition Control Module Mounting Bolts	8-10	-	71-88
Manifold Skin Temperature Sensor	8-10	-	71-88
Spark Plugs	10-20	8-14	-
Throttle Position Sensor	2.8-3.4	-	25-30
42 Pin Connector Bolt	4-5.6	-	35.50

ECM Diagnostic Trouble Codes

The following table lists the Diagnostic Trouble Code (DTC's) supported by this application. If any DTC's not listed here are flashed by the Malfunction Indicator Lamp (MIL) or displayed on a PC, there may be a software error. Notify Ford Power Products Customer Service Center if any DTC's are displayed that are not included in the following table.

Code	Name	Detects this problem	Effect	Safety Level
11	All systems OK			
12	Low Throttle Position Sensor Voltage	TPS: worn, bad, disconnected, wiring damaged	**Shutdown**	I
13	Low Accelerator Pedal Sensor Voltage	Accelerator Pedal Position Sensor: bad, disconnected, worn out, wiring damaged	**Limp Home**	II
14	Low manifold pressure	MAP sensor: bad, bad wiring, disconnected	Set code/open loop	II
15	Low manifold temp.	MST sensor: disconnected sensor, damaged wiring, electrical failure	Set code/open loop	II
16	Pedal Switch Failure	Pedal Position Sensor: out of set range while IVS off, damaged, mis-adjusted, IVS malfunction, damaged wiring, electrical failure, mechanical failure	**Limp Home**	II
17	DBW Actuator Unstable	Actuator: broken spring, dirt in bore, uneven operation, ECM malfunction, TPS problem.	**Shutdown**	I
21	Overspeed	Engine over 4000 RPM	Shutdown	I
22	High Throttle Position	TPS: faulty, tampering, tampering with wires, damaged wiring, electrical failure	**Shutdown**	I
23	High Drive by wire	Pedal Position Sensor: too high, short-circuited by tampering	**Shutdown**	I
24	High Manifold Pressure	MAP sensor: defective, vacuum leak, electrical failure	Set code/open loop	II
25	High manifold surface temp.	MST sensor: defective, damaged wiring, electrical failure	Set code/open loop	II
26	Initial TPS over Max	Actuator: foreign object in bore, e.g. ice, tampering	**no start**	I
27	DBW idle failure	Actuator: throttle plate moving while foot pedal in idle position, e.g. unstable	**Shutdown**	I
31	Low fuel pump voltage	Fuel pump: no voltage, wiring from harness bypassed	Set code/open loop	II
32	Heated Oxygen Sensor (HO2S) Low Voltage	HO2S sensor: defective, damaged wiring, electrical failure	Set code/open loop	II
33	High engine temp	CHT at 240°F	Shutdown	I
35	High intake air temp	IAT sensor: wiring problem in wrong location, bad plumbing, engine overheats	Set code/open loop	II
37	DBW decay failure	Actuator: Throttle plate stuck open	**Shutdown**	I
41	High fuel pump voltage	Fuel pump: on when not requested	Shutdown or no start	II
42	Heated Oxygen Sensor (HO2S) High Voltage	HO2S sensor: defective, damaged wiring, electrical failure	Set code/open loop	II
43	Low engine temp	CHT at 230°F	Set code/open loop	II
45	Low intake air temp, IAT wiring problem	IAT sensor: unplugged, bad wiring, or intake plumbing installed incorrectly	Set code/open loop	II
47	DBW rise failure	Actuator: Throttle plate not opening or stuck	**Shutdown**	I
51	Low Oil Pressure	Oil pressure: low	Shutdown[2]	II
52	Crankshaft sensor error	CKP	Set code	II
53	Camshaft sensor error	CMP	Set code	II
54	Program fault	ECM: malfunction	Set code	I
55	Program fault	ECM: malfunction	Set code	I
56	Program fault	ECM: malfunction	Set code	I
57	Program fault	ECM: malfunction	Set code	I
61	Low system voltage	Alternator: malfunction, alt. belt missing, alternator disconnected	Set code	II
62	High system voltage	Alternator: voltage exceeding 18 volts	Shutdown[3]	II
65	Intake manifold leak	Vacuum leak, IAC motor stuck causing engine rpm over foot pedal command	**Shutdown**	I

NOTE: Bold Print denotes 4.2 Drive By Wire engine safety features.

Safety Concern

- I Protects operator
- II Protects engine/powertrain (if enabled)

Glossary

CHT	Cylinder Head temperature sensor
HO2S	Heated exhaust gas oxygen sensor
ECM	Engine control module
IAC	Idle air control motor
IVS	Idle validation switch
MST	Manifold surface temp
TPS	Throttle Position Sensor

[1] software selectable
[2] software selectable
[3] software selectable

Chart Notes

- NO ACTION means DTC will be stored and MIL illuminated, but engine performance will not be intentionally affected by calibration as a result of the stored DTC.

- MIL = Malfunction Indicator Lamp.

- DTC = Diagnostic Trouble Code.

- HO2S = Heated Oxygen sensor. Closed loop fuel control is based on HEGO readings.

- OPEN LOOP = Fuel metering is not influenced by the HO2S sensor.

- SOFTWARE SELECTABLE means OEM has choice of action A or B as a result of a stored DTC.
  A. Shuts off engine.
  B. NO ACTION.

- The following DTC's are SOFTWARE SELECTABLE:
  DTC 43 – Over maximum coolant temperature or cylinder head temperature.
  DTC 51 – Low oil pressure.
  DTC 62 – Over maximum voltage.

- DTC's may be extracted using either the MIL or a computer. DTC's can only be retrieved with key on / engine off. (KOEO).

- When extracting DTC's via the MIL, the following apply:
  - When the Self Test Input (STI) circuit is grounded to begin flashing the DTCs, there is a 5 second delay before the DTC's begin flashing.
  - The STI circuit is a white wire with a purple stripe, exiting pin H3 from the ECM. It branches off to terminal A of the 6 pin diagnostic connector.
  - Flashing MIL is on for 0.4 second an off for 0.4 second.
  - 1.2 seconds MIL off time between digits of two digit DTC's.
  - 2.4 seconds MIL off time between DTC's.
  - Each DTC repeated 3 times before flashing next stored DTC.
  - Up to 6 DTC's can be stored.
  - Once all stored DTC's are flashed, process repeats with first stored DTC.
  - DTC's are flashed in the order in which they were set.

- If no DTC is stored, a DTC 11 is flashed, indicating all systems are OK.

- All stored DTC's, except DTC 11, will illuminate the MIL during engine operation.

Other Descriptions

MALFUNCTION PROCESS DESCRIPTION

When a malfunction occurs for DTC's with the limp home mode feature, a DTC will be set, the MIL will illuminate and the corrective action (limp home mode/default values) will be initiated. This will continue as long as the engine runs without being shut off. If the malfunction occurs and then corrects itself while the engine is continuously running, the DTC will be stored, the MIL will remain illuminated and the engine will continue to run in the limp home mode until shut off and restarted. Once restarted, the malfunction does not reoccur, the engine will resume in a normal operating mode. Below is a description of possible scenarios.

Scenario 1: Hard DTC (malfunction occurs and stays): Engine running > malfunction occurs > set DTC + turn on MIL + ECM corrective action (limp home mode) > DTC + MIL + limp home mode continues until engine is shut off > engine shut off then restarted > malfunction continues > DTC remains + MIL remains on + ECM corrective action continues.

Scenario 2: Intermittent DTC set (malfunction occurs but corrects itself): Engine running > malfunction occurs > set DTC + turn on MIL + ECM corrective action (limp home mode) > malfunction corrects itself > DTC + MIL + limp home mode continues until engine is shut off > engine shut off then restarted > no malfunction > *DTC + MIL continue but engine returns to normal operation.*

- Limp Home Mode: When an input to the ECM is outside of an established range, the appropriate DTC sets. The ECM will then ignore the errant input signal, and carry on its functions as best it can via default, calculated or estimated values. An engine operating under these conditions is said to be in limp home mode.

- Engines are calibrated to run as smoothly as possible during limp home mode. However, engine performance during limp home mode varies according to which DTC is set.

- Overspeed protection – Hard coded for 4000 rpm. There is a concern of the effect of high engine speeds on attached components (example: flywheels and fans). If engine reaches this hard coded maximum rpm, engine will be shut off and DTC 21 will be set.

HOW TO CLEAR CODES

Conditions for Clearing the DTC (Resetting the MIL)

- The DTC can be cleared from memory by disconnecting the battery for 20 minutes.

- If a personal computer (PC) is connected to the engine, the DTC can be cleared from memory by hitting the "C" key while in the View Sensor Data screen.

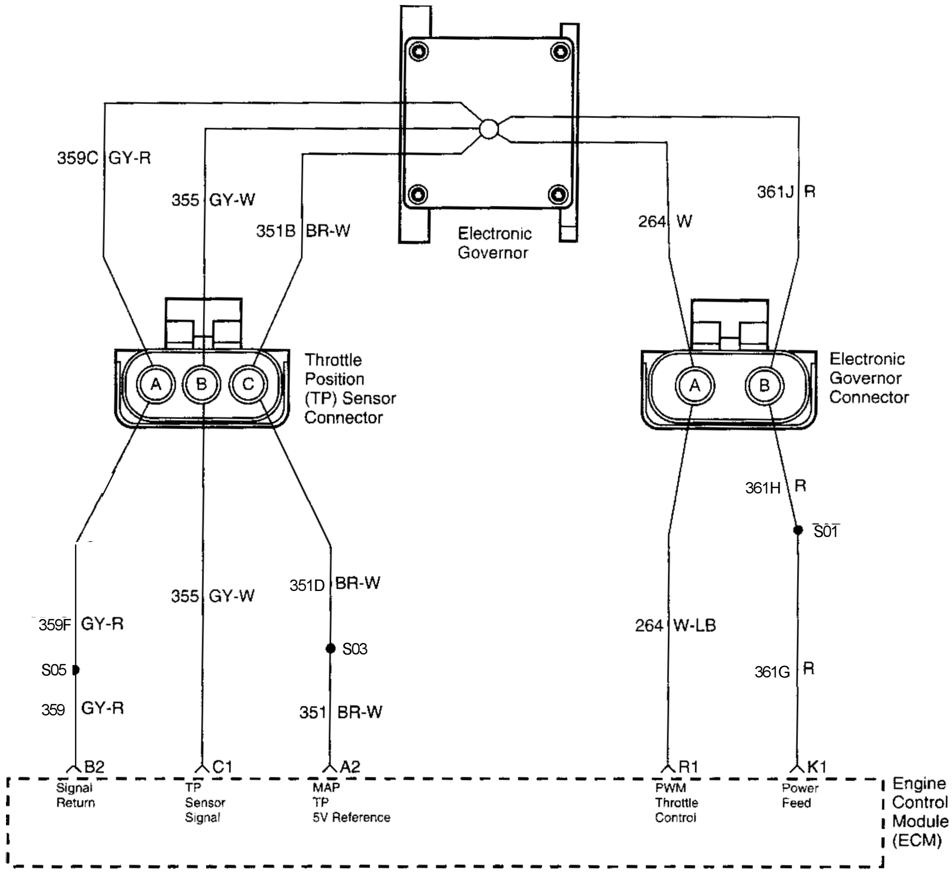
Diagnostic Trouble Code 11

NOTES

This is an all clear trouble code. It is a code to let the technician know all systems are OK.

Diagnostic Trouble Code 12

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 12 THROTTLE POSITION (TP) SENSOR LOW VOLTAGE

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359F) and terminal C (Brown/White, circuit 351D) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

• KOEO or KOER.
• TP signal is 0.3V or less.
• Above conditions are present for at least 2 consecutive seconds.

Diagnostic Trouble Code 12

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM forces the throttle to a default position of 6% open.
• The ECM will shut down engine when using DBW. Engine can be restarted after recycling ignition switch.

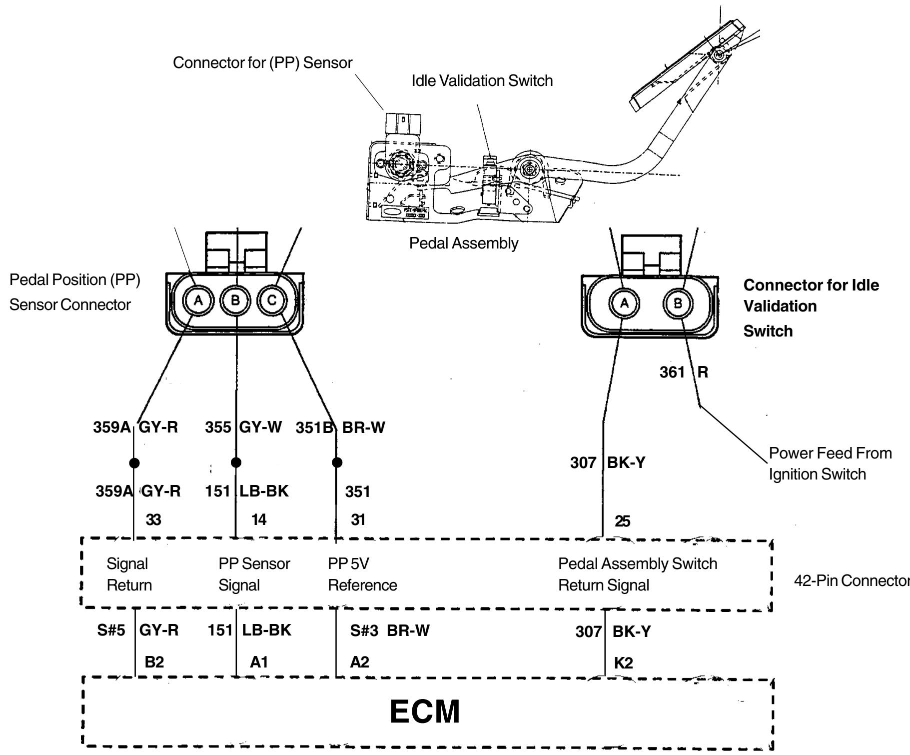
NOTE: Drive By Wire: When code is set the engine may shut down. It can be restarted but will shut down again as long as the code is present.

DTC 12 – Throttle Position Sensor Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	1. KOEO. Check the 5V reference signal from the ECM. 2. Check the voltage between terminals A and C on the electronic governor. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	1. KOEO. Check the TP signal to the ECM. 2. Using a DVOM to pins A and B of the three-wire pigtail on the electronic governor. While observing the voltage reading, operate the engine throughout the widest available range of speeds (ideally, from idle to WOT). **NOTE**: If a PC is available, you can observe TP voltage on the engine data screen instead of using a DVOM. Does the voltage vary between the specified values?	Approx. 1V at idle to 4.8V at WOT	Go to *Step 4*	Go to *Step 8*
4	1. Disconnect ECM connector A thru K. 2. Disconnect the TP sensor connector. 3. Check for shorts or opens on circuit 355 between the TP sensor connector and the ECM connector. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 5*
5	Check circuit 355 for a poor terminal connection at the ECM. Does the terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 9*
6	1. Disconnect ECM connector A thru K. 2. Check for a short or open on circuits 351D and 359F. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 7*
7	Check circuits 351D and 359F for poor terminal connections at the ECM. Does either terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 7*
8	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test.	Remove & replace electronic governor. Go to *Step 9*
9	Install replacement ECM. Is system operation normal with replacement ECM installation?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 13 (DBW)

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 13 ACCELERATOR PEDAL POSITION (APP) SENSOR LOW VOLTAGE

Circuit Description

The Accelerator Pedal Position (APP) sensor is a potentiometer which is attached to the accelerator pedal pivot shaft. The ECM provides a 5V reference voltage to the APP sensor between terminal A (Grey/Red, circuit 359A) and terminal C (Brown/White, circuit 351B) APP. An APP sensor signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The APP sensor signal varies from about 1.0V at idle to 4.8V at WOT. The APP signal is an important input used by the ECM for fuel control and engine RPM.

Conditions for Setting the DTC

• KOEO or KOER.
• APP signal is 0.3V or less.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM forces the APP internally to a default position of 0.235V (limp home mode).

Diagnostic Trouble Code 13

Trouble Shooting:

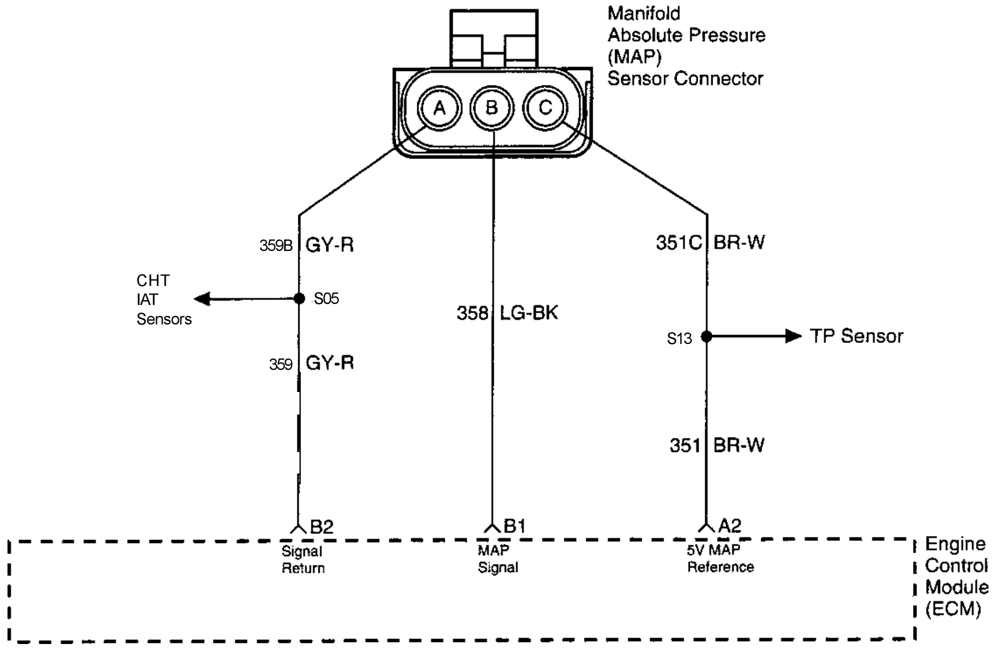
• Potentiometer in APP sensor is bad, bad DBW harness or connectors, electrical failure, APP sensor signal is 0.3V or less.

DTC 13 – Accelerator Pedal Position Sensor Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	1. KOEO. Check the 5V reference signal from the ECM. 2. Check the voltage between terminals A and C on the APP sensor. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	1. KOEO. Check the APP sensor signal to the ECM. 2. Start the engine. 3. Using a DVOM to pins A and B of the three-wire pigtail on the APP check voltage. While observing the voltage reading, step down on the AP and operate the engine throughout the widest available range of speeds (ideally, from idle to WOT). **NOTE**: If a PC is available, you can observe AP voltage on the engine data screen instead of using a DVOM. 4. Shut the engine off. Does the voltage vary between the specified values?	Approx. 1V at idle to 4.8V at WOT	Go to *Step 8*	Go to *Step 4*
4	1. Disconnect ECM connector A thru K. 2. Disconnect the AP sensor connector. 3. Check for shorts or opens on circuit 355/355B, 351B/151 between the APP sensor connector and the ECM connector. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 5*
5	Check circuit 355, 351B/151 and 359A/359 for a poor terminal connection at the ECM & 42 Pin Connector. Does the terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 6*
6	Replace the AP assembly. 1. Clear code. 2. Retest. Did code reset?		Install original AP assembly. Re-test.	
7	Install replacement ECM. Is system operation normal with replacement ECM installation?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
8	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 9*.
9	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 14

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 14 MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR LOW VOLTAGE

Circuit Description

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The ECM provides a 5V reference voltage to the MAP sensor between terminal A (Grey/Red, Circuit 359K) and terminal C (Brown/White, circuit 351C) of the MAP sensor. A MAP signal is returned to the ECM from terminal B (Lt.. Green/Black, circuit 358) of the MAP sensor. The MAP signal varies from about 1V at idle (high vacuum) to 4.8V with KOEO or at WOT (low vacuum). The MAP signal is used by the ECM as an indication of engine load. This information is used to control spark advance and air/fuel ratio. The MAP signal is also used at KOEO to indicate barometric pressure. This information is used for altitude compensation when establishing spark advance and air/fuel ratio.

Conditions for Setting the DTC

• KOEO or KOER.
• MAP signal is significantly lower than estimated by the ECM.
• Above conditions are present for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM uses an estimated MAP value based on throttle position and engine rpm.

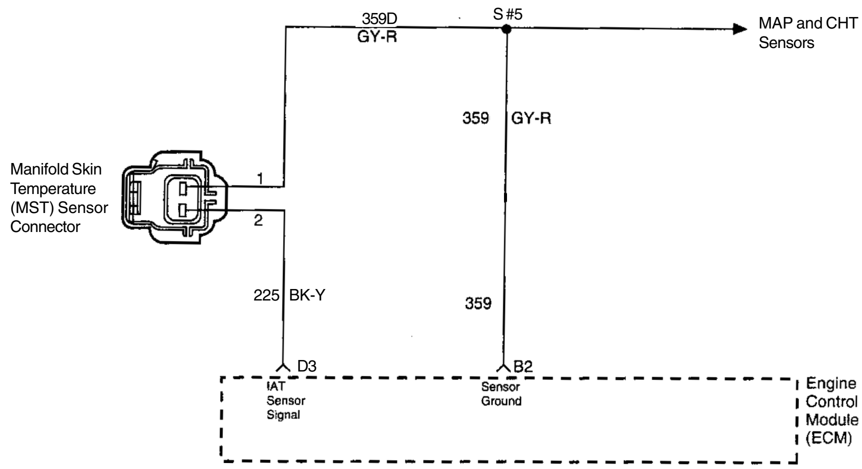
Diagnostic Trouble Code 14

DTC 14 – Manifold Absolute Pressure (MAP) Sensor Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at Step 2.	Go to *Step 2*
2	1. KOEO. Check the 5V reference signal from the ECM. 2. Disconnect the MAP sensor electrical connector. 3. Check the voltage between terminals A and C on the MAP sensor electrical connector. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	Check the MAP signal to the ECM: 1. Reconnect the MAP sensor electrical connector. 2. No load on engine. 3. KOER. 4. Using a suitable backprobing technique, measure the voltage between terminals A and B at the MAP sensor. NOTE: If a PC is available, you can observe TP voltage on the engine data screen instead of using a DVOM. 5. While observing the voltage reading, increase the engine speed from idle to WOT. Does the voltage vary between the specified values?	Approx. 1V at idle to approx. 4.0V at WOT	Go to *Step 4*	Go to *Step 8*
4	1. Ignition OFF. 2. Disconnect ECM connector A thru K. 3. Disconnect the MAP sensor connector. 4. Check for shorts or opens on circuit 358 (Lt. Green/Black) between the MAP sensor connector and the ECM connector. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 5*
5	Check circuit 358 for a poor terminal connection at the ECM. Does the terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 9*
6	1. Disconnect ECM connector A thru K. 2. Check for a short or open on circuits 351C (Brown/White) and 359B (Grey/Red). Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 7*
7	Check circuits 351C and 359B for poor terminal connections at the ECM. Does either terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 9*
8	Replace the MAP sensor. Is the repair complete?		Re-test.	
9	Install replacement ECM. Is the system operation normal with replacement ECM?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 15

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 15 MANIFOLD SKIN TEMPERATURE LOW VOLTAGE

Circuit Description

The manifold skin temperature (MST) sensor is a thermistor which measures the temperature of the air next to the intake manifold of engine. The ECM supplies a ground (circuit 359 and 359D, Grey/Red) from the sensor. When the skin temperature air is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the MST signal circuit. If the skin temperature air is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 15 will set when the ECM detects an excessively low signal voltage on the skin temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- MST sensor signal is $\leq$ 0.22V.
- Above conditions are present for at least $\geq$ 2.64 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the MST sensor to a 50°F default value.
- The fuel system will go into open loop.

Trouble Shooting

- MST is malfunctioning bad, wiring or connectors, or electrical failure.

Diagnostic Trouble Code 15

Diagnostic Aids

The MST sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Cylinder Head Temperature (CHT) sensor. Check the ground circuit 359 (Grey/Red) if this DTC is set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the MST sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the MST sensor.

A change in the voltage reading will indicate the location of the fault. Unplug MST sensor and using and OHM meter, read resistance value. It should be close to intake air temperature reading.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

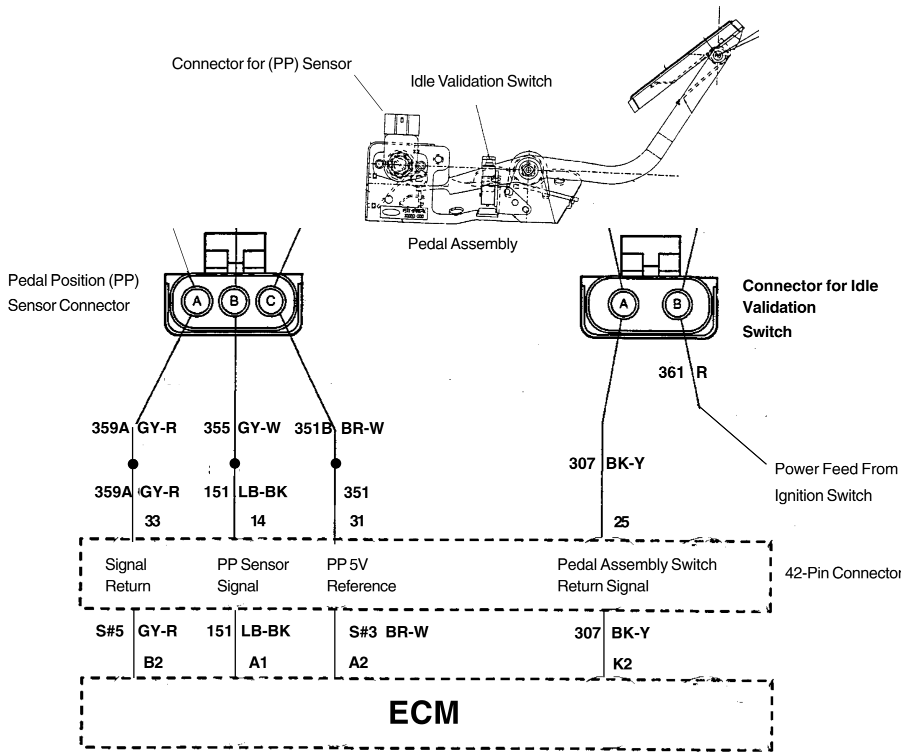
Voltage values calculated for VREF=5 volts (may vary $\pm$ 15% due to sensor and VREF variations).

DTC 15 –Manifold Skin Temperature Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Ignition OFF. 2. Disconnect the MST sensor electrical connector. 3. Check Ohm value across the two pins of the MST. Is it within specs of above chart?		Go to *Step 3*	Go to *Step 7*
3	1. KOEO. 2. With a DVOM check for ground on circuit 359D (Grey/Red) cavity 1. Is there a ground?		Go to *Step 4*	Go to *Step 3*
4	Check for an open on circuit 359D (Grey/Red) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 4*
5	1. Reconnect the MST sensor electrical connector. 2. With a suitable backprobing technique measure the voltage between cavity 2, circuit 225 (BK-Y) and ground. Is the voltage greater than the specified value?	4.9V	Go to *Step 7*	Go to *Step 6*
6	Check for a short to voltage on circuit 225 (BK-Y) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 8*
7	Replace the MST sensor Is the repair complete?		Re-test	
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 16 (DBW)

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 16 IDLE VERIFICATION SWITCH FAILURE

Circuit Description

The idle validation switch (IVS) is an off/on switch (normally open) with 12V as a power supply from the ignition switch on circuit 361 (R). When the accelerator pedal is depressed the switch the switch is closed sending a 12V signal to the ECM on circuit 307 (BK-Y) through the 42 pin connector, pin 25. From the 42 pin connector to the ECM pin K2. The IVS signal is very important input used by the ECM to aid in the control of the engine RPM.

Conditions for Setting the DTC

- KOEO or KOER.
- The accelerator pedal position (APP) sensor is $\leq$ 0.8V with the IVS closed.
- The APP sensor is $\geq$ 1.54V with the IVS opened.
- Above conditions are present for at least $\geq$ 0.032 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The APP sensor internally is forced to 0.235V.
- The ECM will react to a limp home mode allowing the machine to be driven at a very low speed.

Diagnostic Trouble Code 16 (DBW)

Trouble shooting

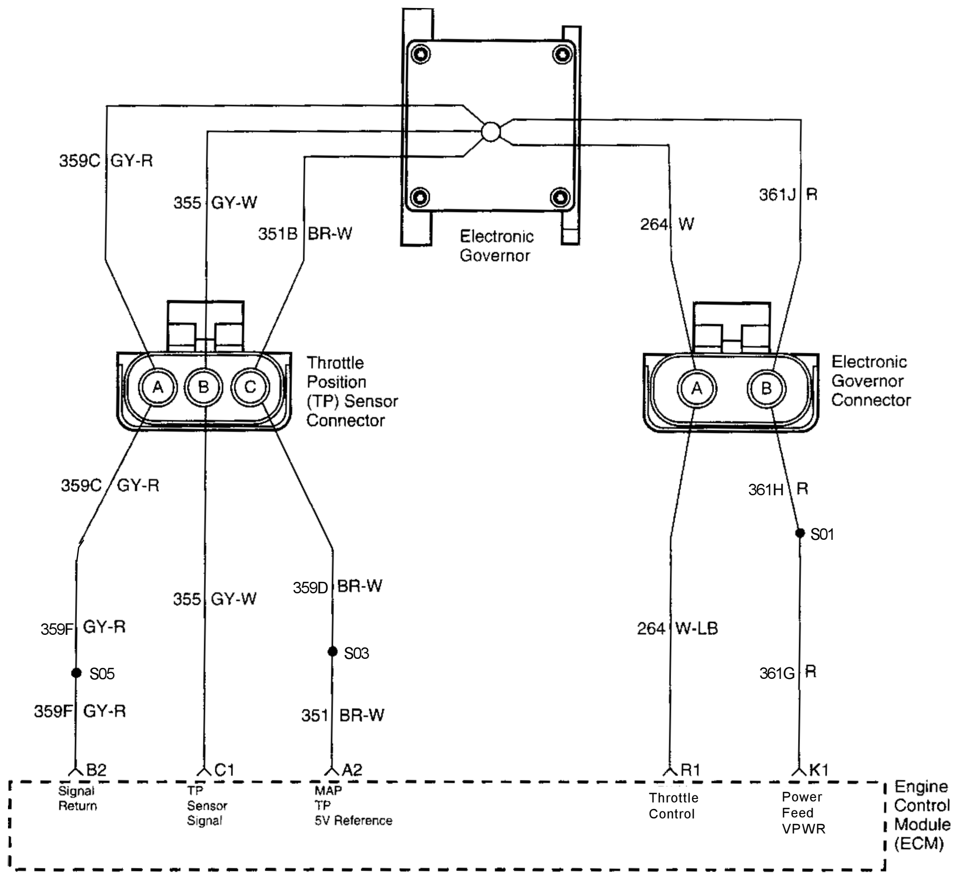
• The APP out of set range while IVS off, is damaged or misadjusted. The IVS malfunction, has damaged wiring, encounters an electrical or mechanical failure.

DTC 16 – Idle Verification Switch

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. KOEO. Check circuit 361 (R) for B+. 2. Is voltage within specification?	VPWR (B+)	Go to *Step 4*	Go to *Step 3*
3	Repair wire on circuit 361 (R). Is repair complete?		Re-test	
4	1. KOEO. Check voltage at circuit 307 (BK-Y). 2. Is voltage within specification?	0V	Replace APP. Re-test	Go to *Step 5*
5	1. Step on AP. Check voltage again. Circuit 307 (BK-Y). 2. Is the voltage within specification?	VPWR (B+)	Go to *Step 6*	Replace APP. Re-test
6	Check for a shut or open circuit 307 at ECM pin 2 for 12 volts.	VPWR (B+)	Go to *Step 7*	Replace the wiring 307. Re-test
7	Check APP sensor follow steps from DTC 13. Does APP check OK		Go to *Step 8*	Replace AP assembly. Re-test
8	Replace ECM.		Re-test	
9	Is system operation normal with replacement ECM installation?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	. Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 17 (DBW)

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 17 ACTUATOR UNSTABLE

Circuit Description

The electronic governor consists of a throttle body, an electronically-actuated throttle plate, and a built-in throttle position (TP) sensor. There are two pigtails that exist the governor body. The 3-wire pigtail connects the TP sensor to the ECM. Refer to “Throttle Position (TP) Sensor” for more information.

The 2-wire pigtail carries the throttle signal from the ECM to the governor. Desired engine speeds are stored in the configuration program for each specific application, and can be changed with the ECM calibration software. When the accelerator pedal is depressed a signal is sent from the APP sensor to the ECM, the ECM responds by sending the appropriate signal to the governor. This is a pulse-width modulated (PWM) signal which cannot be read with conventional diagnostic tools such as a voltmeter. A 12-volt signal which can be read as a steady 12V with a DVOM, is pulsed on and off at a high rate of speed by the ECM through circuit 264 (W-LB) pin R-1. The width of the “on” pulse determines the amount of throttle opening. The ECM grounds the VPWR current sent through the governor with the appropriate pulse width base on the position of the accelerator pedal.

Diagnostic Trouble Code 17 (DBW)

Conditions for Setting DTC

• KOER
• Two or more opposing differences of normalized TPS signals which exceed 0.98V within 0.5 consecutive seconds.

Actions Taken When the DTC Sets

• The ECM will shut down the engine. Engine can be restarted after cycling ignition switch off for 20 seconds.
• The ECM will light the MIL.

Trouble Shooting

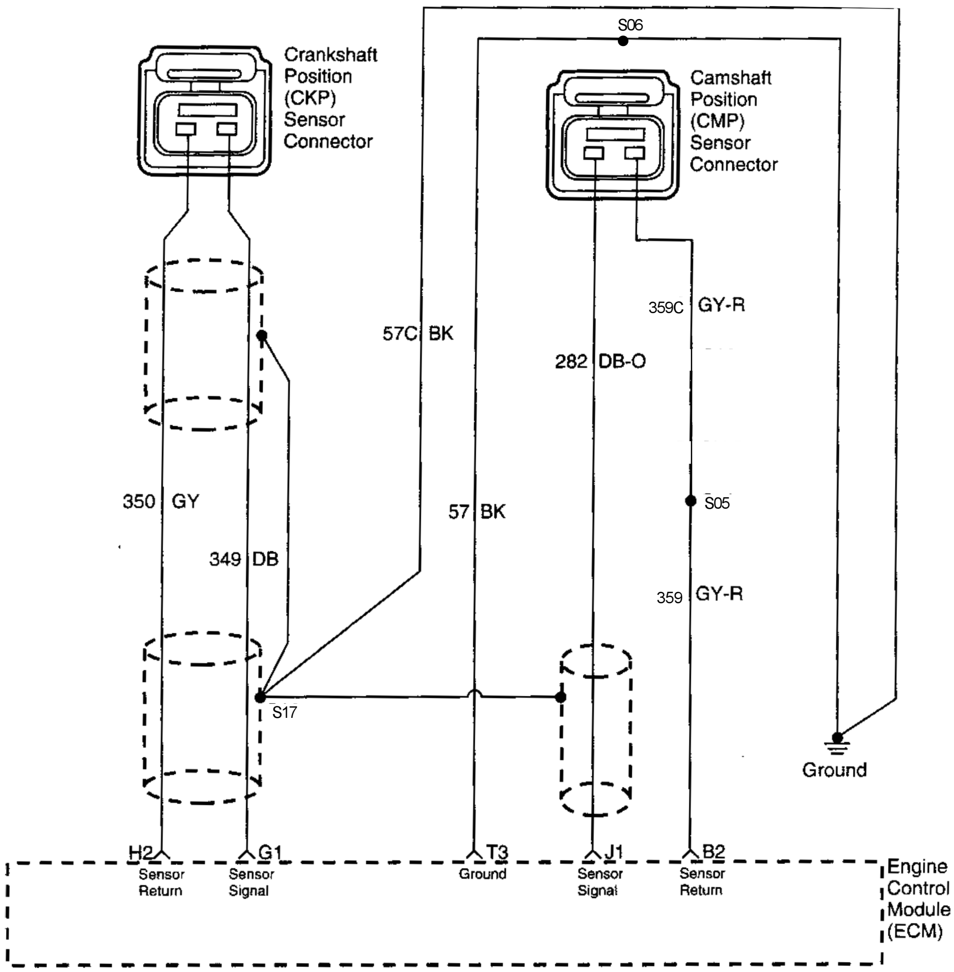
• The actuator may not be operating. ECM is programmed incorrectly, ECM malfunctions and bad ground.

DTC 17 – Actuator Unstable

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	1. Disconnect electronic governor electrical connector. 2. KOEO check for voltage at circuit 361H. Was voltage within specification?	VPWR (B+)	Go to *Step 3*	Repair wire and re-test.
3	Using a DVOM check circuit 361H and 264 for open or to ground. Was a problem found?		Complete repair and Re-test.	Go to *Step 4*
4	Check that ECM has correct program to match application. Is the correct program installed?	Varies per manufacture	Go to *Step 5*	Install correct program. Re-test.
5	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test	Remove & replace electronic governor with original. Go to *Step 6*
6	Is system operation normal with replacement ECM install?		Remove replacement ECM and install original ECM. Go to *Step 7*	
7	Is the repair complete. Does system operate normal with original ECM?		Keep original ECM installed. Re-test.	Remove original ECM and re-insall replacement ECM. Go to *Step 8*
8	Is the repair complete? Is the system operation normal with replacement ECM?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 21

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 21 OVERSPEED

Circuit Description

The ECM monitors engine speed through the crankshaft position (CKP) sensor. If the engine speed reaches 4000 RPM, the fuel is immediately removed to shut off the engine. DTC 21 will set at this time. The engine may be restarted after the ignition switch is cycled off and back on.

Conditions for Setting the DTC

- KOER..
- Engine reaches a threshold at 4000 RPM.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The engine will shut off.

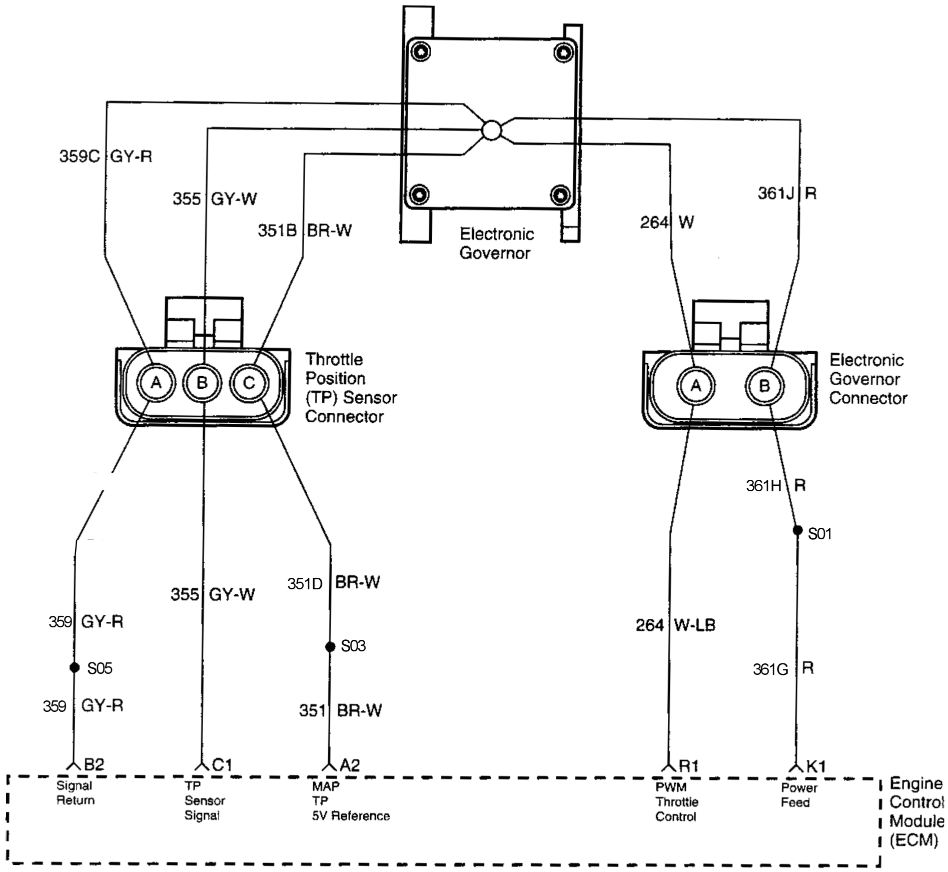
Diagnostic Trouble Code 21

DTC 21 – Overspeed

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to Diagnostic System Check before continuing.	Go to *Step 2*
2	Check for obstructions in the throttle, crack in the intake manifold or vacuum leak that would produce WOT and repair as necessary. Was a repair necessary?		Re-test.	Go to *Step 3*
3	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go at *Step 4*.	
4	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test. Leave replacement ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 5*.
5	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 22

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 22 THROTTLE POSITION (TP) SENSOR HIGH VOLTAGE

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/ Red, circuit 359F) and terminal C (Brown/White, circuit 351D) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

• KOEO or KOER.
• TP signal is 4.9V or more.
• Above conditions are present for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• When DBW the ECM will shut the engine down. Engine can be restarted by recycling the ignition switch.

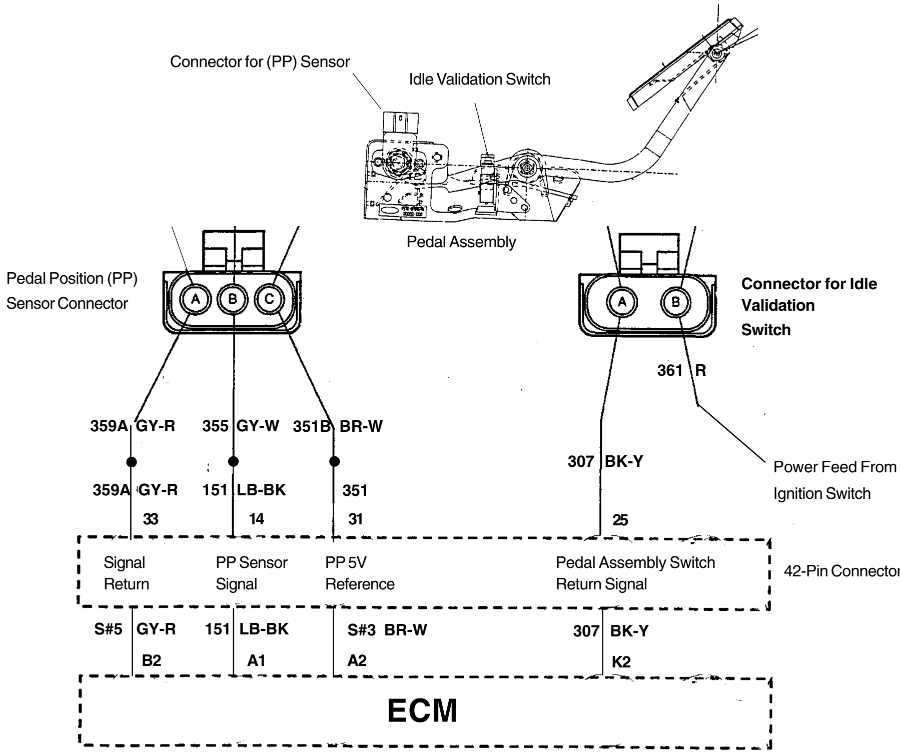
Diagnostic Trouble Code 22

DTC 22 – Throttle Position Sensor High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	1. KOEO. Check the 5V reference signal from the ECM. 2. Check the voltage between terminals A and C on the electronic governor. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	1. KOEO. Check the TP signal to the ECM. 2. Start the engine. 3. Using a DVOM to pins A and B of the three-wire pigtail on the electronic governor. While observing the voltage reading, operate the engine throughout the widest available range of speeds (ideally, from idle to WOT). **NOTE**: If a PC is available, you can observe TP voltage on the engine data screen instead of using a DVOM. 4. Shut the engine off. Does the voltage vary between the specified values?	Approx. 1V at idle to 4.8V at WOT	Go to *Step 4*	Go to *Step 8*
4	1. Disconnect ECM connector A thru K. 2. Disconnect the TP sensor connector. 3. Check for shorts or opens on circuit 355 between the TP sensor connector and the ECM connector. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 5*
5	Check circuit 355 for a poor terminal connection at the ECM. Does the terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 9*
6	1. Disconnect ECM connector A thru K. 2. Check for a short or open on circuits 351B and 359C. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 7*
7	Check circuits 351D and 359F for poor terminal connections at the ECM. Does either terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 7*
8	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test.	Remove & replace electronic governor with original. Go to *Step 9*.
9	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 23 (DBW)

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 23 APP SENSOR HIGH VOLTAGE

Circuit Description (APP)

The Accelerator Pedal Position (APP) sensor is a potentiometer which is attached to the accelerator pedal pivot shaft. The ECM provides a 5V reference voltage to the APP sensor between terminal A (Grey/Red, circuit 359A) and terminal C (Brown/White, circuit 351B) APP. An APP sensor signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The APP sensor signal varies from about 1.0V at idle to 4.8V at WOT. The APP signal is an important input used by the ECM for fuel control and engine RPM.

Conditions for Setting the DTC

- KOEO or KOER.
- APP signal is 4.9V or more.
- Above conditions are present for at least 2 consecutive seconds.

Diagnostic Trouble Code 23

Actions Taken When the DTC Sets

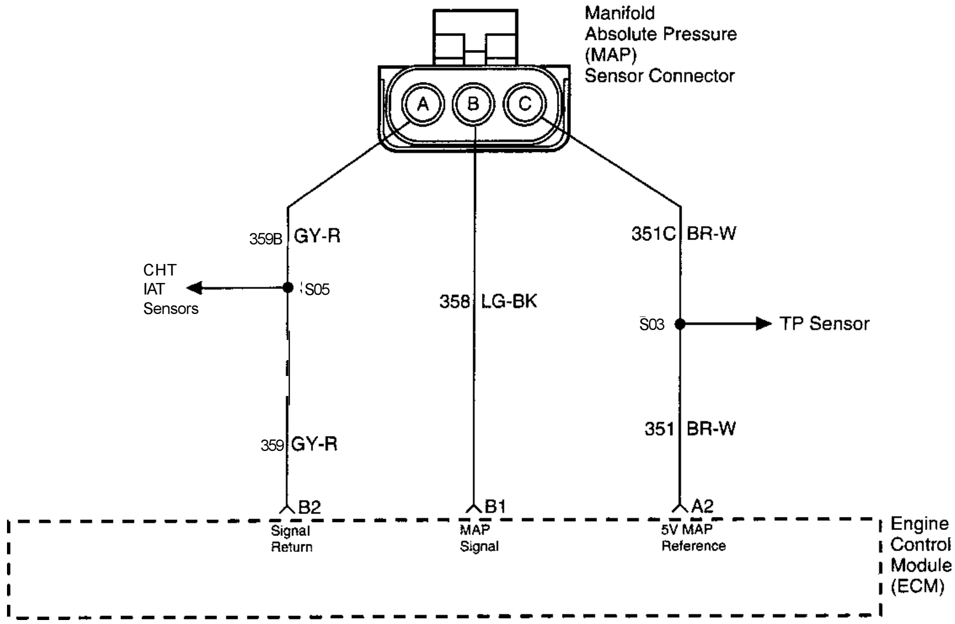
- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM forces the PPS internally to 0.235V.
- The ECM will shutdown engine. Engine can be restarted after cycling ignition switch.

DTC 23 – Accelerator Pedal Position Sensor Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	1. KOEO. Check the 5V reference signal from the ECM. 2. Check the voltage between terminals A and C on the APP sensor. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	1. KOEO. Check the APP sensor signal to the ECM. 2. Start the engine. 3. Using a DVOM to pins A and B of the three-wire pigtail on the APP check voltage. While observing the voltage reading, step down on the AP and operate the engine throughout the widest available range of speeds (ideally, from idle to WOT). **NOTE**: If a PC is available, you can observe AP voltage on the engine data screen instead of using a DVOM. 4. Shut the engine off. Does the voltage vary between the specified values?	Approx. 1V at idle to 4.8V at WOT	Go to *Step 8*	Go to *Step 4*
4	1. Disconnect ECM connector A thru K. 2. Disconnect the AP sensor connector. 3. Check for shorts or opens on circuit 355/355B, 351B/151 between the APP sensor connector and the ECM connector. Were any shorts or opens found?		Repair the wiring. Re-test.	Go to *Step 5*
5	Check circuit 355, 351B/151 and 359A/359 for a poor terminal connection at the ECM & 42 Pin Connector. Does the terminal need to be replaced?		Repair the terminal. Re-test.	Go to *Step 6*
6	Replace the AP assembly. 1. Clear code. 2. Retest. Did code reset?		Install original AP assembly. Re-test.	
7	Install replacement ECM. Is system operation normal with replacement ECM installation?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
8	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 9*.
9	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 24

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 24 MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR HIGH VOLTAGE

Circuit Description

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The ECM provides a 5V reference voltage to the MAP sensor between terminal A (Grey/Red, Circuit 359K) and terminal C (Brown/White, circuit 351C) of the MAP sensor. A MAP signal is returned to the ECM from terminal B (Lt.. Green/Black, circuit 358) of the MAP sensor. The MAP signal varies from about 1V at idle (high vacuum) to 4.8V with KOEO or at WOT (low vacuum). The MAP signal is used by the ECM as an indication of engine load. This information is used to control spark advance and air/fuel ratio. The MAP signal is also used at KOEO to indicate barometric pressure. This information is used for altitude compensation when establishing spark advance and air/fuel ratio.

Conditions for Setting the DTC

• KOEO or KOER.
• MAP signal is significantly higher than that estimated by the ECM.
• Above conditions are present for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM uses an estimated MAP value based on throttle position and engine rpm.

Diagnostic Trouble Code 24

Diagnostic Aids

The MAP sensor share the same ground with the Engine Coolant Temperature (ECT) sensor and the Intake Air Temperature (IAT) sensor. Check the ground circuit 359 (Gray/Red-Gray/Yellow) if these DTC's are also set.

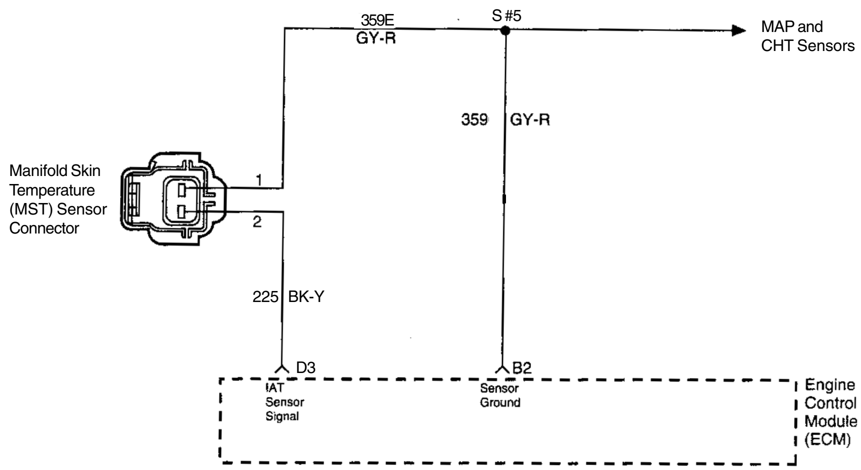
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage.

DTC 24 – Manifold Absolute Pressure (MAP) Sensor High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Disconnect the MAP sensor electrical connector. 2. KOEO. 3. Check the voltage between terminals A and C on the MAP sensor electrical connector. Is the voltage within the specified values?	4.9-5.1V	Go to *Step 3*	Go to *Step 6*
3	1. Reconnect the MAP sensor electrical connector. 2. KOER with no load on engine. 3. Using a suitable backprobing technique, measure the voltage between terminals A and B at the MAP sensor. 4. While observing the voltage reading, increase the engine speed from idle to WOT. Does the voltage vary between the specified values?	Approx. 1V at idle to approx. 4.8V at WOT	Go to *Step 4*	Go to *Step 8*
4	1. Ignition OFF. 2. Disconnect ECM connector A thru K. 3. Disconnect the MAP sensor connector. 4. Check for an open or short to ground on circuit 358 (Lt. Green/Black) between the MAP sensor connector and the ECM connector and repair as necessary. Was a repair necessary?		Re-test.	Go to *Step 5*
5	Check circuit 358, (Lt. Green/Black) for a poor terminal connection at the ECM and repair if necessary. Was a repair necessary?		Re-test.	Go to *Step 9*
6	1. Disconnect ECM connector A thru K. 2. Check for a and open or short to ground on circuits 351C (Brown/White) and 359B (Grey/Red) between the MAP sensor connector and the ECM connector and repair as necessary. Was a repair necessary?		Re-test.	Go to *Step 7*
7	Check circuits 351C (Brown/White) and 359B (Grey/Red) for a poor terminal connection at the ECM and repair if necessary. Was a repair necessary?		Re-test.	Go to *Step 9*
8	Replace the MAP sensor. Is the repair complete?		Re-test.	
9	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 25

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 25 MANIFOLD SKIN TEMPERATURE HIGH VOLTAGE

Circuit Description

The manifold skin temperature (MST) sensor is a thermistor which is used to calculate the temperature of the air entering the cylinder. The ECM provides a ground (circuit 359E, Grey/Red) from the sensor and supplies 5V reference signal on circuit 255 (BK-Y). When the intake air is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the MST signal circuit. If the intake air is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 35 will set when the ECM detects an excessively high signal voltage on the intake air temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- MST sensor signal is $\geq$ 4.96V.
- Above conditions are present for at least $\geq$ 2.64 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the MST sensor to a 50°F default value.
- The fuel system will go into open loop.

Trouble shooting

- MST is malfunctioning, bad wiring or connections, electrical failure.

Diagnostic Trouble Code 25

Diagnostic Aids

The sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Engine Coolant Temperature (ECT) sensor. Check the ground circuit 359E and 359 (Grey/Red-Grey/Yellow) if these DTC's are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the MST sensor.

A change in the voltage reading will indicate the location of the fault.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

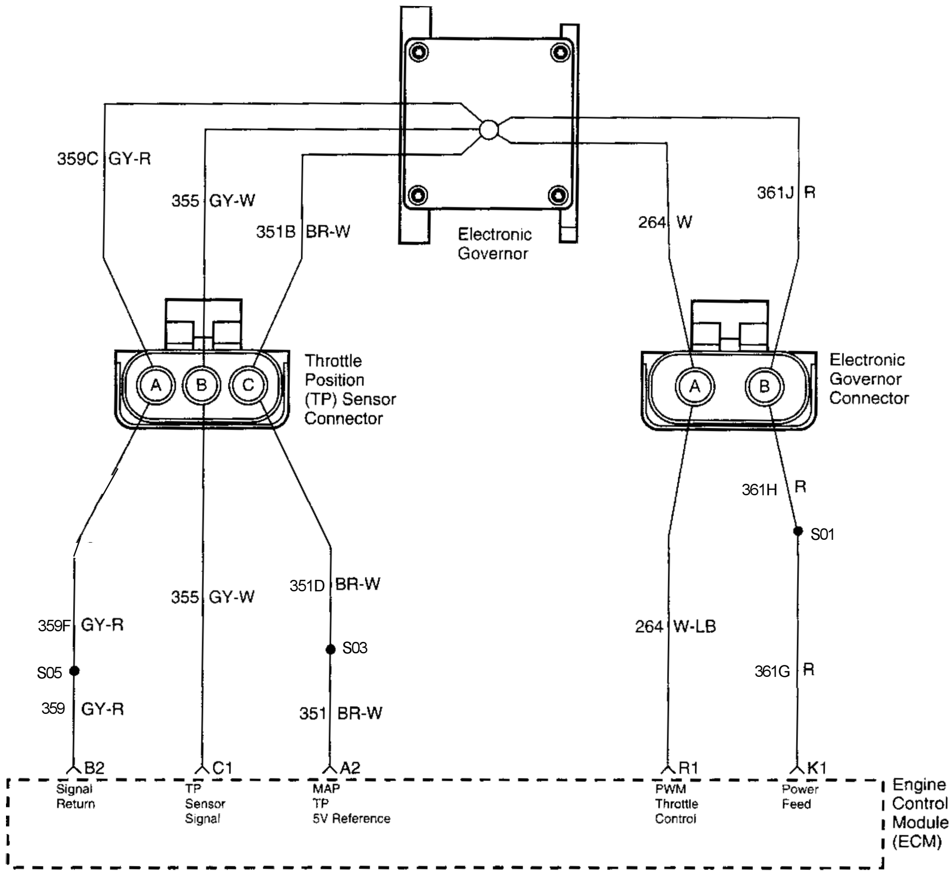
Voltage values calculated for VREF=5 volts (may vary ± 15% due to sensor and VREF variations).

DTC 25 – Manifold Skin Temperature High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Ignition OFF. 2. Disconnect the MST sensor electrical connector. 3. Check Ohm value across the two pins of the MST. Is it within specs of above chart?		Go to *Step 3*	Go to *Step 7*
3	1. KOEO. 2. With a DVOM check for ground on circuit 359E (Grey/Red) cavity 1. Is there a ground?		Go to *Step 4*	Go to *Step 2*
4	Check for an open on circuit 359E (Grey/Red) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 5*
5	1. Reconnect the MST sensor electrical connector. 2. With a suitable backprobing technique measure the voltage between cavity 2, circuit 225 (BK-Y) and ground. Is the voltage greater than the specified value?	4.9V	Go to *Step 6*	Go to *Step 7*
6	Check for a short to ground or open on circuit 255 (BK-Y) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 7*
7	Replace the MST sensor. Is the repair complete?		Re-test	
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 26

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 26 THROTTLE POSITION (TP) SENSOR HIGH VOLTAGE AT START UP

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359F) and terminal C (Brown/White, circuit 351D) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

- KOEO or KOER.
- TP signal at start up is $\geq$ 1.39V.
- Above conditions are present for at least 2 consecutive seconds.

Diagnostic Trouble Code 26

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM will not allow engine to start.

Trouble shooting

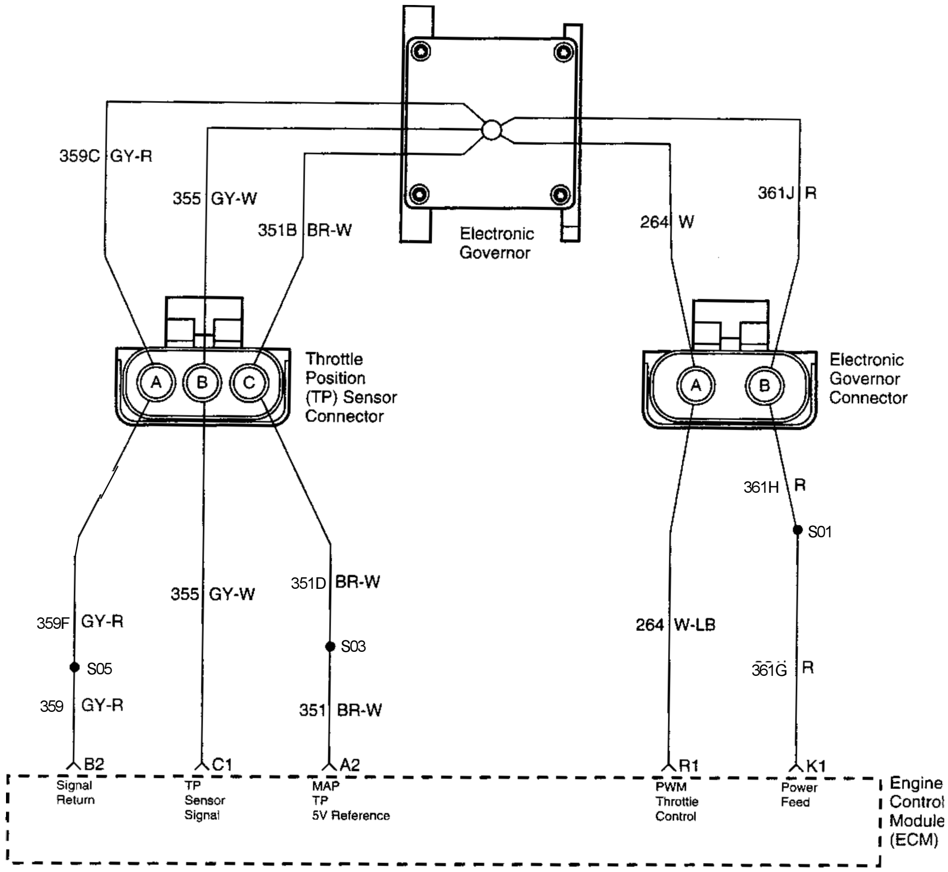
- Check for ice or foreign object in actuator. Check actuator for tampering.

DTC 26 – Throttle Position Sensor High Voltage At Start Up

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	Key off. Check actuator for ice build up or foreign objects stuck in throttle plate. Check for bent throttle plate. Check ECM ground. Were any problems found? **NOTE:** Ice can build up even at 45°F with the right conditions.		Repair as needed. Re-test & start engine.	Go to *Step 3*
3	KOEO. Check the 5V reference signal from the ECM on circuit 351D / 351. Where any shorts or opens found?	5V	Repair the wiring and retest.	Go to *Step 4*
4	KOEO. Check the signal return circuit 355 from TPS to ECM pin C-1 for signal valve.	1V to 1.1V	Clear DTC. Restart engine. Retest.	Go to *Step 5*
5	Replace the electronic governor. Is the repair complete and engine operating to specification? **NOTE:** Do not attempt to disassemble the actuator. This will void the warranty.		Re-test.	Remove & replace electronic governor with original. Go to *Step 6*.
6	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 7*.	
7	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 8*.
8	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 27

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 27 DRIVE BY WIRE IDLE FAILURE

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359F) and terminal C (Brown/White, circuit 351D) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

• KOER.
• For DBW with IAC only, actuators is moving while idle validation switch is off (opened) for more than 1 second.
• Normalized TPS > 0.1V for more than 0.1 second when engine has been idling for at least 1 second.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM shuts down the engine. The engine can be restarted by recycling the ignition switch.

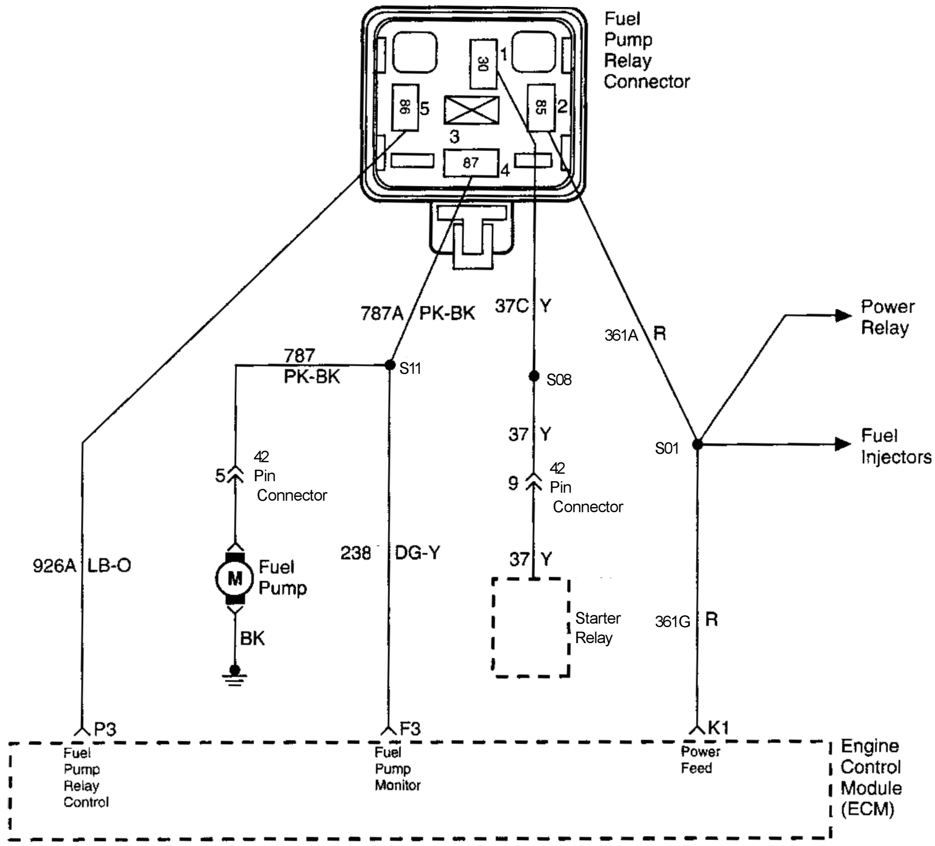
Diagnostic Trouble Code 27

DTC 27 – Drive By Wire Idle Failure

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis? **NOTE:** This test cannot be made without a PC or a very high tech DVOM.		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	Visually check for dirt or carbon in the throat of the actuator or on the throttle plate. Is there any dirt or carbon?		Clean with a carb cleaner. Re-test.	Go to *Step 3*
3	Is the normalized TPS > 0.1V above ECM set point for more than 0.1 second when engine has been at idle for at least 1 second?		Go to *Step 4*	Re-start.
4	Does the ECM have correct program for this application? The program can be checked by using the monitoring screen on your PC.	If needed contact FPP or OEM for correct program.	Go to *Step 5*	Download correct program & re-test.
5	Using EEMS/SERV program read graph for throttle body position (TPS) in relation to the ECM set point. Are graph lines close together but not even?		Go to *Step 6*	Re-test.
6	1. Disconnect battery ground. 2. Disconnect ECM connector L-Y. 3. Check for a short or open on circuit 264 (W-LB), circuit 361H (R), and 361G (R). Where any shorts or opens found?		Repair wire. Reconnect battery and re-test.	Go to *Step 7*
7	Check circuits 264 (W-LB) and 361G and 361H (R) for poor terminal connectors at ECM. Do any of the terminals need to be repaired or replaced?		Repair or replace terminals. Reconnect battery. Re-test.	Go to *Step 8*
8	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test.	Remove & replace electronic governor with original. Go to *Step 9*.
9	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 31

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 31 FUEL PUMP LOW VOLTAGE

Circuit Description

When the ignition switch is first turned on, the ECM energizes the fuel pump relay which applies power to the fuel pump. The fuel pump relay will remain active as long as the engine is running or cranking. If the fuel pump is not active the ECM will receive no signal. This condition may indicate a problem with the relay or the wiring.

Conditions for Setting the DTC

- KOER or KOEO.
- Fuel pump voltage is $\geq$ 4.9V below ignition voltage for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).

Diagnostic Trouble Code 31

Diagnostic Aids

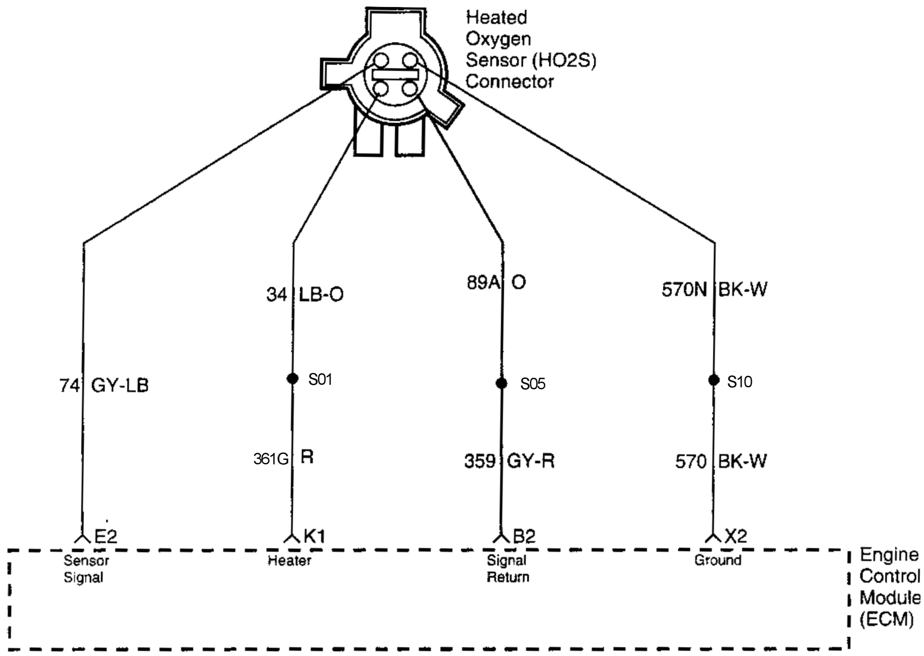
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the fuel pump relay connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the fuel pump relay. A change in the fuel pump voltage display will indicate the location of the fault.

DTC 31 – Fuel Pump Low Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Ignition OFF. 2. Remove the fuel pump relay. 3. KOEO. 4. Connect a DVOM from cavity 86 to ground. Does the DVOM show battery voltage?	VPWR (B+)	Go to *Step 4*	Go to *Step 3*
3	Repair the open or short to ground in circuit 361A (Red) between the ECM and the fuel pump relay. Is the repair complete?		Re-test.	
4	Connect a DVOM from cavity 85 to ground. Does the DVOM show battery voltage?	VPWR (B+)	Go to *Step 6*	Go to *Step 5*
5	Repair the open or short to ground in circuit 926A (Lt. Blue/Orange) between the ECM and the fuel pump relay. Is the repair complete?		Re-test.	
6	Connect a DVOM from cavity 87 to ground. Do you have battery voltage?		Go to *Step 8*	Go to *Step 7*
7	Repair the open or short to ground in circuit 37 (Yellow) between the ECM and the ignition. Is the repair complete?		Re-test.	
8	Connect the DVOM (ohms) from cavity 30 to ground. Do you have continuity?		Go to *Step 10*	Go to *Step 9*
9	Repair the open or short to ground in circuit 787 (Pink/Black) and circuit 238A (Dk. Green/Yellow) between the ECM and the fuel pump relay. Is the repair complete?		Re-test.	
10	Connect a DVOM between cavity 87 to cavity 30. Does the DVOM show battery voltage?		Go to *Step 11*	Go to *Step 12*
11	Replace the fuel pump relay. Is the repair complete?		Re-test.	
12	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 13*	
13	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 14*
14	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 32

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 32 HO2S SENSOR (LOW VOLTAGE) STUCK LEAN

Circuit Description

The ECM supplies a voltage of about 0.45 volts to the heated exhaust gas oxygen sensor. This may read as low as 0.32 volts with a 10 megohm digital voltmeter. The oxygen sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about 0.10 volts if the exhaust is lean. A cold sensor causes an open loop operation.

If the sensor pigtail wiring, connector, or terminal is damaged the entire oxygen sensor assembly must be replaced. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the signal return wire. Any attempt to repair the wires, connector, or terminals could result in the obstruction of the air reference and degrade the sensor performance.

Conditions for Setting the DTC

- KOER and in closed loop.
- HO2S sensor voltage is less than or equal to 0.20 volts for 20 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM will switch to open loop fuel control.

Diagnostic Trouble Code 32

Diagnostic Aids

Even small amounts of water delivered to the fuel injectors can cause a lean condition.

A misfiring cylinder will result in unburned oxygen in the exhaust which can cause a lean condition.
A plugged fuel filter can cause a lean condition.

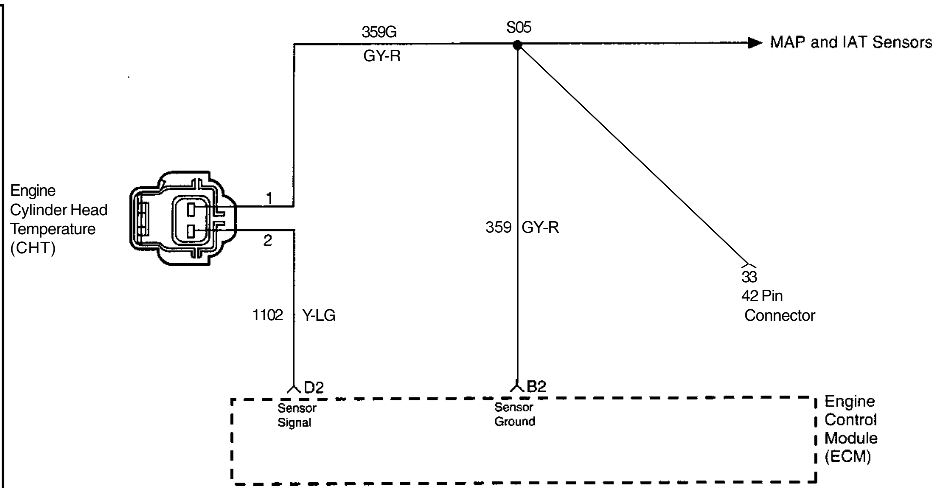
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, go to diagnostic chart below.

DTC 32 – HO2S Sensor (Low Voltage) Stuck Lean

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Let the sensor cool. 2. KOEO. 3. With a DVOM check the voltage between the signal circuit 74 (GY-LB) and the return circuit 89A (O) on the HO2S Sensor. **NOTE**: If a PC is available, you can observe HO2S voltage on the engine data screen instead of using a DVOM. Is the sensor voltage approximate to the specified value?	0.45V	Go to Diagnostic Aids	Go to *Step 3*
3	1. Disconnect the HO2S sensor electrical connector. 2. Check the sensor signal circuity 74 (GY-LB) for a short to ground and repair if necessary. Was a repair necessary?		Re-test	Go to *Step 4*
4	Replace HO2S. Is system working to specification?		Re-test	Remove replacement HO2S and install original. Go to *Step 5*
5	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM Go to *Step 6*	
6	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM Go to *Step 7*
7	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test	

Diagnostic Trouble Code 33

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 33 ENGINE CYLINDER HEAD TEMPERATURE HIGH VOLTAGE

NOTE: This is a software serviceable DTC.

Circuit Description

The cylinder head temperature (CHT) sensor is a thermistor which measures the temperature of the cylinder head in the engine. The ECM supplies a ground circuit 359G (Grey/Red-Grey/Yellow) to the sensor and supplies a 5V signal circuit 1102 (Yellow/Lt. Green) to the sensor. When the engine coolant is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the CHT signal circuit. If the cylinder head is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 33 will set when the ECM detects an excessively low signal voltage on the engine cylinder head temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- CHT sensor signal is $\leq$ 0.22V.
- Above conditions are present for a least 3 consecutive seconds.

Actions Taken When the DTC Sets

- MIL blinks at 230°F $\pm$ .36V.
- The ECM will force the ECT sensor to a 50°F default value.
- The ECM illuminates the malfunction indicator lamp (MIL) when temperature reaches 240°F $\pm$ 0.32V and will shut engine down if software selected.

Diagnostic Trouble Code 33

Diagnostic Aids

The CHT sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Intake Air Temperature (IAT) sensor. Check the ground circuit 359 (Grey/Red-Green) if these DTC's are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the CHT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the CHT sensor.

A change in the CHT display will indicate the location of the fault.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

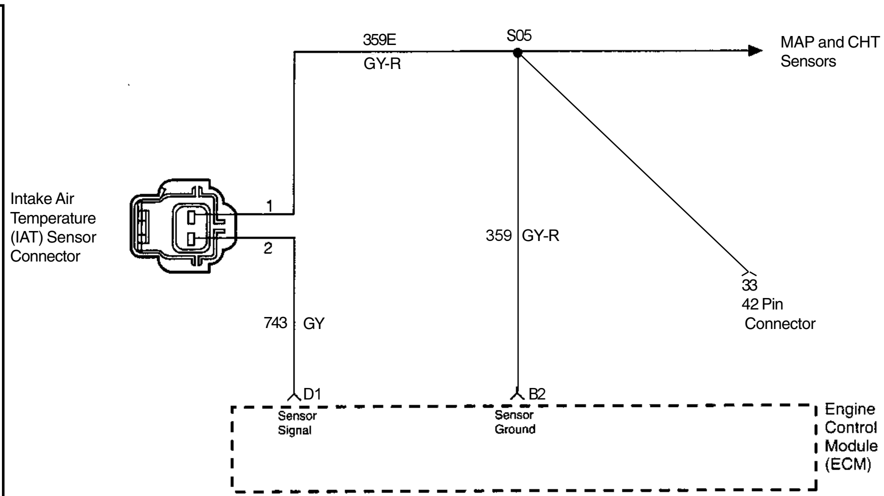
Voltage values calculated for VREF=5 volts (may vary ± 15% due to sensor and VREF variations).

DTC 33 – (4.2L) Engine Cylinder Head Temperature High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Ignition OFF. 2. Disconnect the CHT sensor electrical connector. 3. Check ohm value across the two pins of the CHT. Is it within specs of above chart?		Go to *Step 3*	Go to *Step 7*
3	1. KOEO. 2. With a DVOM, measure the voltage on circuit 359G (Grey/Yellow) cavity 1. Is the voltage greater then the specified value?	4.9V	Go to *Step 4*	Go to *Step 5*
4	Check for a short to voltage on circuit 359G (Grey/Yellow-Grey/Red) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 8*
5	1. Reconnect the CHT sensor electrical connector. 2. With a suitable backprobing technique measure the voltage between cavity 2, circuit 1102 (Y-LG) and ground. Is the voltage greater than the specified value?	4.9V	Go to *Step 7*	Go to *Step 6*
6	Check for a short to voltage on circuit 1102 (Y-LG) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 8*
7	Replace the CHT sensor Is the repair complete?		Re-test	
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 8*	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 9*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 35

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 35 INTAKE AIR TEMPERATURE HIGH VOLTAGE

Circuit Description

The intake air temperature (IAT) sensor is a thermistor which measure the temperature of the air entering the engine. The ECM supplies a ground (circuit 359, Grey/Red) from the sensor and sends a 5V signal (circuit 743, Grey) to the sensor. When the intake air is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the IAT signal circuit. If the intake air is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 35 will set when the ECM detects an excessively high signal voltage on the intake air temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- IAT sensor signal is $\geq$ 4.96V.
- Above conditions are present for at least 3 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the IAT sensor to a 50°F default value.

Diagnostic Trouble Code 35

Diagnostic Aids

The IAT sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Cylinder Head Temperature (ECT) sensor. Check the ground circuit 359 (Grey/Red-Grey/Yellow) if these DTC's are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the IAT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the IAT sensor.

A change in the voltage reading will indicate the location of the fault.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

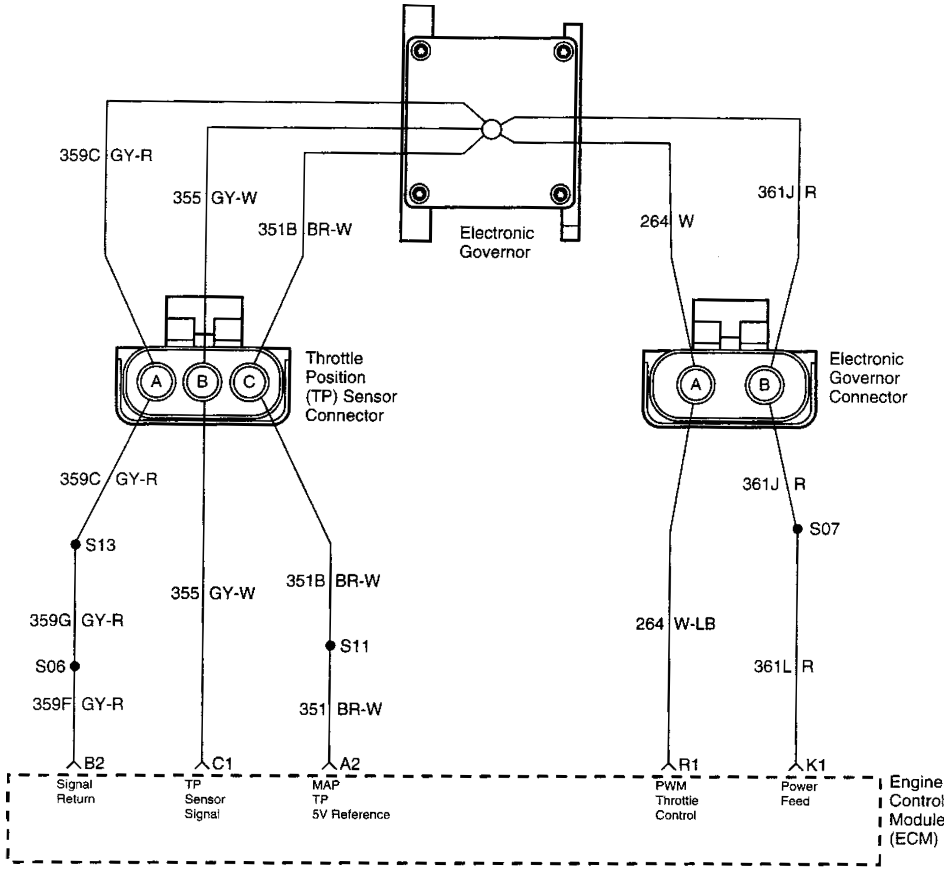
Voltage values calculated for VREF=5 volts (may vary $\pm$ 15% due to sensor and VREF variations).

DTC 35 – Intake Air Temperature High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Ignition OFF. 2. Disconnect the IAT sensor electrical connector. 3. Check ohm value across the two pins of the IAT. Is it within specs of above chart?		Go to *Step 3*	Go to *Step 7*
3	1. KOEO. 2. With a DVOM check for ground on circuit 359E (Grey/Red) cavity 1. Is there a ground?		Go to *Step 5*	Go to *Step 4*
4	Check for an open on circuit 359E (Grey/Red) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 5*
5	1. Reconnect the IAT sensor electrical connector. 2. With a suitable backprobing technique measure the voltage between cavity 2, circuit 743 (Grey) and ground. Is the voltage greater than the specified value?	4.9V	Go to *Step 6*	Go to *Step 7*
6	Check for a short to voltage on circuit 743 (Grey) and repair as necessary. Was a repair necessary?		Re-test	Go to *Step 8*
7	Replace the IAT sensor Is the repair complete?		Re-test	
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 37

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 37 DRIVE BY WIRE DECAY FAILURE

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359C) and terminal C (Brown/White, circuit 351B) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

• KOER.
• Throttle plate stuck open.
• Normalized TPS > TPS set point + 0.5V for at least 1 second when not at idle.
• Above conditions are present for at least 1 second.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM shuts down the engine. The engine can be restarted by recycling the ignition switch.

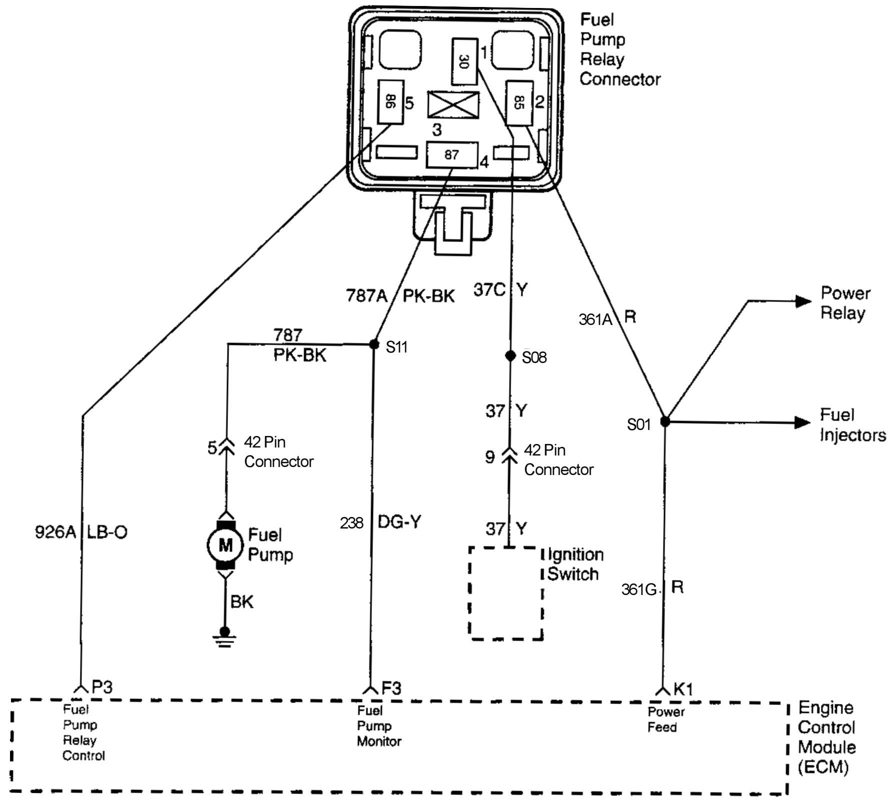
Diagnostic Trouble Code 37

DTC 37 – Drive By Wire Decay Failure

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis? **NOTE:** This test cannot be made without a PC or a very high tech DVOM.		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	Visually check for dirt or carbon in the throat of the actuator or on the throttle plate. Is there any dirt or carbon?		Clean with a carb cleaner. Re-test.	Go to *Step 3*
3	Is the normalized TPS within specification of the TPS set point?	Normalized TPS $\leq$ TPS set point.	Re-test.	
4	Does the ECM have the correct program for this application?	If needed contact FPP or OEM for correct program.	Go to *Step 5*	Download correct program & re-test.
5	Using EEMS/SERV program, read graph for throttle body position (TPS) in relation to the ECM set point. Are graph lines close together but not even?		Go to *Step 6*	Re-test.
6	1. Disconnect battery ground. 2. Disconnect ECM connector L-Y. 3. Check for a short or open on circuit 264 (W-LB), circuit 361H (R) and 361G (R). Where any shorts or opens found?		Repair wire. Reconnect battery and re-test.	Go to *Step 6*
7	Check circuits 264 (W-LB) and 361G (R) for poor terminal connectors at ECM. Do any of the terminals need to be repaired or replaced?		Repair or replace terminals. Reconnect battery. Re-test.	Go to *Step 8*
8	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test.	Remove & replace electronic governor with original. Go to *Step 9*.
9	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 41

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 41 FUEL PUMP HIGH VOLTAGE

Circuit Description

When the ignition switch is first turned on, the ECM energizes the fuel pump relay which applies power to the fuel pump. The fuel pump relay will remain active as long as the engine is running or cranking. If the fuel pump is active when the ECM is not commanding it then DTC 41 will set. This condition indicates a problem with the relay or the wiring.

Conditions for Setting the DTC

- KOEO.
- Fuel pump voltage is active when the ECM is not commanding it.
- Above conditions must be met for at least 2 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The drive by wire engine will shut down and/or will not start.

Diagnostic Trouble Code 41

Diagnostic Aids

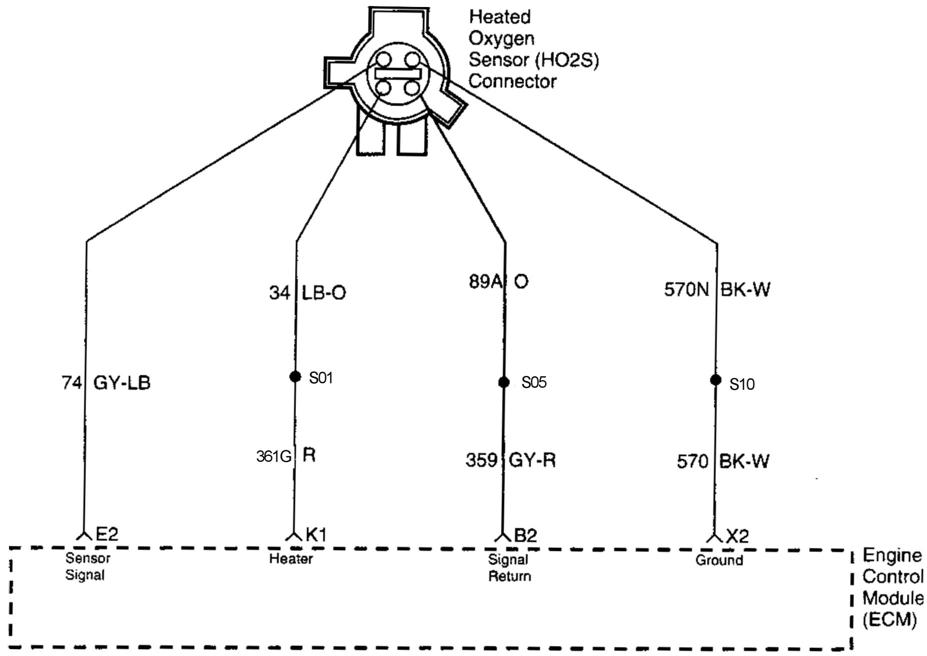
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage.

DTC 41 – Fuel Pump High Voltage

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. KOEO. 2. Connect a DVOM from the ECM connector back probe K1 to ground. Does the DVOM show battery voltage?	B+	Go to *Step 4*	Go to *Step 3*
3	Repair the open or short to ground in circuit 361A & 361G (Red) between the ECM and the fuel pump relay. Is the repair complete?	B+	Re-test.	
4	Connect a DVOM from cavity 85 to ground. Recycle ignition switch to KOEO. Does the DVOM show battery voltage?	B+ (3 sec.)	Go to *Step 6*	Go to *Step 5*
5	Repair the open or short to ground in circuit 926A (Lt. Blue/Orange) between the ECM and the fuel pump relay. Is the repair complete?	B+	Re-test.	
6	Connect a DVOM from circuit 37 at fuel pump relay to ground. Does the DVOM show battery voltage?	B+	Go to *Step 8*	Go to *Step 7*
7	Repair the open or short to ground in circuit 37 (Yellow) between the ECM and the ignition. Is the repair complete?	B+	Re-test.	
8	Connect the DVOM from F3 to ground. Recycle ignition switch to KOEO. Do you have battery + for 3 seconds?	B+ (3 sec.)	Go to *Step 10*	Go to *Step 9*
9	Repair the open or short to ground in circuit 787 (Pink/Black) and circuit 238 (Dk. Green/Yellow) between the ECM and the fuel pump relay. Is the repair complete?	B+ (3 sec.)	Re-test.	
10	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 11*.	
11	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 12*
12	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 42

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 42 HO2S SENSOR (HIGH VOLTAGE) STUCK RICH

Circuit Description

The ECM supplies a voltage of about 0.45 volts to the heated exhaust gas oxygen sensor. This may read as low as 0.10 volts with a 10 megohm digital voltmeter. The oxygen sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about 0.10 volts if the exhaust is lean. A cold sensor causes an open loop operation.

If the sensor pigtail wiring, connector, or terminal is damaged the entire oxygen sensor assembly must be replaced. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the signal return wire. Any attempt to repair the wires, connector, or terminals could result in the obstruction of the air reference and degrade the sensor performance. There must be no crimp connectors in the wiring.

Conditions for Setting the DTC

- KOER and in closed loop.
- HO2S sensor voltage is greater than or equal to 0.65 volts for 20 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will switch to open fuel control.

Diagnostic Trouble Code 42

Diagnostic Aids

A leaking or malfunctioning fuel injector can cause the system to go rich.

A misfiring cylinder will result in unburned oxygen in the exhaust which can cause a lean condition.

An intermittent throttle position sensor output will cause the system to go rich due to a false indication of the engine accelerating.

Inspect the oxygen sensor for silicone contamination from fuel or the use of improper room temperature vulcanizing (RTV) sealant. The sensor may have a white powdery coating which may result in a high but false voltage signal (rich exhaust indication).

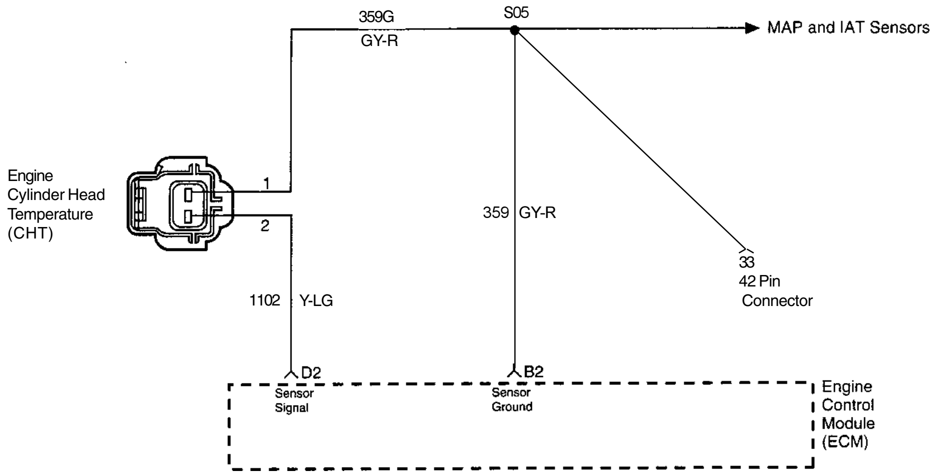
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, go to diagnostic chart below.

DTC 42 – HO2S Sensor (High Voltage) Stuck Rich

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Let the sensor cool. 2. KOEO. 3. With a suitable backprobing technique, measure the voltage between the signal circuit 74 (Grey/Lt. Blue) and the return circuit 89A (Orange). **NOTE**: If a PC is available, you can observe HO2S voltage on the engine data screen instead of using a DVOM. Is the HO2S voltage below the specified value?	0.45V	Go to *Diagnostic Aids.*	Go to *Step 3*
3	1. Disconnect the HO2S sensor electrical connector. 2. Check the sensor signal circuit 74 (Grey/Lt. Blue) for an open or a short to ground and repair if necessary. Was a repair necessary?		System OK	Go to *Step 4*
4	Replace HO2S. Is system working to specification?		Re-test	Remove replacement HO2S and install original. Go to *Step 5*
5	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM Go to *Step 6*	
6	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM Go to *Step 7*
7	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test	

Diagnostic Trouble Code 43

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 43 ENGINE CYLINDER HEAD TEMPERATURE LOW VOLTAGE

Circuit Description

The engine cylinder head temperature sensor is a thermistor which measures the temperature of the cylinder head on the engine. The ECM supplies a ground (circuit 359G, Grey/Red-Grey/Yellow) from the sensor and sends a 5V signal (circuit 1102 Y-LG) to the sensor. When the engine cylinder head is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the CHT signal circuit. If the engine cylinder head is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 43 will set when the ECM detects an excessively high signal voltage on the engine cylinder head temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- ECT sensor signal is $\leq$ 0.32V.
- Above conditions are present for at least 3 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will set code 43 and go into open loop.

Diagnostic Trouble Code 43

Diagnostic Aids

The CHT sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Intake Air Temperature (IAT) sensor. Check the ground circuit 359 (Grey/Red-Grey/Yellow) if these DTC's are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the CHT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the CHT sensor.

A change in the CHT display will indicate the location of the fault.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

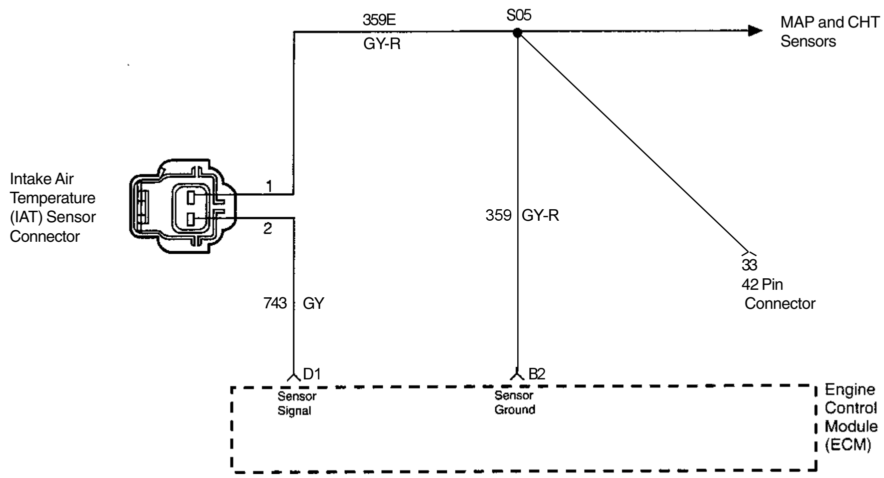
Voltage values calculated for VREF=5 volts (may vary $\pm$ 15% due to sensor and VREF variations).

DTC 43 – (4.2L) Cylinder Head Temperature Low Voltage (DVOM Diagnostic Method)

Step	Action	Values	Yes	No
1	1. Key off. Disconnect the CHT sensor connection. 2. Check ohm value across the two pins of the CHT. Is it within specs of above chart?		Go to *Step 2*	Go to *Step 7*
2	1. KOEO. 2. With a DVOM measure the voltage from the CHT sensor connector circuit, 1102 (Y-LG) to ground. Is the voltage greater than the specified value?	0V	Go to *Step 4*	Go to *Step 3*
3	Locate and repair the open or short to ground in circuit 1102 (Y-LG) between the CHT sensor connector and the ECM. Is the repair complete?		Re-test.	
4	Measure the voltage across the CHT sensor connector between cavity 1 and cavity 2. Is the voltage greater than the specified value?	0V	Re-test.	Go to *Step 5*
5	Locate and repair the open or short to ground in circuit 359 (Grey/Red-Grey/White, between the CHT sensor connector and the ECM. Is the repair complete?		Re-test.	
6	1. Connect the CHT sensor connector to the sensor. 2. With a suitable backprobing technique, measure the voltage across the CHT sensor connector between cavity 1 and cavity 2. Is the voltage less than the specified value?	5V	Go to *Step 8*	Go to *Step 7*
7	Replace the CHT sensor. Is the repair complete?		Re-test	
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 45

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 45 INTAKE AIR TEMPERATURE HIGH VOLTAGE

Circuit Description

The intake air temperature (IAT) sensor is a thermistor which measures the temperature of the air entering the engine. The ECM supplies a ground (circuit 359E, Grey/Red) from the sensor. When the intake air is cold, the sensor resistance is high and the ECM will monitor a high signal voltage at the IAT signal circuit. If the intake air is warm, the sensor resistance is lower, causing the ECM to monitor a lower voltage. DTC 45 will set when the ECM detects an excessively low signal voltage on the intake air temperature sensor signal circuit.

Conditions for Setting the DTC

- KOEO or KOER.
- IAT sensor signal is $\geq$ 4.96V.
- Above conditions are present for at least 3 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will force the IAT sensor to a 50°F default value.

Diagnostic Trouble Code 45

Diagnostic Aids

The IAT sensor shares the same ground with the Manifold Absolute Pressure (MAP) sensor and the Cylinder Head Temperature (CHT) sensor. Check the ground circuit 359 (Grey/Red) if these DTC's are also set.

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, backprobe the IAT sensor connector with a digital voltmeter and observe the voltage while moving connectors and wiring harnesses related to the IAT sensor.

A change in the voltage reading will indicate the location of the fault.

ECT, CHT, IAT & MST Sensors

°C	°F	OHMS	Volts
Temperature vs. Ohm or Volts Values (approx.)			
100	212	2,080	.47
80	176	3,837	.79
60	140	7,548	1.34
45	113	13,236	1.93
35	95	19,716	2.39
25	77	30,000	2.86
15	59	46,774	3.32
5	41	74,914	3.71
-5	23	123,485	4.02
-15	5	209,816	4.25
-30	-22	496,051	4.46
-40	-40	925,021	4.54

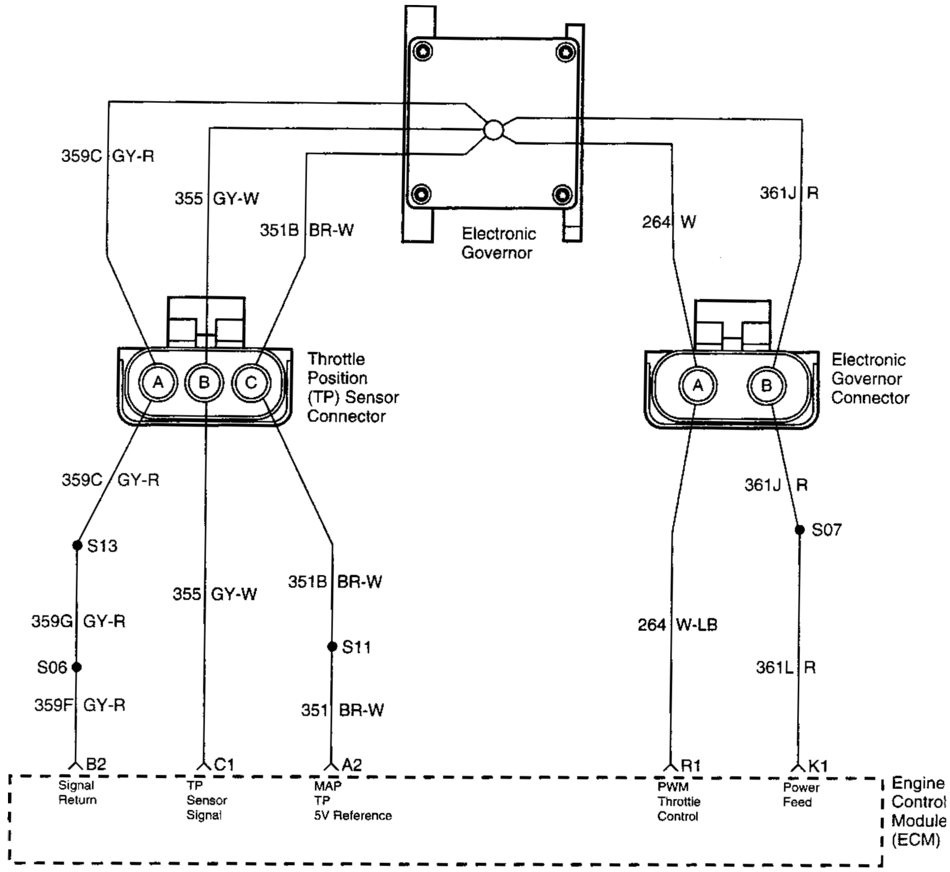
Voltage values calculated for VREF=5 volts (may vary ± 15% due to sensor and VREF variations).

DTC 45 – Intake Air Temperature Low Voltage

Step	Action	Values	Yes	No
1	Check ohm value across the two pins of the IAT. Is within specs of above chart?		Go to *Step 2*.	Go to *Step 7*
2	1. KOEO. Disconnect the IAT sensor connector. 2. With a DVOM measure the voltage from the IAT sensor connector, cavity 2 (circuit 743) to ground. Is the voltage greater than the specified value?	0V	Go to *Step 4*	Go to *Step 2*
3	Locate and repair the open or short to ground in circuit 743 (Grey) between the IAT sensor connector and the ECM. Is the repair complete?		Re-test.	
4	Measure the voltage across the IAT sensor connector between cavity 1 and cavity 2. Is the voltage greater than the specified value?	0V	Re-test.	Go to *Step 5*
5	Locate and repair the open or short to ground in circuit 359 / 359E (Grey/Red) between the IAT sensor connector and the ECM. Is the repair complete?		Re-test.	
6	1. Connect the IAT sensor connector to the sensor. 2. With a suitable backprobing technique, measure the voltage across the IAT sensor connector between cavity 1 and cavity 2. Is the voltage less than the specified value?	5V	Go to *Step 8*	Go to *Step 7*
7	Replace the IAT sensor. Is the repair complete?		Re-test.	
8	Install replacement ECM. Is the system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*.	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10*.
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 47

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 47 DRIVE BY WIRE RISE FAILURE

Circuit Description

The throttle position (TP) sensor is a potentiometer which is attached to the throttle plate shaft inside the electronic governor. The ECM provides a 5V reference voltage to the TP sensor between terminal A (Grey/Red, circuit 359C) and terminal C (Brown/White, circuit 351B) of the electronic governor. A TP signal is returned to the ECM from terminal B (Grey/White, circuit 355) of the electronic governor. The TP signal varies from about 1.0V at idle to 4.8V at WOT. The TP signal is an important input used by the ECM for fuel control and other engine-control functions.

Conditions for Setting the DTC

• KOER.
• Actuator is lower than the commanded position by the ECM.
• TPS set point > normalized TPS + 0.5V for at least 2 consecutive seconds when not at idle.

Actions Taken When the DTC Sets

• The ECM illuminates the malfunction indicator lamp (MIL).
• The ECM shuts down the engine. The engine can be restarted by recycling the ignition switch.

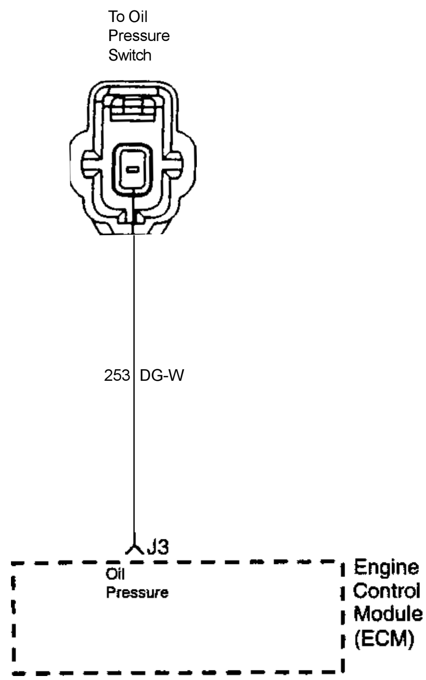
Diagnostic Trouble Code 47

DTC 47 – Drive By Wire Rise Failure

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis? **NOTE:** This test cannot be made without a PC or a very high tech DVOM.		Go to *Diagnostic System Check* before continuing at *Step 2*	Go to *Step 2*
2	Visually check for dirt or carbon in the throat of the actuator or on the throttle plate. Is there any dirt or carbon?		Clean with a carb cleaner. Re-test.	Go to *Step 3*
3	Is the TPS set point > normalized TPS + 0.5V for at least 2 consecutive seconds when not at idle?		Go to *Step 4*	Re-start.
4	Does the ECM have the correct program for this application?	If needed contact FPP or OEM for correct program	Go to *Step 5*	Download correct program & re-test.
5	Using EEMS/SERV program either view the monitor screen or read the graph for throttle body position (TPS) in relation to the ECM set point. Are graph lines close together but not even?		Go to *Step 6*	Re-test.
6	1. Disconnect battery ground. 2. Disconnect ECM connector L-Y. 3. Check for a short or open on circuit 264 (W-LB), circuit 361H (R), and 361G (R). Where any shorts or opens found?		Repair wire. Reconnect battery and re-test.	Go to *Step 7*
7	Check circuits 264 (W-LB) and 361G (R) for poor terminal connectors at ECM. Do any of the terminals need to be repaired or replaced?		Repair or replace terminals. Reconnect battery. Re-test.	Go to *Step 8*
8	Replace the electronic governor. Is the repair complete and engine operating to specifications?		Re-test.	Remove & replace electronic governor with original. Go to *Step 9*.
9	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 10*.	
10	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 11*.
11	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 51

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 51 LOW OIL PRESSURE

NOTE: This is a software selectable DTC.

Circuit Description

The ECM monitors the oil pressure through circuit 253 (Dk. Green/White) from the oil pressure switch. If the oil pressure gets below an established pressure value the oil pressure switch will close to ground and the oil pressure light will come on. This action will set DTC 51.

Conditions for Setting the DTC

- KOER.
- Engine must be above 850 RPM's and 250 crankshaft rotations must have occurred.
- Oil switch must be closed to ground for at least 2.0 consecutive seconds.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- Software selectable: The ECM will shut down the engine. The engine can be restarted by recycling ignition switch.

Diagnostic Trouble Code 51

Diagnostic Aids

Check that the ECM has the correct governing program.

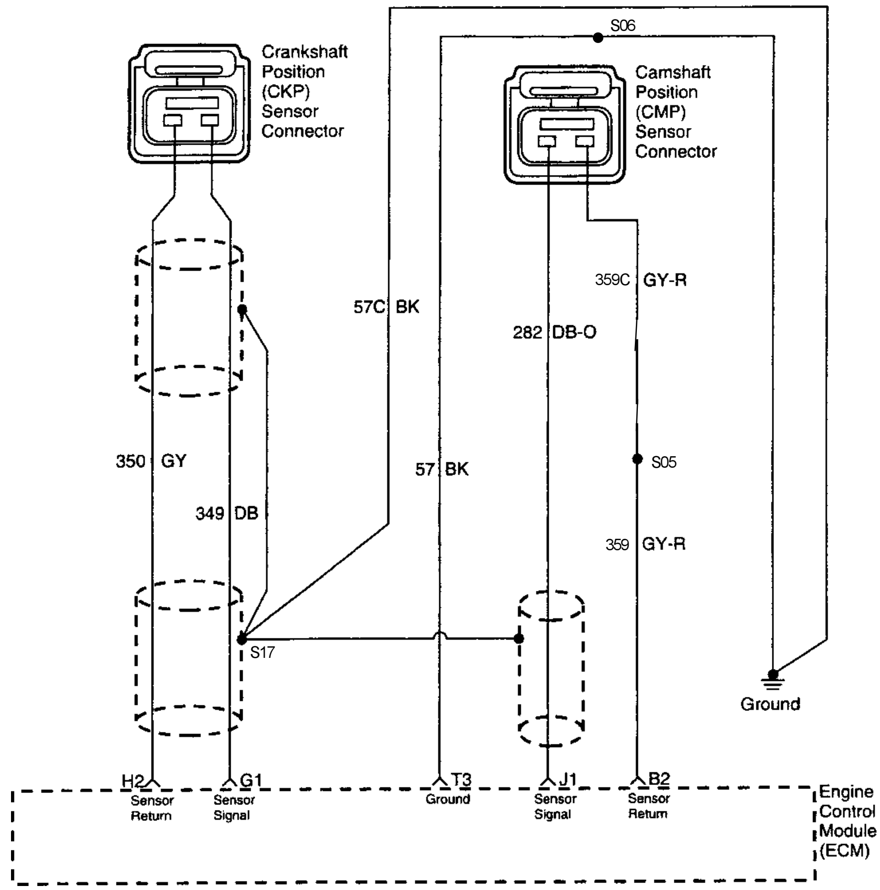
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, go to diagnostic chart below.

DTC 51 – Low Oil Pressure

Step	Action	Values	Yes	No
1	1. Ignition OFF. 2. Disconnect the circuit 253 (Dk. Green/White) oil pressure switch wire from the oil pressure switch. 3. With a DVOM, measure the continuity on circuit 253 (Dk. Green/ White). Is there continuity?		Go at *Step 2*	Go to *Step 3*
2	Locate and repair the short to ground in circuit 253 (Dk. Green/White) between the oil pressure switch and the ECM connector, cavity J3. Is the repair complete?		Re-test.	
3	1. KOER. 2. Connect a DVOM to the oil pressure switch post and ground. Is there continuity?		Go to *Step 4*	Go to *Step 5*
4	Replace the oil pressure switch. Is the repair complete?		Re-test.	
5	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 6*.	
6	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 7*.
7	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 52

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 52 CRANKSHAFT POSITION SENSOR EXTRA/MISSING PULSES

Circuit Description

The reference signal is produced by the crankshaft position (CKP) sensor. During one crankshaft revolution, a predetermined number of crankshaft pulses will be produced. The ECM uses the reference signal to calculate engine RPM and crankshaft position. The ECM constantly monitors the number of pulses on the reference circuit and compares them to the number of camshaft position signal pulses being received. If the ECM receives an incorrect number of pulses on the reference circuit, DTC 52 will set.

Conditions for Setting the DTC

- KOER.
- Extra or missing pulses are checked for after very 35 pulses.

Actions Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will turn off the injectors and ignition for a minimum of one crankshaft rotation and wait for a valid pattern before turning the injectors and ignition back on. If a valid pattern is not available the engine will not start.
- The ECM will shutdown engine if the crankshaft pattern is lost.

Diagnostic Trouble Code 52

Diagnostic Aids

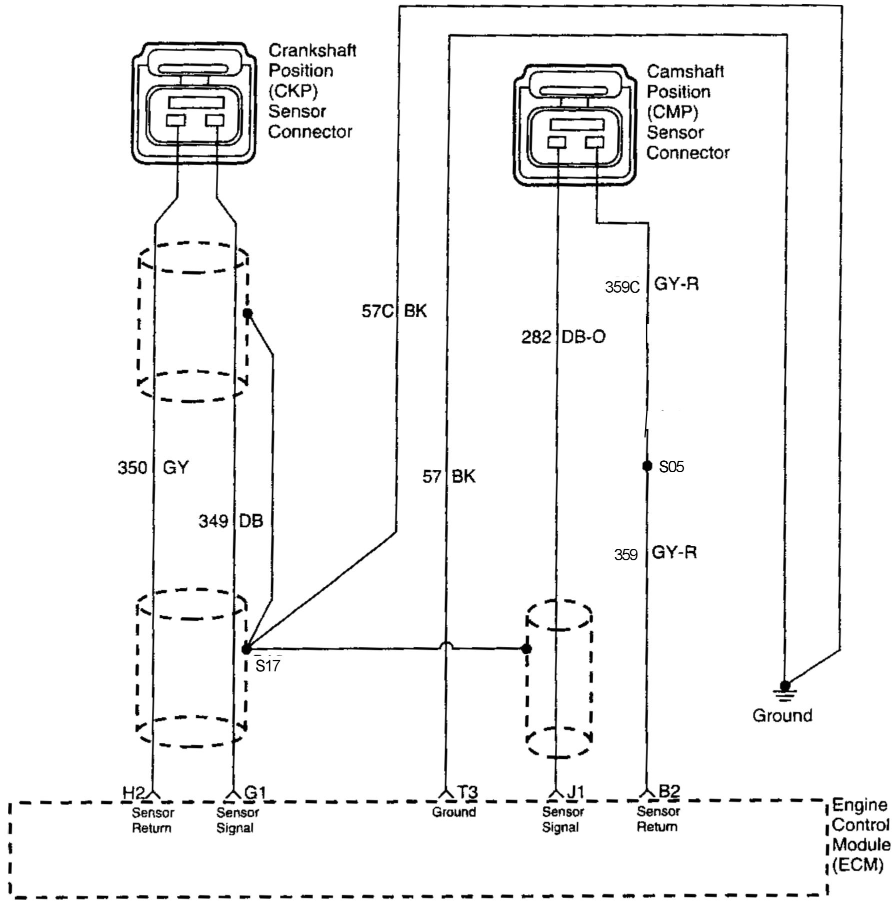
Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, go to diagnostic chart below.

DTC 52 – Crank Position Extra/Missing Pulses

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Attempt to start the engine. Does the engine start?		Go to *Step 3*	Go to *Engine Cranks But Will Not Run*
3	1. KOEO. Disconnect the ECM and the CKP sensor. 2. Check for an open or a short to ground in the CKP reference circuit 350 (Grey) between the sensor connector and the ECM harness connector. Repair as necessary. Was a repair necessary?		Re-test.	Go to *Step 4*
4	1. Reconnect the ECM and the CKP sensor. 2. Connect a DVOM to measure the voltage on the CKP reference circuit, terminal H2, at the ECM connector. 3. Observe the voltage while cranking the engine. Is the voltage near the specified value?	2.5v	Re-test.	Go to *Step 5*
5	Check the connections at the CKP sensor and replace the terminals if necessary. Was a repair necessary?		Re-test.	Go to *Step 6*
6	Replace the CKP sensor. Is the repair complete?		Re-test.	
7	Check the connections at the ECM and replace the terminals if necessary. Was a repair necessary?		Re-test.	Go to *Step 8*
8	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 9*.	
9	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 10.*
10	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 53

NOTES



DIAGNOSTIC TROUBLE CODE (DTC) 53 CAMSHAFT POSITION SENSOR ILLEGAL PATTERN

Circuit Description

The camshaft position (CMP) sensor signal is produced by the CMP sensor pulses when the engine is running and CKP sync pulses are also being received. The ECM uses the CMP signal pulses to initiate sequential fuel injection. The ECM constantly monitors the number of pulses on the CMP signal circuit and compares the number of CMP pulses to the number of CKP reference pulses received. If the ECM receives an incorrect number of pulses on the CMP reference circuit, DTC 53 will set. The engine will perform with little or no degradation in perceived performance.

Conditions for Setting the DTC

- KOER.
- The correct number of crankshaft pulses (70) are not detected between each CKP pulse.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM will default to the previously established injection sequence.

Diagnostic Trouble Code 53

Diagnostic Aids

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. If the harness appears to be OK, go to diagnostic chart below.

DTC 53 – Camshaft Position Sensor Illegal Pattern

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	1. Disconnect the CMP sensor. 2. Measure the voltage between the sensor signal circuit 282 (Dk. Blue/ Orange) and the sensor ground circuit 359C (Grey/Red) at the CMP sensor connector. Does the voltage measure near the specified value?	4-6V	Go to *Step 5*	Go to *Step 3*
3	Check the sensor signal circuit 282 (Dk. Blue/Orange) and the sensor ground circuit 359 (Grey/Red) for an open or short to ground and repair as necessary. Was a repair necessary?		Re-test.	Go to *Step 4*
4	Check for poor connections at the ECM and repair if necessary. Was a repair necessary?		Re-test.	Go to *Step 5*
5	1. Connect the CMP sensor. 2. With a DVOM, backprobe the CMP sensor signal circuit, terminal J1, while cranking the engine. Does the voltage toggle between the specified value?	4-0V	Go to *Step 7*	Go to *Step 6*
6	Replace the camshaft position sensor. Is the repair complete?		Re-test.	
7	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 8*.	
8	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test the system.	Remove original ECM and reinstall replacement ECM. Go to *Step 9*.
9	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 54

DIAGNOSTIC TROUBLE CODE (DTC) 54 ECM FAULT ILLEGAL OPERATION

Circuit Description

The ECM continuously monitors electrical signals form the engine. If for some reason the ECM receives an illegal instruction it then executes an “exception handling code”, the ECM will then go to a default program and return to normal operation, but it will set DTC 54 and will need to be replaced.

Conditions for Setting the DTC

• KOEO or KOER.

Action Taken When the DTC Sets

• The ECM will illuminate the malfunction indicator lamp (MIL).

Diagnostic Aids

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage. Check for shorts or open in the spark plug wires.

DTC 54 – ECM Fault Illegal Operation

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Check the MIL or the PC engine data screen. Are any other DTC’s set?		Go to applicable DTC.	Go to *Step 3*
3	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go at *Step 4*.	
4	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 5*.
5	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 55

DIAGNOSTIC TROUBLE CODE (DTC) 55 ECM FAULT ILLEGAL INTERRUPTION

Circuit Description

The ECM continuously monitors electrical signals form the engine. If for some reason the ECM receives an illegal interruption from one of those signals it then executes an “exception handling code”, the ECM will then go to a default program and return to normal operation, but it will set DTC 55 and will need to be replaced.

Conditions for Setting the DTC

• KOEO or KOER.

Action Taken When the DTC Sets

• The ECM will illuminate the malfunction indicator lamp (MIL).

Diagnostic Aids

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage.

DTC 55 – ECM Fault Illegal Interruption

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Check the MIL or the PC engine data screen. Are any other DTC’s set?		Go to applicable DTC.	Go to *Step 3*
3	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go at *Step 4*.	
4	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 5*.
5	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 56

DIAGNOSTIC TROUBLE CODE (DTC) 56 ECM FAULT – COMPUTER OPERATING PROPERLY (COP) FAILURE

Circuit Description

The ECM continuously monitors electrical signals form the engine. Under normal operation the ECM will store numbers into memory. If this does not happen, the ECM will execute an “exception handling routine” and rest itself from the beginning. This is a “watch dog timer” function. If DTC 56 is set, the ECM will have to be replaced.

Conditions for Setting the DTC

• KOEO or KOER.

Action Taken When the DTC Sets

• The ECM will illuminate the malfunction indicator lamp (MIL).

Diagnostic Aids

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage.

DTC 56 – ECM Fault Computer COP Failure

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Check the MIL or the PC engine data screen. Are any other DTC’s set?		Go to applicable DTC.	Go to *Step 3*
3	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go at *Step 4*.	
4	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 5*.
5	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 57

DIAGNOSTIC TROUBLE CODE (DTC) 56 ECM FAULT – COMPUTER OPERATING PROPERLY (COP) FAILURE

Circuit Description

The ECM continuously monitors electrical signals form the engine. Under normal operation the ECM will store numbers into memory. If this does not happen, the ECM will execute an “exception handling routine” and rest itself from the beginning. This is a “watch dog timer” function. If DTC 57 is set, the ECM will have to be replaced.

Conditions for Setting the DTC

• KOEO or KOER.

Action Taken When the DTC Sets

• The ECM will illuminate the malfunction indicator lamp (MIL).

Diagnostic Aids

Inspect the harness connectors for backed-out terminals, improper mating, broken locks, improperly formed or damaged terminals, and poor terminal-to-wire connections. Inspect the wiring harness for damage.

DTC 57 – ECM Fault Computer COP Failure

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Check the MIL or the PC engine data screen. Are any other DTC’s set?		Go to applicable DTC.	Go to *Step 3*
3	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go at *Step 4*.	
4	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 5*.
5	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 61

DIAGNOSTIC TROUBLE CODE (DTC) 61 SYSTEM VOLTAGE LOW

Circuit Description

The ECM monitors the system voltage through circuit 361 (Red) terminal K1 (power feed) and circuit 37 (Yellow) terminal F2 (battery feed). DTC 61 will set whenever the ECM detects a voltage that is below a calibrated value.

Conditions for Setting the DTC

• KOER.
• Engine RPM is greater than 700.
• System voltage is less than or equal to 8.0V for at least 2 consecutive seconds.

Action Taken When the DTC Sets

• The ECM will illuminate the malfunction indicator lamp (MIL).

Diagnostic Aids

The DTC sets when an accessory is operated, check for a poor connection or excessive current draw. Excessive current draw can be a result of a short circuit or partial short circuit due to corrosion, moisture or chafed insulation.

DTC 61 – System Voltage Low

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Using a DVOM, measure the battery voltage at the battery. Is the battery voltage less than the specified value?	$\le$ 8.0V	Go to *Step 3*	Change the battery, the go to *Step 3*
3	1. Ignition OFF. 2. Disconnect the ECM connector A thru K. 3. With a DVOM, measure the battery voltage at the ECM connector, terminal F2. Is it approximately equal to the battery voltage?	VPWR (B+)	Go to *Diagnostic Aids*.	Go to *Step 4.*
4	Check for fault connections at the ECM harness terminals and repair if necessary. Was a repair necessary?		Re-test.	Go to *Step 5*
5	Check for an open battery feed circuit 37 (Yellow) to the ECM and repair if necessary. Was a repair necessary?		Re-test.	Go to *Step 6*
6	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 7.*	
7	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 8.*
8	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

Diagnostic Trouble Code 62

DIAGNOSTIC TROUBLE CODE (DTC) 62 SYSTEM VOLTAGE HIGH

NOTE: This is a software selectable DTC.

Circuit Description

The ECM monitors the system voltage through circuit 361 (Red) terminal K1 (power feed) and circuit 37 (Yellow) terminal F2 (battery feed). DTC 62 will set whenever the ECM detects a voltage that is above a calibrated value.

Conditions for Setting the DTC

- KOER.
- Engine RPM is greater than 700.
- System voltage is more than or equal to 18.0V for at least 2 consecutive seconds.

Action Taken When the DTC Sets

- The ECM will illuminate the malfunction indicator lamp (MIL).
- The ECM will shut down engine. Engine can be restarted by recycling ignition switch.

Diagnostic Aids

The DTC sets when an accessory is operated, check for a poor connection or excessive current draw. Excessive current draw can be a result of a short circuit or partial short circuit due to corrosion, moisture or chafed insulation.

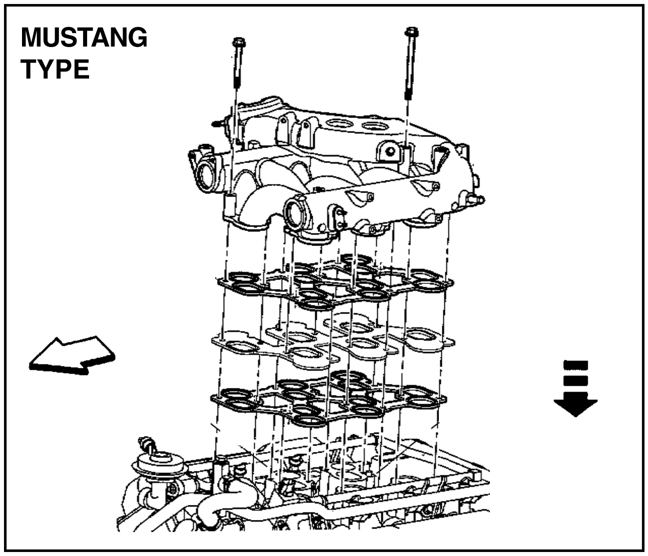
DTC 62 – System Voltage High

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Using a DVOM, measure the battery voltage at the battery. Is the battery voltage greater than the specified value?	VPWR (B+)	Go to *Step 4*	Go to *Step 3*
3	1. Charge the battery and clean the battery terminals. 2. Clean the battery ground cable connection if corrosion is indicated. Is the battery voltage less than the specified value?	VPWR (B+)	Replace battery.	Go to *Step 4*
4	1. Turn off all electrical accessories, if applicable. 2. Start the engine. Is the ignition voltage more than 8 volts ?		Verify that the alternator is functioning correctly.	Go to *Step 5*
5	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 6*.	
6	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 7*.
7	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

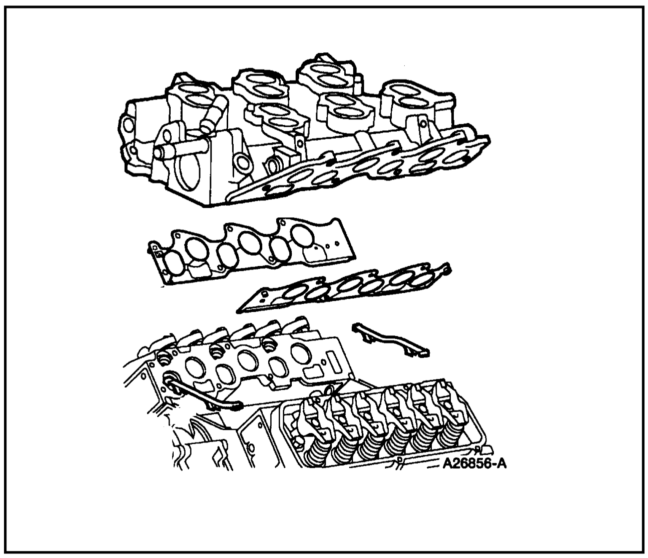
Diagnostic Trouble Code 65

NOTES

Installation of Upper Intake Manifold



Installation of Lower Intake Manifold



DIAGNOSTIC TROUBLE CODE (DTC) 65 INTAKE MANIFOLD LEAK

Circuit Description

The ESG 642 intake manifold is in two parts, upper and lower, and made of aluminum. The lower intake bolts down to the cylinder heads and is sealed with a gasket for each cylinder head. The upper intake bolts to the lower with a gasket, spacer, and gasket to make the seal. A throttle body is bolted to the intake mounted with a gasket to form a seal. The throttle plate mounted inside the throttle body controls the amount of air entering into the intake manifold. The two parts of the intake manifold are made of tubes or runners to control the air flow to each cylinder evenly. With some application idle air control motor is mounted on either the throttle body or upper intake manifold. This IAC is mated up to a gasket to form an air tight seal.

Diagnostic Trouble Code 65

Conditions for Setting the DTC

- KOER.
- IAC and actuator duty cycles are at their minimums, start up gain phase-in = 1 and rpm > (set +300).
- Above conditions are present for at least 2.6 seconds.
- Driving machine and letting up on gas to gear down.

Actions Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL).
- The ECM shuts down the engine. The engine can be restarted by recycling the ignition switch.

Trouble Shooting:

- Check PCV system for leaks.
- Check IAC motor stuck open.
- Check booster brake system for leaks.
- Check intake manifold for gasket leaks.

DTC 65 – Intake Manifold Leak

Step	Action	Values	Yes	No
1	Are you using a personal computer (PC) to perform this diagnosis?		Go to *Diagnostic System Check* before continuing at *Step 2*.	Go to *Step 2*
2	Visually check: For vacuum leaks • Vacuum hoses. • Intake manifold gaskets. • IAC motor stuck open. • PCV system. • Brake booster. Are any of the above components causing a vacuum leak?		Make necessary repairs and re-test.	Go to *Step 3*
3	Using a vacuum gage, check engine vacuum at idle. Is vacuum within specification?	18 to 24 inch. and steady.	Go to *Step 3*	Find leak and repair as necessary. Re-test.
4	Using a PC confirm correct program is downloaded into ECM. Is the program correct?		Replace ECM. Go to *Step 5*	Download correct program. Re-test.
5	Install replacement ECM. Is system operation normal with replacement ECM installed?		Remove replacement ECM and install original ECM. Go to *Step 6*	
6	Is the repair complete (system operation normal with original ECM reinstalled)?		Keep original ECM installed. Re-test.	Remove original ECM and reinstall replacement ECM. Go to *Step 7*
7	Is the repair complete (system operation normal with replacement ECM reinstalled)?		Leave replacement ECM installed. Re-test.	

METRICS INDEX

SUBJECT **PAGE**

METRICS

Introduction

Most threaded fasteners are covered by specifications that define required mechanical properties, such as tensile strength, yield strength, proof load and hardness. These specifications are carefully considered in initial selection of fasteners for a given application. To ensure continued satisfactory vehicle performance, replacement fasterners used should be of the correct strength, as well as the correct nominal diameter, thread pitch, length, and finish.

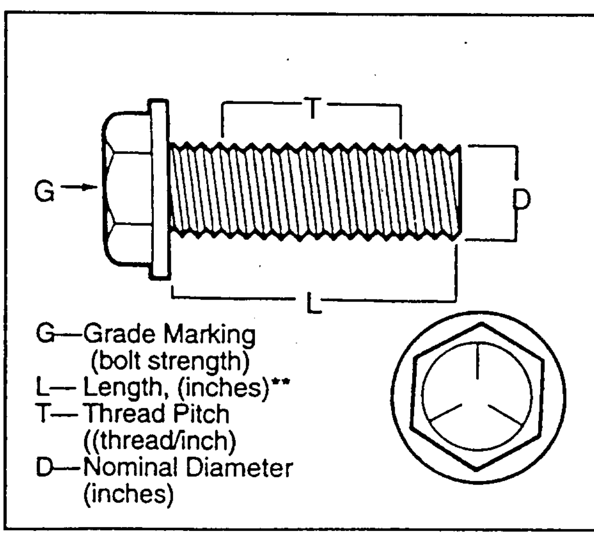
Most original equipment fasteners (English or Metric system) are identified with markings or numbers indicating the strength of the fastener. These markings are described in the pages that follow. Attention to these markings is important ot ensure that the proper replacement fastenres are used.

Further, some metric fasteners, especially nuts, are colored blue. This metric blue identification is in most cases a temporary aid for production start-up, and color will generally revert to normal black or bright after start-up.

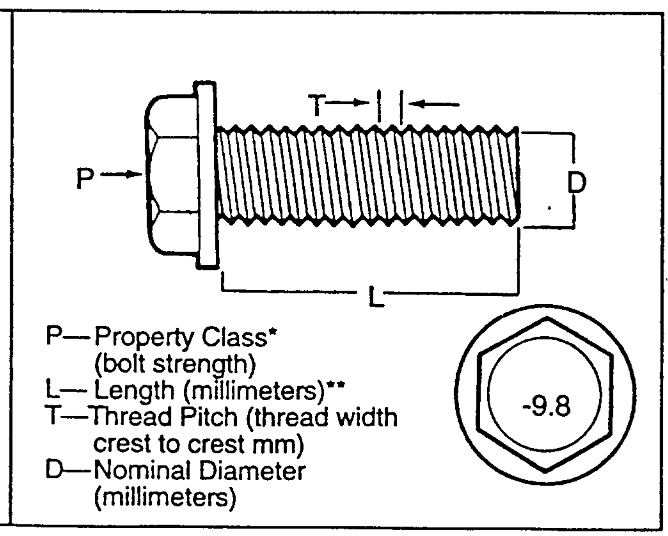
English or Metric system fasteners are available through your Ford Parts and Service operation.

Nomenclature for Bolts

English System
Bolt, 1/2-13x1



Metric System
Bolt, M12-1.75x25



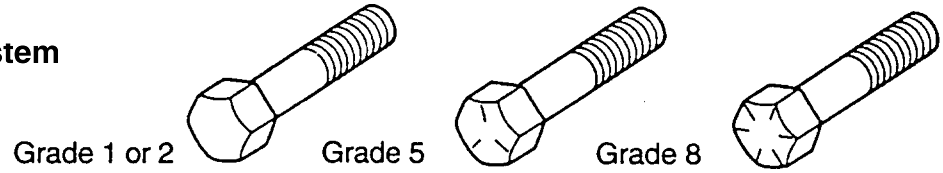
*The property class is an Arabic numeral distinguishable from the slash SAE English grade system.

**The length of all bolts is measured from the underside of the head to the end.

METRICS (Continued)

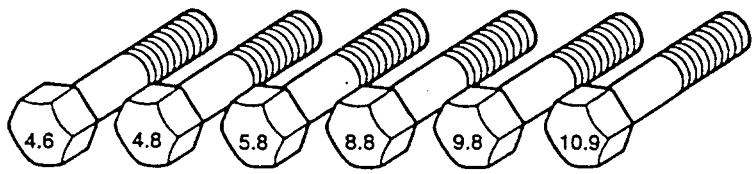
Bolt Strength Identification

English System



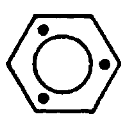
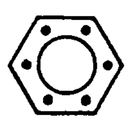
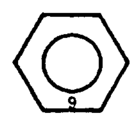
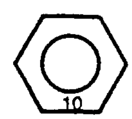
English (Inch) bolts: Identification marks correspond to bolt strength, increasing number of slashes represent increasing strength.

Metric System



Metric bolts: Identification class numbers correspond to bolt strength, increasing numbers represent increasing strength. Common metric fastener bolt strength property are 9.8 and 10.9 with the class identification embossed on the bolt head.

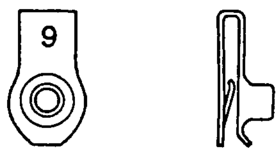
Hex Nut Strength Identification

ENGLISH SYSTEM			METRIC SYSTEM		
Grade	Hex Nut Grade 5	Hex Nut Grade 8	**Class**	Hex Nut Property Class 9	Hex Nut Property Class 10
Identification			**Identification**		
	3 Dots	6 Dots		Arabic 9	Arabic 10
Increasing dots represent increasing strength.			May also have blue finish or paint daub on hex flat. Increasing numbers represent increasing strength.		

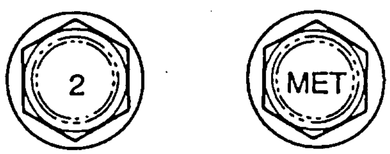
METRICS (Continued)

Other Types of Parts

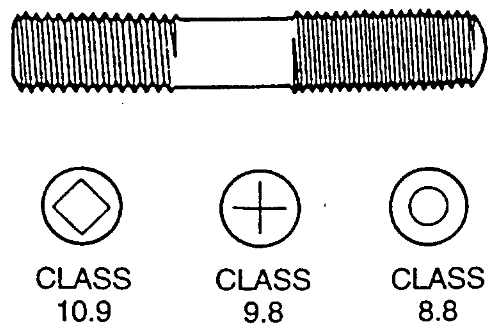
Metric identification schemes vary by type of part, most often a variation of that used of bolts and nuts. Note that many types of English and Metric fasteners carry no special identification if they are otherwise unique.



— Stamped U-Nuts



— Tapping, thread forming and certain other case hardened screws



— Studs, Large studs may carry the property class number. Smaller studs use a geometric code on the end.

METRICS (Continued)

English/Metric Conversion

DESCRIPTION	MULTIPLY	BY	FOR METRIC EQUIVALENT
Acceleration	ft/s²	0.3048	m/s²
	in/s²	0.0254	m/s²
Torque	lb-in	0.11298	N·m
	lb-ft	1.3558	N·m
Power	horsepower	0.746	kW
Pressure or Stress	inches of water	0.2491	kPa
	psi	6.895	kPa
	psi	0.069	bar
Energy or Work	BTU	1 055.0	Joules (J)
	lb-ft	1.3558	Joules (J)
	kiloWatt-hour	3,600,000. or 3.6×10^6	Joules (J)
Light	foot candle	10.764	lumens/square meter (lm/m²)
Fuel Performance	miles/gal	0.4251	kilometers/liter (km/L)
	gal/mile	2.3527	liters/kilometer (L/km)
Velocity	mph	1.6093	km/h
Length	inch	25.4	mm
	foot	0.3048	m
	yard	0.9144	m
	mile	1.609	km
Area	square inch (in²)	645.2	mm²
		6.45	cm²
	square ft (ft²)	0.0929	m²
	square yard	0.8361	m²
Volume	cubic inch (in³)	16 387.0	mm³
		16.387	cm³
		0.0164	liters (L)
	quart	0.9464	liters (L)
	gallon	3.7854	liters (L)
	cubic yard	0.7646	m³
Mass	pound	0.4536	kg
	ton	907.18	kg
	ton	0.9078	tonne (t)
Force	kilogram	9.807	N
	ounce	0.2780	N
	pound	4.448	N
Temperature	degree Farenheit (°F)	(°F -32) 0.556	degree Celsius (°C)

METRICS (Continued)

Decimal and Metric Equivalents

FRACTIONS	DECIMAL INCH	METRIC MM
1/64	.015625	.397
1/32	.03125	.794
3/64	.046875	1.191
1/16	.0625	1.588
5/64	.078125	1.984
3/32	.09375	2.381
7/64	.109375	2.778
1/8	.125	3.175
9/64	.140625	3.572
5/32	.15625	3.969
11/64	.171875	4.366
3/16	.1875	4.763
13/64	.203125	5.159
7/32	.21875	5.556
15/64	.234375	5.953
1/4	.250	6.35
17/64	.265625	6.747
9/32	.28125	7.144
19/64	.296875	7.54
5/16	.3125	7.938
21/64	.328125	8.334
11/32	.34375	8.731
23/64	.359375	9.128
3/8	.375	9.525
25/64	.390625	9.922
13/32	.40625	10.319
27/64	.421875	10.716
7/16	.4375	11.113
29/64	.453125	11.509
15/32	.46875	11.906
31/64	.484375	12.303
1/2	.500	12.7

FRACTIONS	DECIMAL INCH	METRIC MM
33/64	.515625	13.097
17/32	.53125	13.494
35/64	.546875	13.891
9/16	.5625	14.288
37/64	.578125	14.684
19/32	.59375	15.081
39/64	.609375	15.478
5/8	.625	15.875
41/64	.640625	16.272
21/32	.65625	16.669
43/64	.671875	17.066
11/16	.6875	17.463
45/64	.703125	17.859
23/32	.71875	18.256
47/64	.734375	18.653
3/4	.750	19.05
49/64	.765625	19.447
25/32	.78125	19.844
51/64	.796875	20.241
13/16	.8125	20.638
53/64	.828125	21.034
27/32	.84375	21.431
55/64	.859375	21.828
7/8	.875	22.225
57/64	.890625	22.622
29/32	.90625	23.019
59/64	.921875	23.416
15/16	.9375	23.813
61/64	.953125	24.209
31/32	.96875	24.606
63/64	.984375	25.003
1	1.00	25.4

METRICS (Continued)

Torque Conversion

NEWTON METRES (N•m)	POUND-FEET (LB-FT)
1	0.7376
2	1.5
3	2.2
4	3.0
5	3.7
6	4.4
7	5.2
8	5.9
9	6.6
10	7.4
15	11.1
20	14.8
25	18.4
30	22.1
35	25.8
40	29.5
50	36.9
60	44.3
70	51.6
80	59.0
90	66.4
100	73.8
110	81.1
120	88.5
130	95.9
140	103.3
150	110.6
160	118.0
170	125.4
180	132.8
190	140.1
200	147.5
225	166.0
250	184.4

POUND-FEET (LB-FT)	NEWTON METRES (N•m)
1	1.356
2	2.7
3	4.0
4	5.4
5	6.8
6	8.1
7	9.5
8	10.8
9	12.2
10	13.6
15	20.3
20	27.1
25	33.9
30	40.7
35	47.5
40	54.2
45	61.0
50	67.8
55	74.6
60	81.4
65	88.1
70	94.9
75	101.7
80	108.5
90	122.0
100	135.6
110	149.1
120	162.7
130	176.3
140	189.8
150	203.4
160	216.9
170	230.5
180	244.0

J1930 TERMINOLOGY LIST

NOTE: Certain Ford Component names have been changed in this Service Manual to conform to Society of Automotive Engineers (SAE) directive J1930.

SAE J1930 standardizes automotive component names for all vehicle manufacturers.

New Term	New Acronym	Old Terms (Acronyms)
Accelerator Pedal	AP	– Accelerator
Air Cleaner	ACL	– Thermac Air Cleaner
Air Cleaner Element	ACL Element	– Air Cleaner Element (ACL Element)
Air Cleaner Housing	ACL Housing	– Air Cleaner Housing (ACH)
Air Cleaner Housing Cover	ACL Housing Cover	– Air Cleaner Housing Cover (ACL Housing Cover)
Air Conditioning	A/C	– Air Conditioning (AC)
Air Conditioning Clutch	A/C Clutch	– Air Conditioning Clutch (ACC)
Air Conitioning Cycling Switch	A/C Cycling Switch	– Air Conditioning Cycling Switch (ACCS)
Air Conditioning Sensor	A/C Sensor	– Air Conditioning Sensor (A/C Sensor)
Air Conditioning System	A/C System	– Air Conditioning System (SCS)
Automatic Transaxle	A/T	– Electronic Automatic Transaxle (EATX)
Automatic Transmission	A/T	– Electronic Automatic Transmission (EATX)
Barometric Pressure	BARO	– Barometric Pressure (BARO)
Barometric Pressure Sensor	BARO Sensor	– Absolute Pressure Sensor (APS) – Barometric Pressure Sensor (BP Sensor)
Battery Positive Voltage	B+	– Battery Positive Voltage (B+)
Camshaft Position	CMP	– Snyc Pickup
Camshaft Position Sensor	CMP Sensor	– Camshaft Position Sensor (CPS) – Camshaft Sensor – Cylinder Identification Sensor (Cylinder ID Sensor) (CID)
Canister	Canister	– Canister
Carburetor	CARB	– Feed Back Carburetor (FBC)
Central Multiport Fuel Injection	Central MFI	– Central Multiport Fuel Injection (CMFI) – Fuel Injection (FI)
Charge Air Cooler	CAC	– After Cooler – Inter Cooler
Closed Loop	CL	– Closed Loop System (CLS)
Closed Throttle Position	CTP	– Closed Throttle Position (CTP)
Closed Throttle Position Switch	CTP Switch	– Closed Throttle Switch
Clutch Pedal Position	CPP	– Clutch Pedal Position (CPP)
Clutch Pedal Position Switch	CPP Switch	– Clutch Engage Switch (CES) – Clutch Start Switch – Clutch Switch
Compact Disc Read Only Memory	CDROM	– Compact Disc Read Only Memory (CDROM)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Continuous Fuel Injection	CFI	– Continuous Injection System (CIS)
		– Continuous Injection System – Electronic (Continuous Injection System-E) (CIS-E) – Fuel Injection (FI) – K-Jetronic – KE-Jetronic – KE-Motronic
Continuous Fuel Injection system	CFI System	– Continuous Injection System (CIS)
Continuous Trap Oxidizer	CTOX	– Continuous Trap Oxidizer (CTO)
		– Trap Oxidizer – Continuous (TOC)
Crankshaft Position	CKP	– Crankshaft Position (CP) – Position Indicator Pulse (PIP)
Crankshaft Position Sensor	CKP Sensor	– Crankshaft Position Sensor (CPS) – Crank Angle Sensor
Data Link Connector	DLC	– Assembly Line Communications Link (ALCL) – Assembly Line Diagnostic Link (ALDL) – Self Test Connector – Vehicle In Process Connector (VIP Connector)
Diagnostic Test Mode	DTM	– Modes
Diagnostic Trouble Code	DTC	– Self Test Codes
Differential Pressure Feedback Gas Recirculation System	Differential Pressure Feedback EGR System	– Differential Pressure Feedback EGR System
Direct Fuel Injection	DFI	– Direct Injection (DI) – Direct Injection – Diesel (DID) – Fuel Injection (FI)
Distributor Ignition	DI	– Capacitive Discharge Ignition (CDI) – Closed Bowl Distributor – Electronic Ignition (EI) (with Distributor) – Electronic Spark Advance Control (ESAC) – High Energy Ignition (HEI) – Remote Mount Thick Film Ignition (Remote Mount TFI) – Thick Film Ignition (TFI)
Distributor Ignition Capacitor	DI Capacitor	– Condenser
Distributor Igniition Control Module	Distributor ICM	– Electronic Distributor Ignition System Module (EDIS Module)
Distributor Ignition System	DI System	– Electronic Distributor Ignition System (EDIS)
Early Fuel Evaporation	EFE	– Early Fuel Evaporation (EFE)
Electrically Erasable Programmable Read Only Memory	EEPROM	– Electrically Erasable Programmable Read Only Memory (E2PROM)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Electronic Continuous Fuel Injeciton System	Electrnic CFI System	– Continuous Injection System – Electronic (Continuous Injection System-E) (CIS-E)
Electronic Engine Control	Electronic EC	– Electronic Engine Control (EEC)
Electronic Ignition	EI	– Computer Controlled Coil Ignition (C3I) – Distributorless Ignition (DLI) – Electronic Ignition (EI) (without Distributor) – Integrated Direct Ignition (IDI)
Electronic Ignition System	EI System	– Direct Ignition System (DIS) – Distributorless Ignition System (DIS) – Electronic Distributorless Ignition System (EDIS)
Engine Control	EC	– Electronic Engine Control (EEC)
Engine Control Module	ECM	– Engine Control Module (ECM)
Engine Coolant Level	ECL	– Engine Coolant Level (ECL)
Engine Coolant Level Indicator	ECL Indicator	– Engine Coolant Level Indicator
Engine Coolant Temperature	ECT	– Engine Coolant Temperature (ECT)
Engine Coolant Temperature Sensor	ECT Sensor	– Coolant Temperature Sensor (CTS) – Engine Coolant Temperature Sender (ECT Sender)
Engine Coolant Temperature Switch	ECT Switch	– Coolant Temperature Switch (CTS)
Engine Speed	RPM	– Crankshaft Speed – Revolutions Per Minute (RPM)
Engine Speed Sensor	RPM Sensor	– Crankshaft Speed Sensor
Erasable Programmable Read Only Memory	EPROM	– Erasable Programmable Read Only Memory (EPROM)
Evaporative Emission	EVAP	– Evaporative Emission (EVAP)
Evaporative Emission Canister	EVAP Canister	– Canister – Charcoal Canister
Evaporative Emission Canister Purge	EVAP Canister Purge	– EVAP CANP – Canister Purge (CANP)
Evaporative Emission Canister Purge Valve	EVAP Canister Purge Valve	– Canister Purge Valve – Canister Purge Vacuum Switching Valve (Canister Purge VSV) – Duty Solenoid for Purge Valve – Evaporative Emission Purge Valve (EVAP Purge Valve) – Vacuum Solenoid Valve (Canister) (VSV) – Vacuum Solenoid Valve (EVAP) (VSV)
Evaporative Emission System	EVAP System	– Evaporation Emission Control System (EECS)
Exhaust Gas Recirculation	EGR	– Digital Exhaust Gas Recirculation (Digital EGR)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Exhaust Gas Recirculation Backpressure Transducer	EGR Backpressure Transducer	– Backpressure Transducer
Exhaust Gas Recirculation Diagnostic Valve	EGR Diagnositc	– EGR Diagnostic Valve
Exhaust Gas Recirculation System	EGR System	– EGR System
Exhaust Gas Recirculation Temperature	EGRT	– EGR Temperatur
Exhaust Gas Recirculation Temperature Sensor	EGRT Sensor	– Recirculated Exhaust Gas Temperature Sensor (REGTS)
Exhaust Gas Recirculation Thermal Vacuum Valve	EGR TVV	– EGR Thermal Vacuum Valve (EGR TVV)
Exhaust Gas Recirculation Vacuum Regulator Solenoid	EGR Vacuum Regulator Solenoid	– EGR Vacuum Regulator Solenoid Solenoid (EVR Solenoid)
Exhaust Gas Recirculation Vacuum Regulator Valve	EGR Vacuum Regulator Valve	– EGR Vacuum Regulator Valve Valve (EVRV)
Exhaust Gas Recirculation Valve	EGR Valve	– EGR Valve (EGRV)
Exhaust Gas Recirculation Valve Control	EGR Valve Control	– EGR Valve Control (EGRVC)
Exhaust Gas Recirculation Valve Position Sensor	EGR Valve Position Sensor	– EGR Valve Position Sensor (EVP Sensor)
Fan Control	FC	– Electro-Drive Fan Control (EDF Control) – Engine Coolant Fan Control – High Electro-Drive Fan Control (HEDF Control) – Radiator Fan Control
Fan Control Module	FC Module	– Fan Control Module
Fan Control Relay	FC Relay	– Fan Motor Control Relay – Radiator Fan Relay
Feedback Pressure Exhaust Gas Recirculation	Feedback Pressure EGR	– Pressure Feedback Exhaust Gas Recirculation
Feedback Pressure Exhaust Gas Recirculation Sensor	Feedback Pressure EGR Sensor	– Pressure Feedback Exhaust Gas Recirculation (PFE) Sensor
Flash Electrically Erasable Programmable Read Only Memory	FEEPROM	– Flash EEPROM
Flash Erasable Programmable Read Only Memory	FEPROM	– Flash EPROM
Flexible Fuel	FF	– Flexible Fuel (FF)
Flexible Fuel Sensor	FF Sensor	– Alcohol Concntration Sensor – Fuel Concentration Sensor – Fuel Quality Sensor – Percent Alcohol Sensor – Variable Fuel Sensor
Fourth Gear	4GR	– Fourth Gear (4GR)
Fuel Level Sensor	Fuel Level Sensor	– Fuel Sensor
Fuel Pressure	Fuel Pressure	– Fuel Pressure

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Fuel Pressure Regulator	Fuel Pressure Regulator	– Fuel Regulator
Fuel Pump	FP	– Fuel Pump (FP)
Fuel Pump Module	FP Module	– Fuel Module – Fuel Sender – Fuel Tank Unit – In Tank Module
Fuel Pump Relay	FP Relay	– Fuel Pump Relay
Fuel Trim	FT	– Adaptive Fuel Strategy
Generator	GEN	– Alternator (ALT)
Governor	Governor	– Governor
Governor Control Module	GCM	– Governor Electronic Module (GEM)
Ground	GND	– Ground (GRD)
Heated Oxygen Sensor	HO2S	– Heated Exhaust Gas Oxygen Sensor (HEGO Sensor) – Heated Oxygen Sensor (HOS)
High Speed Fan Control Switch	High Speed FC Switch	– High Speed Fan Control Switch (High Speed FC Switch)
Idle Air Control	IAC	– Idle Air Bypass Control – Idle Speed Control (ISC) – idle Speed Control Bypass Air (ISC BPA)
Idle Air Control Thermal Valve	IAC Thermal Valve	– Fast Idle Thermo Valve
Idle Air Control Valve	IAC Valve	– Air Valve – Fast Idle Thermo Valve – Idle Air Control Valve (IACV)
Idle Speed Control	ISC	– Throttle Opener
Idle Speed Control Actuator	ISC Actuator	– Idle Speed Control Actuator (ISC Acutator)
Idle Speed Control Solenoid Vacuum	ISC Solenoid Vacuum Valve	– Throttle Opener Vacuum Switching Valve (Throttle Opener VSV) – Vacuum Solenoid Valve (Throttle) (VSV)
Ignition Control	IC	– Electronic Spark Advance (ESA) – Electronic Spark Timing (EST)
Ignition Control Module	ICM	– Distributorless Ignition System Module (DIS Module) – Thick Film Ignition Module (TFI Module)
Indirect Fuel Injection	IFI	– Fuel Injection (FI) – Indirect Fuel Injection (IDFI) – Indirect Diesel Injection (IDI)
Inertia Fuel Shutoff	IFS	– Inertia Fuel Shutoff (IFS)
Inertia Fuel Shutoff Switch	IFS Switch	– Inertia Switch – Inertia Fuel – Shutoff Switch
Intake Air	IA	– Intake Air

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Intake Air Duct	IA Duct	– Intake Air Duct
Intake Air System	IA System	– Air Intake System
Intake Air Temperature	IAT	– Air Charge Temperature (ACT) – Manifold Air Temperature (MAT) – Throttle Body Temperature (TBT) – Vane Air Temperature (VAT)
Intake Air Temperature Sensor	IAT Sensor	– Air Temperature Sensor (ATS) – Intake Air Temperature Sensor (IATS) – Manifold Air Temperature Sensor (MATS)
Keep Alive Random Access Memory	Keep Alive RAM	– Keep Alive Memory (KAM)
Knock Sensor	KS	– Detonation Sensor (DS)
Long Term Fuel Trim	Long Term FT	– Block Learn Matrix (BLM) – Block Learn Memory (BLM) – Block Learn Multiplier (BLM)
Low Speed Fan Control Switch	Low Speed FC Switch	– Low Speed Fan Control Switch (Low Speed FC Switch)
Malfunction Indicator Lamp	MIL	– Check Engine – Service Engine Soon
Manifold Absolute Pressure	MAP	– Manifold Absolute Pressure (MAP)
Manifold Absolute Pressure Sensor	MAP Sensor	– Intake Manifold Absolute Pressure Sensor – Manifold Absolute Pressure Sensor (MAPS) – Pressure Sensor (P-Sensor)
Manifold Differential Pressure	MDP	– Manifold Differential Pressure (MDP)
Manifold Differential Pressure Sensor	MDP Sensor	– Vacuum Sensor (VAC Sensor)
Manifold Surface Temperature	MST	– Manifold Surface Temperature (MST)
Manifold Vacuum Zone	MVZ	– Manifold Vacuum Zone (MVZ)
Manifold Vacuum Zone Switch	MVZ Switch	– Vacuum Switches
Mass Air Flow	MAF	– Air Flow Control (AFC) – Air Flow Meter
Mass Air Flow Sensor	MAF Sensor	– Air Flow Meter – Air Flow Sensor (AFS) – Hot Wire Anemometer
Mixture Control	MC	– Feed Back Control (FBC) – Mixture Control (M/C)
Mixture Control Solenoid	MC Solenoid	– Mixture Control Solenoid (MCS)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Multiport Fuel Injection	MFI	– D-Jetronic – Digital Fuel Injection (EFI) – Electronic Fuel Injection (EFI) – Fuel Injection (FI) – L-Jetronic – LH-Jetronic – Motronic – Multipoint Injection (MPI) – Multiport Injection (MPI) – Port Fuel Injection (PFI) – Programmed Fuel Injection (PGM-FI) – Tuned Port Injection (TPI)
Nonvolatile Random Access Memory	NVRAM	– Keep Alive Memory (KAM) – Nonvolatile Memory (NVM)
Oil Pressure Sensor	Oil Pressure Sensor	– Oil Pressure Sender
Oil Pressure Switch	Oil Pressure Switch	– Oil Pressure Switch
On-Board Diagnostic	OBD	– Self Test
Open Loop	OL	– Open Loop (OL)
Oxidation Catalytic Converter	OC	– Continuous Oxidation Catalyst (COC) – Oxidation Catalyst (OC)
Oxygen Sensor	O2S	– Exhaust Gas Oxygen Sensor (EGO Sensor, EGOS) – Exhaust Gas Sensor (EGS) – Exhaust Oxygen Sensor (EOS) – Lambda – Oxygen Sensor (O2 Sensor, OS)
Park/Neutral Position	PNP	– Park/Neutral (P/N)
Park/Neutral Position Switch	PNP Switch	– Neutral Drive Switch (NDS) – Neutral Gear Switch (NGS) – Neutral Position Switch (NPS) – Neutral Safety Switch
Periodic Trap Oxidizer	PTOX	– Trap Oxidizer – Periodic (TOP)
Positive Crankcase Ventilation	PCV	– Positive Crankcase Ventilation (PCV)
Positive Crankcase Ventilation (Valve)	PCV Valve	– Positive Crankcase Ventilation (PCV) Valve)
Power Steering Pressure	PSP	– Power Steering Pressure (PSP)
Power Steering Pressure Switch	PSP Switch	– Power Steering Pressure Switch (P/S Pressure Switch, PSPS)
Powertrain Control Module	PCM	– Electronic Control Assembly (ECA) – Electronic Control Unit 4 (ECU4) – Electronic Engine Control Processor (EEC Processor) – Microprocessor Control Unit (MCU) – Single Board Engine Control (SBEC) – Single Module Engine Control (SMEC)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
Pressure Transducer Exhaust Gas Recirculation System	Pressure Transducer EGR System	– Pressure Transducer EGR System
Programmable Rad Only Memory	PROM	– Programmable Read Only Memory (PROM)
Pulsed Secondary Air Injection	PAIR	– Air Injection Reactor (AIR) – Air Injection Valve (AIV) – Pulsair – Thermactor II
Pulsed Secondary Air Injection Valve	PAIR Valve	– Reed Valve
Random Access Memory	RAM	– Random Access Memory (RAM)
Read Only Memory	ROM	– Read Only Memory (ROM)
Relay Module	RM	– Integrated Relay Module
Scan Tool	ST	– Scan Tool
Secondary Air Injection	AIR	– Air Injection (AI) – Air Injection Reactor (AIR) – Thermac – Thermactor
Secondary Air Injection Bypass	AIR Bypass	– Air Management 1 (AM1) – Secondary Air Injection Bypass (AIRB) – Thermator Air Bypass (TAB)
Secondary Air Injection Bypass Valve	AIR Bypass Valve	– Secondary Air Bypass Valve (SABV)
Secondary Air Injection Check Valve	AIR Check Valve	– Secondary Air Check Valve
Secondary Air Injection Control Valve	AIR Control Valve	– Air Control Valve – Secondary Air Check Valve (SACV)
Secondary Air Injection Diverter	AIR Diverter	– Air Management 2 (AM2) – Secondary Air Injection Diverter (AIRD) – Thermactor Air Diverter (TAD)
Secondary Air Injection Pump	AIR Pump	– Air Injection Pump (AIP)
Secondary Air Injection Switching Valve	AIR Switching Valve	– Secondary Air Switching Valve (SASV)
Sequential Multiport Fuel Injection	SFI	– Fuel Injection (FI) – Sequential Electronic Fuel Injection (SEFI) – Sequental fuel Injection (SFI)
Service Reminer Indicator	SRI	– Check Engine – Engine Maintenance Reminder (EMR) – Oxygen Sensor Indicator (OXS) – Service Engine Soon
Short term Fuel Trim	Short Term FT	– Integrator (INT)
Smoke Puff Limiter	SPL	– Smoke Puff Limiter (SPL)
Supercharger	SC	– Supercharger (SC)
Supercharger Bypass	SCB	– Surpercharger Bypass (SCB)
Supercharger Bypass Solenoid	SCB Solenoid	– Supercharger Bypass Solenoid (SBS)

J1930 TERMINOLOGY LIST

New Term	New Acronym	Old Terms (Acronyms)
System Readiness Test	SRT	– System Readiness Test (SRT)
Thermal Vacuum Valve	TVV	– Thermal Vacuum Switch (TVS)
Third Gear	3GR	– Third Gear (3GR)
Three Way Catalytic Converter	TWC	– Three Way Catalytic Converter (TWC)
Three Way + Oxidation Catalytic Converter	TWC + OC	– Dual Bed
Throttle Body	TB	– Fuel Charging Station
Throttle Body Fuel Injection	TBI	– Central Fuel Injection (CFI) – Electronic Fuel Injection (EFI) – Fuel Injection (FI) – Monotronic – Single Point Injection (SPI)
Throttle Position	TP	– Throttle Position (TP)
Throttle Position Sensor	TP Sensor	– Throttle Position Sensor (TP) – Throttle Potentiometer
Throttle Position Switch	TP Switch	– Throttle Position Switch (TPS)
Torque Converter Clutch	TCC	– Converter Clutch Control (CCC) – Converter Clutch Override (CCO) – Viscous Converter Clutch (VCC)
Torque Converter Clutch Relay	TCC Relay	– Lock Up Relay
Torque Converter Clutch Solenoid Valve	TCC Solenoid Valve	– Lock Up Solenoid Valve (LUS)
Transmission Control Module	TCM	– Transmission Control Module
Transmission Range	TR	– Park, Reverse, Neutral, Drive, Low (PRNDL) – Selection Lever Position (SLP) – Transmission Range Selection (TRS)
Transmission Range Sensor	TR Sensor	– Manual Lever Position Sensor (MLP Sensor)
Transmission Range Switch	TR Switch	– Manual Range Position Switch (MRPS) – Transmission Position Switch – Transmisison Range Selection Switch (TRSS)
Turbocharger	TC	– Turbo
Vehicle Speed Sensor	VSS	– Distance Sensor – Pulse Generator (PG)
Voltage Regulator	VR	– Voltage Regulator (VR)
Volume Air Flow	VAF	– Air Flow Control (AFC) – Air Flow Meter – Vane Air Flow
Volume Air Flow Sensor	VAF Sensor	– Aif Flow Meter – Air Flow Sensor (AFS)
Warm Up Oxidation Catalytic Converter	WU-OC	– Light Off Catalyst
Warm Up Three Way Catalytic Converter	WU-TWC	– Light Off Catalyst
Wide Open Throttle	WOT	– Full Throttle
Wide Open Throttle Switch	WOT Switch	– Wide Open Throttle Switch (WOTS)

WE WANT TO HEAR FROM YOU!

Your suggestions will help us to improve this manual.
Mail this form or fax your comments to:
Ford Power Products
28333 Telegraph Rd., Suite 300
Southfield, Michigan 48034

Or Fax your comments to:
Ford Power Products Publication
(248) 945-4431

Manual ____________ Vehicle ____________ Year ________

Are you reporting an error in the procedures or illustrations? YES ☐ NO ☐

If yes, page ________ please describe in detail: ____________________

____

____

Did the procedures make sense and were they easy to follow? YES ☐ NO ☐

If no, page ________ please describe: ____________________

____

____

Is the organization of the manual clear and easy to follow? YES ☐ NO ☐

Please comment: ____________________

____

Are there any important procedures not covered in this manual that you would like to see included? YES ☐ NO ☐

If yes, please describe: ____________________

____

Please enclose a copy of each page marked with your suggestions.
Please tell us who you are:

Name ____________________

Street ____________________

City ____________ State ____________ Zip ________

Company ____________ Position ____________

Thank You for Your Help – Ford Power Products Publications Department